Carbohydrates

Phytochemical studies, concerning the carbohydrates and protein constituents of some species of the family have been reported. The analysis of *Allamanda cathartica, Allamanda violacea, Plumeria alba* and *Plumeria rubra* revealed the presence of sucrose, glucose and proline in all species. Raffinose in *A. violacea* and *P. alba*, tryptophane and tyrosine in *Allamanda*, alanine in *P. alba* and *A. cathertica*, valine in *A. cathartica*, valine in *A. cathartica* and lysine in *P. rubra* and *A. violacea* were found. Mannose and xylose were absent in *Plumeria* and fructose was absent in *A. violacea* (Marimuthu *et al*., 1986). The following are examples of carbohydrates of some studied species:

1. *Acokanthera spectabilis*: Sucrose from the seeds (Karawya *et al*., 1973a).
2. *Allamanda cathartica*: 3-*O*-Methyl D-glucose, a major constituent of the leaves (11.03%) and stems (20.86%) (Prabhadevi *et al*., 2012).
3. *Alstonia boonei* (DC) Willd Complex polysaccharides (Kone *et al*., 2012).
4. *Amsonia angustifolia*: Raffinose, sucrose, glucose and fructose from the seeds; raffinose, sucrose and glucose from the leaves and roots (Tomczyk, 1964).
5. *Alstonia venenata* R. Br.: 3-*O*-Methyl D-glucose (87.64%) and methyl β-D-arabino-pyranoside (0.09%) from the leaves (Sutha *et al*., 2012).
6. *Anodendron affine*: Sucrose from the stems (Shima *et al*., 1971b).
7. *Apocynum venetum*: Hydratopectins (10.2-10.4%), giving 45.01% galacturonic acid (Pryanishnikov and Frolova, 1936).
8. *Catharanthus roseus*: The common constituents of the mucilage from callus cultures were glucose and mannose (Kokate and Radwan, 1979).
9. *Epigynum auritum*: α-Methyl-L-*bis*[α-methyl fructopyranosyl(1→2),(1→3)]-arabino-furanose and 5-hydroxymethyl-2-furancarboxaldehyde from dried stem (Cao *et al*., 2003).
10. *Funtania elastica*: A complex polysaccharide from the ground bark (Graff *et al*., 2009).
11. *Himatanthus sucuuba* (Spruce) Woodson: Arabinose, glucose, xylose, rhamnose and galactose from the latex (Silva *et al*., 2003).
12. *Holarrhena antidysentrica* (Roxb.) Wall: Two polysaccharide fractions A (5.76%) and B (0.74%) were isolated from the *in vitro* cultivated callus tissue. Both fractions were heteropolysaccharides containing glucose, arabinose and the same amino acids, alanine, glycine, aspartic acid, serine and threonine (Ekiert and Kohlmunzer, 1998).
13. *Mandevilla velutina*: D-Glucose, L-rhamnose and D-xylose are the major components of the hemicellulosic fractions of the cell wall polysaccharides. The deoxy-sugar L-fucose was also found as a minor constituent (Maraschin *et al*., 1999).

14. *Ichnocarpus frutescens*: Butyl α-L-sorbopyranoside was isolated from the plant (Verma *et al*., 1988).
15. *Nerium indicum* Mill.: A neutral polysaccharide (NIB-1), from the fresh leaves, composed of L-arabinose, D-galactose and D-glucose in a molar ratio of 1:6:10 (Li *et al*., 1999b). A polysaccharide fraction, NIB-2, from leaves, composed of rhamnose, arabinose, galactose, in the ratios of 1.0:10.4:4.4, along with 4% of galacturonic acid. (Dong and Fang, 2001). A rhamno-galacturonan (J1) and a xyloglucan (J2) (Ding *et al.*, 2003) and neuroprotective polysaccharides (J2, J3, J4 and J6), from the flowers (Yu *et al.*, 2004, 2007a).
16. *Nerium oleander*: Several polysaccharide fractions, containing galacturonic acid, rhamnose, arabinose and galactose from the leaves (Müller *et al*., 1991) and flowers (Dong *et al.*, 2010), and an immunostimulant polysaccharide consisting entirely of D-galacturonic acid units (Oezel *et al*., 1990). The mucilage hydrolyzate of the aerial parts of the plant, growing in Egypt, was found to contain rhamnose, arabinose and galactose (Shams *et al.*, 2012). The plant contains 0.3-0.4% (dry weight) apiose (Duff and Knight, 1963).
17. *Ochrosia nakaiana* (Koidz.) Koidz. ex H. Hara: Sucrose, D-glucose and D-fructose from the leaves (Sakushima *et al*., 1980c).
18. *Poacynum hendersonii* (Hook. f.) Woodson: A sugar ester poacynose [benzoyl β-D-xylopyranosyl-(1→6)-β-D-glucopyranose) from the flowers (Morikawa *et al*., 2012). Saccharose (Zhang *et al.*, 2006a) and a polysaccharide from the leaves (Shi *et al.*, 2010).\
19. *Poacynum pictum* (Schrenk) Baill: Saccharose and Δ'-prenyl-3-*O*-β-D-glucopyranosides from the leaves (Zhang *et al*., 2009d).
20. *Rauwolfia heterophylla* Roem. and Schult: Sucrose (Djerassi *et al*., 1954).
21. *Rauwolfia serpentina* Benth.: Sucrose (Khaleque *et al*., 1969) and a sucrose derivative, 6'-*O*-(3,4,5-trimethoxybenzoyl)glomeratose A from the roots (Itoh *et al*., 2005). Water soluble seeds polysaccharide consisting of D-glucose and D-mannose, from the seeds (Singh, 2009; Singh *et al*., 2009). A pectic polysaccharide, rauvolfin, from the dried callus (Popov *et al*., 2007).
22. *Strophanthus divaricatus*: 2,6-Dimethoxy-D-galactose (3.091%) from the leaves (Cheng *et al*., 2013).
23. *Thevetia peruviana* (Pers.), Merr: A polysaccharide, consisting mainly of L-arabinose, D-galactose, and D-galacturonic acid together with D-glucose and D-xylose from the fruits (Haq and Hannan, 1984).
24. *Trachelospermum gracilipes*: A disaccharide, rhamno(α1→2)glucoside (Lin *et al*., 1993a).
25. *Winchia calophylla* A. DC.: Butyl α-glucopyranoside and butyl β-glucopyranoside from the stem bark (Chen *et al*., 2012a).
26. *Wrightia tinctoria*: D-Galactose, D-mannose, 3 disaccharides, a trisaccharide (Srivastava *et al*., 2010, Srivastava and Chakravarty, 2011a,b), erythritol (a sugar alcohol, (2*R*,3*S*)-butane-1,2,3,4-tetraol), thritol (Srivastava and Chakravarty, 2011b) and a polysaccharide composed of D-galactose and D-mannose (Singh, 2013a,b) from the seeds.

Proteins and Amino Acids

The study of the proteins and amino acids of few species of the family have been reported; examples of these are:

1. *Allamanda cathartica*: In leaves, 13 peptides with molecular weight (M.wt.) from 27 to 168 kDa were detected, while in shoots 10 peptides with M.wt. from 30 to 95 kDa were

resolved. Similarly, in roots, 10 peptides of 30-880 kDa and in flower seven peptides of 30-88 kDa were detected (Hameed *et al.*, 2014).

2. *Alstonia scholaris*: The protein of the plant comprised 12 amino acids including 5 essential ones (Vashi and Patel, 1989).
3. *Catharanthus roseus*: Glycoproteins were isolated from cultured cells (Dupaix and Arrio, 1991). Two phytocystatins (thiol protease inhibitors, a group of proteins that inhibit cysteine) have been isolated from the plant (Sharma *et al.*, 2011a). Arabinogalactan protein (AGP), a class of cell wall proteoglycan, was isolated from the hairy root cultures of a newly developed hairy root line IIT-BT/D1 of *C. roseus*. AGP was found to be present both in the roots (0.3 mg/g fresh wt.) and in the spent media (47 mg/L). The compositional analysis revealed the predominance of arabinose and galactose sugars, a characteristic feature of AGP (Mishra *et al*., 2006).
4. *Cerbera manghas*: The leaves contained 16 amino acids, including 2 semi-essential amino acids and 6 essential amino acids amounting to 33.20% of the total amino acids (Wang *et al*., 2009d).
5. *Ecdysanthera rosea* Hook. et Arn.: Ternatin (a heptapeptide) was isolated from the plant (Zhu *et al.*, 2011a).
6. *Holarrhena antidysentrica*: The seeds contain 31.5% crude protein. Aspartic acid and arginine were the major free amino acids detected (Thanki and Thaker, 1980).
7. *Nerium oleander*: The following amino acids were detected in the stem: alanine (0.99), arginine (1.12), aspartic acid (1.98), cysteine (1.09), glutamic acid (2.27), glycine (2.01), histidine (0.89), leucine and isoleucine (2.13), lysine (0.78), phenylalanine (1.02), proline (1.32), serine (1.05), threonine (0.12), tryptophan (0.14), tyrosine (1.20) and valine (0.95 mg) (Saxena *et al.*, 1989). The crude protein of the plant growing in Egypt amounted to 12.33 %. Alanine (15.49 %) represented the main amino constituent of the 14 amino acids detected inthe protein hydrolysate (Shams *et al*., 2012).
8. *Rauwolfia serpentina*: The globulin proteins of the seeds contained asparagine, serine, threonine, alanine, methionine, phenylanaline, and leucine (Nath and Rao, 1962). Arginine, lysine, serine, aspartic acid, glutamic acid, threonine, alanine, proline, valine, tyrosine, phenylalanine, isoleucine, and leucine were found in all plant parts (roots, stems, leaves, flowers, and fruit). Cystine occurred in protein hydrolyzates of all plant parts. Histidine and glycine occurred only in the protein hydrolyzates of roots and leaves. Free γ-aminobutyric acid was found in all plant parts, while tryptophan occurred only in the hydrolyzates (Madan, 1967).
9. *Tabernaemontana divaricata*: Aurantiamide acetate (a dipeptide) was isolated from the plant (Pratchayasakul *et al*., 2008).
10. *Thevetia peruviana*: The leaves contain 18 amino acids; among them glutamic acid, leucine, glycine, and isoleucine were predominating over arginine, valine, alanine, proline, phenylalanine, aspartic acid, cystine, lysine, serine, tyrosine, histidine, threonine, methionine and tryptophan. Sulphur containing amino acid, cystine is also present in good concentration (Jain and Yadav, 1991). The detoxified seed cake contains 30-37% protein, containg the following amino acids: lysine, 4.47; histidine, 1.62; arginine, 4.48; aspartic acid, 109.85; threonine, 2.61, serine, 3.9; glutamic acid, 14.21; proline, 4.24; glycine, 3.63; alanine, 4.49; cysteine, 1.69; valine, 4.01; methionine, 0.88; isoleucine, 2.94; leucine, 5.49; tyrosine, 2.49 and phenylalanine, 3.38 (Usman *et al.*, 2009).
11. *Wrightia tinctoria*: An 11S globulin, exhibiting hemagglutinating activity was characterized from the seeds (Kumar *et al.*, 2013a).

12. *Wrightia tomentosa*: The seeds contain 35.59% protein. Percentages of arginine, threonine and valine were higher than in soybean (Jain *et al*., 1992). An amyloid β-protein ($A\beta_{17-28}$) was characterized from the roots (Nagarajan *et al*., 2012).

Fatty Acids and Related Compounds

The following are examples of the fatty acids identified from some species of the family:

1. *Aganosma cymosa*: The plant yielded 10.3% oil., which contained higher quantities of saturated fatty acids than unsaturated fatty acids (Augustus and Seiler, 2011).
2. *Allamanda cathartica* L.: 9,12,15-Octadecatrienoic acid *(Z,Z,Z*) (16.39%), *n*-hexadecanoic acid (14.08%) and 9,12,15-octadecatrienoic acid ethyl ester (*Z,Z,Z*)- (10.58%), *n*-hexadecanoic acid, 9,12,15-octadecatrienoic acid (*Z,Z,Z*)-, hexanoic acid ethyl ester, octanoic acid ethyl ester, decanoic acid ethyl ester, tetradecanoic acid, pentadecanoic acid, *n*-hexadecanoic acid, hexadecanoic acid ethyl ester, 9,12-octadecadienoic acid ethyl ester, octadecanoic acid ethyl ester, nonadecanoic acid ethyl ester, dodecanoic acid, tetradecanoic acid and oleic acid from the leaves (Prabhadevi *et al.*, 2012). 17-Methyl-5,9-octadecadienoic acid was also identified in the plant (Caraballeira and Cruz, 1998).
3. *Allamanda neriifolia:* Hexadecanoic acid, octadecanoic acid, ethyl (9*Z*,12*Z*)-octadeca-9,12-dienoate, 9,12,15-octadecatrienoic acid, *cis*-11,14,17-eicosatrienoic acid methyl ester and 2-propenoic acid 3-(4-methoxyphenyl)-2-ethylhexyl ester (Chaveerach *et al.*, 2014).
4. *Allamanda schottii*: Hexadecanoic acid,9,12,15-octadecatrienoic acid methyl ester were identified from the plant (Chaveerach *et al.*, 2014).
5. *Allamanda violaceae* A. DC.: Hexadecanoic acid ethyl ester (15.63%), 9*Z*-octadecenoic acid ethyl ester (47.26%), 9*Z*,12*Z*-octadecadienoic acid (15.21%), methyl 19-methyleicosanoate (3.34%), eicosanoic acid (3.04%), hexadecanoic acid, 2-(hydroxyl)-1,3-propanediol ester (3.83%) and docosanoic acid (0.40) from the flowers (Sethi *et al*., 2013). Octadecanoic acid was detected in the plant (Chaveerach *et al.*, 2014).
6. *Alstonia boonei* De Wild: Capric acid, 1.55; 7-octadecenoic acid methyl ester, 12.89; stearic acid methyl ester, 9.02; 9-octadecenoic acid, 1,2,3-propanetriyl ester (*E,E,E*) [2,3-bis (9*E*)-9-octadecenoyloxyl (9*E*)-9-octadecenoate], 15.46; stearic acid, 10.31 and hexadecanedioic acid (hexadecane-1,16-dioc acid), 2.58% from the leaves (Okwu and Ighodaro, 2010).
7. *Alstonia scholaris* (Linn.) R. Br.: Saturated fatty acids make up 26.06% of the total fatty acids, with the major one being stearic acid (16.69%). The percentage of unsaturated fatty acids was 70.48%, with linoleic acid being the major component (48.89%) of the plant growing in Egypt (El-Askary *et al.*, 2012). The fatty acids of the seed oil (23.9%) were oleic acid (65.66%), linoleic acid (12.15%), palmitic acid (13.77%) and stearic acid (8.42%) (Dutta *et al.*, 2010). Palmitic acid was identified from the flowers (Adotey *et al*., 2012).
8. *Alstonia venenata* R. Br.: Oleic acid (about 64%) occurred predominantly in the seed oil (Farooqi *et al*., 1983). Pentanoic acid, 2-hydroxy-ethyl ester (0.04); decanoic acid, 2-methyl- (0.30); *n*-hexadecanoic acid (1.70) and hexanedioic acid bis(2-ethylhexyl) ester (1.87%) were identified from the leaves (Sutha *et al*., 2012).
9. *Alstonia verticillosa*: The seeds oil contained palmitic, oleic and linoleic acids. The oil was comparable to groundnut oil with respect to its fatty acid composition especially in the contents of oleic (~54%) and linoleic (~20%) acids (Ahmad *et al.*, 1986b).
10. *Beaumontia grandiflora* Wall.: The fatty acids of the plant, grown in Egypt, were lauric (0.09), tetracosanoic (0.34), myristic (1.43), pentadecanoic (0.73), palmitic (19.2), palmitoleic (1.38), stearic (17.02), linoleic (29.6), linolenic (18.71), nonadecanoioc

(3.57), behenic (6.38) and erucic (1.45%) acids (Abdelshafeek *et al*., 2010).

11. *Ctharanthus roseus*: The seeds contain 27.36% oil (Dolya *et al.*, 1985). The relative contents of the main fatty acids of the seed oil were oleic acid (73.92%), linoleic acid (16.93%), palmitic acid (5.58%) and arachidic acid (3.40%) (Niu *et al.*, 2008). The major fatty acids found, after the elicitation of cell suspension cultures with jasmonic acid, a lipid-derived phytohormone, were palmitic acid, linoleic acid and linolenic acid, being the saturated acids predominant over the unsaturated ones (Goldhaber-Pasillas *et al*., 2012).
12. *Cerbera manghas* L.: *n*-Hexadecane acid monoglyceride from the leaves (Zhang *et al.*, 2010c).
13. *Cerbera odollam* Gaertn.: The seeds contain 54-62.1% oil (Subbaram, 1952; Kansedo *et al.*, 2009). Stearic 10.8, palmitic 32.0, oleic 38.8, linoleic 18.4% (Subbaram, 1952), myristic and lignoceric acids (Ghanekar and Ayyar, 1927a; Kafuku and Hata, 1936).
14. *Chonemorpha macrophylla*: The root contained 0.54% lipids, as glycerides of lauric acid (11.9), stearic acid (13.3), arachidic acid (17), myristic acid (20.2), palmitic acid (10.4), oleic acid (9.6), linolenic acid (11.8), and ricinoleic acid (5.2%) (Shrivastava and Saxena, 1984).
15. *Ecdysanthera rosea* Hook. et Arn.: Halicerebroside A (*N*-[(6*E*)-1-(β-D-gluco-pyranosyl-oxy)-3,4-dihydroxy-6-octadecen-2-yl]-2-hydroxydocosanamide) (Zhu *et al.*, 2011a).
16. *Funtumia elastica* (Wild rubber): The seed oil consisted of 14.33-17.77 % saturated fatty acids, palmitic and stearic acids and 70.90-88.35 % unsaturated fatty acids, oleic, linoleic and linolenic acids, linoleic acid being the most abundant (Oyewusi *et al*., 2007). The presence of heptadecanoic acid, or margaric acid was also reported (Hebert, 1912).
17. *Holarrhena antidysentrica*: The seeds contain 19% of a drying oil composed of the glycerides of the following acids: linolenic acid 10, linoleic acid 54.7, oleic acid 21, palmitic acid 5.6, stearic acid 6.8 and lignoceric acid 1.9% (Ghanekar and Ayyar, 1927b). Powell *et al.* (1969) reported that the seed oil contains 73% 9-D-hydroxy-*cis*-12-octadecenoic acid.
18. *Kopsia fruticosa*: The seed oil contains palmitic, 13.2; stearic, 8.9; oleic, 7.3 and linoleic 61.2% (Badami and Shanbhag, 1973).
19. *Landolphia dawei* Stapf.: Palmitic acid (28.25%) is the major fatty acids of the leaves of the plant cultivated in Egypt (Michel and Sleem, 2003).
20. *Landolphia owariensis* O. Beauv.: The seed oil (6.40±1.00) (Akubugwo and Ugbogu, 2007) contains the following fatty acids: pentadecanoic acid, 1.85; palmitoleic acid, 18.54; palmitic acid, 54.38; capric acid, 0.49; undecanoic acid, 3.41; lauric acid, 3.56; myristic acid, 1.93; linoleic acid, 9.56; heptadecanoic acid, 1.48; linolenic acid, 0.19 and stearic acid, 4.59 % (Okonkwo *et al.*, 2014).
21. *Macrosiphonia petraea* (A. St.-Hil.) Kuntze: 5-Hydroxy-octadeca-6(*E*)-8(*Z*)-dienoic acid from the roots (De Assis Junior *et al.*, 2013).
22. *Mandevilla laxa*: Linoleic acid was the major component of the total fatty acid content, with palmitic and oleic acid as important constituents of both *Mandevilla laxa and Mandevilla pentlandiana* (Rodriguez and Guzman, 1995).
23. *Mandevilla pentlandiana*: Lauric, myristic, palmitic, stearic, oleic, linoleic, linolenc and *cis*-11,14-eicosadienoic acids (Michelotti and Gros, 1983).
24. *Nerium indicum* f. *plenum*: Lauric, tridecanoic, myristic, pentadecanoic, palmitic, heptadecanoic, stearic, oleic, nonadecanoic, eicosanoic and dicosanoic acids from the flower (Asakawa *et al*., 1969); *n*-hexadecanoic acid, and squalene from the leaves (Hao *et al*., 2013).
25. *Nerium odorum*: Two hydroxy acid methyl esters, neriumol (methyl (7*S*,16)-dihydroxyhexadeca-8Z-enoate) and nerifol (methyl (7*S*,16)-dihydroxyhexadeca-8Z-

enoate and methyl (8,16)-dihydroxyhexadecanoate) from the fresh, undried, uncrushed leaves (Siddiqui *et al*., 1987i).

26. *Nerium oleander*: The oil from the pods and seeds of the pink flower variety contains caproic, caprylic, capric, lauric, palmitic, oleic, and stearic acids (Dominguez and Villarreal, 1963). The kernel oil obtained from the fruits amounted to 21% (Saxena *et al.*, 1990).Main constituents of the flowers were oleic (24%), palmitic (~21.5%), linolenic (~ 11%) and linoleic (10%) acids (Chiarlo, 1964b). Elevn fatty acids were detected in the lipid fraction of the plant growing in Egypt, in which palmitic acid (27.88 %) represented the main constituent (Shams *et al.*, 2012).
27. *Pachypodium lamerei* Drake: The following acids were identified from the leaves and stems of the plant cultivated in Egypt: palmitic (8.90%), stearic (5.86%), nonadecanoic (9.77%), 4-hydroxyoctadecanoic (9.96%), arachidic (1.25%), behenic (0.86%), tricosanoic (0.79), heptacosanoic (1.69%), montanoic (1.31%) and nonacosanoic (1.88%) acids (El-Kashef *et al*., 2014).
28. *Peschiera australis*: The seed oil contains oleic acid (75%) as the main fatty acid (Spitzer *et al*., 1995).
29. *Plumeria accuminata*: Palmitic acid (32.7%), oleic acid (23.0%) and linoleic acid (42.7%) and stearic acid from the seed oil (Qazi *et al.*, 1973).
30. *Plumeria rubra*: Palmitic acid, tetradecanoic acid and other fatty acids were reported as the main constituents of the volatile oil (Peng *et al*., 2013). A sphingolipid, rubranin (= (2*S*,3*S*,4*R*)-2-{[(2*R*,16*E*)-2-hydroxyhexaeico-16-en]amino}octadecane-1,3,4-triol-1-*O*-β-D-glucopyranoside, was identified from the plant (Akhtar *et al.*, 2013).
31. *Plumeria rubra* var. *acutifolia*: The fatty acids fraction of the leaves of the plant growing in Egypt, comprised saturated fatty acids (63.66%) and unsaturated fatty acids (34.4%) (Sengab *et al*., 2009).
32. *Poacynum hendersonii* (Hook. f.) Woodson: *n*-Hexadecanoic acid from the leaves (Zhang *et al*., 2006a).
33. *Poacynum pictum* (Schrenk) Baill: Palmitic acid, n-hexacosanoic acid from the leaves (Zhang *et al*., 2009d).
34. *Rauwolfia serpentina*: The fatty acids of the seed oil, of the plant growing in India, were reported as lauric 0.2 %, myristic 0.8 %, palmitic 17.7%, stearic 4.9 %, arachidic 0.9 %, behenic 0.6 %, oleic 34.4 %, and linoleic 40.5 % (Daulatabad and Ankalgi, 1985). Palmitic acid (25%), oleic acid (38.5%) and linoleic acid (34.5%) were also the main component fatty acids in the seed oil plant collected from Bangladesh. Stearic (1.6%) and linolenic (0.4%) were also detected (Khaleque *et al.*, 1988).
35. *Rauwolfia tetraphylla* L. (syn. *Rauwolfia canescens* Linn., *Rauwolfia heterophylla* Roem and Schult): Lauric 0.9 %, myristic 3.4 %, palmitic 25.7 %, stearic 10.3%, arachidic 1.6%, behenic 1.4%, oleic 36.5 %, and linoleic 20.2 % acids (Daulatabad and Ankalgi, 1985).
36. *Strophanthus divaricatus* (Loureiro) Hooker et Arnott: Palmitic acid, oleic acid from the leaves (Cheng *et al.*, 2013) and ethyl palmitate and palmitic acid from the roots (Yan *et al*., 2012b).
37. *Strophanthus sarmentosus*: Major fatty acids of the seed oil are palmitic (11.9%), oleic (38.3%) and linoleic (29.8%) acids; the minor acids include stearic acid (9.2%), some saturated acids (4.0%) higher than stearic and 9-hydroxy-12-octadecenoic acid (6.6%) (Gunstone, 1952a,b).
38. *Strophanthus* spp.: A wide range of *Strophanthus* oils was examined. All contained 9-hydroxy-12-octadecenoic acid (6-15%) and perhaps minor amounts of erythro-9,10-dihydroxystearic acid (Gunstone and Morris, 1959). 9-Hydroxyoctadec-12-enoic acid

(characterized as 9,12,13-trihydroxystearic acid) was present in the seed oils of *Strophanthus sarmentosus* (forest form), *Strophanthus hispidus* and *Strophanthus courmontii* (6.5-13.5%). The other characterized fatty acids were palmitic (11.9-13.4%), stearic (4.5-8.1%), oleic (35.5-43.5%), linoleic (26.4-30.4%), myristic (0.1-0.2%) and arachidic (2.0-3.1%) acids (Gunstone, 1953).

39. *Tabernaemontana cymosa:* 9-Octadecenoic (53%), 9,12-octadecadienoic (23%), hexadecanoic (15 %), octadecanoic (6%) and 9,12,15-octadecatrienoic (2%) acids from the leaves (Achenbach *et al.*, 1997).
40. *Tabernaemontana divaricata:* Palmitic acid and glycerol monopalmitate were identified from the roots and stems (Liang *et al.*, 2007a). The composition of the biodiesel, prepared from the seed oil, is estimated as 27.0 % Me palmitate (C16:0), 10.54% Me linoleate (C18:2), 56.23% Me oleate (C18:1) and 6.20% Me stearate (C18:0) (Basumatary *et al*., 2013).
41. *Tabernaemontana pachysiphon* var. *pachysiphon*: Oleic (59.4%), palmitic (18.51%), stearic (2.71%), linoleic (16.81%) and myristic (2.56%) acids from the seeds (Ambujam *et al*., 1981a,b).
42. *Tabernaemontana penduliflora*: Oleic (48.14%); palmitic (25.35%); stearic (18.6%); linoleic (7.82%) and myristic (0.7%) acids from the seed oil (Ambujam *et al*., 1981a,b).
43. *Thevetia ahouri* (L.) DC.: Caproic, 12.40; lauric, 18.36; myristic, 10.10, palmitic, 8.86, stearic, 7.26; oleic, 28.40; linoleic, 10.45; and linolenic, 4.18% acids from the seed oil (Beauregard Cruz *et al*., 1986).
44. *Thevetia neriifolia*: Ghatak (1932) reported that the kernels yielded 68.7% of a non-drying oil. The seeds yielded 57.0% oil which is rich in palmitic (24.5%) and oleic (39.6%) acids (Badami and Shanbhag, 1974). The fatty acids of the seed oil (55%) was reported as follows: palmitic (31.3), stearic (5.0), oleic (4.2), arachidic (28.8) and linoleic (29.3%) acids (Salam *et al*., 1970). Also, Qazi *et al.* (1973) reported that the oil contains palmitic (25.9), oleic acid (41.6), linoleic acid (24.3) and trace amounts of stearic acid. The phospholipid composition of the seed was phosphatidylcholine, phosphatidyl-ethanolamine, phosphatidylinositol, cardiolipin, and unidentified components (Kulkarni *et al*., 1992).
45. *Thevetia peruviana* (Pers.) L. Schum. (Yellow oleander, Milk bush): The study of the fatty acids of the seed oil (60-65%), from different countries, revealed the presence of the following fatty acids: capric, caprilic, lauric, myristic, palmitic, stearic, arachidic, arachidonic, behenic oleic, linoleic, linolenic, palmitoleic, and erucic acids (Calle, 1980; Obasi *et al*., 1990; Gata Gonçalves *et al*., 2003; Usman *et al.*, 2009; Mthuravalli and Lakshmi, 2012; Alabi *et al.*, 2013). The seed oil showed good thermal stability and has been reported as a good frying and cooking oil (Ibiyemi *et al*., 1995). The seed oil has a high potential for use in production of environmentally friendly biodiesel (Deka and Basumatary, 2011; Sahoo *et al*., 2012;Yarkasuwa *et al*., 2013; Oseni *et al*., 2014).
46. *Vallaris heynei:* The seed oil (33.0%) linoleic 40.4, oleic 35.3, stearic 14.4, palmitic 7.2, arachidic 1.8, lignoceric 0.5 and behenic 0.4% (Paul *et al.*, 1960).
47. *Vallaris solanacea* (Roth) Kuntza: The root bark oil (40%) contains the following fatty acids: capric (15.0957), lauric (0.0086), palmitic (37.8001), erucic (0.0120), arachidonic (42.4008), caprylic (0.7412), oleic (0.0182) and linolenic (0.1705%) acids (Punam *et al*., 2012).
48. *Vinca rosea* Linn (syn. *Lochnera rosea*, Linn.): Lauric (0.2%), myristic (1.0%), palmitic (1.4 %), stearic (6.8 %), arachidic (1.3 %), behenic (0.6 %), oleic (73.6 %), linoleic (15.1%) (Daulatabad and Ankalgi, 1985) and ricinoleic (2.27%) (Garg *et al*., 1987) acids from the seed oil.

49. *Voacanga africana*: The seed oil contained oleic, linoleic, palmtic, and stearic acids (Rafidison *et al*., 1987; Su *et al.*, 2011).
50. *Wrightia annamensis* Dubard and Eberhardt: An oil, similar to castor oil was obtained from the seeds. A hydroxyoleic acid, probably analogous to ricinoleic acid, has been determined as the principal fatty acid (Margaillan, 1931).
51. *Wrightia coccinea*: Isoricinoleic acid (9-hydroxy-12-*cis*-octadecanoic acid) is found at 76.1% in the seed oil (Siddiqui *et al.*, 1980). The seeds are reported as a rich source of isoricinoleic acid. The fatty acid composition of the oil was palmitic acid 7.5, stearic acid 1.8, oleic acid 7.8, linoleic acid 6.7, and isoricinoleic acid 76.1% (Siddiqi *et al.*, 1980). Among two possible precursors for the biosynthesis of isoricinoleic acid, 9-hydroxy-stearic acid, but not *cis*-12-octadecenoic acid, is detectable in the seed lipids of both *Wrightia coccinea* and *Wrightia tinctoria* (Ahmad *et al*., 1986a).
52. *Wrightia tinctoria*: The seeds contain 30.5% of a deep red semidrying fixed oil, containing the glycerides of the following acids: linolic 31.8, oleic 33.98, myristic 0.07, palmitic 8.65, stearic 18.24, arachidic 5.82% (Parihar and Dutt, 1946). Isoricinoleic acid (9-hydroxy-12-*cis*-octadecanoic acid) [also named strophanthus acid (Ansari *et al*., 1971)] is a major constituent of the seed oil (Ahmad *et al*., 1986a). The fatty acids of the seed oil (30.5%) were reported as linoleic (38.8%), oleic (34.0%), myristic (0.1%), palmitic (8.7%), stearic (18.2%) and arachidic (5.81%) acids (Srivastava *et al*., 2010). The composition of the acyl moieties of the total lipids was reported (Ahmad *et al*., 1986a). Lauric acid and dodecanoic acid were detected in the bark (Jose and Jesy, 2014).
53. *Wrightia tomentosa* Roem & Schult: Strophanthus acid (9-hydroxy-12-*cis*-octadecanoic acid) was a major component of the seed fat (Ansari *et al*., 1971). A fatty acid derivative, methyl 6,7-dithia stearate was isolated from the root (Nagarajan *et al*., 2011).

Hydrocarbons and Other Related compounds

Hydrocarbons and related compounds have been identified from the waxes of different parts of several species; the following are some examples:

1. *Alstonia scholaris* (Linn.) R. Br.: The surface wax of the leaves contained 18 identified long chain (C_{17}-C_{34}) *n*-alkanes. The predominant *n*-alkanes were C_{31} (46.43%) and C_{33} (21.85%), while C_{29} (6.16%), C_{32} (4.28%), C_{25} (3.74%) were moderately abundant. The C_{17} (0.39%) and C_{22} (0.44%) *n*-alkanes were present only in minor amounts (Dutta and Laskar, 2009).
2. *Apocynum venetum*: Nonacosane and 1-triacontanol from leaves (Jiang *et al.*, 1985).
3. *Catharanthus longifolius*: A wax material, a mixture of the 7 *n*-alkanes from C_{27}-C_{33}, was separated from the roots (Farnsworth *et al*., 1968a).
4. *Landolphia* species: The latex from *Landolphia owariensis*, *Landolphia owariensis* var. *owariensis*, *Landolphia dulcis* and *Landolphia dulcis* var. *barteri* yielded *cis*-1,3-polyisoprene rubber in 24.20, 23.35, 16.08 and 17.44% respectively (Nwadinigwe, 1981).

Essential Oils

Several species of the family Apocynaceae contain essential oils; the constituents of which have been reported. The following are examples of these species.

1. *Allamanda cathartica* L.: The following volatile constituents were identified in the flowers: phenylacetaldehyde, 0.3; *cis*-linalool oxide (furanoid), 0.1; *trans*-linalool oxide (furanoid), 0.6, linalool, 39.3; phenylacetonitrile, 9.4; α-terpineol, 0.1; nerol, trace; geraniol, 0.1; cumin alcohol, trace; α-cubebene, 0.1; benzyl isothiocyanate, 8.7; α-copaene, 0.3; β-cubebene, 0.6; β-elemene, 0.5; β-caryophyllene, 15.7; α-humulene, 0.9; germacrene D, 1.7; bicyclogermacrene, 0.3; δ-cadinene, 0.1; (*E*)-nerolidol, 0.1 and dendrolasin, 20.2%

(Maia *et al*., 2000). A total of 42 compounds were identified, from flowers of the plant growing in Cuba; from which major components were *n*-tricosane(17.0%), 1,8-cineole (12.6%), *n*-pentacosane (11.4%) and (*E*,*E*)-geranyl linalool (11.3%) (Baez *et al*., 2012a).

2. *Alstonia boonei* De Wild: Eleven compounds which constitute 95.16% of the leaf volatile oil were identified: 3,7-dimethylnonane, 0.67; 2-octylchloride, 0.65; Z-11-tetradecen-1-ol, 1.00; 2-ethylhexylisohexylsulfurate, 1.17; 14-methylpentadecanoate, 3.65; hexadecanoic acid, 22.84; methyl-7*E*-octadecenoate , 9.33; (*Z*)-9-octadecenoic acid, 37.78; octadecanoic acid, 11.58; heneicosane, 5.65; and methyl tetracosanoate, 0.84%. The leaf essential oil consists of acids (72.20%), esters (13.82%), hydrocarbons (6.32%), sulphur and chlorine hetero-compounds (1.82%), and alcohol (1%). Thirteen compounds represent 97.22% of stem bark oil were identified: 2,3-heptanedione, 0.30; 8-methyl-1-decene, 0.60; 1-iodoundecane, 0.72; (3*E*)-3-icosene, 1.09; methylhexadecanoate, 4.52; hexadecanoic acid, 15.01; methyl(7*E*)-7-octadecenoate, 11.65; (*Z*)-9-octadecenoic acid, 28.50; octadecanoic acid, 12.69; dodecanoyl chloride, 7.48; 2,3-bis[(9*E*)-9-octadecenoyloxy]propyl(9*E*)-9-octadecenoate, 9.26; di-*n*-octylphthalate, 4.19 and methyl nonadecanoate, 1.21%. Acids are 56.20%, esters 30.83%, halogen-compounds 8.20%, hydrocarbons 1.69%, and carbonyl compounds 0.30% of the oil. Twelve compounds were identified in root oil *viz*. 4-(benzyloxy)-3-methoxy-2-nitrobenzaldehyde, 0.36; (1-pentylhexyl)benzene, 0.69; methylnonanoate, 0.52; methylhexadecanoate, 15.42; *n*-hexadecanoic acid, 4.73; methyl-linoleate, 26.47; methyl(7*E*)-7octadecenoate, 27.03; methyloctadecanoate, 13.48; (6*Z*)-6-octadecenoic acid, 5.79; octadecanoic acid, 2.84; methylphosphonic acid fluoroanhydride 4-*tert*-butylcyclohexyl ester, 0.19 and dioctylphthalate, 2.48 (Moronkola and Kunle, 2012).
3. *Alstonia scholaris* (L.) R.Br.: The essential oil obtained from fresh flowers, of the plant growing in India, contained 6.6% α-pinene, 7.9% Δ^3-carene, 10.5% limonene, 10.0% terpinolene, 31.3% linalool, 4.9% linalyl acetate, 4.2% citral, 0.3% citronellol, 1.2% geraniol, and 4 unidentified sesquiterpene alcohols (Gupta and Chandra, 1975). More than 34 components were identified, representing about 92.5% of the flower oil (0.03 w/w) of the plant growing in Vietnam: ethyl benzene, 0.5; *m*- and/or *p*-xylene, 1.5; 3-methyl-1-butyl acetate, trace; *o*-xylene, 0.8; nonane, 0.7; β-pinene, 0.3; 1,3,5-trimethylbenzene, 4.1; ethyl hexanoate, 0.6; decane, trace; 1,2,4-trimethylbenzene, 0.9; 1,8-cineole, 0.7; γ-terpinene, 1.6; *cis*-linalool oxide (furanoid), 10.3; *trans*-linalool oxide (furanoid), 2.0; 2-phenylethyl alcohol, 1.2; linalool, 35.7; methyl octanoate, 0.1; camphor, 0.2; benzyl acetate, trace; *cis*-linalool oxide (pyranoid), 1.7; *trans*-linalool oxide (pyranoid), 0.7; terpinen-4-ol, 5.6; methyl salicylate, 1.1; α-terpineol, 12.3; ethyl octanoate, 0.3; citronellol, 0.7; 2-phenylethyl acetate, 6.3; ethyl salicylate, 0.3; γ-nonalactone, 0.6; 2-phenylethyl propionate, 0.2; eugenol, trace; methyl *p*-anisate, 0.2; ethyl palmitate, 0.8 and unidentified compounds, 7.7%. The volatile constituents contained more than 90% of oxygenated compounds, which contributed to its fragrant odour (Dung *et al*., 2001). About sixty compounds were identified from the essential oil (0.02-0.10%) from the flowers of the plant growing in Bangladesh: 2-dodecyloxirane, 31.83; benzene-1,2-dimethoxy-4-(2-propenyl), 8.49; spinacene, 6.09; 1,54-dibromotetrapentacontane, 5.13; 2,6,10,15-tetra-methylheptadecane, 4.91; terpinyl acetate, 3.74; linalool, 2.22; tritetracontane, 2.17; 1-cyclohexanol, 2-(3-methyl-1,3-butadienyl)-1,3,3-trimethyl-, 1.78; 9-methyl-5-methylene-8-decen-2-one, 1.58; 7-hexylicosane, 1.39; methyl tridecanoate, 1.23 ; palmitic acid, 1.01; oxirane, 2,2-dimethyl-3-(3,7,12,16,20-pentamethyl-3,7,11,15,19-heneicosapentaenyl)-, (all-*E*)-, 0.88; [(4-chloro-[1,2,3]dithiazol-5-ylidene)(nitro)methyl](2,6-dimethylphenyl) diazene, 0.86; 2,6-dimethyl-2,6-undecadien-10-ol, 0.82 ; rhamnitol, 1-*O*-octyl-, 0.74; eugenol, 0.68; 2,6,10,15-tetramethylheptadecane, 0.68; 1,3-dioxolane,2-(5-bromopentyl)-,

0.65; 4-terpineol, 0.62; *E*-2-tetradecen-1-ol, 0.61; 10-heneicosene, 0.61; 2-methylene-cholestan-3-ol, 0.51; 2,4-*bis*(dimethylbenzyl)phenol, 0.50; 2,3-*bis*(acetyloxy) propyl laurate, 0.48; cyclopentadecanone, oxime, 0.44; *cis*-myrtanol, 0.41; 4-terpineol acetate, 0.31; α,4-trimethylbenzyl carbanilate, 0.21; nerolidyl acetate, 0.25; 2-(5-bromopentyl)-1,3-dioxolane, 0.36 ; dihydroartemisinin, 10-*O*-(*tert*-butyloxy)-, 0.26 ; malonic acid, *bis*(2-trimethylsilylethyl ester, 0.32; 2,3-dipentyl-2-cyclopropene-1-carboxylic acid, 0.34; 4-(1,3,2-dioxaborinan-2-yl)-2-nitrobenzoic acid, 0.38 ; dithioerythritol, *O,O',S,S'*-tetrakis (trimethylsilyl), 0.29; benzeneacetic acid, 3-[(trimethylsilyl)oxy]-, trimethylsilyl ester, 0.33 ; methyl 10-methylundecanoate, 0.29; 6,11-dimethyl-2,6,10-dodecatrien-1-ol, 0.15; dithioerythritol, *O,O',S,S'*-tetrakis(trimethylsilyl)-, 0.19; 2-methylenecholestan-3-ol, 0.30; *N,N'*-diacetylethylenediamine, 0.15; 1-heptatriacotanol, 0.24; 2,3-*bis*(acetyloxy)propyl laurate, 0.24; 2,3-*bis*(acetyloxy)propyl laurate, 0.33; 3,7,11,15-tetramethylhexadecyl acetate, 0.23; 1-ethyldecyl acrylate, 0.15; 6,11-dimethyl-2,6,10-dodecatrien-1-ol, 0.15; 2,6-*bis*(*tert*-butyl)-4-(dimethylbenzyl)phenol, 0.14; 9,9-dimethoxybicyclo[3.3.1]nona-2,4-dione, 0.34; *tert*-butoxyformamid, *N*-methyl-*N*-[4-(1-pyrrolidinyl)-2-butynyl]-, 0.37; 1,6,10,14-hexadecatetraen-3-ol, 3,7,11,15-tetramethyl-, (*E,E*)-, 0.26; 3,7,11,15-tetra-methyl-2-hexadecen-1-ol, 0.26; methyl (3-hydroxy-14-methyl-7-oxopodocarpan-13-yl) acetate, 0.25; ethyl 6-(diethoxyphosphoryl)hexanoate, 0.12; capric ether, 0.16; imidazole-2-carboxylic acid, 0.16; 3,6-dimethyl-2,4-heptadione, 0.17; 3-buten-2-amine, 4-(2,6,6-trimethyl-1-cyclohexen-1-yl)-, 0.13; malonic acid and bis(2-trimethylsilylethyl ester, 0.14% (Islam *et al.*, 2013). Zhang *et al.* (2010a) also reported that the main components of the essential oil from flowers were: squalene (39.44%), octacosane (9.93%), 3,7-dimethyl-1,6-octadien-3-olbenzoate (5.43%), linalool oxide (5.05%), eucalyptol (4.59%), β-phellandrene (1.01%).

4. *Amsonia illustris*: More than 80% of the thirty volatile compounds in the leaf oil were identified, the major constituents being mainly sesquiterpenes like α-humulene (14.5%), β-caryophyllene (12.4%) and guaiol (11.6%). The volatile ingredients of the root oil were pinocampheol, methyl salicylate, (2*E*,4*E*)-decadienal, eugenol and *trans*-isoeugenol (London *et al.*, 2011).
5. *Apocynum cannabinum* (Hemp dogbane): Fifty-nine compounds, accounting for 80.06 of the volatile oil were identified. The main constituents in volatile oil were alcohols, ketones, esters and acids (Zhou and Kong, 2011).
6. *Apocynum venetum* (dogbane): The major constituents of the volatile oil are caryophyllene-oxide (10.57%), 1-α-terpineol (10.38%), 3-hexen-1-ol benzoate (6.45%), 3,7,11,15-tetramethyl-2-hexadecen-1-ol (5.99%), β-damascenone (5.85%), *trans*-farnesol (5.27%), 2-methyl-5-(1-methylethyl)phenol (4.77%), pulegeone (4.25%) (Faan *et al*., 2005). The main volatile fraction in the flower comprises (*E*)-3-penten-2-one, di-*sec*-buty ether, hexanoic acid, methyl salicylate, nonanoic acid, tridecane, 4,7-dimethyl-undecane, tetradecane, (*E*)-6,10-dimethyl-5,9-undecadien-2-one, 2,6,10-trimethyl-dodecane, hepta-decane, (-)-spathulenol, ledol, 2-pentadecanone, tetradecanoic acid, benzyl benzoate, phenanthrene, 6,10,14-trimethyl-2-pentadecanone, 2-heptadecanone, (*E,E*)-6,10,14-tri-methyl-5,9,13-pentadecatrien-2-one, methyl hexadecanoate, oxacycloheptadecan-2-one, hexadecanoic acid, 5-dodecyl dihydro-2(3*H*)-furanone, (*Z*)6, (*Z*)9-diene-1-pentadecanol, oleic acid, tetracosane, 4,8,12,16-tetramethylheptadecan-4-olide, heptacosane, nonacosane, hentriacontane and triacontane (Chen *et al.*, 2006a). Sixty-one and forty-four compounds were identified from the volatile oils of the bast and fibers of the plant respectively. The fatty acids, esters, ketones, aldehydes, alkanes, phenols, and miscellaneous compounds were found as the major components in both samples (Li *et al*., 2012a). The constituents of the essential oils of the plant, collected from various habitats in China differ qualitatively

and quantitatively (Li *et al.*, 2009; Zhang *et al*., 2009a). Among the compounds identified were longifolene, cedrene, geranylacetone, palmitic acid and Me palmitate, 2-methyl-6-p-methylphenyl-2-heptene, tetradecanal, 7-methyl-1-oxacyclo-dodeca-6,9-dien-2-one, 3-tert-butyl-4-hydroxyanisole, piperonylamine, and phenanthrene (Li *et al.*, 2009).

7. *Aspidosperma cylindrocarpon* Muell. Arg.: The volatile oil of the leaves was characterized by the presence of a high percentage of sesquiterpene hydrocarbons (45.6%) and aliphatic compounds (35.9%). The major constituents were β-caryophyllene (14.3%), bicycle-germacrene (14.2%) and nonadecanal (22.9%). Oxygenated sesquiterpenes (6.5%) and monoterpenes (6.4%) were also identified (Cornelio *et al.*, 2005).
8. *Aspidosperma polyneuron* Muell. Arg.: Kaurene (73.7%) and pentadecanal (6.3%) were the main constituents identified in the essential oil of the leaves (Cornelio *et al.*, 2004).
9. *Catharanthus roseus* (L.) G. Don: Brun *et al*. (2001) reported the identification of 76 compounds in the volatile oil. The major substances were represented by a homologous series of alkanes, alcohols, aldehydes, ketones, fatty acids, fatty acid esters, terpenoids and phenylpropanoids. A total of 52 components were identified, accounting for the 91.3% of the leaf oil. Among these the main constituents were as follows: (*E*,*E*)-2.4-hexadienal (7.7%), citronellol (7.9%), geraniol (7.9%), *p*-cresol (4.7%), (*Z*,*E*)-pentadecanal (6.6%), hexadecanoic acid (4.9%), palmitic acid (4.9%) and phytol (6.4%). A total of 41 compounds were identified, accounting for 99.4% of the flower oil, whose main constituents were heneicosane (20.8%), tricosane (37.9%), tetracosane (6.1%) and docosane (4.3%). Pandey-Rai *et al*. (2006) identified 24 compounds in both the leaf and flower oils. A total of 88 volatile and semi-volatile components were formally or tentatively identified in flowers, leaves and stems of *C. roseus* (L.) G. Don (cv. Little Bright Eye). These include some diterpenic compounds (manool and manoyl oxides), a sesquiterpene (α-bisabolol), and some pyridine, pyrazine, indol and carotenoid derivatives. The flowers were richer in terpenic molecules (including limonene), α-bisabolol, methyljasmonate, *cis*-jasmone, 2-phenylethanol, phenylacetaldehyde, *trans*-2-octenal, benzylic alcohol and 2-isobutyl-3-methoxypyrazine. Leaves can be characterized by the methyl and propyl esters of fatty acids, mono- and disaturated, trans-phytol, carotenoid derivative compounds, hydrofarnesylacetone, methylanthranilate, manool and epi-manool oxide, while stems have high levels of volatile aldehydes, such as hexanal, octanal, *cis*-2-nonenal, *cis*-2-decenal, *cis*, *trans*-2,6-nonadienal, trans, *trans*-2,4-decadienal and *cis*, *trans*-2,4-decadienal (De Pinho *et al.*, 2009).
10. *Cerbera manghas*: Several compounds were identified from the essential oil of the leaves (Zhuang *et al*., 2010), fruits (Zhuang and Zhu, 2009) and the volatile components of the roots (Li *et al.*, 2010a). The main volatile substances of the stem were fatty acids, sterols and alkanes (Li *et al.*, 2010b).
11. *Landolphia heudelotti* DC.: More than 70% of the volatile compounds of the fruit were characterized; the major constituents were linalool (10.5%) and *E*-β-farnesene (8.8%) (Pelissier *et al*., 1996).
12. *Landolphia senegalensis* (DC.) Kotschy et Peyr.: Pelissier *et al*. (1996) identified more than 90% of the volatile compounds of the fruits, with linalool (18.0%) and α-terpineol (29.8%) being the major constituents.
13. *Lochnera rosea* (*Vinca rosea*): Citronellyl acetate, cadinene, and 2-heptanol were among the compounds identified in the leaves (Oliveros-Belardo *et al*., 1965).
14. *Mandevilla guanabarica*: The common volatile compounds in the leaves are 3-hexen-1-ol, β-caryophyllene, germacrene D, cubebene, α-cubebene, α-copaene, β-ocimene, α-caryophyllene, germacrene B, β-elemene and alloaromadendrene (Cordeiro *et al*., 2012).
15. *Nerium oleander* L.: The following thirty four compounds, representing 93.21% of the

flower oil (1.76%), were identified from the plant growing in Morocco: α-thujone, 0.10; β-pinene, 2.01; humulene, 2.29; isoledene, 2.94; 3-carene, 2.56; α-terpinene, 1.52; camphene, 0.98; α- elemene, 0.36; α-cubebene, 0.30; γ-cadinene, 0.72; *cis*-ocimene, 0.42; β-caryophyllene, 0.28; myrtenal, 1.25; amorphane, 8.11; neriine, 22.56; α-pinene, 5.54; isocaryophyllene, 1.10; digitoxigenine, 11.25; 1.8-cineole, 6.58; terpinene-4-ol, 3.98; cymen-8-ol, 1.67; globulol, 1.11; verbenol, 1.24; isosativene, 0.85; limonene, 5.01; seychellene, 1.09; β-phellandrene, 4.84; calarene, 5.12; ylangene, 1.20; solanone, 0.05; sabinene, 3.22; patchoulene, 1.02; germacrene-D, 1.01 andspathulenol, 0.29 (Derwich *et al.*, 2010). Sixty four compounds, representing 94.69% were identified in the essential oil (0.1%) of fresh flowers of *Nerium oleander* (syn. *Nerium odorum* Soland, *Nerium indicum* Mill.), collected from Taif desert, Saudi Arabia (Table **1**). Among which 34.2% were oxygenated compounds, 60.54%, 60.54% terpenes and 2.02% alkanes (Ali *et al*., 2010).

16. *Plumeria acuminata* Ait: Tohar *et al*. (2006a,b) studied the composition of floral oils of both yellow flower and white flower (Table **2**).
17. *Plumeria acutifolia* Poir.: Steam distillation of the flowers yielded 0.04 to 0.07% containing geraniol, citronellol, farnesol, phenylethyl alcohol and linalool (Menon and Menon, 1957). The composition of the essential oil was reported by several researchers e.g. Sulaiman *et al*. (2008).
18. *Plumeria alba* L.: Twenty eight compounds were identified from the flower oil of the plant, growing in Egypt (Karawya *et al.*, 1994).
19. *Plumeria obtusa* L.: The following forty-seven components were identified, representing 97% of the fresh flowers oil [0.031% (w/w) fresh weight and 0.2% (w/w) dry weight]: *E*-Linalool oxide (furanoid), 0.1; *Z*-linalool oxide, 0.1; neroloxide, tr, α-copaene, tr;3-nonen-2-one, 0.1; benzaldehyde, 0.2; linalool, 3.0; neral, 0.2; heptadecane, 0.1; α-terpineol, 0.7; geranyl formate, 0.1; heptadecene, 0.4; geranial, 0.6; citronellol, 0.8; methyl salicylate, 0.3; nerol, 0.7; 4,8,12-trimethyl-1,3(*E*),7(*E*),11-tridecatetraene, 0.1; ethyl salicylate, tr; geraniol, 1.7; *E*-geranyl-acetone, 0.1; nonadecane, 0.8; nonadecene, 1.6; eicosane, tr; *E*-nerolidol, 5.3; hexyl benzoate, 0.1; heneicosane, 2.3; heneicosene, 0.4; (*Z*)-3-hexenyl benzoate, 0.1; α-bisabolol, 0.2; (2*Z*, 6*E*)-farnesyl acetate, 0.4; (2*E*, 6*E*)-farnesyl acetate, 0.8; (2*Z*, 6*Z*)-farnesol, 1.2; isophytol, 0.9; tricosane, 0.8; (2E, 6Z)-farnesol, 2.8; (2Z, 6E)-farnesol, 0.8; (2*E*, 6*E*)-farnesol, 8.2; citronellyl benzoate, 0.6; geranyl linalool, 2.9; neryl benzoate, 1.1; 9-hexacosene, 0.2; geranyl benzoate, 3.0; benzyl benzoate, 11.0; tetradecanoic acid, 1.1; benzyl salicylate, 38.9; hexadecanoic acid, 2.1 and (2*E*, 6*E*)-farnesyl benzoate, 0.4 (Kamariah *et al*., 1999).
20. *Plumeria rubra* L.: The flower essential oils of four *Plumeria* species: *Plumeria obtusa* L., *Plumeria acuminata* Ait. (yellow flower), *Plumeria rubra* L. (pink flower) and *Plumeria rubra* (orange flower) hydrodistilled from samples grown on peninsular Malaysia have been studied (Table 3). The oil of *Plumeria obtusa* was found to be rich in benzyl salicylate (45.4%) and benzyl benzoate (17.2%), but also minute concentrations of alkanoic acids. Oil obtained from *Plumeria acuminata* was rich in palmitic acid (36.2%), linoleic acid (16.8%), lauric acid (10.4%) and myristic acid (10.3%). The pink flowered *Plumeria rubra* oil was similar to *Plumeria acuminata* oil in that it was also devoid of benzyl salicylate and benzyl benzoate and rich in alkanoic acids but linoleic acid was absent in the oil of the former. However, the orange flowered *Plumeria rubra* oil contained both the non-terpene esters (benzyl salicylate, benzyl benzoate and 2-phenylethyl benzoate) and alkanoic acids in significant amounts. The orange flowered cultivar had the highest concentration. of (*E*)-nerolidol (14.4%) and geraniol (4.1%) among the species studied (Tohar *et al*., 2006a). Also, Tohar *et al*. (2006b) found that the

oil of *Plumeria acuminata* (white flower) was made up predominantly of benzyl salicylate (39.0%), benzyl benzoate (17.2%), *trans*-nerolidol (10.6%), neryl phenylacetate (10.5%) and linalool (8.9%). Phenylethyl benzoate at 12.3% was the most abundant compound in the oil of *Plumeria rubra* Linn. (reddish-orange flower), followed

Table **1**. Chemical composition of the essential oil of *Nerium oleander* (Ali *et al*., 2010).

No.	Compound	(%)	No.	Compound	(%)
1	2-Heptanol	0.38	39	γ-Bisabolene	0.78
2	α-Thujene	0.43	40	*trans*-Calamenene	0.82
3	α-Pinene	0.94	41	β-Sesquiphellandrene	1.98
4	Camphene	2.75	42	δ-Cadinene	1.27
5	Sabinene	0.61	43	Myristicin	1.04
6	α-Pinene	0.77	44	γ-Cuprenene	0.92
7	2-Heptanol-5-methyl	0.54	45	Spathulenol	0.06
8	Myrcene	1.31	46	Caryophyllene	3.43
9	α-Phellandrene	1.43	47	Carotol	0.97
10	Octanal	0.70	48	Guaiol	1.88
11	Thymol	8.43	49	α-Humulene	2.43
12	β-Ocimene	1.05	50	Unknown	1.17
13	γ-Terpinene	0.98	51	(*E*)-and-Farnesene	0.22
14	Unknown	1.51	52	α-Acoradiene	0.08
15	Camphor	12.76	53	Unknown	0.02
16	Terpinolene	0.86	54	β-Acoradiene	0.05
17	Perillene	0.48	55	β-Chamigrene	1.08
18	Nonanal	0.32	56	Unknown	0.26
19	Octyl acetate	0.21	57	Germacrene D	2.76
20	α-Campholenal	5.05	58	β-Selinene	1.98
21	Ocimene	1.79	59	γ-Curcumene	1.09
22	Nonen-1-al	0.72	60	Unknown	0.88
23	Nonanol	0.26	61	Cuparene	1.76
24	α-Cubebene	3.43	62	α-Zingiberene	0.76
25	Eugenol	10.45	63	β-Bisabolene	1.01
26	Unknown	0.43	64	Unknown	0.09
27	α-Copaene	1.50	65	α-Famesene	0.94
28	Daucene	0.97	66	γ-Cadinene	0.02
29	β-Bourbonene	0.32	67	γ-Bisabolene	0.76
30	β-Cubebene	1.87	68	*trans*-Calamenene	1.03
31	β-Elenene	1.08	69	Tetracosane	0.76
32	Italicene	0.1	70	Pentacosane	0.95
33	β-Funebrene	2.77	71	Heptacosane	0.34
34	α-Cedrene	0.31		Total unknown	5.31
35	Aristolene	0.98		Total identified compounds	94.98
36	β-Barbatene	0.21		Oxygenated compounds	34.20
37	Unknown	0.11		Terpenes	60.54
38	Unknown	0.86		Alkane compounds	2.05

Table **2**. Percentage composition of the floral oils of some *Plumeria* species (Tohar *et al*., 2006a)

Compound	1	2	3	4
α-Thuiene	-	t	-	T
Sabinene	0.1	-	-	-
Benzaldehyde	-	-	-	1.4
Isobutyl valerate	-	-	-	0.1
cis-Linalool oxide (furanoid)	t	t	0.1	0.6
trans-Linalool oxide (furanoid)	t	t	0.2	0.4
Linalool	1.9	0.3	4.8	3.3
α-Fenchyl alcohol	0.3	t	0.3	2.1
Terpinene-4-ol	t	t	t	0.3
α-Terpineol	0.3	0.1	1.4	0.2
Nerol	0.7	t	0.3	0.3
Neral	0.4	t	t	0.1
Geraniol	2.3	0.1	1.0	4.1
Geranial	0.5	0.1	t	1.0
Neryl formate	-	-	0.1	0.1
Neryl acetate	-	-	0.2	-
β-geranic acid	1.4	-	-	-
(*E*)-Methyl cinnamate	-	-	-	0.4
α-Copaene	-	-	0.2	t
β-Patchoulene	-	0.2	-	-
β-Bourbonene	0.1	-	-	-
β-Caryophyllene	0.1	-	-	0.1
β-Santalene	-	-	-	t
γ-Himachalene	-	-	0.2	-
Amyl salicylate	-	-	0.5	-
Elemol	0.2	-	-	-
(*E*)-Nerolidol	2.5	-	1.5	14.4
Caryophyllene oxide	0.4	-	-	3.1
Dodecanoic acid (lauric acid)	0.1	10.4	30.8	0.1
2-Phenylethyl hexanoate	-	-	0.3	-
Heptyl octanoate	-	-	0.3	-
(*Z*,*E*)-Farnesol	1.5	-	0.3	0.3
(*Z*,*Z*)-Farnesol	1.4	0.6	-	0.4
(*E*,*E*)-Farnesol	4.8	-	1.4	4.4
Benzyl benzoate	17.2	-	-	8.6
Myristic acid	0.5	10.3	17.4	2.9
2-Phenylethyl benzoate	-	-	-	3.9
Benzyl salicylate	45.4	-	-	20.9
1-Octadecene	2.0	-	-	-
Nonadecane	1.6	2.0	8.2	0.8
2,6,10,14-Tetramethyl-heptadecane	-	-	-	2.8
Neryl phenylacetate	2.6	-	-	4.1
Palmitic acid	1.2	36.2	9.8	4.4
Eicosane	-	-	0.7	-
Ethyl palmitate	2.2	-	-	3.1

Table **2**. Percentage composition of the floral oils of some *Plumeria* species (cont.)

Compound	1	2	3	4
Cinnamyl cinnamate	0.3	-	-	0.5
Heneicosane	0.5	1.2	2.7	0.9
Methyl stearate	3.7	4.4	5.6	1.6
Linoleic acid	-	16.8	-	1.1
Docosane	0.2	-	2.8	0.4
Octadecanal (stearaldehyde)	0.1	-	-	-
Tricosane	1.4	5.1	2.8	2.0
Docosene*	0.3	0.8	0.7	0.9
Pentacosane	0.5	8.1	0.3	0.2

1 = *Plumeria obtusa*; 2 = *Plumeria acuminata* (yellow flower); 3 = *Plumeria rubra* (pink flower); 4 = *Plumeria rubra* (orange flower); t = trace (< 0.05%); * =

by dodecanoic acid at 11.8% concentration. Hexadecanoic acid constituted 9.3% and 27.2% of the oils of *Plumeria rubra* Linn. (reddish-orange flower) and *Plumeria rubra* Linn. (red flower), respectively (Tohar *et al*., 2006b). A total of 73 compounds were identified from *Plumeria rubra* forma *acutifolia* (Poir.) Woodson cv. "common yellow" (Table **3**). Forty-one components were identified from the essential oil *Plumeria rubra* (reddish-orange), growing in Nigeria: nine alkanes (51.19%), three monoterpene alcohols (26.93%), an alkene (5.86%), an acyclic sesquiterpene alcohol (1.28%), an alcohol (1.34%) and thirty-six traces. The predominant constituent of the oil is an alkane heneicosane (19.15%) while the other constituents of the essential oil in order of increasing concentration are nonadecane (15.63%), citronellol (14.63%), geraniol (9.17%), tricosane (6.06%), nonadecene (5.86 %), eicosane (3.22%), nerol (3.13%), pentacosane (2.63%), benzyl alcohol (1.34%), farnesol (1.28 %), heptacosane (1.28%), tetratriacontane (1.11%), octacosane (1.06%) and nonacosane (1.05%) (Obuzor and Nweke, 2011). Linalol, phenylacetaldehyde, *trans*, *trans*-farnesol, β-phenylethyl alcohol, geraniol, α-terpineol, neral and geranial were found to make a major contribution to the floral scent of this flower (Omata *et al*., 1991). The following compounds were identified in the essential oil of the flowers of *Plumeria rubra* L. cv. 'Irma Bryan': ethyl formate, 2.02; ethyl acetate, 2.66; ethanol, 2.03; α-pinene, 0.14; hexanal, 0.59; heptanal, 0.23; 2-methylbutan-l-ol, 10.49; 1,8-cineole, 0.77; *cis*-β-ocimene, 0.12; *trans*-β-ocimene, 1.91; pentanol, (< 0.01); terpinolene, 0.09; acetoin, 0.15; 3-methylbut-2-en-1-o1, 0.10; octanal, 0.08; hexanol, 0.06; *cis*-hex-3-en-l-ol, 0.17; nonanal, 1.03; acetic acid, 0.96; *cis*-linalool oxide (furanoid), 0.27; *trans*-linalool oxide (furanoid), 0.38; benzaldehyde, 0.75; linalool, 0.21; terpinen-4-o1, 0.11; methyl benzoate, 0.16; phenylacetaldehyde, 12.09; 2-methyl-butyric acid, 1.32; γ-terpineol, 0.05; heptadecane, (< 0.01); α-terpineol, 1.76; β-farnesene, 0.05; δ-cadinene, 0.06; methyl salicylate, 0.13; β-phenylethylformate, 0.09; β-phenyl-ethyl acetate, 0.07; gerdniol, 0.04; *p*-cymene-8-o1, 0.13; benzyl alcohol, 1.49; nonadecane, 0.54; β-phenylethyl alcohol, 31.64; benzyl cyanide, 1.51; β-ionol, (< 0.01); dodecanol, 0.08; isoamyl salicylate, 0.08; octanoic acid, (< 0.01); methyl cinnamate, 1.00; heneicosane, 1.20; nonanoic acid, 0.12; β-phenylethyltiglate, 0.03; docosane, 0.10; decanoic acid, 0.04; tricosane,1.77; octadecanal, 0.05; *trans,trans*-farnesol, 0.05; tetracosane, 0.10; benzoic acid, 0.04; dodecanoic acid, 1.62; eicosanal, 0.60; 2-phenylacetic acid, 0.18; benzyl benzoate, 0.11; heptacosane, 0.34; tetradecanoic acid, 0.50; β-phenylethyl benzoate, 1.39; benzyl salicylate, 0.25; heneicosane, 0.04; β-phenylethyl salicylate, 0.33 and hexanoic acid, 0.13% (Omata *et al*., 1992). The essential

Table **3**. Volatile compounds identified in the essential oil of Plumeria flower (*Plumeria rubra* forma *acutifolia* (Poir.) Woodson) (Omata *et al*., 1991)

No.	Compound	%	No.	Compound	%
1	Ethyl formate	1.69	37	*cis*-Linalool oxide (pyranoid)	0.14
2	Ethyl acetate	2.38	38	Methyl phenylacetate	0.05
3	Ethanol	0.86	39	*trans*-Linalol oxide (pyranoid)	0.63
4	α-Pinene	0.09	40	Methyl salicylate	0.24
5	*n*-Hexanal	0.17	41	Nerol	0.42
6	*n*-Heptanal	0.14	42	β-Phenylethyl acetate	0.06
7	Limonene	0.52	43	Geraniol	5.36
8	2,3-Dehydro-1,8-cineole	0.44	44	Benzyl alcohol	1.47
9	*cis*-β-Ocimene	0.34	45	*n*-Nonadecane	0.33
10	*trans*-β-Ocimene	0.19	46	β-Phenylethyl alcohol	8.82
11	*n*-Pentanol	+	47	Benzyl cyanide	0.55
12	Terpinolene	0.04	48	β-Ionol	0.05
13	Acetoin	0.16	49	3,7-Dimethylocta-1,5-dien-3,7-diol	0.02
14	Prenol (3-Methylbut-2-en-1-ol)	0.09	50	Methyl eugenol	0.07
15	2-Methylhept-2-en-6-one	0.05	51	Nerolidol	1.86
16	*n*-Hexanol	0.04	52	*n*-Octanoic acid	0.02
17	*cis*-Hex-3-en-1-ol	0.12	53	*n*-Hexyl benzoate	0.03
18	*n*-Nonanal	1.21	54	*n*- Heneicosane	0.24
19	Acetic acid	0.71	55	*n*-Nonanoic acid	0.11
20	*cis*-Linalool oxide (furanoid)	0.42	56	β-Phenylethyltiglate	0.02
21	Nerol oxide	0.09	57	Farnesyl acetate	0.19
22	*trans*-Linalool oxide (furanoid)	2.18	58	*cis*,*cis*-Farnesol	0.63
			59	*n*-Tricosane	0.27
23	α-Copaene	0.20	60	*cis*,*trans*-Farnesol	0.20
24	Benzaldehyde	0.63	61	*trans*, *trans*-Farnesol	10.95
25	Linalool	16.11	62	Benzoic acid	0.06
26	*n*-Octonal	0.21	63	Indole	+
27	Methyl *n*-nonyl ketone	+	64	*n*-Dodecanoic acid	1.03
28	Terpinen-4-o1	0.27*	65	*n*-Eicosanal	0.40
29	3,7-Diemethylocta- 1,5(*E*),7-trien-3-ol	0.27*	66	2-Phenylacetic acid	0.29
			67	Benzyl benzoate	0.54
30	Methyl benzoate	0.91	68	*n*-Heptacosane	0.38
31	Phenylacetaldehyde	14.38	69	*n*-Tetradecanoic acid	0.28
32	γ-Terpineol	0.38	70	β-Phenylethyl benzoate	2.37
33	Neral	0.45	71	Benzyl salicylate	1.37
34	α-Terpineol	2.84	72	β-Phenylethyl salicylate	1.18
35	β-Farnesene	0.02	73	*n*-Hexadecanonic acid	0.17
36	Geranial	0.40			

*Sum of components No. 27 and 28 ; + : < 0.01%

oil of the flowers of *Plumeria rubra* var. *acutifoli*a was found to have a high content of carboxylic acids (59.7%) with *n*-hexadecanoic acid (35.8%) and n-tetradecanoic acid (11.2%) as main components, whereas, the flower oil of *Plumeria rubra* was characterized by high hydrocarbon content (38.6%), in which 9-hexacosene (14.6%) was found to be the major constituent (Liu *et al*., 2012b). The flowers of *Plumeria rubra* var.

acutifolia, growing in Egypt, yielded 1.4% essential oil. Oxygenated compounds were dominant; being 70.6%, while hydrocarbons amounted to 25.07%. The main oxygenated compounds are farnesol, geraniol and phenylethyl benzoate, while the major hydrocarbons are methyl pentadecane and α-terpinolene (Sengab *et al*., 2009). The main constituents of the essential oil of *Plumeria rubra* cv. *acutifolia* were geraniol esters(50%), geraniol terpenoids (28%); fatty acids (17%) and alkane (2.6%) (Zhang *et al.*, 2010f). The sum of the relative contents of identified volatile compounds in the fresh flowers of *Plumeria rubra* Linn. cv. *acutifolia* was 77.31%, and among them, aldehydes were the most predominant group of compounds, with a relative content of 29.5%, followed by oximes (24.99%), derivatives of aldehydes, and nitriles (5.34%), alkanes (3.68%), aromatic hydrocarbons (1.42%), ethers (4.64%), terpenes (6.67%) and alcohols (1.67%) were also included. Besides some of the identified aldehydes, the compounds responsible for the characteristic aroma of the flowers also consist of limonene and phenyl ethanol (Zhang *et al.*, 2010g). Twenty-eight compounds were identified from the essential oil of *Plumeria rubra* L. var. *actifolia* Bailey, such as d-nerolidol, farnesol, benzyl benzoate, geranyl benzoate, neryl linalool isomer and α-terpinyl isovalerate (Zhang *et al*., 2012a). Fifty-three components were identified from the essential oil of *Plumeria rubra* var. *acutifolia* (5.8927%), obtained by supercritical carbon dioxide extraction. The main components were 1,6,10-dodecatrien-3-ol, 3,7,11-trimethyl, 2-hydroxy-benzoic acid, phenylmethyl ester, 1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester, etc. 1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester took up 66.11% of the total amount, and there was much difference of the results from steam distillation method (Xiao *et al.*, 2011). A total of 27 volatile compounds were identified from an alcoholic extract of *Plumeria rubra* var. *acutifolia* (Pino *et al*., 1994). The percentages of steam-distilled flowers volatile oils of *P. rubra* and *P. rubra alba*, growing in Egypt (0.01-0902 and 0.017-0940 respectively) were maximum for the half-opened blossoms and 11 components (accounting for ~20-5% of the total oils) were identified. Common to both varieties were α-pinene, 2-carene, β-pinene, phellandrene, *p*-cymene, linalool, phenethyl alcohol, and citral. Also identified in *P. rubra alba* were farnesol, nerol, and linalyl acetate (Mahran *et al*., 1974c).

21. *Plumeria tuberculata* Lodd.: Twenty-five compounds were identified, representing 100% of the total composition of the volatile compounds of the flower. The volatile fraction was characterized by oxygenated monoterpenes (79.6%), oxygenated sesquiterpenes (8.4%), sesquiterpene hydrocarbons (7.6%), and benzenoid esters (2.6%). The major components were geraniol (34.9%), citronelol (21.5%) and geranial (16.2%), and they were found to make the major contribution to the typical scent of this flower (Baez *et al*, 2012b).
22. *Rauwolfia serpentina*: Serpoterpine (a triterpene constituent) was reported as the chief constituent of the steam-distilled essential oil (0.22%), obtained by extracting the roots with methanol (Pillay and Nair, 1959).
23. *Tabernaemontana catharinensis* A. DC.: A total of 18 substances were identified from the essential oil of the leaves, consisting of a complex mixture of sesquiterpenes (83.52%), monoterpenes (5.46%) and triterpenes (4.56%). The main components in the oil were β-caryophyllene (56.87%), α-cadinol (12.52%), 8S,13-cedran-diol (5.41%), α-terpineol (3.99%), β-eudesmol (2.54%), caryophyllene oxide (2.51%) and ethyl iso-allocholate (2.03%) along with β-cubebene, γ-cadinene, cubenol, 1,8-cineol, *o*-cymene, curcumenol, spathulenol, friedeline and β-sitosterol as minor constituents (Boligon *et al.*, 2013).
24. *Tabernaemontana longipes* Donn. Sm.: A total of 37 compounds, representing 86.6% of the floral essential oil were identified *viz*.dehydro-1,8-cineole, 1.9; 1,8-cineole, 0.1; (*E*)-β-

ocimene, 30.0; indole, 2.2; α-copaene, 0.9; daucene, trace; β-cubebene, 0.4; β-elemene, 2.2; (*Z*)-jasmone, 0.3; (*E*)-caryophyllene, 1.7; α-*trans*-bergamotene, 2.2; α-humulene, 0.3; sesquisabinene, 0.4; *cis*-muurola-4(14),5-diene, 0.2; germacrene D, 12.5; β-selinene, 1.3; ledene (= viridiflorene), 0.7; bicyclogermacrene, 1.3; isodaucene, 0.4; β-bisabolene, 1.1; (*Z*)-α-bisabolene, 0.7; δ-cadinene, 0.2; (*E*)-nerolidol, 0.4; dendrolasin, 2.0; nonadecane, 0.6; eicosane, 0.2; heneicosane, 12.9; unidentified diterpenoid, 2.5; unidentified diterpenoid, 4.3; docosane, 0.4; tricosane, 3.5; tetracosane, 0.1; pentacosane, 1.2; hexacosane, 0.1; heptacosane, 2.6; octacosane, 0.2; unidentified diterpenoid, 5.7; nonacosane, 1.3; unidentified diterpenoid, 0.9%; triacontane, trace; untriacontane, trace (Setzer, 2013).

25. *Thevetia peruviana* (Pers.) K. Schum.: The volatile constituents identified in the flowers are α-pinene, 0.5; sabinene, 1.7; α-terpinene, 1.2; limonene, 0.3; 1,8-cineole, 10.6; γ-terpinene, 0.2; benzofuran, 5.3; terpinolene, 0.5; *trans*-sabinene hydrate, 0.6; 2-methylbenzaldehyde, 1.2; 3-phenyl-2-propenal, 0.7; terpinen-4-ol, 6.5; α-terpineol, 2.0; α-ylangene, 0.3; α-copaene, 2.2; β-elmene, 0.5; (*E*)-β-lonone, 17.2; bicyclogermacrene, 2.8; δ-cadinene, 2.3; α-cadinol, 0.2; (*E,E*)-farnesol, 0.1; myristic acid, 3.1; pentadecanoic acid, 0.2; methyl hexadecanoate, 0.2; palmitic acid, 22.9; heneicosane, 0.3; tricosane, 1.3; tetracosane, 0.1; pentacosane, 0.6; hexacosane, 0.1 and heptacosane, 0.6% (Maia *et al*., 2000).1-Nonene, 3-methylcyclohexanone, 2-nonenal, isopulegol, pulegone, *cis*-pulegone oxide, citonellol, spathulenol, nerolidol tetrahydrogeraniol, 4-isopropyl-1,3-cyclo-hexanedione, 3-butyl-hexa-3-ene-2-one, carvacrol, 2-propyl-1-heptanol and 8-methyl-1-undecene, have been identified from the seeds (Gata Gonçalves *et al*., 2003).
26. *Vallaris glabra* Kitze (Bread flowers): A total of 50 volatiles components were detected in the fresh bread flowers (Table **4**). Among these, 23 volatiles were identified, predominantly in a group of terpenes. The rice aroma compound, 2-acetyl-1pyrroline was identified in the volatiles (Wongpornchai *et al*., 2003).
27. *Voacanga africana*: Thirty-two kinds of substances were isolated, and 22 compounds were identified representing 97.85% of the total distillate composition, including fatty acids percentage content of 80.93% (Su *et al*., 2011). Also, precocene I (7-methoxy-2,2-dimethylchromene) has been reported as the main compound of the essential oil of the plant (95.2)% (Ehiabhi *et al*., 2006).
28. *Wrightia tinctoria* R. Br.: The following compounds were identified from the essential oil of the leaves (0.15% of fresh weight): phenol, 0.83; 1-methyl-4-(1-methylethyl)-benzene, 0.30; benzyl alcohol, 3.49; *N*-methyl-*N*-pyridinyl formamide 0.96; 4-methyl phenol,1.04; 2-methoxy phenol, 0.43;1,5-dimethyl-1-vinyl-4-hexenyl butyrate, 0.22; 2,4-dimethyl phenol, 0.37; 4-ethyl phenol, 0.65; 3,5-dichloro phenol, 0.74; 2,3-dimethyl phenol, 0.96; 2-methoxy-4-methyl phenol, 1.65; 2-hydroxy benzoic acid methyl ester, 0.42; 2,3-dihydro benzofuran, 1.12; 4-methyl 2-methoxy phenol, 0.78; hydroquinone,13.24; indole, 1.61; α-cubebene, 1.68; 3-methyl-2-(2-pentyl)-2-cyclopenten-1-one, 6.76; 5-chloro-2-thio-phenecarbaldehyde oxime, 1.01; α-caryophyllene, 2.41; 1-methyl-5-methylene-8-(1-methyl ethyl)-1,6-cyclodecadiene, 9.7; butylated hydroxytoluene, 1.62; dodecanoic acid, 1.62; caryophyllene, 0.51; 1,2,3,5,6,8α-hexahydro-4,7-dimethyl-1-(1-methylethyl)-naphthalene, 0.90; caryophyllene oxide, 1.27; 1-ethyl heptyl benzene, 0.40; 1,2,3,4,4α,5,6,8α-(octahydro-7-methyl-4-methylene-1-(1-methylethyl)-naphthalene, 0.37; 1-pentylheptyl benzene, 0.32; τ-cardinol, 34; 1-ethyldecyl benzene, 0.30; 6,10,14-trimethyl 2-pentadecanone, 0.54; *n*-hexadecanoic acid, 0.52; 9,12,15-octadecatrienoic acid, 4.52; 1,2-benzenedicarboxylic acid, diisooctyl ester, 1.84 and urs-12-en-24-oic acid 3-oxo-methyl ester (Jose and Joji, 2014).

Table **4**. The identified volatile components of *Vallaris glabra* fresh bread flowers extracted by SPME and SDS (Wongpornchai *et al*., 2003)

No.	Compound	%	
		SPME	DIST
1	Ethyl acetate		16.02
2	3-Methyl-1-3-pentadiene	0.24	
3	4-Methyl-1,3-pentadiene	0.37	
4	3-Methylbutanal		0.22
5	Benzene		5.56
6	3-Hydroxy-2-butanone (acetoin)		0.12
7	3-Methyl-1-butanol	0.58	2.04
8	Methylbenzene		31.42
9	Hexanal		0.16
10	2-Acetyl-1-pyrroline	0.38	2.71
11	β-Myrcene	0.54	
12	*cis*-β-ocimene	0.05	
13	*trans*-β-ocimene	1.46	
14	Benzyl alcohol		0.06
15	Limonene		0.04
16	*cis*-Linalool oxide	1.23	0.42
17	*trans*-Linalool oxide	7.21	3.87
18	Benzeneethanol	0.14	0.20
19	Nonanal		0.46
20	Linalool	62.24	10.32
21	Epoxylinalol	0.26	1.19
22	Epoxylinalol	1.66	6.72
23	Naphthalene	0.47	
24	α-Terpineol		0.23
25	Nerol		0.05
26	Geraniol		0.48
27	4-Vinyl-2-methoxyphenol		0.32
28	α-Copaene	0.14	
29	β-elemene	1.02	0.10
30	Tetradecane	0.16	
31	*trans*-β-Caryophyllene	5.99	0.54
32	*trans*-β-Bergamotene	0.07	
33	α-Humulene	0.77	0.11
34	Germacrene-D	4.03	0.70
35	2,4-Bis(1,1-dimethylethyl)-phenol		0.06
36	Pentadecane	1.80	0.12
37	γ-Elemene		0.07
38	Ethyl phthalate	0.76	
39	Heptadecane		0.33
40	Nonadecane		0.52

Table **4**. The identified volatile components of fresh bread flowers extracted by SPME and SDS (cont.)(Wongpornchai *et al*., 2003)

No.	Compound	%	
		SPME	DIST
41	Hexadecanoic acid		0.43
42	(*Z*,*Z*)-3,6-*cis*-9,10-Epoxy-nonadecadiene		0.90
43	Heneicosane		1.10
44	Docosane		0.35
45	Tricosane		2.14
46	Hexanedioic acid, dioctylester		0.54
47	Tetracosane		0.19
48	Pentacosane		1.67
49	Hexacosane		0.07
50	Heptacosane		0.98
	Total	91.57	93.53

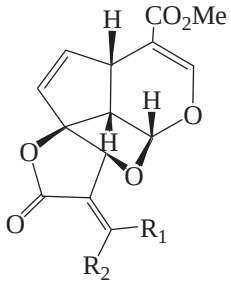
DIST: Hydrodistilled
SPME: Solid-phase microextraction; SDS: Solvent extraction.

Iridoids, Other Monoterpenes and Related Compounds

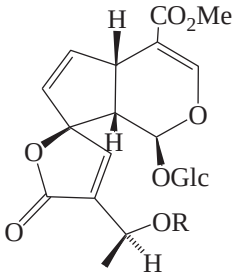
Many iridoids have so far been found to occur in nature, the vast majority of them differing only in the degree and type of substitution in the basic cyclopentano-pyran ring system. A rather rare group of iridoids contains a spiro-lactone ring as an additional feature and comprises plumericin (**1**), isoplumericin (**2**) and plumieride (**3**). Allamandin (**4**) and allamandicin (**5**) were isolated from plants of the family Apocynaceae, particularly of the genera *Allamanda*, *Nerium* and *Plumeria* (Coppen, 1983; Abe *et al*., 1984).

The following are examples of the iridoids and other monoterpenes isolated from some species of the family Apocynaceae:

1. *Allamanda blanchetti* A. DC. (Purple allamanda, violet allamanda): Plumericin and isoplumericin from the root bark (Bhattacharyya and De Morais, 1986).
2. *Allamanda cathartica* L. (Golden trumpet, common allamanda, yellow bell): Plumericin, demethylplumericin, isoplumericin, allamandin (**4**), allamandicin (**5**), allamdin (**6**), pulmieride coumarate (**7**) plumieride coumarate glucoside (**8**), plumieride, plumericin, isoplumericin and fluvoplumierin (**9**) from different parts of the plant (Pai *et al*., 1970; Kupchan *et al*., 1974; Jewers *et al*., 1975; Agarwal and Sharma, 1983; Coppen, 1983; Coppen and Cobb, 1983; Abdel-Kader *et al*., 1997; De Melo and De Mello, 1997). Allamandoside, a fungitoxic substance, was isolated from the flowers (Dixit *et al*., 1982). Three normonoterpenoids, cerberidol (**10**), epoxycerberidol, and cyclocerberidol, and their β-D-allopyranosides were obtained from the air-dried leaves (Abe *et al*., 1989d).
3. *Allamanda doniana*: Plumericin and isoplumericin from the woods and roots (Harumi *et al*., 1995).
4. *Allamanda neriifolia*: Protoplumericin A (**11**, a bisglucoside) (Yamauchi *et al*., 1981), isoallamandicin (**12**), allamcin (**13**), allamancin (**14**), 3-*O*-methyl derivatives of allamcin (**15**) allamancin, allamacidin (**16**), allamacidin glucoside (**17**), 13-*O*-acetylplumieride (**18**), plumiepoxide (**19**), pulumericin, isoplumericin, allamandin, allamandicin, deglucosyl-plumieride (**20**), 13-*O*-*p*-coumaroylplumieride, plumieride, protoplumericin A, protoplumericin B (**21**), gardenoside (**22**), 10-dehydrogardenoside (**23**) (Abe *et al*., 1984), allaneroside (**24**) (Shen and Chen, 1986), plumieride and allamanoid (**25**) (Yu *et al*., 2010).



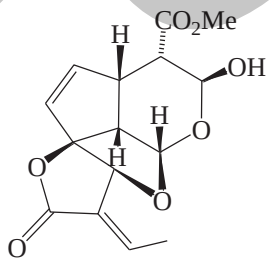
1 Plumericin R_1=Me, R_2=H
2 Isoplumericin R_1=H, R_2=Me



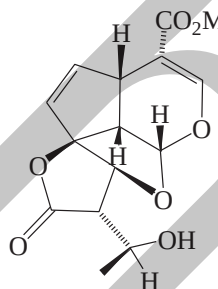
3 Plumieride R =H

7 Plumieride coumarate R=COCH=CH-C$_6$H$_4$-OH

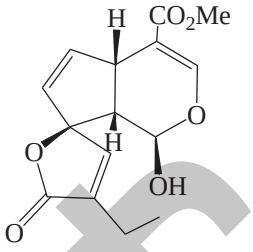
8 Plumieride coumarate glucoside R=COCH=CH-C$_6$H$_4$-OGlc



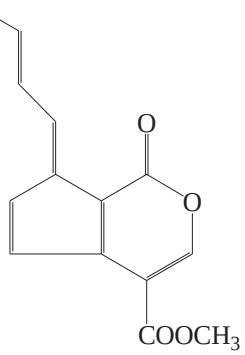
4 Allamandin



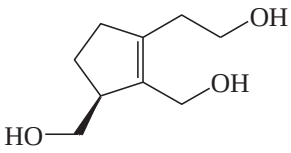
5 Allamandicin



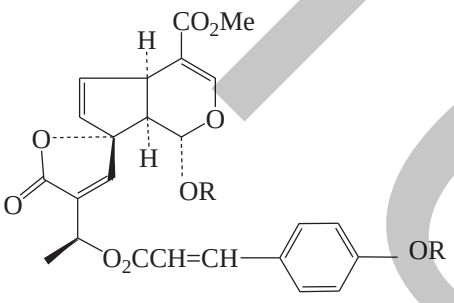
6 Allamdin



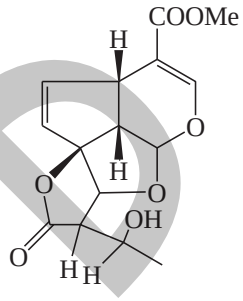
9 Fulvoplumerin



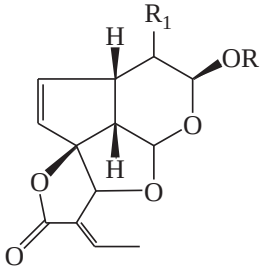
10 Cerberidol



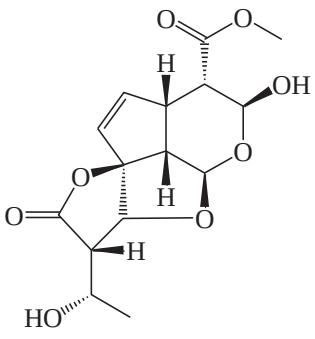
11 Protoplumericin A R=glucose



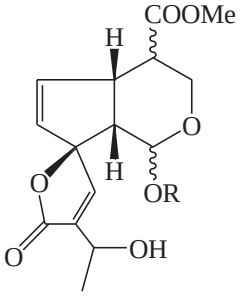
12 Isoallamandicin



13 Allamcin R=R_1=H
15 3-*O*-Methylallamcin R=Me ,R_1=H



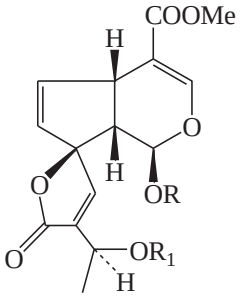
14 Allamancin



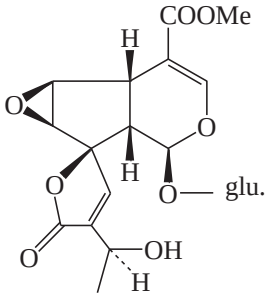
16 α-Allamcidin (1α), R=H
β-Allamcidin (1β), R=H
17 β-Allamcidin Glucoside, R=gluc.

5. *Allamanda schotii* Pohl: Plumieride, plumieride coumarate and plumieride coumarate glycoside were isolated from the flowers (Ganapaty and Rao, 1988). Plumericin, isoplumericin, allamandin and allamacin were identified from the stems (Anderson *et al*., 1988).
6. *Alstonia boonei*: From the bark, boonein (a monoterpenoid δ-lactone) was isolated (Marini-Bettolo *et al*., 1983).
7. *Alstonia glaucescens*: Sweroside (**26**) was isolated from the stem bark (Keawpradub *et al*., 1994).
8. *Alstonia macrophylla* Wall. ex G. Don: Two secoiridoid glycosides, sweroside and naresuanoside (**27**) from the stem (Changwichit *et al*., 2011).
9. *Alstonia scholaris*: *p*-Menthane 1,2,8-triol was isolated from the flowers (Datta and Mathur, 1987). Four 11-noriridoids, scholareins A-D (**28-31**), isoboonein (**32**), alyxialactone (**33**) and loganin (**34**) from the bark (Feng *et al*., 2008). Two secoiridoids *viz.* alstonoside (Thomas *et al*., 2008) and sweroside (Sultana *et al*., 2013a) from the stems and the aerial parts respectively, two C_{13}-norisoprenoids, megastigmane-3β,4α-9-triol and 7-megastigmene-3,6,9-triol from the leaves (Xu *et al*., 2009a) and loganetin (Maurya *et al*., 2014).
10. *Alyxia reinwardtii* BL.: Pulosarioside (**35**), a trimeric-iridoid diglucoside from the bark (Kitagawa *et al*., 1988), and two iridolactones (non glycoside iridoids), alyxialactone (**12**) and 4-*epi*-alexialactone from the leaves (Topcu *et al*., 1990).
11. *Amsonia tabernaemontana*: Secologanin from the shoots (Dabi Lengyel *et al*., 1984).
12. *Apocynum venetum* L.: Two ionone glycosides, apocyonosides I and II, from the roasted leaves (Murakami *et al*., 2001) and grasshopper ketone [$C_{13}H_{20}O_3$ (3*S*,5*R*,6*R*)-3,5-dihydroxy-6,7-didehydro-5,6-dihydro-9-apo-β-caroten-9-one] from the leaves (Kong *et al*., 2013).
13. *Beaumontia grandiflora*: Turpinionoside A (**36**) from the leaves and branches (Kanchanapoom *et al*., 2002).
14. *Cerbera manghas* L. (Sea mango): Theveside (**37**), theviridoside (**38**), loganin (Inouye and Nishimura, 1972, Yamauchi *et al*. 1990b, Wang *et al*., 2007), cerbinal (**39**), norviburtinal (**40**, a yellow pigment having an iridoid skeleton), a pseudoazulene iridoid, cerberic acid (**41**) and cerberinic acid (**42**) from the bark (Abe *et al*, 1977; Zhang *et al*., 2008). Loganin, 10-benzoyltheveside, 10-dehydrogeniposide (Yamauchi *et al*., 1990b), 10-carboxyloganin (**43**), β-D-glucosides of cyclopentano-normonoterpenoids (**44**, **45**) and dinormonoterpenoids (**46- 49**) from the leaves (Abe and Yamauchi, 1996). A linear monoterpene (2*E*,6*S*)-8-hydroxy-2-hydroxymethyl-6-methyl-2-octenoic acid, together with cerbinal, cyclocerberidol and cerberidol were also identified from the plant (Wang *et al.*, 2007;Yu*et al*,, 2009).
15. *Cerbera odallam*: Three normonoterpenoids, cerberidol, epoxycerberidol, and cyclocerberidol, and their β-D-allopyranosides from the leaves (Abe *et al*., 1989d).
16. *Himatanthus articulata* (Vahl) Woodson: Plumericin, isoplumericin and two spirolactone iridoids from the bark (De Sá Barreto *et al*., 1998).
17. *Himatanthus obovatus*: Plumericin and isoplumericin from the roots (Harumi *et al.*, 1995).
18. *Himatanthus phagdeaenica* (Mart) Woodson: Plumericin, isoplumericin and allamandin from the stems (Vanderlei *et al*., 1991). An iridoid lactone, β-dihydro-plumericinic acid from the roots (Veloso *et al*., 1999).
19. *Himatanthus sucuuba* (Spruce ex. Müll, Arg.) Woodson: Fulvoplumierin (Perdue and Blomster, 1978), plumericin, isoplumericin (Silva *et al*., 1998; Wood *et al*., 2001), 15-demethylisoplumieride (De Sá Barreto *et al*., 2007), β-dihydroplumericinic acid,

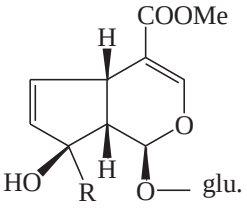
plumieridin, allamandicin, plumeridoid C and others mainly from the bark (Endo *et al*., 1994; Waltenberger *et al*., 2011a,b).



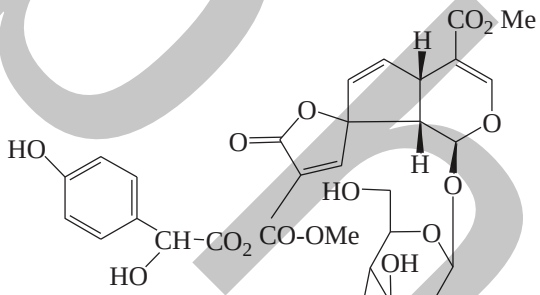
18 13-*O* -Acetylplumieride, R=glc,R_1=MeCO
20 Deglucosyl plumieride, R=R_1=H
21 Protoplumericin B, R=glc., R_1=4-*O*-glucosyl-caffeoyl



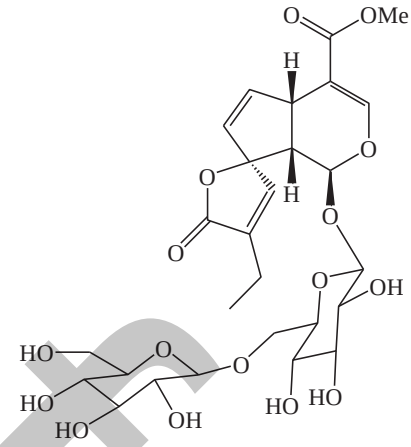
19 Plumiepoxide



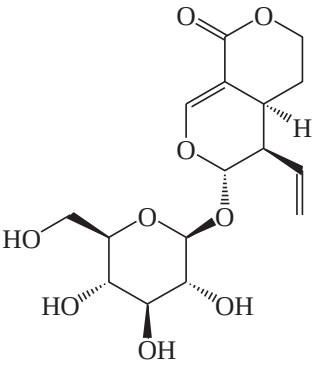
22 Gardenoside R=CH_2OH
23 10-Dehydro gardenoside R=CHO



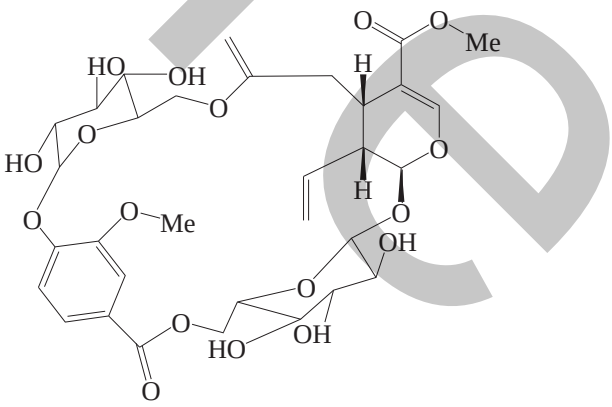
24 Allaneroside



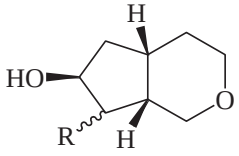
25 Allamanoid



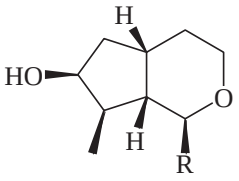
26 Sweroside



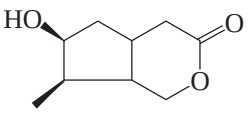
27 Naresuanoside



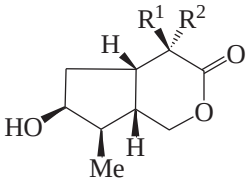
28 Scholarein A, R=β-Me
29 Scholarein B, R=α-Me



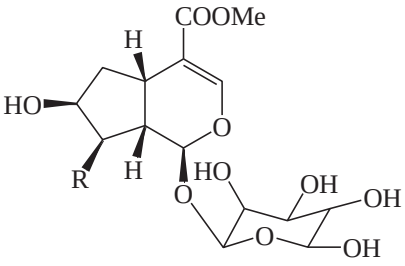
30 Scholarein C, R=OH
31 Scholarein D, R=MeO



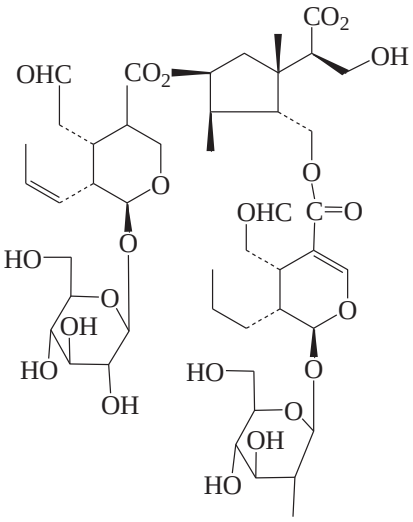
32 Isoboonein



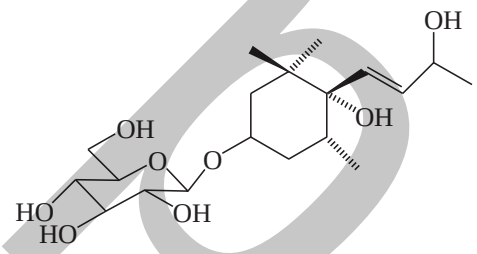
33 I: R^1=H, R^2=CH_2 OH
II: R^1=CH_2 OH, R^2=H



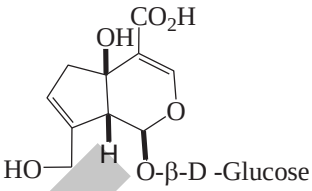
34 Loganin, R=CH_3
43 10-CarboxyLoganin, R=COOH



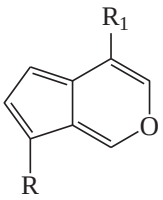
35 Pulosarioside



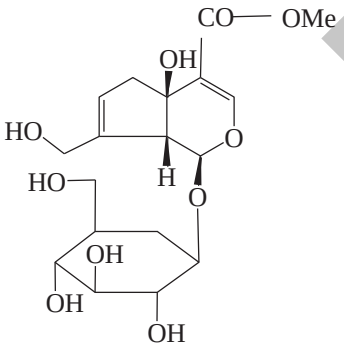
36 Turpinionoside A



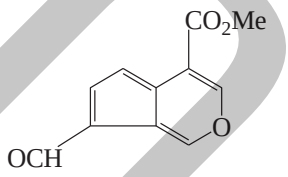
37 Theveside



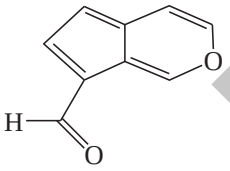
41 Cerberic acid,
R=COOH,R_1=$COOCH_3$
42 Cerberinic acid
R=CHO,R_1=COOH



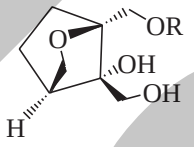
38 Theveridoside

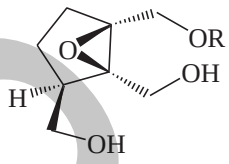


39 Cerbinal



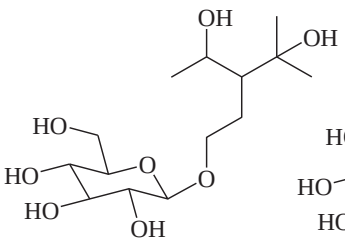
40 Norviburtinal



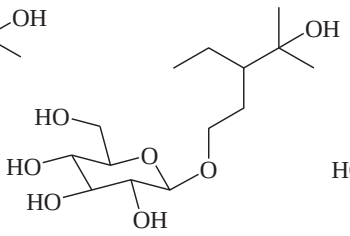


44 R= β-D-glucose **45** R= β-D-glucose

(Cyclopentano normonterpenods β-D-glucosides)



46



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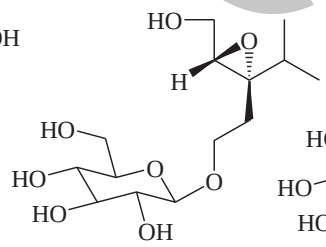

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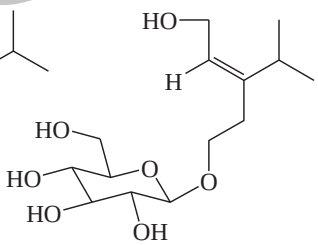


49

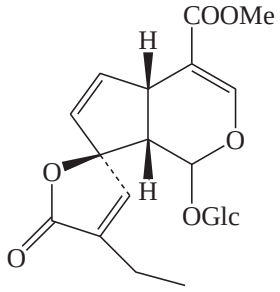
Dinormonotepenoids β-D-glucosides

20. *Hunteria umbellata*: Segunoside and iridolactone-β-glucoside, with a unique fusion of a δ-lactone ring to an unsaturated cyclopentano[c]tetrahydropyran ring system, from the stem bark (Ajala and Coker, 2012).
21. *Melodinus fusiformis*: Loganin from the leaves and twigs (Wang *et al*., 2012a).
22. *Melodinus hemsleyanus*: Loganin from the leaves and twigs (Wang *et al*., 2013b).
23. *Melodinus henyri*: Loganin from the fruit and root (Li *et al*., 1987b).
24. *Nerium indicum*: Plumericin (Basu and Chatterjee, 1973).
25. *Plumeria acutifolia* Poir: 13-*O*-Caffeoylpulmieride, 13-deoxyplumieride (**50**), β-dihydro-plumericinic acid glucosyl ester, plumenoside (**51**), 1α-plumieride (**52**), 1α-protoplumericin A and 8-isoplumieride (**53**) from the roots (Abe *et al*., 1988a); 15-demethylplumeride from the leaves (Hassan *et al*., 2008); plumieride, plumericin and fulvoplumierin from the stem bark and other plant parts (Schmid, H and Bencze, 1953; Hasan *et al*., 1994). Plumirides occurred in both *Plumeria acutifolia* and *Plumeria bracteata* in decreasing amounts, in the order cortex, pith, root-cortex, leaves, flowers, wood. In general, older parts contained less than younger. Latex of young leaves contained twice as much plumieride as older ones (Wanner and Zorn-Ahrens, 1972). Plumeiridine-5-*O*-glucoside was isolated from the stem bark (Rasool *et al.*, 2010). Plumericin and plumieride were isolated from the roots and stem bark of the plant growing in Egypt respectively (El-Sherbeni *et al.*, 2012).
26. *Plumeria alba* L.: Plumieride and plumieride *p*-coumarate were isolated from the air-dried plant (Bramadhayalaselvam *et al*., 1997). Plumieride, protoplumericin A, and plumeride acid have been identified from the bark and leaves of the plant cultivated in Egypt (Afifi *et al*., 2006).
27. *Plumeria acutifolia*: Fulvoplumierin and plumieride from the bark (Rangaswami *et al.*, 1961). 15-Demethylplumeride was also isolated from the plant growing in Egypt (Hassan *et al.*, 2008).
28. *Plumeria bicolor*: Plumericin and isoplumericin, allamacin, allamandin and fulvoplumiericin from the stem bark (Hasan *et al*., 1997; Dobhal *et al*., 1999).
29. *Plumeria bracteata*: Fulvoplumierin and plumiericin in the root cortex (Wanner and Zorn-Ahrens, 1972).
30. *Plumeria inodora*: Plumieride (Grignon-Dubois *et al*., 2005).
31. *Plumeria multiflora*: Plumericin from the roots (Little and Johnstone, 1951).
32. *Plumeria obtusa*: 6"-*O*-Acetylplumieride *p*-*E*-coumarate, 6"-O-acetylplumieride *p*-*Z*-coumarate, plumieride, plumieride *p*-*Z*-coumarate, plumieride *p*-*E*-coumarate from leaves (Siddiqui *et al*., 1994a); 1α-plumieride from stem bark (Siddiqui *et al*. 2004) and champalinin (*p*-methox-*E*-cinnamoyloxy pulmieride) from the leaves and stem bark (Ali *et al*., 2008). Six iridoids, obtusadoids A and B, plumieridin A (**54**), plumieridin B (**55**), 1α-plumieride and 15-demethylplumieride (**56**) from the aerial parts (Saleem *et al.*, 2011).
33. *Plumeria rubra* L.: Plumieride, fulvoplumierin, plumericin, isoplumericin, 13-*O*-coumaroylplumieride, protoplumericin A, plumeridoids A-C, epiplumeridoid C, dihydroplumericin, allamcin, allamandin, α-allamcidin, β-allamcidin 15-demethyl-plumieride, β-dihydroplumericin, 15-demethylisoplumieride, 13-*O*-*trans*-*p*-coumaroyl-plmieride, β-dihydroplumericinic acid, rubradoid (plumieridine-1-*O*-β-D-galacto-pyranoside) (**57**), 1-α-plumieride, plumieride *p*-*Z*-coumarate and plumieride-*p*-*E*-coumarate from the different parts of the plant (stem, leaves, bark, heartwood) (Albers-Schoenberg and Schmid, 1961; Rao and Anjaneyulu 1967; Tandon *et al*., 1976; Kardono *et al.*, 1990a; Hamburger *et al*., 1991; De Sa Barreto *et al*., 2007; Kuigoua *et al.*, 2010; Zaheer *et al*., 2010a; Akhtar *et al*., 2013).The quantitative determination of plmieride in

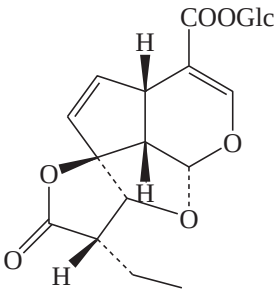
the different organs (roots, leaves, stem barks and stem woods) of *Plumeria rubra* and *Plumeria rubra* var. *alba* (cultivated in Egypt), revealed that the highest content was found in the stem bark of the first species. The organs of *Plumeria rubra* contained more plumieride than those of *Plumeria rubra* var. *alba* (Mahran *et al*., 1974b). The percentages of plumieride found in the young stem, stem wood, leaves, roots, and stem bark of *P. rubra* and *P. rubra alba*,grown in Egypt were 0.2 and 0.15, 0.47 and 0.34, 0.45 and 0.32, 0.52 and 0.46, and 0.96 and 0.85, respectively (Mahran *et al*., 1975b). Plumericin was isolated from the roots of *P. rubra* and *P. rubra alba* grown in Egypt in yields of 0.08 and 0.1%, respectively. Fulvoplumierin was isolated from stem bark of *P. rubra* and *P. rubra alba* in yields of 0.20 and 0.24%, respectively, and roots of *P. rubra* and *P. rubra alba* in yields of 0.06 and 0.08%, respectively (Mahran *et al*., 1975c).

34. *Plumeria rubra* L. var. *acutifolia* (Ait.) Woodson: 15-Demethylisoplumieride from the bark (De Sa Barreto *et al*., 2007), and two diastereoisomers pulmieridin A and B from the flowers (Ye *et al*., 2008). Plumeiride coumarate was isolated from the leaves of the plant growing in Egypt (Sengab *et al*., 2009).
35. *Plumeria rubra* L.var. *alba*: Plumieride was isolated from the fruits of the plant cultivated in Egypt (Shehata and Islam, 2002).
36. *Ravwolfia grandiflora*: Loganin, loganic acid (**58**), boonein, and isoboonein, a monoterpenoid δ-lactone) from the bark (Bianco *et al*., 1994).
37. *Rauwolfia serpentina* Benth.: 7-Epiloganin from the roots (Itoh *et al*., 2005).
38. *Tabernaemontana cymosa*: Sweroside from the leaves (Achenbach *et al*., 1997).
39. *Tabernaemontana psorocarpa*: Sweroside from the leaves (Van Beek *et al*., 1982a; Achenbach and Addae-Mensah, 1982) and twigs (Achenbach and Addae-Mensah, 1982).
40. *Thevetia gaumeri*: Theveridoside from the roots (Peraza-Sanchez *et al*., 2001).
41. *Thevetia peruviana*: Theviridosidefrom the stem bark (Sticher and Schmid, 1969).
42. *Thevetia nereifolia* (Yellow oleander): Theviridoside and theveside from the grains (Sticher, 1971) and others from various tissues (Osisiogu, 1975).
43. *Thevetia peruviana* (Yellow oleander): Theviridoside, theveside (Sticher, 1970); 10-*O*-β-D-glucopyranosyl theviridoside, 3'-*O*-β-D-glucopyranosyl theviridoside, 10-*O*-fructo-furanosyltheviridoside, 6'-*O*-glucopyranosyl theviridoside from the roots (Abe *et al*., 1995a,c) and polyhydroxy-dinormonterpenoids and their apiosylglucosides from the leaves (Abe *et al*., 1996). Aucuboside was identified from the leaves and fruits (Paris and Etchepare, 1966)
44. *Trachelospermum jasminoides* (Lindl.) Lem: A normonoterpenoid glycoside, trachelinoside, (4-(2-*O*-β-D-glucopyranosyl)-hydroxyethyl-5,5-dimethyldihydrofuran-2(3*H*)-one) from the leaves (Tan *et al*., 2010a).
45. *Vinca difformis* (Pourr.) M. Pichon: Loganic acid from the aerial parts (Bianco *et al*., 2005).
46. *Vinca major* L.: Two secoiridoid glucosides, vinmajoroside and (7α)-7-*O*-methyl-morroniside, along with iridoids (loganin, loganic acid and 7-*O*-*p*-coumaroylloganin) from the leaves (Şöhretoğlu *et al*., 2013).
47. *Vinca rosea*: Secologanic acid, secologanoside (**59**) (Guarnaccia and Coscia, 1971), deoxyloganin, loganin, dehydrologanin, sweroside (Bhakuni and Kapil, 1972) and roseoside (C_{13} glycoside) (**60**) (Bhakuni *et al*., 1974).
48. *Vinca sardoa*: Loganin and loganic acid from the aerial parts (Bianco *et al*., 2005).
49. *Winchia calophylla* A. DC.: Wincaloside A (**61**), wincaloside B (**62**) (monoterpene diglycosides), loganin, 7-*O*-formylloganin, 6'-*O*-formylloganin and 7,6'-*O*-diformyl-loganin, winchiepoxide (a derivative of tetrahydroxycyclohexane-carboxylic acid), three butyl acetals *viz*. butyl winchal (**63**), butyl isowinchal (**64**) and ethyl winchal (**65**) (Zhu *et*

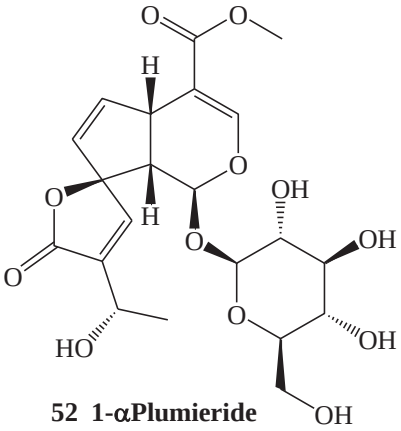
al., 2003, 2004a,b, 2005, 2007), a monoterpene glycoside calophyloside A and iridoid glycoside calophyloside B (Chen *et al*., 2012b) from the stem bark.



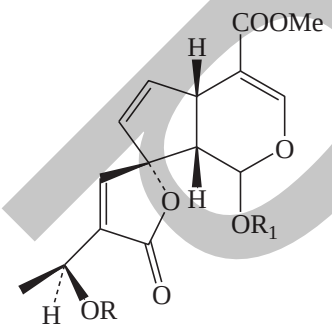
50 13-deoxyplumieride



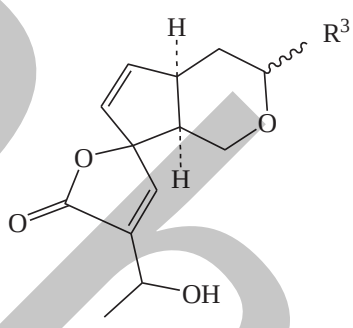
51 Plumenoside



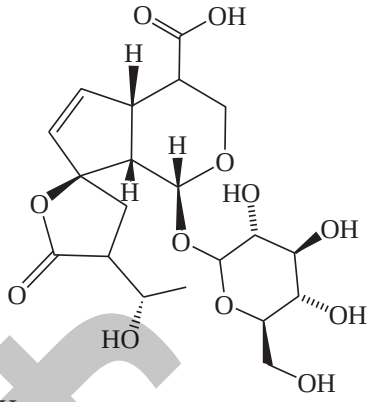
52 1-αPlumieride



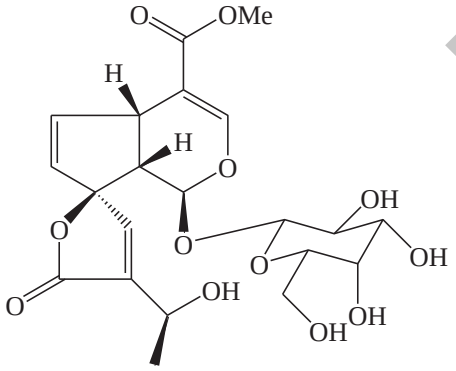
53 8- Isoplumieride
R=H , R_1=Glc



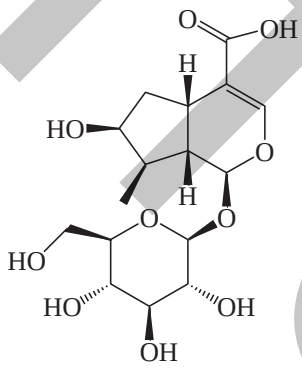
54 Plumieridin A R =α-OH
55 Plumieridin B R =β-OH



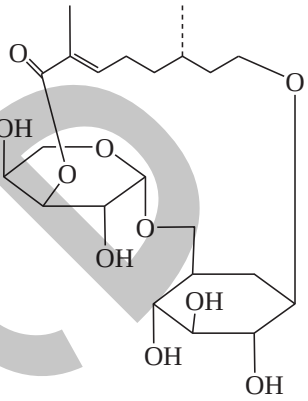
56 Demthyl plumieride



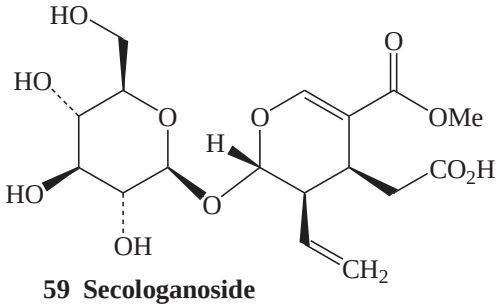
57 Rubradoid



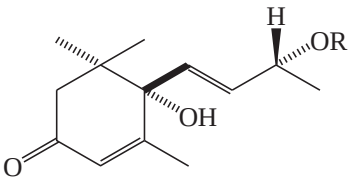
58 Loganic acid



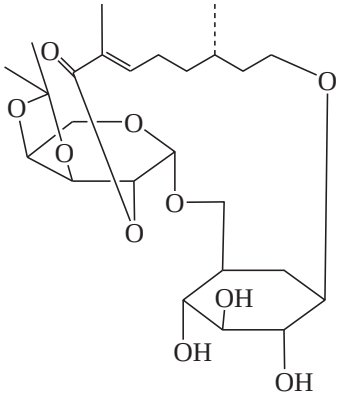
61 Wincaloside A



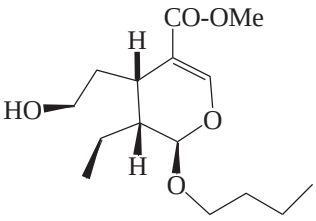
59 Secologanoside



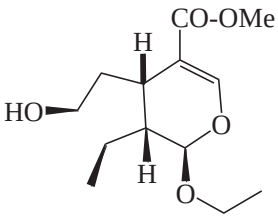
60 Roseoside R=β-D-Glu



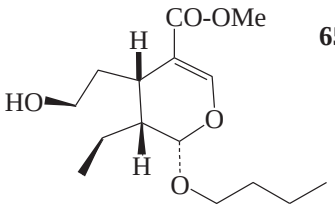
62 Wincaloside B



63 Butyl winchal



65 Ethyl winchal

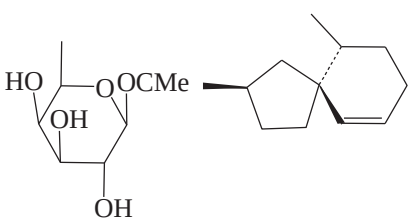


64 Butyl isowinchal

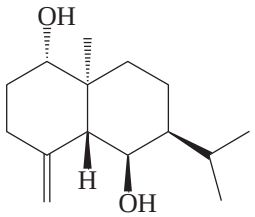
Sesquiterpenes

The following are examples of the sesquiterpenes identified from few species of the family:

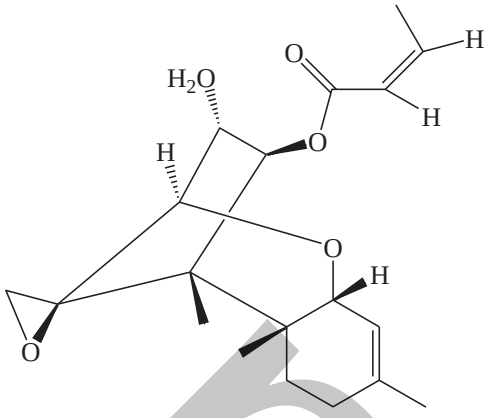
1. *Catharanthus oxyacantha*: Hinesol β-D-fucopyranoside (**66**) (Rustaiyan *et al*., 1976).
2. *Catharanthus roseus*: Cadin-2-en-1β-ol-1β-D-glucopyranoside and guaia-1.7-dien-3β,13-diol-13α-D-glucofuranoside from the culture hairy roots (Chung *et al*., 2007a).
3. *Ecdysanthera rosea*: A sesquiterpenoid named ecdysanthblic acid (Xu *et al.*, 2008), 5α-hydroperoxycostic acid, 5β-hydroperoxycostic acid and 1β,6α-dihydroxy-4(14)-eudesmane (**67**) from the aerial parts (Zhu *et al*., 2010, 2011a).
4. *Holarrhena floribunda*: The following trichothecenes (a family of mycotoxins which are a structurally diverse group of sesquiterpene epoxides) have been isolated from the stem: 8-Dihydrotrichothecinol A (**68**), loukacinol A (**69**), loukacinol B (**70**), trichothecolone (**71**), trichothecin and trichothecinol A (**72**) (Loukaci *et al*., 2000).
5. *Landolphia dulcis* var. *barteri*: Nine aromadendrane-type sesquiterpenes, a cadinane derivative and a muurolane derivative (Staerk *et al*., 2004).
6. *Mandevilla pentlandiana*: (+)-Aromadendra-1(10) and 4-dien-15-al-3-one (**73**) from the roots (Cabrera *et al*., 1993b).
7. *Parepigynum funingense* Tsiang *et* P.T.Li: Eudesmane sesquiterpene glycosides *viz*. pterodontriol D-6-*O*-β-D-glucopyranoside (**74**), ainsliaside E (**75**) (Hua *et al*., 2004a), 1α,6β-dihydroxy-5,10-bis-*epi*-eudesm-6-*O*-β-D-glucopyranoside (**76**), 1α,6β-dihydroxy-5,10-bis-*epi*-eudesm-4(15)-ene-6-*O*-β-D-glucopyranoside funingensin A (**77**), and funingensin B (**78**) (Hua *et al*., 2007a,b) from the roots.
8. *Pentalinon andrieuxii* Muell.-Arg. (Syn. *Urechites andrieuxii*): Two unusual trinor-sesquiterpenoids, urechitols A (**79**) and B (**80**) from the root (Yam-Puc *et al*., 2009).



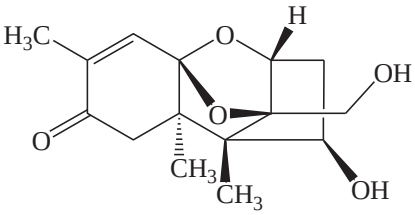
66 Hinesol β-D-fucopyranoside



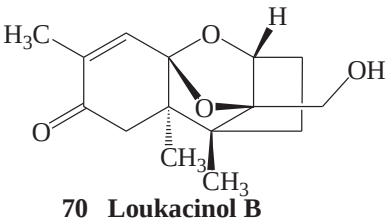
67 1β, 6α-Dihydroxy-4(14)-eudesmane



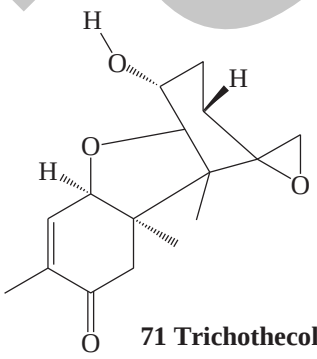
68 8-Dihydrotrichothecinol A



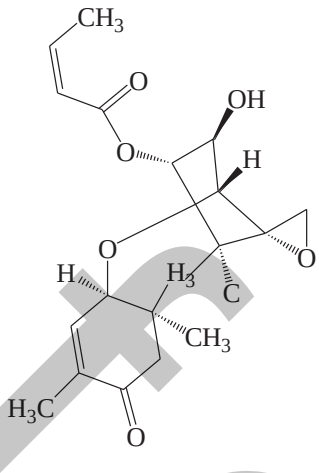
69 Loukacinol A



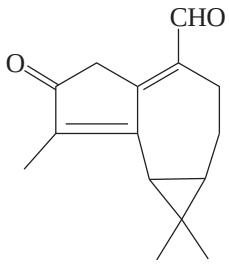
70 Loukacinol B



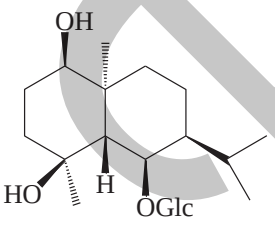
71 Trichothecolone



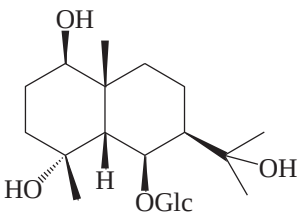
72 Trichothecinol A



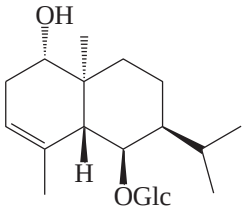
73 (+) Aromadendra-1(10), 4-dien-15-al-3-one



74 Pterodontriol D-6-*O*-β-D-glucopyranoside



75 Ainsliaside E



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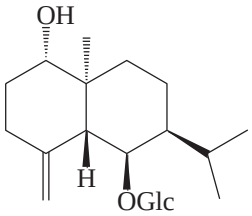
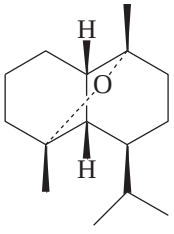
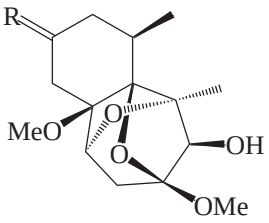


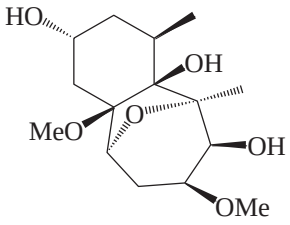
77 Funingensin A



78 Funingensin B



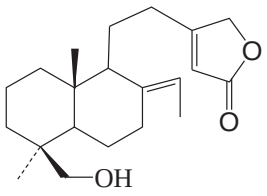
79 Urechitol A R =Hβ,OHα



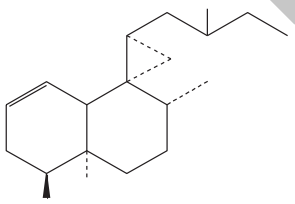
80 Urechitol B

Diterpenoids

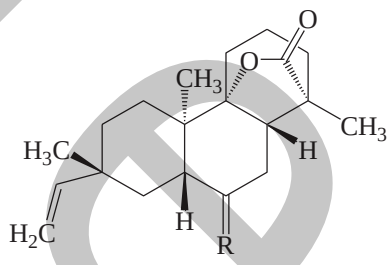
Medigenin (**81**, a labadane diterpene) and its glycoside, medinin were isolated from the root bark of *Melodinus monogynus* (Sethi *et al*., 1988). Another labadane diterpene, oleanderoic acid (8α-methoxylabdan-18-oic acid) was identified from the leaves of *Nerium oleander* (Siddiqui *et al*., 1988b). The air-dried stems and branches of *Rauvolfia tetraphylla* afforded a labdane diterpene characterised as 3β-hydroxy-labda-8(17),13(14)-dien-12(15)-olide(Brahmachari *et al*., 2011). Holarkolevane (**82**) was isolated from the bark of *Holarrhena antidysentrica* (Khan *et al*. 2010a). Rosenonolactone, 6β-hydroxy-rosenonolactone (**83**) and rosololactone (**84**) were identified from *Holarrhena floribunda* (Loukaci *et al*., 2000). Phytol (an acyclic diterpene alcohol) was isolated from the leaves of *Nerium indicum*, as the main constituent (10.02%) (Hao *et al*., 2013) and also identified in *Wrightia tinctoria* (Jayamathi *et al*., 2012). Phytol (9.202%) and neophytadiene (8.288%, dehydrated phytol) were isolated from the leaves of *Strophanthus divaricatus* (Cheng *et al*., 2013). Glaucocalyxin A (**85**, *ent*-kauranoid diterpenoid) was isolated from the leaves and stems of *Ervatamia officinalis* (Zhu *et al*., 2011c). Neoandrographolide (**86**), 19-hydroxy-8(17),13-laboiadien-16,15-olide-*O*-β-D-glucopyranoside) was isolated from *Ervatamia yunnanensis* (Yu*et al*., 1999b). Jatrophone (**87**) (an antitumor compound) is extracted from *Mandevilla velutina* tubers (Takeshita *et al*., 1994). Phytol was identified from the leaves of *Thevetia peruviana* (Mthuravalli and Lakshmi, 2012).



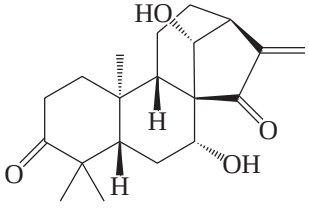
81 Medigenin



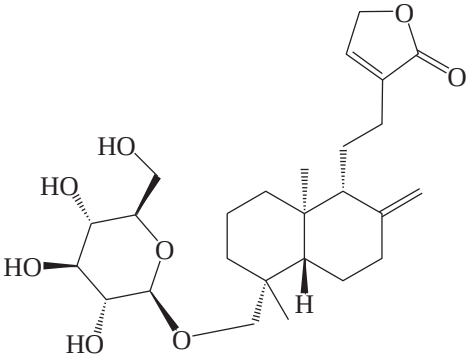
82 Holarkolavene



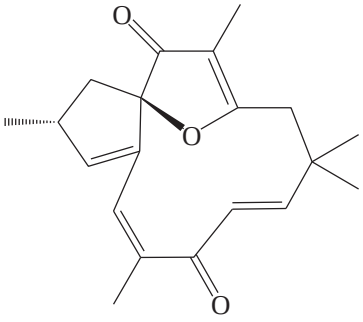
83 Rosenonolactone R=O
84 Rosalolactone R=H



85 Glaucocalyxin A



86 neo-Andrographolide



87 Jatrophone

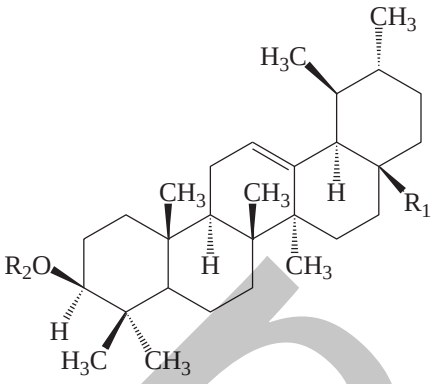
Triterpenoids and Related Compounds

α-Amyrin, β-amyrin, lupeol and ursolic acid (**88**) have been isolated from several species, and they appear to be the most common triterpenes of the plants of this family. Ursolic acid was identified from many of the studied species; its content in 7 different species varied from 0.3 to 2.4% (Le Men and Pourrat, 1953). The content of ursolic acid in some species of the family was (percent of dry wt.): *Vinca minor* 1.34, *Vinca herbacea* 1.28, *Vinca major* 1.16, *Vinca rosea* 1.02, *Vinca pubescens* 1.37, *Vinca erecta* 0.94, *Amsonia tabernaemontana* 1.80, *Nerium oleander* 0.80, *Rauwolfia serpentina* 0.32, *Rauwolfia verticillata* 0.20, *Rauwolfia canescens* 0.40. Ursolic acid could not be detected in *Apocynum androsaemifolium* and *Apocynum cannabinum* (Bocharova, 1966). However, the presence of several others have been detected. The leaves of *Nerium oleander* L. (oleander)-contain the following triterpenes, belonging to ursane-oleanane-, dammarane-, lupine-and taraxarane-types: kaneric acid (**89**), uvaol (**90**) (Siddiqui *et al*., 1988c), oleanderen (**91**) (Siddiqui *et al*., 1988b), betulin, betulinic acid, oleanolic acid, oleanderol (**92**), ursolic acid (Siddiqui *et al*., 1988a), two coumaryloxy triterpenoids, neriucoumaric (**93**) and isoneriucoumaric acids (**94**) (Siddiqui *et al*., 1987h), kanerin (**95**), 12.13-dihydroursolic acid (Siddiqui *et al*., 1989a), oleanderolic acid, kenerodione (Siddiqui *et al*., 1989b), *cis*-karenin (3β-hydroxy-28-*Z*-*p*-coumaroyloxy-urs-12-en-27-oic acid) and *trans*-karenin (3-β-hydroxy-28-*E*-*p*-coumaroyloxy-urs-12-en-27-oic acid) (Siddiqui *et al*., 1995a), 3β,27-hudroxy-urs-18-en-13,18-olide, 3β,22,28-trihydroxy-25-*nor*-lup-1(10), 20 (29)-dien-2-one (Begum *et al*., 1997), 3β,27-dihydroxy-12-ursen-28-oic acid, 3β, 13β-dihydroxyurs-11-en-28-oic acid, 3β-hydroxy-urs-12-en-28-aldehyde, 28-norurs-12-en-3β-ol,urs-12-en-3β-ol,urs-12-ene-3β,28-diol, 3β,27-dihydroxy-12-oleanen-28-oic acid (20*S*, 24*R*)-epoxydaamma-rane-3β,25-diol, 3β,20α-dihydroxyurs-21-en-28-oic acid, 3β,12α-dihydroxyoleanan-28,13β-olide, and (20*S*,24*S*)-epoxydammarane-3β,25-diol (Fu *et al*., 2005), 20β,28-epoxy-28α-methoxy-taraxasteran-3β-ol 20β, 28-epoxytaraxaster-21-en-3β, 17β-diol and 3β-hydroxyurs-12-en-28-aldehyde (Zhao *et al*., 2006b), (20*S*,24*R*)-epoxy-drammarane-3β, 25-diol, 3β, 20α-dihydroxy 3β,20α-dihydroxyurs-21-ene-28-oic acid, 28-norurs-12-en-3β, 17β-diol, 28,28-dimethoxyurs-12-en-3β-ol, 3β, 12α-dihydroxyoleanan-28, 13β-olide, 20β, 28-epoxy-28α-methoxytaraxasteran-3β-ol,20β,28-epoxytaraxaster-21-en-3β-ol, (20S,24S)-epoxydammarane-3β,25-diol (Zhao *et al*., 2007b), and oleanderocioic acid (**96**) (Siddiqui *et al*., 2012). A high amount of squalene was found in *Allamanda blanchetii* (55.81%) and *Allamanda violacea* (51.09%) (Chaveerach *et al*., 2014). Examples of the triterpenes isolated from some species of the family are shown in Table **5**.

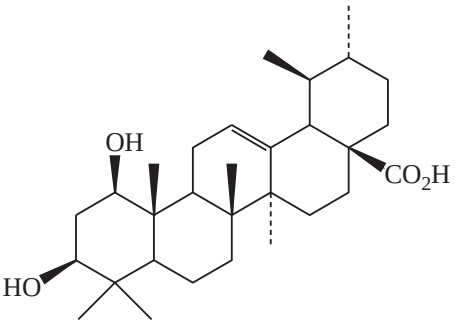
Limonoids (classed as tetranortriterpenes, chemically consist of variations of the furanolactone core structure) are rarely represented in the family. A cytotoxic limonoid, odontadenin A (**144**) was isolated from *Odontadenia macrantha* (Prakash Chaturvedula *et al*., 2003a).

Triterpenoid glycosides have been also isolated from plants of the family. The whole plant of *Trachelospermum asiaticum* yielded eight triterpenoid glycosides, including the two glycosides suavissimoside R1 and the 3.28-bis-*O*-glucoside of 19 α-hydroxyasiatic acid, were determined to be 28-*O*-or 3.28-bis-*O*-glucosides of 19 α-hydroxyursolic acid derivatives except for one 28-*O*-xylosyl-glucoside. The major compound was the 28-*O*-glucoside of 2 α,3β,19 α,23,24-pentahydroxyurs-12-en-28-oic acid. Five trachelosperosides A-1 (**145**), B-1, B-2, C-1, and C-2. Three aglycons were named trachelosperogenins A, B, and C (Abe and Yamauchi, 1987a). Eight glycosides of 2α,19α-dihydroxyoleanolic acid derivatives including trachelosperosides D-1 (**146**), D-2, E-1, F-2, and arjungenin-23,28-bis-*O*-glucoside and -1-*O*-xylopyranosyl-(1→2)-glucopyranoside, from the whole plant along arjunglucoside I and arjungenin-3, 28-bis-*O*-glucoside (Abe and Yamauchi, 1987b). From canes with leaves of *Trachelospermum jasminoides*, eight triterpenoids were identified as: trachelosperoside F,

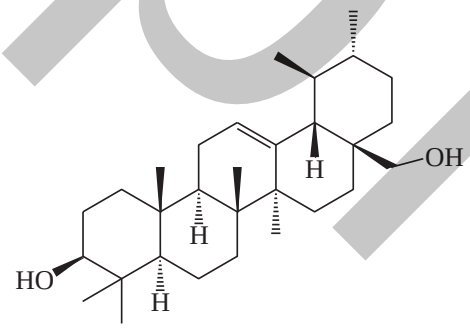
trachelosperoside B-1, trachelosperoside D-1, trachelosperoside E-1, 3β-*O*-D-glucopyranoside quinovic acid, 3β-*O*-β-D-glucopyranoside quinovic acid 27-*O*-β-D-glucopyranosyl ester, 3β-*O*-β-D-glucopyranoside cincholic acid 27-*O*-β-D-glucopyranosyl ester and trachelosperogenin B (Tan *et al*., 2006). Seven triterpenoid saponins *viz*. saponin B-1,



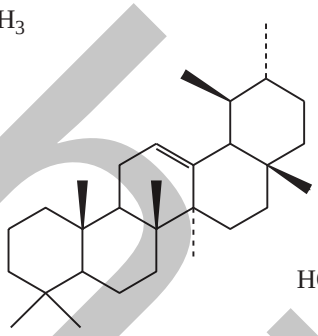
88 Ursolic acid R_1 = COOH, R_2 = H
100 Cycloartanol R_1 = CH_3, R_2 = $COCH_3$



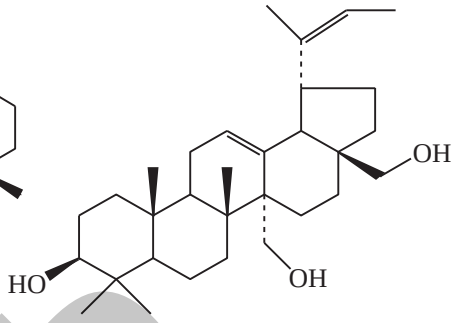
89 Kaneric acid



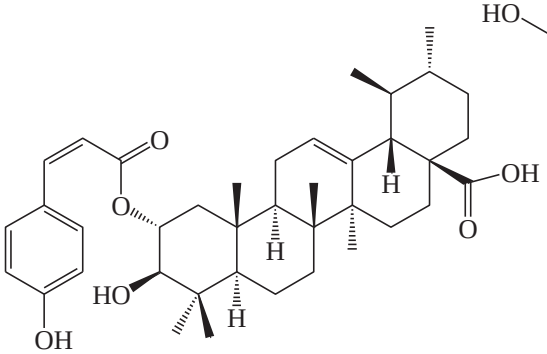
90 Uvaol



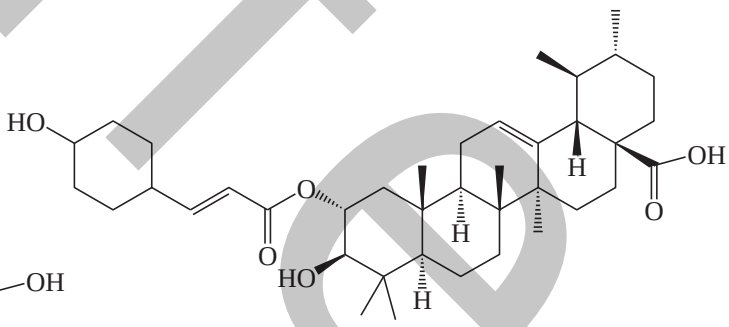
91 Oleanderen



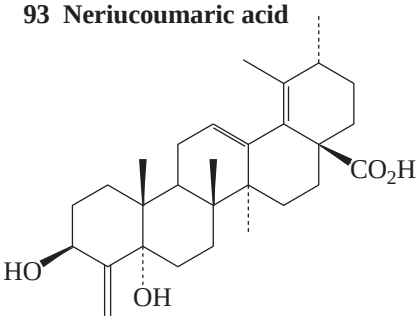
92 Oleanderol



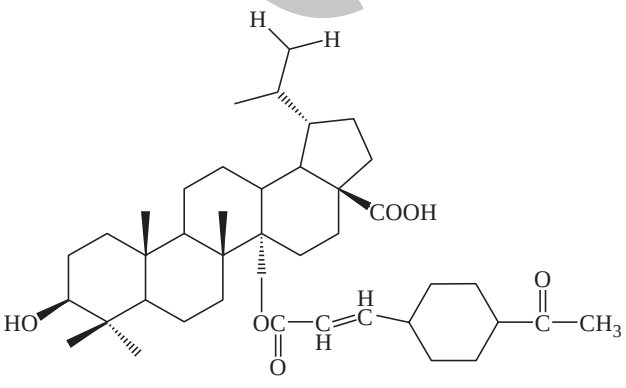
93 Neriucoumaric acid



94 Isoneriucoumaric acid



95 Kanerin



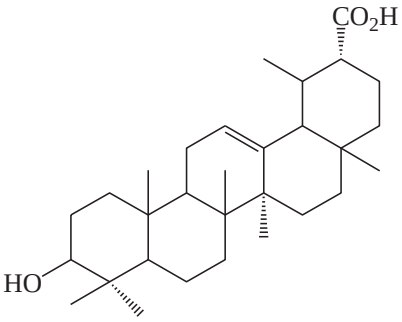
96 Oleanderocioic acid

Table **5**- Triterpenes of some species of the family Apocynaceae

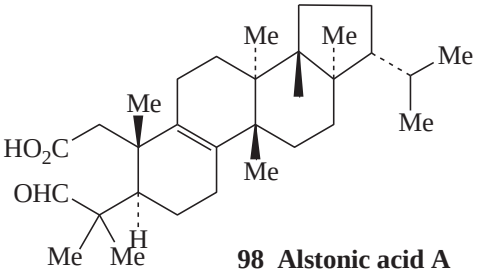
Species	Plant Part	Triterpenes	References
1. *Acokanthera oblongifolia*	L	α-Amyrin, lupeol, lupeol acetate, botulin-aldehyde and betulinic acid	Hassan *et al.* (2015)
2. *Acokanthera spectabilis*	L	Friedelin	Kapadia *et al.* (1964)
	Dp	β-Amyrin, Friedelin	Govind *et al.* (1964); Abbasy *et al.* (1977); Karawya *et al.* (1973a)
3. *Adenium obesum*	….	Dihydroifflaionic acid (**97**)	Hoffmann and Cole (1977)
	Stb	Betulin	Tijjani *et al.* (2012)
4. *Aganosma caryophllata*	F	Ursolic acid	Sekhar *et al.* (1985)
5. *Allamanda blanchetii*	F	Lupeol and lupeol acetate	Ganapaty and Rao (1989)
6. *Allamanda cathartica*	….	α-Amyrin and ursolic acid	Agarwal and Sharma (1983)
	L	Ursolic acid and Friedelin, lupeol	Jewrs *et al.* (1971); Tiwari *et al.* (1979, 1998); Arthur and Hui (1954)
	L,S	β- Amyrin and ursolic acid	Gupta *et al.* (1969)
7. *Allamanda schotii*	F	β-Amyrin	Ganapaty and Rao (1988)
8. *Alstonia boonei*	….	β-Amyrin acetate, α-amyrin palmitate, amyrenone, lupeol and ursolic acid	Faparusi and Bassir (1972); Gosse *et al.* (1999); Adotey *et al.* (2012)
	Rb	α- Amyrin, lupeol and their esters	Rajic *et al.* (2000)
	L,B	β-Amyrin, lanosta-7,24-dien-3-one and lanosta-7,24-dien-3-one acetate	Gosse *et al.* (1997)
	Stb	β-Amyrin and α-amyrin acetate	Okoye *et al.* (2014)
9. *Alstonia congensis*	L	Ursolic acid	Le Men and Pourrat (1953)
	Stb	α-Amyrin, β-amyrin and lupeol	Monseur and van Bever (1955); Ferreira *et al.* (1968)
10. *Alstonia macrophylla*	L	Ursolic acid	Arunachalam *et al.* (2009)
11. *Alstonia neriifolia*	Stb	β-Amyrin and lupeol	Chakravarti *et al.* (1960); Roy and Chatterjee (1968)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

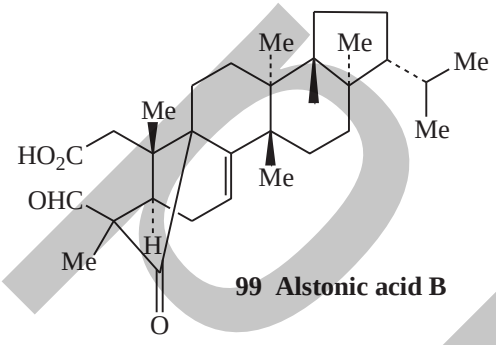
Species	Plant Part	Triterpenes	References
12. *Alstonia scholaris*	B	α-Amyrin, α-amyrin acetate, β-amyrin acetate, lupeol and lupeol acetate	Chakravrti *et al*. (1957); Khaleque *et al*. (1991); Ismail *et al*. (1999); Sharma *et al*. (2013)
	L	α-Amyrin acetate, β-amyrin 3-palmitate, cycloeucalenol, squalene, lup-20(29)-en-3-ol, lup- 20(29)-en-3-ol palmitate, betulin, betulinic acid, cylicodiscic acid, oleanolic acid, ursolic acid and alstonic acids A (**98**) and B (**99**) (2,3-secofernane triterpenes), cycloartanol (**100**), lupeol and lupeol actetate	Banerji and Banerji (1977) Desoky *et al*. (2000); Du *et al*. (2007a); Wang *et al*. (2009b, 2014a); Feng *et al*. (2013); Ragasa *et al*. (2013)
	Rb	α-Amyrin, α-amyrin acetate, lupeol and lupeol acetate	Talapatra *et al*. (1968); Dhar *et al*. (1977); Hemalatha *et al*. (2008)
	F, L	Betulin, Betulinic acid and ursolic acid	El-Askary *et al*. (2012)
	F	α-Amyrin acetate, ursolic acid, 3β-acetate-24-nor-urs-4,12-diene ester triterpene (**101**), 3β-hydroxy-24-nor-urs-4,12,28-triene triterpene (**102**), 3,28-β-diacetoxy-5-olea triterpene (**103)** α-amyrin, β-amyrin, lupeol, alstoprenyol (3β-hydroxy-28β-acetoxy-5-olea-triterpene), alstoprenylene 3β-acetate-24-nor-urs-4,12,2'-triene ester, lupeol acetate and 3β-hydroxy-24-nor-urs-4,12,28-triene	Sultana and Saleem (2010); Sultana *et al*. (2013b)
	Wp	Lupeol	Thara and Zuhra (2013)
13. *Alstonia verticillosa*	B	β-Amyrin and lupeol	Musgrave and Wagner (1952)
14. *Alstonia venenta*	FP	β-Amyrin, a lupeol ester and ursolic acid	Pandey and Ray (1973); Pandey and Dutta (1979)
15. *Alyxia buxifolia*	….	Betulic acid, oleanolic acid and ursolic acid	Anstee *et al*. (1952)
16. *Alyxia insularis*	L	α-Amyrin, α-amyrin acetate, lupeol, lupenyl acetate, methylbetulinate, ursolic acid, oleanolic acid, neoilexonol acetate (**104**), 3β-hydroxyl-urs-11-en-13,28-olide, and betulin	Wang *et al*. (1993)
	St	α-Amyrin, α-amyrin actate, neoilexonol acetate, ursolic acid, lupenyl acetate, lupeol and methylbetulinate	Huang *et al*. (1990a)



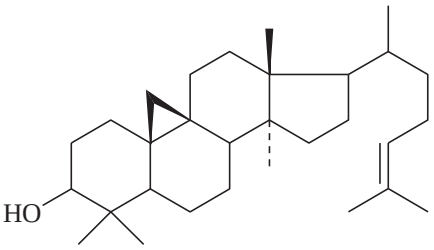
97 Dihydroifflaionic acid



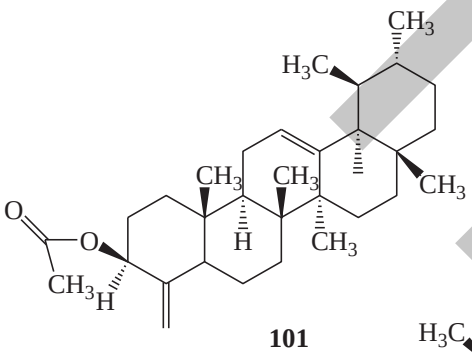
98 Alstonic acid A



99 Alstonic acid B



100 Cycloartenol



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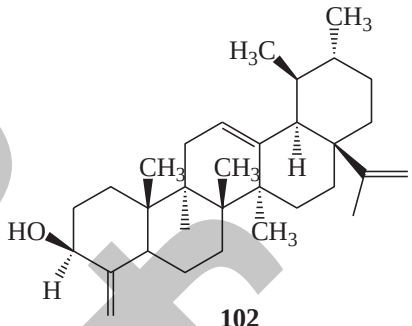

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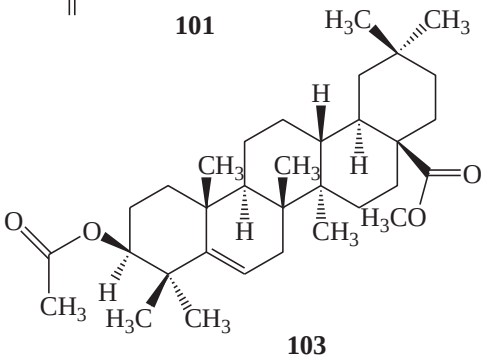

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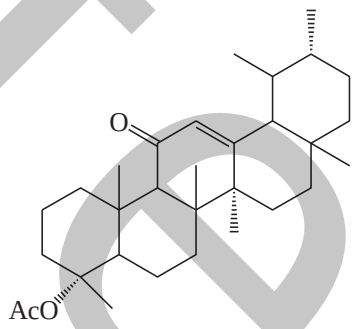
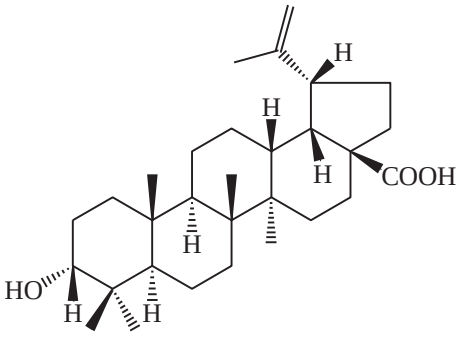


104 Neoilexonol acetate



105 3-Epibetulinic acid

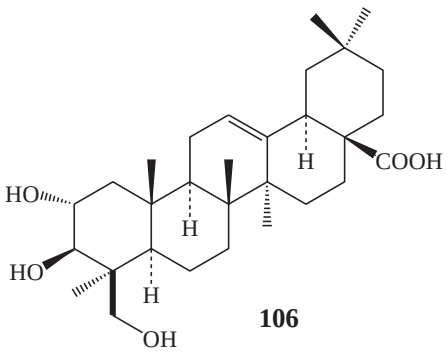


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Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
17. *Alyxia levinei*	L, St	Betulin and oleanolic acid	Yuan *et al.* (1991)
18. *Alyxia reinwardtii*	B	Lup-20(30)-en-3β-yl acetate	Kitagawa *et al*. (1988)
19. *Alyxia sinensis*	St	Betulin, lupeol, oleanolic acid and ursolic acid Baurenyl acetate	Wang *et al.* (2002a) Wang *et al.* (2002b)
20. *Amsonia angustifolia*	S	β-Amyrin and ursolic acid	Tomczyk (1964); Tomczyk and Kisiel (1977)
21. *Amsonia grandiflora*	L	Betulinic acid, lupeol, lupeol acetate and oleanolic acid	Wahyuono *et al.* (1987)
22. *Amsonia tabernaemontana*	….	Ursolic acid	Bocharova (1966)
23. *Anacampta angulate*	Stb	α-Amyrin acetate	Garnier *et al.* (1984a)
24. *Anodendron affina*	F	Ursolic acid	Shima *et al*. (1971b)
25. *Apocynum androsaemifolium*	R	α-Amyrin acetate	Murzagaliev *et al*. (1977)
26. *Apocynum cannabinum*	R	α-Amyrin acetate, α-amyrin, lupeol and oleanolic acid	Trabert (1957); Murzagaliev *et al.* (1977)
27. *Apocynum lancifolium*	Ug	Lupeol acetate	Murzagaliev and Tegisbaev (1975)
28. *Apocynum venetum*	St	α-Amyrin acetate, oleanolic acid acetate, lupeol 3-hydroxyarachidate and lupeol palmitate	Jiang *et al.* (1985); Yan *et al.* (1985)
	L	β-Amyrin and Lupeol	Chen and Liu (1991); Kong *et al.* (2013)
29. *Apocynum venetum* var. *basikurumon*	L	β-Amyrin	Sakushima *et al.* (1978)
	….	Ursolic acid	Sharma *et al.* (1981)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
30. *Aspidosperma illustre*	StB	α-Amyin acetate, β-amyrin, lupeol, lupeol acetate, olean-12-ene-11α-methoxy-3β-acetate, olean-12-ene-28-hydroxy-3-β-tetradecanoste, olean-12-ene-28-carboxy-3β-hexadecanoate and ursolic acid	Barbosa *et al.* (2010)
31. *Aspidosperma macrocarpon*	L	Ursolic acid	Bannwart *et al.* (2013)
32. *Aspidosperma nitidum*	B	α-Amyrin and lupeol	Pereira *et al.* (2006c)
33. *Aspidosperma arvifolium*	B	Lupeol	Jácome *et al.* (2004)
34. *Aspidosperma quebracho-blanco*	B	α-Amyrin and lupeol	Tunmann and Hermann (1970)
35. *Aspidosperma omentosum*	Ap	α-Amyrin, β-Amyrin and lupeol	Kohn *et al.* (2006)
36. *Aspidosperma ulei*	Wp	Ursolic acid	dos Santos Torres *et al.* (2013)
37. *Beaumontia grandiflora*	…..	Hederagenin, lupeol, oleanolic acid, ursolic acid and 2α,3α, 23-3-hydroxy-12-en-28 ursolic acid	Wang *et al.* (2009c)
38. *Bleekeria vitiensis*	…..	Ursolic acid	Kilminster *et al.* (1972)
39. *Catharanthus pusillus*		α-Amyrin acetate, lupeol acetate and ursolic acid	Subramanian and Lakshmanan (1980)
	L	Ursolic acid	Tin-Wa *et al.* (1970)
40. *Catharanthus roseus*	…..	Ursolic acid	Nguyen Ngoc Suong *et al.* (1984)
	Hrc	3-Epibetulinic acid (**105**)	Chung *et al.* (2007b)
	St	α-Amyrin acetate	Khan and Chakraborty (1981)
41. *Catharanthus trichophyllus*	Ap	Ursolic acid	Kim *et al.* (1970)
	R	Ursolic acid	Segelman and Farnsworth (1974)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
42. *Cerbera manghas*	C	α-Amyrin	Zhang *et al.* (2008)
	S	2α, 3β, 24-Trihydroxyolea-12-en-28-oic acid (**106**)	Yu *et al.* (2009)
	Wp	Lupeol acetate	Wang *et al.* (2007)
	L	α-Amyrin, (23*Z*)-9,19-cycloart-25-ene-3β,24-diol, euphorbol, ursolic acid, 2α-hydroxyursolic acid, 3-*O*-acetyl ursolic acid, and uvaol	Zhang *et al.* (2011a)
	F	Ursolic acid	Cao *et al.* (2013a)
43. *Cerberiopsis candelabra*	L	Betulinic acid and ursolic acid	Frerejacque (1970)
44. *Chonemorpha griffithii*	Ap	β-Amyrone, arjunolic acid, oleanolic acid, hederagenin, cycloeucalanol, cycloeucalanone	Bai *et al.* (2013)
45. *Chonemorpha macrophylla*	L	Baurenol acetate	Banerji *et al.* (1978)
	R	Taraxasterol	Shrivastava and Saxena (1984)
46. *Conopharyngia durissima*	Stb	α-Amyrin acetate, β-amyrin acetate and lupenyl acetate	Hanna (1964)
47. *Dyera constulata*	L	β-Amyrin	Subhadhirasakul *et al.* (2003)
48. *Dipladenia martiana*	Ap	Lupeol, pomolic acid (**107**) and ursolic acid	Geraldo de Carvalho *et al.* (2001)
49. *Ecdysanthera rosea*	Ap	D-Friedours-14-en-llα, 12α-epoxy-3β-yl palmitate, 3-acetyl- 20-hydroxyl-28-formyl lupeol, cyclocaducinol (**108**), lupeol, 24- methylenecycloartenol, uvaol, betulin and friedelin	Huang *et al.* (1990b); Xu *et al.* (2007)
	….	α-Amyrin, lupeol, 3β-lupeol palmitate and oleanolic acid	Zhu *et al.* (2011a)
50. *Echites hirsuta*	Wp	Ursolic acid	Chien *et al.* (1979)
51. *Ervatamia coronaria*	Stb	α-Amyrin and lupeol	Raman and Barua (1957)
52. *Ervatamia divaricata*	….	β-Amyrin acetate, cycloart-23- ene-3β, 25-diol, 3β-hydroxycycloart-25-ene-24-one and cycloeucalenol	Yu and Liu (1999)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

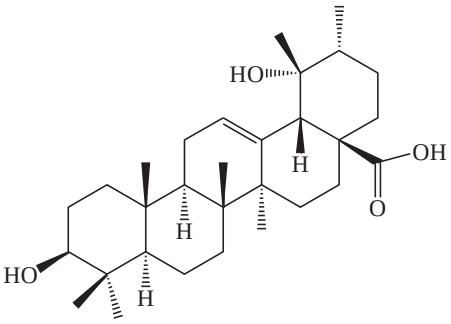
Species	Plant Part	Triterpenes	References
53. *Ervatamia hainanesis*	R, St	α-Amyrin, α-amyrin acetate, 11-oxo-α-amyrin acetate, β-amyrin acetate, cycloartenol, cycloart-23-ene-3β, 25-diol cycloart-25-ene-3β, 24-diol and obtusifoliol	Huang *et al.* (2006b); Liang *et al.* (2007c); Jin *et al.* (2008)
	L,T	Asiatic acid (**109**) and ursolic acid	Yang *et al.* (2013)
	…..	β-Amyrin acetate and cycloartenol	Tan *et al*. (2003)
54. *Ervatamia mucronata*	B	α-Amyrin acetate	Herrera *et al*. (1986)
55. *Ervatamia officinalis*	L,St	α-Amyrin, α-amyrin acetate and lupeol	Zhu *et al.* (2011c)
	….	α-Amyrin acetate	Zhou *et al.* (1988a)
56. *Ervatamia orientalis*	L	β-Amyrin, β-amyrin acetate, lupeol, lupeol acetate, and ursolic acid.	Jewers *et al.* (1969b)
	B, St	β-Amyrin, β-amyrin acetate, lupeol and lupeol acetate.	Jewers *et al*. (1969b)
	R	β-Amyrin, β-amyrin acetate and lupeol	Jewers *et al*. (1969b)
57. *Ervatamia pandacaqui*	B	α-Amyrin acetate	Herrera *et al*. (1986)
58. *Ervatamia wallichiana*	L	Bauerenol acetate	Talapatra *et al*. (1967)
59. *Ervatamia yunnanensis*	….	Cycloeucalenol and lupenyl acetate	Luo *et al.* (2002)
60. *Formosia bantheniana*	St	Betulinic acid, oleanolic acid, ursolic acid, 13,3β-acetoxyolean-12-en-28-oic acid and 3β-hydroxyurs-11-28, 3-olide	Chang and Huang (1991)
	L	Ursolic acid and 2α-hydroxyursolic acid	Chang *et al.* (1990)
61. *Funtumia elastica*	S	Cycloartenol and 31-norlanosterol	Charles *et al.* (1969)
62. *Funtumia latifolia*	L	Ursolic	Takahashi (1961)
	….	Ursolic acid	Savoir (1965)
63. *Gabunia odoratissima*	B	α-Amyrin acetate and lupeol	Cava *et al*. (1963c)
64. *Haplophyton cimicidum*	Wp	Baurenol, betulin and erythrodiol monoacetate	Cava *et al*. (1967b)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

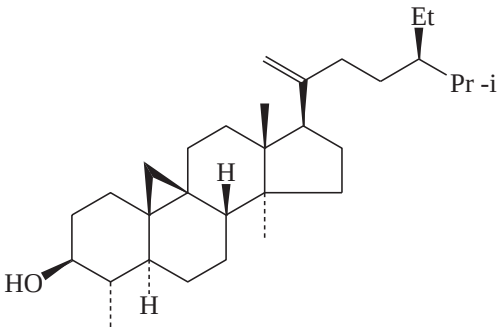
Species	Plant Part	Triterpenes	References
65. *Himatanthus articulata*	B	α-Amyrin cinnamate, α-Amyrin cinnamate, β-amyrin cinnamate, α-amyrin acetate, β-amyrin acetate, lupeol, lupeol acetate, cycloartenol, ursolic acid and lupeol cinnamate	Ferrigni *et al*. (1976); De Sá Barreto *et al*. (1998)
66. *Himatanthus drasticus*	Stb	Lupeol cinnamate	Colares *et al*. (2008)
67. *Himatanthus phagedaenica*	Lt	α-Amyrin, lupeol acetate, α-amyrin and lupeol cinnamates	De Miranda *et al.* (2000)
	St	α-Amyrin acetate, β-amyrin acetate and lupeol acetate	Vanderlei *et al*. (1991)
68. *Himatanthus sucuuba*		α-Amyrin cinnamate, lupeol acetate, lupeol cinnamate and lupeol β-phenyl propionate	Silva *et al.* (1998); Wood *et al.* (2001)
69. *Holarrhena antidysentrica*	L	Holarrhenol (**110**)	Ali and Gupta (1994)
	B	5, 20(29)-Lupadien-3β-ol and lupeol	Siddiqui and Pillay (1933); Narayanan and Naik (1981)
70. *Holarrhena floribunda*	Stb	Lupeol, 3-*O*-(3'-hydroxyeicosanoyl)lupeol, 3-*O*-[(2'-(tetracosyloxy)acetyl]]lupeol, and 3-O-[(1' '-hydroxyoctadecyloxy)-2'-hydroxypropanoyl]]lupeol	Fotie *et al*. (2006)
	S	Cycloartenol and 31-nor-lanosterol	Conreur *et al*. (1970)
71. *Holarrhena mitis*	Fr, S	Cycloartenol and 31-nor-lanosterol	Leboeuf *et al*. (1972b)
	S	Betulin aldehyde, betulinic acid and lupeol	Bhattachartya *et al.* (2009)
72. *Holarrhena pubescens*	L	Lupeol, lupeol β-hydroxyhexadecanoate and ursolic acid	Tuntiwachwuttikul *et al*. (2007)
	S	Betulin aldehyde, betulinic acid and lupeol	Sanjib *et al.* (2009)
73. *Ichnocarpus frutescens*	St	α-Amyrin, α-amyrin acetate, friedelin, *epi*-friedelinol, lupeol acetate, rhamnopyranosylglucopyranosylamyrin	Minocha and Tandon lupeol (1980); Lakshmi *et al*. (1985)
	L	Urosolic acid	Khan *et al.* (1995)
	R	α-Amyrin and ursolic acid	Pandurangan *et al.* (2010); Singh and Singh (2014)
	…..	Δ^{12}-Dehydrolupanyl 3β-palmitate, lupeol acetate, friedelin, friedelinol, Δ^{12}-dehydrolupeol and oleanolic acid	Verma *et al.* (1987)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

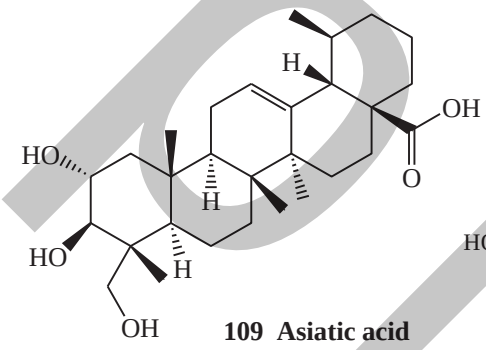
Species	Plant Part	Triterpenes	References
74. *Hunteria umbellata*	L, S, Stb	Urosolic acid	Ajala *et al*. (2011)
75. *Kopsia fruticosa*	Stb	β-amyrin and β-amyrin acetate	Talapatra and Bhattacharya (1968)
76. *Kopsia hainanensis*	L,T	β-Amyrin, ursolic acid and 2α,3β-dihydroxyursolic acid	Yang *et al.* (2012c)
77. *Kopsia longifolia*	B	β-Amyrin and ilexol acetate (**112**, baurenol acetate)	Crow and Michael (1955); Iseda (1959)
78. *Kopsia officinalis*	Br,L	β-Amyrin, β-amyrin acetate, bauerenyl acetate, lupeol, erythrodiol (**113**) and myrtifolic acid (3α-hydroxy-D:C-friedours-7-en-28-oic acid)	Li and Song (2008)
79. *Landolphia dawei*	L, St	β-Amyrin	Michel and Sleem (2003)
80. *Laseguea erecta*	St	Lupeol	Geraldo de Carvalho *et al*. (2006)
	F	Lupeol and ursolic acid	Geraldo de Carvalho *et al*. (2007)
81. *Leuconotis eugenifolia* (=*Leuconotis eugenifolius*)	L	α-Amyrin, β-amyrin, baurenol, β-amyrenyl behenate and β-amyrenyl eicosanoate	Kim *et al.* (1971)
	L,St	Lupeol acetate and leuconol (a mixture consisting mainly of bauerenol (**111**), α-amyrin, β-amyrin, lupenyl acetate, β-amyrin behenate and β-amyrin eicosonate	Chatterjee *et al.* (1959); Kim *et al.* (1971)
	B	β-Amyrin	Das and Mukherjee (1962)
82. *Macrosiphonia petraea*	R	α-Amyrin, α-amyrin acetate, β-amyrin, β-amyrin acetate, arjunolic acid, asiatic acid, lupeol, lupeol acetate, 3-acetyl oleanolic acid and 3-acetyl ursolic acid	De Assis Junior *et al.* (2013)
83. *Mandevilla guanabarica*	L	Lupeol and pentacyclic triterpenes of the α- and β-amyrin class	Cordeiro *et al.* (2011)
84. *Mandevilla moricandiana*	L	Lupeol and pentacyclic triterpenes of the α- and β-amyrin class	Cordeiro *et al.* (2011)
85. *Mandevilla pentlandiana*	Ap	α-Amyin	Michelotti and Gros (1983)



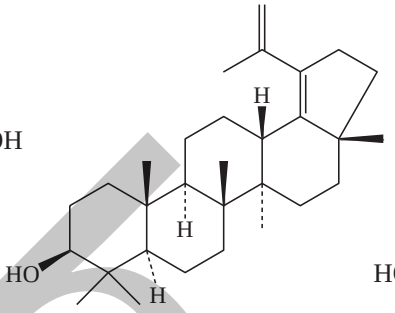
107 Pomolic acid



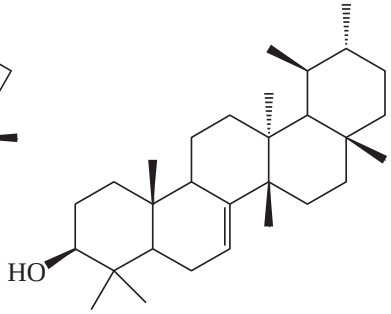
108 Cyclocaducinol



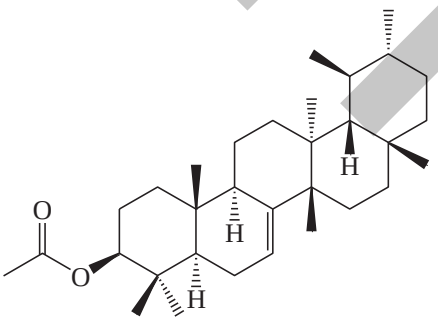
109 Asiatic acid



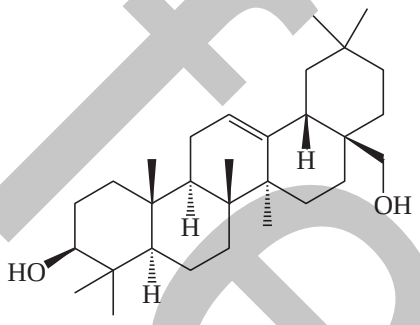
110 Holarrhenol



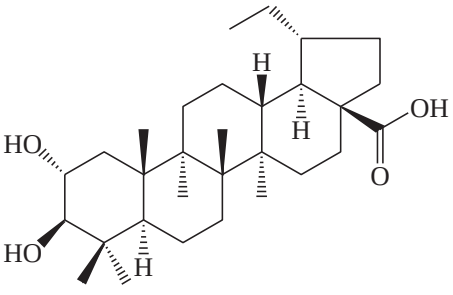
111 Baurenol



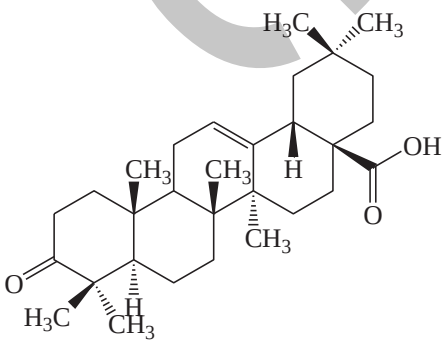
112 Ilexol acetate



113 Erythrodiol



114 Alphitolic acid



115 Oleanonic acid

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

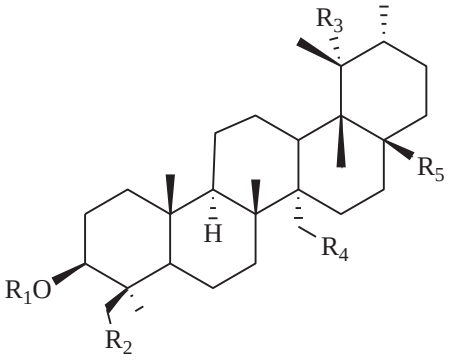
Species	Plant Part	Triterpenes	References
86. *Melodinus aeneus*	….	Ursolic acid	Baassou *et al*. (1978)
87. *Melodinus australis*	Ap	Betulin and oleanolic acid (**115**)	Mitscher and Vorperian (1971)
88. *Melodinus fusiformis*	L,T	Alphitolic acid (**114**), 3β-acetoxylup-20(29)-ene, 11,12-dehydroursolic acid lactone, oleanolic acid lactone and ursolic acid	Wang *et al*. (2012a)
89. *Melodinus hemsleyanus*	L,T	Betulin, oleanolic acid and ursolic acid	Zhang *et al*. (2013b)
90. *Melodinus henyri*	Fr, R	α-Amyrin acetate	Li *et al.* (1987b)
91. *Melodinus monogynus*	Rb	Monogynol A (3,20-lupanediol) and monogynol B (lupeol)	Chatterji *et al*. (1954, 1959)
92. *Melodinus reticulatus*	L, St	Uvaol	Mehri *et al*. (1983)
93. *Melodinus suaveolens*		Betulinic acid, betulinic alcohol, ursolic acid and 22α-hydroxyursolic acid	Tong *et al.* (2013)
94. *Mucoa duckei*	L	α-Amyrin, β-amyrin, betulinic acid, lupeol oleanolic acid and ursolic acid	De Assis Galotta *et al*. (2012)
95. *Nerium indicum*	F	Oleanolic acid and ursolic acid	Cheng (1966); Lin *et al.* (1975)
96. *Nerium odorum*	Rb	α-Amyrin	Satyanarayana *et al.* (1975)
97. *Nerium oleander*	Dp	α-Amyrin, oleanolic acid and ursolic acid	Karawya *et al.* (1970a,c); Fayez and Negm (1973); Hassan *et al.* (1977b); Shams *et al.* (2012)
	L	Kaneric acid, oleanderol, betulin, betulinic acid, ursolic acid, oleanolic acid and oleanderocioic acid 3β,27-dihydroxy-12-ursen-28-oic acid, 3β,13β-dihydroxyurs-11-en-28-oic acid, 3β-hydroxyurs-12-en-28-aldehyde, 28-norurs-12-en-3β-ol, urs-12-en-3β-ol, oleanolic acid, 3β,27-dihydroxy-12-oleanen-28-oic acid, betulinic acid, betulin, (20*S*,24*R*)-epoxydrammarane-3β,25-diol, oleanderic acid, 3β,20α-dihydroxyurs-21-en-28-oic acid), oleanderolide (3β,12α-dihydroxyoleanan-28,13β-olide and (20*S*,24*S*)-epoxydrammarane-3β,25-diol *cis*-karenin, *trans*-karenin, 3β,27-dihydroxy-urs-18-en-	Fu *et al*. (2005); Siddiqui *et al.* (1995a, 2012); Begum *et al.*, (1996); Siddiqui *et al.* (1995a, 2009)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

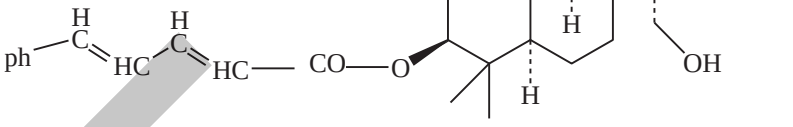
Species	Plant Part	Triterpenes	References
		13,28-olide, 3β,27-dihydroxy-urs-18-en-13,28-olide, 3β,22α,28-trihydroxy-25-nor-lup-1(10),20(29)-dien-2-one, α-neriursate (3α-*p*-acetophenoxy-urs-12-en-28-oic acid), β-neriursate (3β-*p*-acetophenoxy-urs-12-en-28-oic acid)	
	Fl	Kanerin, 12,13-dihydroursolic acid, oleanderoic acid, oleanderen, kanerodione, kanerocin, ursolic acid, neriucoumaric acid and isoneriucoumaric acid	Siddiqui *et al.* (1986c, 1987h, 1989a,b,e)
	St	Betulin and betulininic acid	Sharma *et al.* (2010)
98. *Odontadenia macrantha*	…	α-Amyrin and lupeol	Prakash Chaturvedula (2003a)
99. *Pachypodium lamerei*	L,St	β-Amyrin and lupeol	El-Kashef *et al.* (2014)
100. *Parahancornia amapa*	B, Lt	α-Amyrin, β-amyrin, lupeol and their acetyl derivatives and other 3-*O*-acetyllupeol esters	Sobrinho *et al.* (1991)
	R	α-Amyrin, β-amyrin, lupeol and their acetyl derivatives and 18 3-*O*-acyllupeol esters	De Carvalho *et al.* (2001)
101. *Paravallaris maingayi*	B	α-Amyrin, α-amyrin acetate, lupeol, lupeol acetate, ψ-taraxasterol and taraxeryl acetate	Jewers and Manchanda (1970)
102. *Parsonia laevigata*	L	Lupeol, taraxerone and taraxer-14-ene-3β,24-diol	Ogihara *et al.* (1987)
103. *Parsonia straminea*	L	α-Amyrin, lupeol, ursolic acid and others	Griffin and Perkin (1971); Jewers *et al.* (1973)
104. *Peltastes peltatus*	St	β-Amyrin juarezate, peltastine A (**116**) and peltastine B (**117**)	Humberto *et al.* (2004)
105. *Peschiera affinis*	R,St	α-Amyrin acetate and β-amyrin acetate	Santos *et al*. (2009a)
	Rb	β-Amyrin, lupeol, lupeol acetate	Matos *et al*. (1976)
106. *Pleiocarpa pycantha*	L	Ursolic acid, [27-*E* (**118**) and 27-*Z*-p-coumaric esters of ursolic acid (**119**)] and pycanocarpine (**120**), 2,3-*seco*-taraxer-14-en-2,3-lactone	Omoyeni *et al.* (2014)

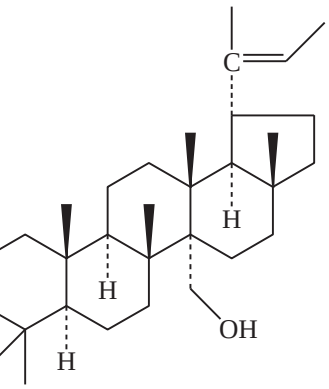
Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
107. *Pleiocarpa talbotii*	Stb	α-Amyrin, β-amyrin, lupeol and their acetats	Pinar (1974)
108. *Plumeria acuminate*	L	Lupeol carboxylic acid and ursolic acid	Guevara *et al.* (1996)
109. *Plumeria acutifolia*	B	α-Amyrin and amyrin acetate	Rangaswami *et al.* (1961)
	L	Plumeric acid and methyl plumerate, lupeol, uvaol and ursolic acid	Fujimoto and Made (1988); Hassan *et al.* (2008)
110. *Plumeria alba*	B	β-Amyrin, α-amyrin acetate, β-amyrin acetate and ursolic acid	Rangaswami and Rao (1960); Bramadhayalaselvam *et al.*, (1997)
	L	α-Amyrin acetate	Bramadhayalaselvam *et al.*, (1997)
111. *Plumeria bicolor*	B	α-Amyrin and α-amyrin acetate	Pandey *et al*. (2005)
	StB	3β-Hydroxy-plumerian-12-ene and 3β-acetoxy-plumerian-12-ene	Hasan *et al.* (1997)
112. *Plumeria inodora*	L	Lupeol, lupeol acetate, lupenone and ursolic acid	Grignon-Dubois and Rezzonico (2007)
113. *Plumeria obtuse*	L	Obtusalin (**121**), betulinic acid, oleanolic acid, ursolic acid, obutsilinin (**122**, 3β-hydroxy-27-*p*-*Z*-coumaroyloxyolea-12-en-28-oic acid), 3β-hydroxy-27-*p*-*Z*-coumaroyloxyurs-12-en-28-oic acid, obtusol (3β,27-dihydroxyurs-12-ene), zamanic acid (3β-hydroxyurs-30-*p*-*E*-hydroxycinnamoyl-12-en-28-oic acid), obtusic acid (**123**) obtusilinic acid coumarobtusanoic acid (**124**) and coumarobtusane (**125**), Obtusin (, 24-*E*-*p*-coumaric ester of 3β,24-dihydroxyurs-12-en-28-oic acid), obtusilic acid (27-*Z*-*p*-coumaric ester of 3β,27-dihydroxyurs-12-en-30-oic acid), α-amyrin, neriucoumaric acid, isoneriucoumaric acid, alphitolic acid	Siddiqui *et al.* 1989c,d, 1990a,b, 1991, 1992a); Siddiqui and Firdous (1999)

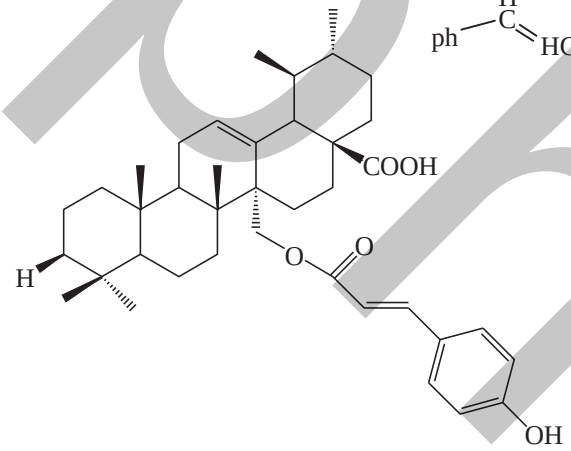


116 Peltastine A R_1 =(2 *E*,4*E*)-5-Phenylpenta-2,4-dienoyloxy, R_2, R_3, R_4=H, R_5=CH_3





117 Peltastine B



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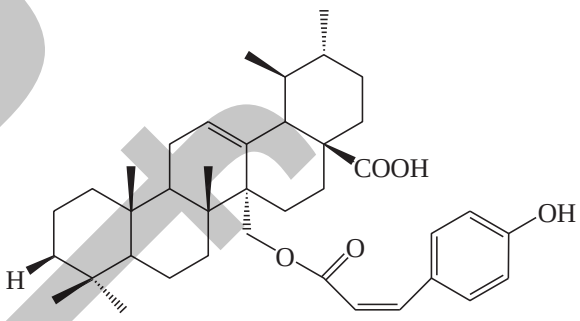

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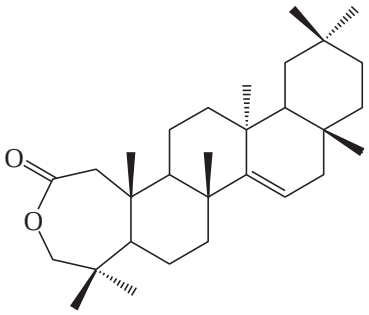
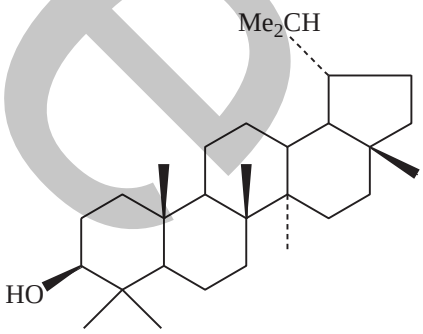
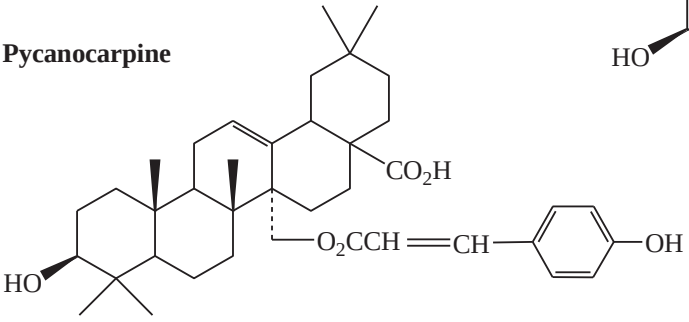


120 Pycanocarpine



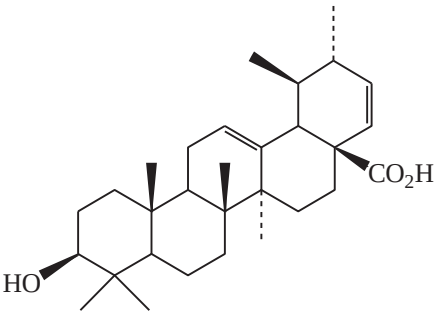
121 Obtusalin



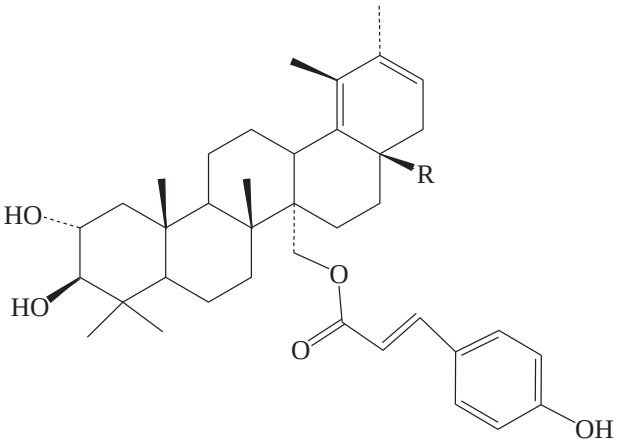
122 Obutsilinin

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

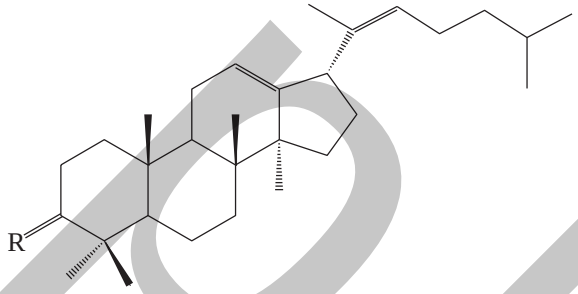
Species	Plant Part	Triterpenes	References
	L, Stb	3β-Hydroxy- urs-12-one-13β,28-olide, dammara-12,20 (22) *Z*-dien-3-one (**126**), dammara-12,20 (22)*Z*-dien-3β-ol (**127**), 3β,27-dihydroxy-olean-12-one- (**128**), 27-hydroxyolean- 12-en-3-one (**129**), dammara-3β,20(*S*),25-triol, urs-12-en-3β-hydroxy-27-*Z*- feruloyloxy-28-oic acid, 3β-hydroxyolean-12-en-28-oic acid, 3β,27-dihydroxylupan-29-ene, 3β-hydroxylupan- 29-en-28-oic acid, 3β-hydroxyursan-12-en-28-oic acid, 3β-hydroxy-27-*p*-coumaroyloxy-olea-12-en-28-oic acid and urs-12-en-3-one	Siddiqui *et al.* (2004); Ali *et al.* (2008)
114. *Plumeria obtujsifolia*	B	Lupeol, lupeol acetate and a series of lupeol fatty esters (fatty acids with carbon numbers 16,18,20,28) e.g. (**130**)	Schmidt *et al.* (1983)
115. *Plumeria rubra*	….	6α-Hydroxy-3-*epi*-oleanolic acid and 3α,27-dihydroxyolean-12-ene and rubrinol (3β,30-dihydroxy-12-ursene), cycloart-22-ene-3α,25-diol, lupeol, oleanolic acid and taraxateryl acetate	Akhtar and Malik (1993); Akhtar *et al.* (1994); Zaheer *et al.* (2010)
	Lupeol		
	B	Amyrin and lupeol	Rao and Anjaneyulu (1967)
	St	Rubrajaleelol (**131**) and rubrajaleelic acid (**132**)	Tandon *et al.* (1976)
	….	Cycloart-25-en-3β,24-diol, ajunolic acid, ursolic acid,	Akhtar *et al.* (2013)
	Stb	oleanolic acid, β-amyrin acetate, betulinic acid, lupeol and lupeol acetate	Kuigoua *et al.* (2010)
116. *Plumeria rubra* var. *acutifolia*	L	lupeol nanoate, lupeol heptanoate and rubrinol glucoside	Sengab *et al.* (2009)
117. *Plumeria rubra var. alba*	Fr	α-Amyrin, β-amyrin, lupeol acetate and ursolic acid	Shehata and Islam (2002)
118. *Poacynum hendersonii*	F	Betulin, betulinic acid, 3-*O*-acetylepibetulinic acid, 3-*O*-acetylbetulinic acid, lupeol, ursonic acid (**133**) and 3-*O*-acetylepiursolic acid	Morikawa *et al.* (2012)
	Dp	Lupeol palmitate	Wei *et al.* (2008)



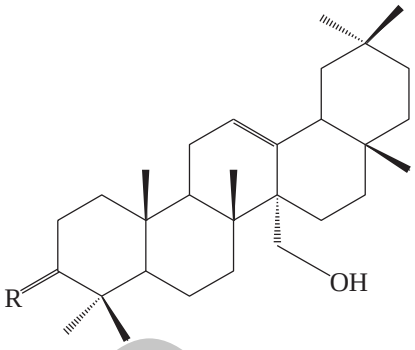
123 Obtusic acid



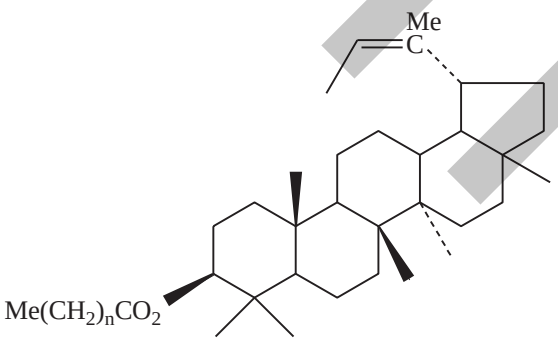
124 Coumarobtusanoic acid R=COOH
125 Coumarobtusane R=Me



126 R=O
127 R=β OH



128 R=β OH, H
129 R=O



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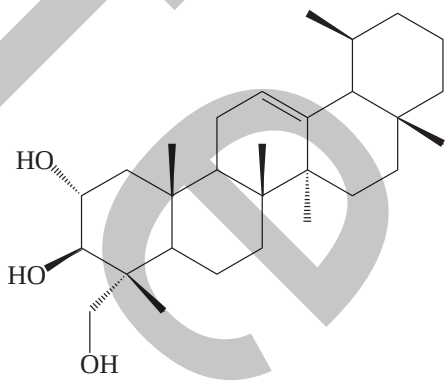
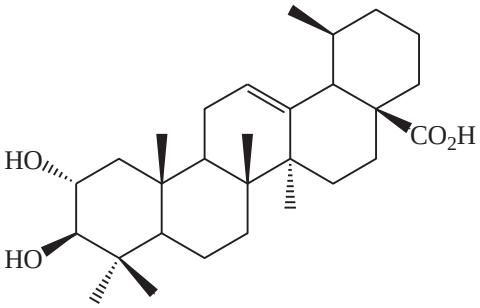
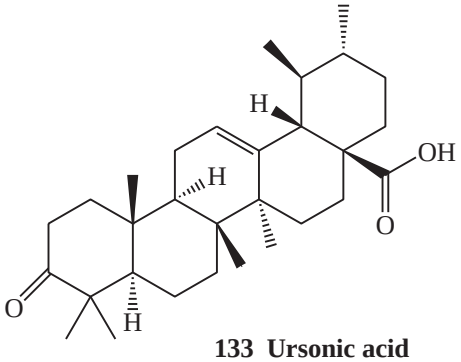


131 Rubrajaleelol



132 Rubrajeleelic acid



133 Ursonic acid

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
	L	Lupenyl palmitate	Zhang *et al.* (2006a)
119. *Poacynum pictum*	L	Lupenyl palmitate	Zhang *et al.* (2009d)
120. *Pterotaberna inconspicua*	L	α-Amyrin and β-amyrin	Bakana *et al.* (1984)
121. *Rauwolfia canescens*	….	Ursolic acid	Bocharova (1966)
122. *Rauwolfia mattfeldiana*	B	Lupeol	Vieira *et al.* (1998)
123. *Rauwolfia psychotrioides*	….	Lupeol	Cordova B. and Pena (1979)
124. *Rauwolfia serpentine*	….	Ursolic acid	Bocharova (1966)
125. *Rauwolfia verticillata*	….	Ursolic acid	Bocharova (1966)
126. *Rejoua aurantiaca*	B	β-Amyrin	Guise *et al.* (1965)
127. *Stemmadenia bella*	L	Taraxasteryl acetate	Talapatra *et al.* (1973)
	Stb	Lupeol and taraxasteryl acetate	Talapatra *et al.* (1973)
128. *Stemmadenia glabra*	Fr	Taraxasterol and taraxasteryl acetate	Cicció-Alberti *et al.* (1982)
	L	Taraxasteryl acetate	Cicció-Alberti *et al.* (1982)
129. *Stemmadenia donnell-smithii*	Fr	ψ-Taraxasterol acetate	Estrada *et al.* (1962)
130. *Stemmadenia galeottiana*	Frr	Taraxasterol acetate	Dominguez *et al.* (1976)
131. *Strophanthus divaricatus*	R	Hop-22(29)-en-3-β-ol (**134**) and taraxerone	Yan *et al.* (2012b)
132. *Tabernaemontana arborea*	Fr	Lupeol acetate	Chaverri and Cicio (1980a)
	L	Lupeol acetate	Cabezas and Ciccio (1986)
133. *Tabernaemontana brachyantha*	StB	A triterpene of the amyrin group	Patel *et al.* (1973)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
134. *Tabernaemontana cathariensis*	L	Friedelin	Boligon *et al*. (2013)
	RB	20(30)-Taraxasten-3β-yl, iso-lupeyl, bauerenyl, β-amyrin, pseudotaraxastenyl, α-amyrin, iso-ursenyl, lupeyl and 20(30)-ursen-3β-yl acetates, betulinic acid, oleanolic acid and ursolic acid	Pereira *et al.* (2008)
135. *Tabernaemontana coronaria*	L	α-Amyrin, lupeol and their acetates.	Udayasankar *et al*. (1972); Talapatra *et al.* (1975)
136. *Tabernaemontana crassa*	…..	Isoursenol [(13α-)-D-friedours-14-en-3β-ol], isoursenol acetate and lupeol	Kuete (2010)
137. *Tabernaemontana cymosa*	L	Lupeol and obtusifoliol	Achenbach *et al*. (1997)
138. *Tabernaemontana dichotoma*	….	β-Amyrin acetate	Wijayabandara *et al.* (2008)
139. *Tabernaemontana divaricate*	Rb	α- Amyrin, α-amyrin acetate cycloartenol and lupeol acetate	Rastogi *et al*. (1980)
	CSC	squalene, squalene 2,3-oxide, α-amyrin, β-amyrin, uvaal, oleanal, ursolic acid, oleanolic acid, some monohydroxy derivatives of these acids, and dihydroxy derivatives of 3-*epi*-ifflaconic acid (phytoalexins)	Vander Heijden *et al*. (1989)
	R,St	α-Amyrin, α-amyrin acetate and taraxasterol acetate	Liang *et al.* (2006b)
140. *Tabernaemontana glandulosa*	L, S	Pentacyclic triterpenes	Achenbach *et al*. (1994)
141. *Tabernaemontana heterophylla*	R	Lupeol and lupeol acetate	Filho *et al.* (1983)
142. *Tabernamontana heyneana*	B	Lupeol	Subbaratanam (1955)
	Fr	α-Amyrin, tabernol A and tabernol B	Pillai (1955a)
143. *Tabernaemontana hystrix*	Rb	α-Amyrin acetate, β-amyrin acetate and lupeol acetate	Monnerat *et al*. (2005)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
144. *Tabernaemontana laeta*	Rb	α-Amyrin acetate, β-amyrin acetate, acetate, lupeol acetate and taraxasterol acetate	Medeiros *et al*. (2001)
	St	α-Amyrin acetate and β-amyin acetate	Vieira *et al*. (2008)
145. *Tabernaemontana laurifolia*	B	Bauerenyl acetate (**135**)	Cava *et al*. (1967a,b)
146. *Tabernaemontana longipes*	Fr	Cycloeucalenol and baurenyl acetate	Ciccio and Hoet (1981)
	Fr	Cycloeucalenol, baurenyl acetate, multiflorenyl acetate (**136**) and multiflorenyl palmitate	Cicció and Hoet (1981)
147. *Tabernaemontana markgrafiana*	B	α-Amyrin acetate, β-amyin acetate, burenyl acetate, *iso*-ursenyl acetate and 20(30)-taraxasten-3β-yl acetate	Nielsen *et al*. (1994)
148. *Tabernaemontana pacifica*	B, St,	α-Amyrin, β-amyrin, lupeol, ψ-taraxasterol and their acetates	Jewers *et al*. (1969a)
149. *Tabernaemontana Subglobosa*	T	α-Amyrin acetate, β-amyrin acetate, lupenyl acetate and ursolic acid	Huang *et al*. (1991)
150. *Tabernaemontana ventricosa*	Lt	α-Amyrin acetate, β-amyrin acetate and lupeol acetate	Schripsema *et al*. (1986)
151. *Thevetia neriifolia*	B	Lupeol acetate	Rao *et al*. (1967)
	F	Lupeol acetate	Gunasegaran and Nair (1983)
	R	α-Amyrin, β-amyrin, lupeol, ψ-taraxasterol and taraxasterol	Dinda and Saha (1990)
	L, S,	α-Amyrin	Mahran *et al*. (1970)
	L	3β-Hydroxy-11α,12α-epoxy-urs-13β-28-olide	Begum *et al*. (1993a)
	St	Cycloartenol	Miralles (1981)
	S	α-Amyrin acetate, β-amyrin, acetate, oleanolic acid, ursolic acid and 3β-hydroxy-11α, 12α-epoxy-urs-13β, 28-olide (**137**)	Siddiqui *et al*. (1992b), Begum *et al*. (1993a)
152. *Thevetia peruviana*	L	Betulin, lupeol and lupenyl acetate	Chen and Chen (1974)
	Stb	α-Amyrin acetate, lupeol acetate, peruvianursenyl acetate A (**138**), peruvianursenyl acetate B (**139**), peruvianursenyl	Ali *et al*. (2000d)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

Species	Plant Part	Triterpenes	References
		acetate C (**140**),isolupenyl acetate, lupadienyl acetate and pruviaursenyl glucoside	
	F	α-Amyrin	Rao *et al.* (1975)
	Pr	Epiperuviol acetate	Rao *et al.* (1975)
	….	α-Amyrin, α-amyrin acetate, β-amyrin, β-amyrin acetate, lupeol and lupeol acetate	Gupta *et al.* (2011)
153. *Trachelospermum asiaticum* var. *intermedium*	St	β-Amyrin and β-amyrin acetate	Inagaki *et al.* (1970a)
154. *Trachelospermum fragrans*	L, T	β-Amyrin and ursolic acid	Rao and Rao (1977)
155. *Trachelospermum jasminoides*	Wp	β-Amyrin, β-amyrin acetate, lupeol, lupeol acetate and an unsaturated fatty ester of lupeol	Lin and Liu (1981)
		α-Amyrin, α-amyrin acetate, α-amyrin palmitate, β-amyrin acetate, cycloeucalenol, lupeol and ursolic acid	Zhang *et al.*, (2012b)
156. *Vallaris glabra*	L	Ursolic acid	Wong *et al.* (2014b)
157. *Vallaris solanacea*	L	β-amyrin and ursolic acid	Gopinath *et al.* (1963); Khosa *et al.* (1979)
158. *Vinca elegantissima*	Wp	α-Amyrin, α-amyrin acetate, lupeol and Lupeol acetate	Bhattacharyya and Parkashi (1972)
159. *Vinca erecta*	….	Ursolic acid	Bocharova (1966)
160. *Vinca herbacea*	….	Ursolic acid	Bocharova (1966)
161. *Vinca major*	….	Ursolic acid	Trojanek and Hodkova (1962); Bocharova (1966)
162. *Vinca minor*	….	Ursolic acid	Le Men and Hammouda (1956); Hajkova and Homola (1962);

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

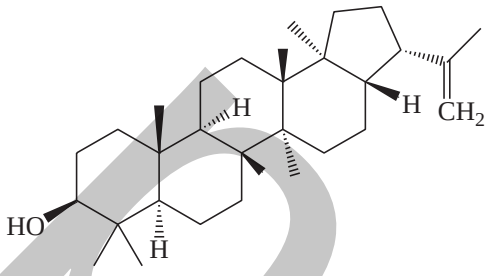
	Species	Plant Part	Triterpenes	References
		L, St	Ursolic acid	Bocharova (1966) Trojanek *et al*. (1959)
163.	*Vinca pubescens*	….	Ursolic acid	Bocharova (1966)
164.	*Vinca rosea*	….	Oleanolic acid and ursolic acid	Farnsworth, (1961); Bocharova (1966); Ali *et al.* (1979)
165.	*Voacanga africana*	B	β-amyin, 3-*O*-acetyl-Δ^7-baurenyl acetate and oleanolic acid	Dan *et al.* (2013)
166.	*Voacanga grandifolia*	Stb	Lupeol and lupeol acetate	Majumder *et al.* (1973b)
		Fr	Lupeol acetate	Majumder and Dinda (1974)
167.	*Voacanga papuana*	B	Lupenone, lupeol and lupenyl acetate	Guise *et al*. (1965)
168.	*Willughbeia firma*	St	3-Docosanoyl lupeol	Subhadhirasakul *et al.* (2000)
169.	*Winchia calophylla*	Stb	β-Amyrin acetate, β-amyrin, betulinic acid, cycloeucalenol, lupenone, lupenyl acetate, ptiloepoxide (**141**), ursolic acid and winchic acid (**142**)	Zhu *et al.* (2002)
170.	*Wrightia coccinea*	Wp	α-Amyrin acetate and ursolic acid	Majumder *et al*. (1979a)
171.	*Wrightia mollissima*	L, S	α-Amyrin acetate, lupenone, taraxerol and taraxerol acetate	Sharma *et al*. (1982)
172.	*Wrightia tinctoria*	L	α-Amyrin, α-amyrin acetate, β-amyrin, lupeol, lupenone, taraxerol and taraxeryl acetate	Rao *et al*. (1966); Devi and Divakar (2014)
		P	α-Amyrin, oleanolic acid and ursolic acid	Rao *et al*. (1966, 1968)
		Sp*	β-Amyrin, cycloartenone, cycloeucalenol, ursolic acid and wrightial (**143**)	Ramachandra *et al*. (1993); Devi and Divakar (2014)
		wSt	Lupeol	Jain and Bari (2010)
		B	β-Amyrin and lupeol	Rangaswami and Nageswara Rao (1963)
		P	α-Amyrin, oleanolic acid and ursolic acid	Deiv and Divakar (2014)

Table **5**- Triterpenes of some species of the family Apocynaceae (cont.)

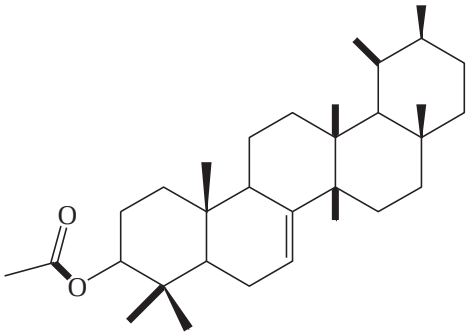
Species	Plant Part	Triterpenes	References
	wSt	3,4-*seco*-Lup-20 (29)-en-3-oic acid	Ghosh *et al.* (2010); Srivastava (2014)
	….	Squalene	Jayamathi *et al.* (2012)
173. *Wrightia tomentosa*	L	β-Amyrin acetate and β-amyrin palmitate	Maurya *et al*. (2012)
	….	Oleanolic acid ursolic acid	Chakravarti *et al*. (2012)
	B	α-Amyrin acetate	Maiti and Beri (1962)

Ap: aerial parts; B: bark; Br: branch C: cortex; CSC: Cell suspension culture infected with *Candida albicans*; Dp: different parts; F: flowers; Fl: fresh leaves; Fp: fruit pod; Fr: fruits; Frr: Fruit rind; Hrc: hairy root culture; L: leaves; Lt: latex; P: pod; Pr: fruit pericarp; R: roots; Rb: root bark; S: seeds; Sp: seed pod; St: stems or stalks; Stb: stem bark; T: twigs; Ug: underground parts; Wp: whole plant.; wSt: woody stem; *: immature.

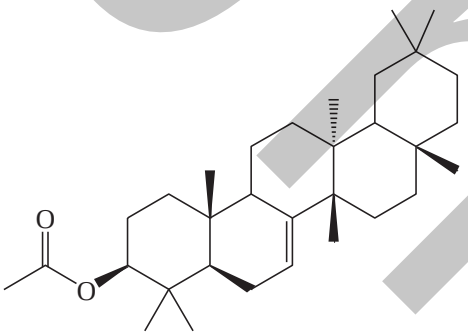
saponin D-1, saponin E-1, saponin F, quinovic acid-3β-*O*-D-glucopyranoside, quinovic acid-3β-*O*-D-glucopyranoside 27-*O*-β-D-glucopyranosyl ester and cincholic acid-3β-*O*-D-glucopyranoside 27-*O*-β-D-glucopyranosyl ester were isolated from *Trachelospermum jasminoides* vine (Tan *et al.*, 2010f). Lanast-5,8-dien-3β-ol-27-oic acid-3β-D-glucopyranosyl (4'-1")-10",11"-dimethoxy-anthracene was isolated from *Catharanthus roseus* hair culture (Chung *et al.*, 2007c). The triterpenes and sterols of the family Apocynaceae (1955-2013) have been recently reviewed (El-Kashef *et al.*, 2015).



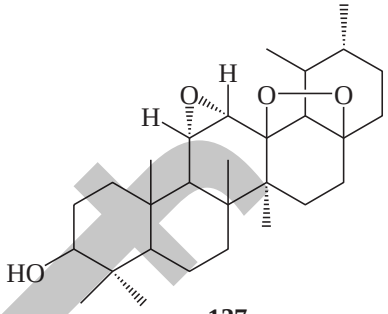
134 Hop-22(29)-en-3β-ol



135 Bauerenyl acetate



136 Multiflorenyl acetate



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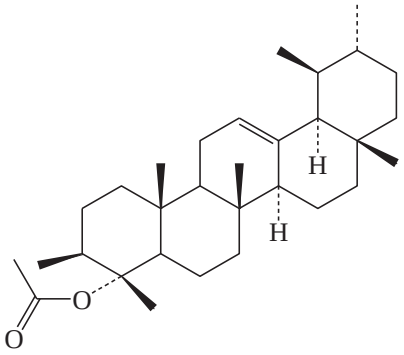
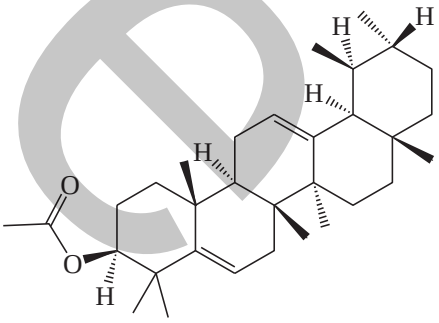


138 Peruvianursenyl acetate A



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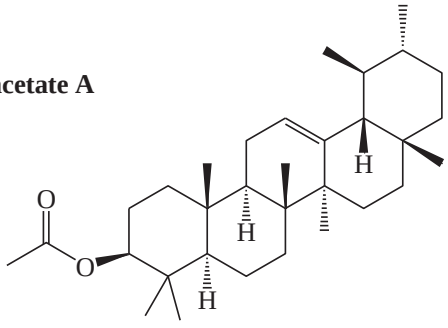

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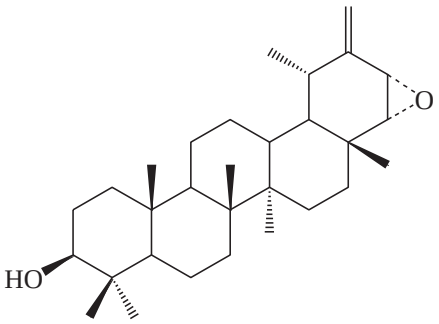
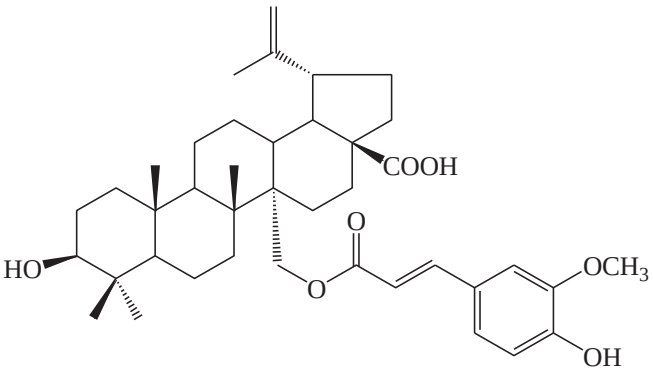
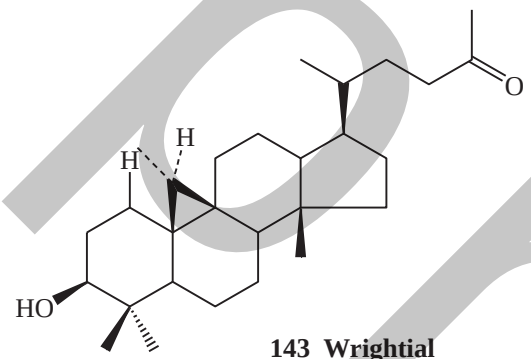


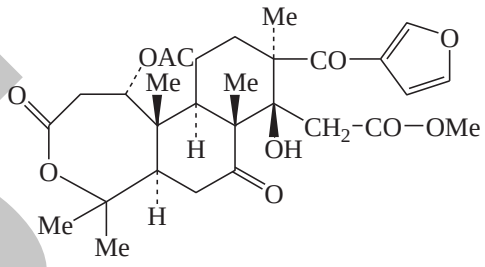
141 Ptiloepoxide



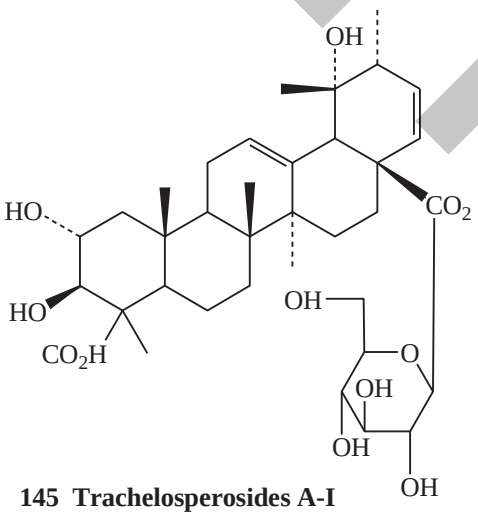
142 Winchic acid



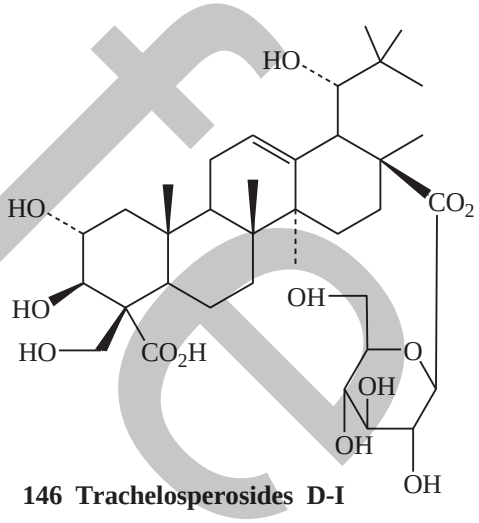
143 Wrightial



144 Odontadenin A



145 Trachelosperosides A-I

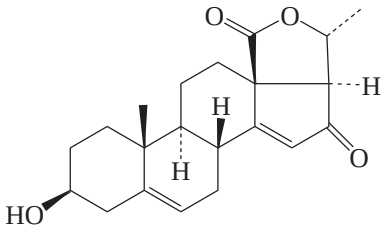


146 Trachelosperosides D-I

Saponins

Saponins have been isolated from some species of the family. Two sapogenins *viz*. ecdysantherin (**147**, 3β-hydroxy-20-methylpreg-5.14-dien-16-one-(18-20)-lactone) and 3,14-20-trihydroxypregn-5-ene-oic-(18-20)-lactone have been isolated from *Ecdysanthera rosea* Hook. et Arn. (Luger *et al*., 1996; Pham and Le, 1997). α-L-Rhamnopyranosyl-(1→4)-β-D-glucopyranosyl-(1→3)-α-amyrin was identified from the stems of *Ichnocarpus frutescens* (Minchona and Tandon, 1980). A triterpenoid saponin identified as 6β-hydroxy-oleanolic acid 3-*O*-[β-D-mannopyranosyl(1→4),(2*O*→3]β-D-glucuronate methyl ester was isolated from the dried stem of *Epigynum auritum* (Cao *et al*., 2003). The flowers of *Nerium indicum*

contain kanerocin-3-*O*-β-D-glucopyranosyl (1→4)-*O*-α-L-arabinopyranosyl (28→1)-β-D-glucopyranosyl ester (Saxena and Albert, 2004). The presence and/or isolation from *Strophanthus* species has been also reported e.g. *Strophanthus gratus* (Trotin *et al*., 1977) and *Strophanthus ramosus* (Ruppol and Turcovic, 1951). A steroidal saponin (campesterol-3-*O*-L-rhamnopyranosyl (1→4)-*O*-β-D-glucopyranaside) was isolated from the roots of *Rauwolvia serpentina* Benth. (Srivastava *et al*., 2007). A lipoxygenase active saponin named leucioside has been isolated from the leaves of *Trachelospermum lucidum* (Ahmad *et al*., 2005a).



147 Ecdysantherin

Steroids

The plants of the family Apocynceae contain several classes of sterols *viz.* the common phytosterols (C_{28} e.g. campesterol and C_{29} e.g. sitosterol), pregnanes (C_{21} steroids), and cardenolides (cardiac glycosides, C_{23} steroids).

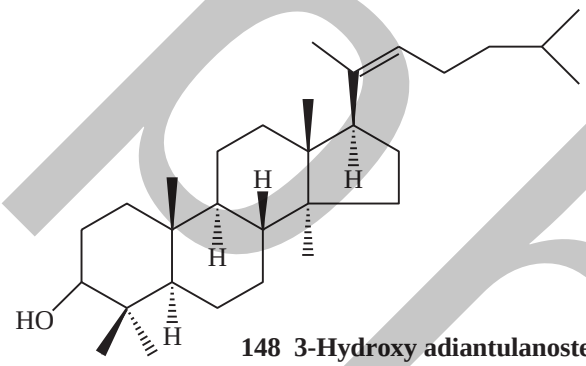
In addition to the phytosterols, sitosterol (and its glucoside), campsterol, stigmasterol and brassicasterol, identified in most of the studied species, several other sterols have been identified. A steroid called serposterol found in several species of *Rauwolfia* was shown to be the same as stigmasterol (Hampel and Rosenberg, 1962). The following are examples of these sterols:

1. *Allamanda blanchetii* DC.: Diosgenin from the flowers (Ganapaty and Rao, 1989).
2. *Allamanda cathartica*: 5.6-Dihydrostigmasterol and β-sitostenone (Agarwal and Sharma, 1983).
3. *Allamanda neriifolia*: 24(*Z*)-Methyl-25-homocholesterol (Chaveerach *et al*., 2014).
4. *Allamanda schottii*: 24(*Z*)-Methyl-25-homocholesterol and (22*R*,24*S*)-22,24-dimethyl-cholesterol (Chaveerach *et al*., 2014).
5. *Allamanda violaceae* A. DC. (syn. *Allamanda blanchetii*) (Purple Allamanda, Violet Allamanda): Androsta-5,7-diene,4,4-dimethyl, hydrocortisone acetate, ergosta-5,7,22-trien-3-ol(3β,22*E*) and 11-methyl spirostan-3,11-diol from the flowers (Sethi *et al*., 2013).
6. *Alstonia scholaris* R. Br.: 4α,14α-24-Trimethyl-9β,19-cyclo-5α-cholest-24(29)-en-3β-ol (Desoky *et al*., 2000) and 3-hydroxy-adiantulanosterol (**148**) (Sharma *et al*., 2013) from the leaves and stem bark respectively.
7. *Amalocalyx yunnanensis*: Steroidal constituents having the rare *cis*-B/C ring junctions (8α-OH, 9α-H), named amalogenin A (**149**) (3β,8α- dihydroxy-8α,9α,14β,17β,2(*R*)- pregn-5-ene-14,20-epoxy-13-carboxylic-20-lactone), amaloside A (**150**) (amalogenin A 3-*O*-β-D-diginopyranoside), and amaloside B (**151**) (amalogenin A 3-*O*-β-D-glucopyranosyl(1–4)-β-D-diginopyranoside), were isolated from the vine of the plant (Hu *et al*., 1992, 1993a,b), amaloside C (**152**), amaloside D (**153**) and amalogenin B (**154**) (Shen *et al*., 1993). Amalogenin A and amaloside A were isolated from the rhizome (Hu *et al*., 1991).
8. *Catharanthus pusillus* G. Don.: Stigmast-4-en-3-one, stigmasta-4.22-dien-3-one and campest-4-en-3-one (Subramanian and Lakshmanan, 1980).
9. *Cerbera manghas* L.: 5α-Stigmast-3.6-dione and daucosterol from the cortex (Zhang *et al*.,

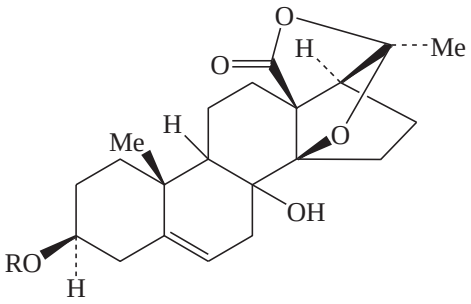
2008).

10. *Cerbera odollam* Gaertn: A14β (H) steroid compound, triticusterol (**155**, 4α-methyl-5α,14β-ergosta-8,24(24^1)-dien-3β-ol) from the stem bark (Hasan *et al*., 2011).
11. *Conopharyngia durissima*: Clionasterol (**156**) from the stem bark and roots (Hanna, 1964)
12. *Dipladenia maritiana*: Sitostenone from the aerial parts (Geraldo de Carvalho *et al*., 2001).
13. *Epigynum auritum*: 12β-Hydroxy-androst-4,6,8(9),13(14)-tetraene-3,11,16-trione (Cao *et al*., 2013b).
14. *Ervatamia divaricata* (L.) Burk.: Daucosterol from the aerial part (Yu and Liu, 1999).
15. *Ervatamia hainanensis*: Stigmast-4-en-3-one from the roots and stems (Jin *et al*., 2008).
16. *Funtumia elastica*: A 4α-methyl C31 sterol, cyclofuntumienol ((Z)-28-methyl-cyclo-eucalenol) from the bark and leaves (Mukam *et al*., 1973), 24-dehydro-lophenol (**157**) and desmosterol from the seeds (Charles *et al*., 1969).
17. *Holarrhena antidysentrica*: Sitost-5,23 dien-3β-ol, a steroid isolated from the sponge *Calyx nicaensis*, from the bark (Narayanan and Naik, 1981). Holarrhenosterol, (5α-stigmasta-9(11),20(21)-dien-3β-ol), β-sitosterol (Kumar and Ali, 2001) from the seeds and 24-methylenecholesterol from the callus tissues (Heble *et al*., 1971).
18. *Holarrhena floribunda*: Progesterone (**159**) from the leaves (Leboeuf *et al*., 1964, 1969). 24-Dehydrolophenol and desmosterol 24-dehydrocholesterol) from the seeds (Conreur *et al*., 1970).
19. *Holarrhena mitis*: 24-Dehydrolophenol 4α-methyl-5α-cholesta-7,24-dien-3β-ol) and desmosterol (**158**) from the fruits and seeds (Leboeuf *et al*., 1972b).
20. *Holarrhena pubescens* Puboestrene [3-acetoxy-17-oxo-1,3,5(10)-estratriene] and kurchinicin (**160**) from the bark (Siddiqui *et al*., 2001).
21. *Holarrhena wulfsbergii*: Androsta-1,4-dien-12β-ol-3,17-dione from the leaves (Nelle *et al*., 1970).
22. *Ichnocarpus frutescens*: Sitosterol palmitate (Verma *et al*., 1987).
23. *Mandevilla pentlandiana*: Two sterol peroxides (Cabrera *et al*., 1991a), six Δ^{20}-steroids and 6-keto-5α-stanols, from the roots (Cabrera *et al*., 1991b).
24. *Melodinus fusiformis*: 24*R*-Ethyl-5α-cholestane-3β,6α-diol from the leaves and twigs (Wang *et al*., 2012a).
25. *Nerium oleander* L.: β-Sitosterol, α-spinasterol, stigmasterol and campesterol from fruits (Saxena *et al*., 1990), Neristigmol (*n*-hexyl *p*-stigmasteryloxy-benzoate) from the leaves (Siddiqui *et al*., 2006). Diosgenin was identified from the plant (Zibbu and Batra, 2011).
26. *Pentalinon andrieuxii* Mueller-Argoviensis (syn. *Urechites andrieuxii*): Pentalinonsterol (cholest-4,20,24-trien-3-one), 24-methylcholesta-4,24(28)-dien-3-one, cholest-4-en-3-one, stigmast-4,22-dien-3-one, stigmast-4-en-3-one, cholest-5,20,24-trien-3β-ol (**7**), cholest-5,24-dien-3β-ol (demosterol), 24-methylcholest-5,24(28)-dien-3β-ol , cholesterol isofucosterol, β-sitosterol, 7-ketositosterol and 7-ketostigmasterol from the roots (Pan *et al*., 2012).
27. *Plumeria acuminata* Ait: Stigmast-7-enol from the leaves (Guevara *et al*., 1996).
28. *Plumeria obtusa*: 3β-Hydroxy-Δ^5-stigmastane from the stem bark (Siddiqui *et al*., 2004).
29. *Rauwolfia caffra*: Caffrosterol and serposterol (17-β-methyl-Δ^5-androsten-3-β-ol) from the root (Khan *et al*., 1965a).
30. *Rauwolfia heterophylla*: γ-Sitosterol (Djerassi *et al*., 1954).
31. *Rauwolfia perakensis*: γ-Sitosterol from the roots (Chatterjee and Talapatra, 1955a).
32. *Rauwolfia serpentina*: Serposterol (28-hydroxystigmasterol) (Siddiqui and Alauddin, 1958) and 7-dehydrositosterol (Karmakar and Chakraborty, 1983) from the roots.
33. *Rauwolfia vomitoria* Afzuelia: Serposterol (Malik and Siddiqui, 1980).

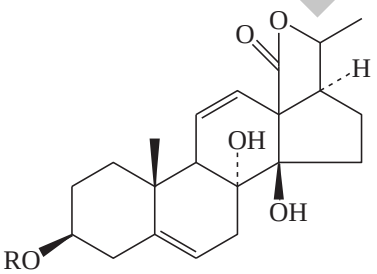
34. *Thevetia neriifolia* Juss.: Gramisterol from the seed oil (Miralles, 1981).
35. *Thevetia peruviana:* β-Ergosterol from the seeds (Gata Gonçalves *et al*., 2003).
36. *Trachelospermum asiaticum intermedium*: A steroidal glycoside ($C_{28}H_{46}O_7$) was isolated from the hydrolysate of the chloroform extract (Inagaki *et al.*, 1972a).
37. *Trachelospermum jasminoids*: Stigmast-4-en-3-one (Zhang *et al.*, 2012b).
38. *Voacanga africana* Stapf: Ergosterol from the seed oil (Rafidison *et al*., 1987). 6β-Hydroxystigmast-4-en-3-one, 22*E*,24*R*-5α,8α-epidioxyergosta-6,22-dien-3β-acetate and (22*E*)-5α,8α-epidioxyergosta-6, 22-dien-3β-ol from the bark (Dan *et al*., 2013).
39. *Wrightia tinctoria* (Roxb) R. Br.: Desmosterol, 14α-methyl zymosterol, clerosterol, 24-methylene-25-methyl cholesterol, 24-dehdropollinastanol, 24-methyl cholesterol, 24-methylene cholesterol, 24-ethyl cholesterol and isofucosterol from the seeds (Akihisa *et al*., 1988; Devi and Divakar, 2014; Jose and Jesy, 2014).

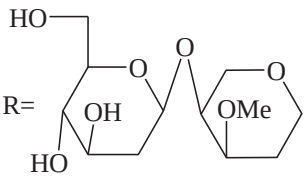


148 3-Hydroxy adiantulanosterol

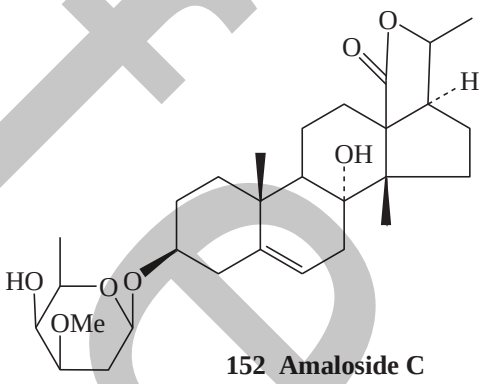


149 Amalogenin A R=H
150 Amaloside A R=β-D-diginoryranside

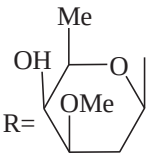




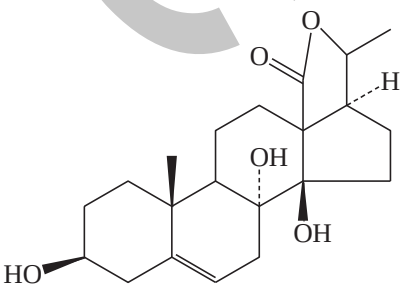
151 Amaloside B R=



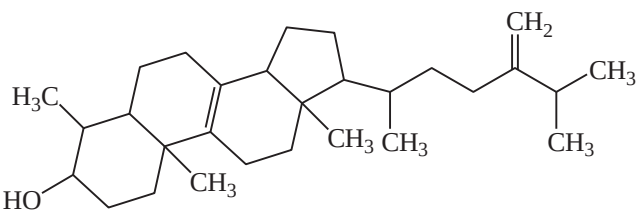
152 Amaloside C



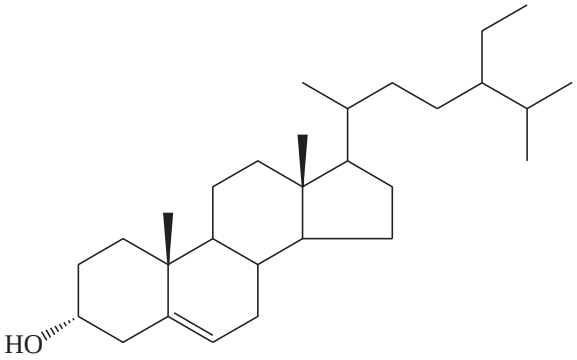
153 Amaloside D R=



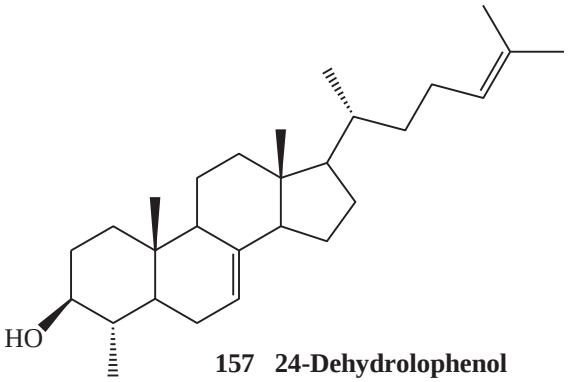
154 Amalogenin B



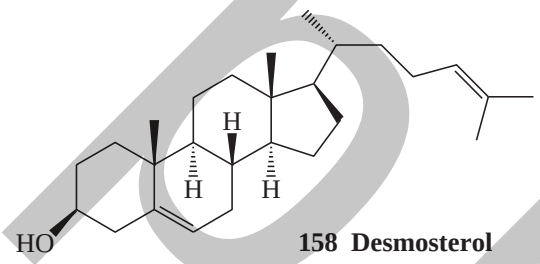
155 Triticusterol



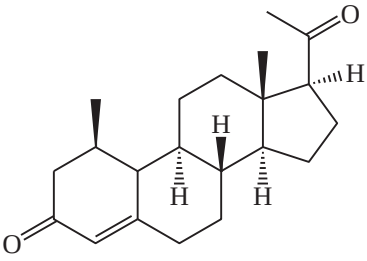
156 Clionasterol



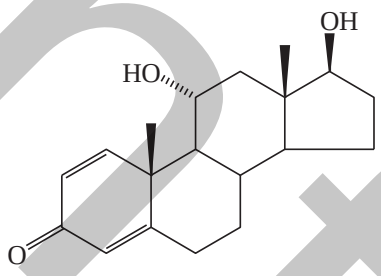
157 24-Dehydrolophenol



158 Desmosterol



159 Progesterone



160 Kurchinicin

Pregnanes

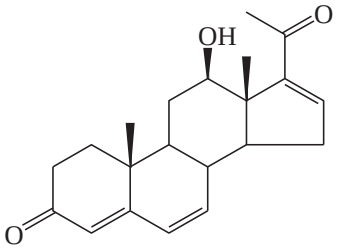
Pregnanes and pregnane glycosides have been identified in some species of the family Apocynaceae. The following are examples of the isolated compounds:

1. *Adenium obesum*: Neridienone A (**161**) and 16,17-dihydroneridienone (**162**) A were identified from roots and stems (Yamauchi and Abe, 1990a). The leaves contain in addition, two pregnanes, 12β-hydroxypregna-4,16-diene-3,20-dione (**163**) and 12β-hydroxypregna-4-ene-3,20-dione (**164**) (Nakamura *et al*., 2000).
2. *Anodendron affine*: Neridienone A, pregnadienes I (R = OH, R^1 = H; RR^1 = O) and pregnatri-4,6,16-ene-3,12,20-trione were isolated from the plant (Yamauchi *et al.*, 1979a).
3. *Apocynum cannabinum*: Two pregnanes, neridienone A and 6.7-didehydrocortexone were isolated from the roots (Abe and Yamauchi, 1994a).
4. *Apocynum venetum* L. var. *basikurumon* Hara: The following pregnanes were isolated from the roots: neridienone A, 12β-hydroxypregna-4,6-diene-3,20-dione, 21-hydroxypregna-4,6-dien-3,20-dione (**165**, 6,7-didehydrocortexone), teikagenin 3-*O*-β-D-fucopyranoside (**166**), 3'-*O*-acetylteikagenin-3-*O*-β-D-fucopyranoside (**167**), teikagenin 3-*O*-β-D-fucopyranosyl-20-*O*-β-D-canaroside (**168**), and teikagenin 3-*O*-β-D-fucopyranosyl-20-*O*-β-D-diginopyranosyl- (1→3)-β-D-canaropyranoside (**169**) (Abe *et al*., 1987).
5. *Catharanthus roseus*: Three brassinosteroids (steroidal plant growth hormones) *viz.* brassinolide (**170**) and castasterone (**171**) from cultured crown gall cells (Park *et al*., 1989)

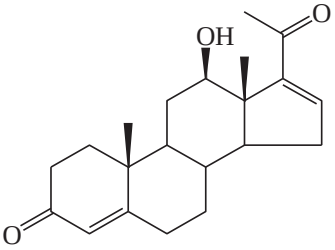
and cathasterone (**172**) from cultured cells (Fujioka *et al*., 1995) were identified.

6. *Cerbera manghas*: 12β-Hydroxyl-5α-pregn-16-ene-3,20-dione, 12β-hydroxyl-pregn-4,16-diene-3,20-dione, 3β,12β-dihydroxypregn-16-en-20-one and 3α,12β-dihydroxypregn-16-en-20-one were isolated from the leaves (Zhang *et al.*, 2006b). Two pregnane saponins, ecdysantheroside A and ecdysantheroside B were isolated from the stem bark (Zhu *et al*., 2011b).
7. *Ecdysanthera rosea*: 3β,14β,20-Trihydroxypregnen-5-oic-18 (18→20)lactone was isolated from the plant (Luger *et al.*, 1998). Two pregnane saponins, ecdysantheroside A and ecdysantheroside B were isolated from the stem bark (Zhu *et al.*, 2011b).
8. *Epigynum auritum*: Three pregnane glycosides with an unusual aglycone, epigynosides A, B and C were isolated from the aerial part (Cao *et al*., 2005).
9. *Holarrhena antidysentrica*: Holadysone, a digitenol (11α,20-dihydroxy-18,20-epoxy-pregna-1,4-dien-3-one) was isolated from the plant (Tschesche *et al.*, 1963).
10. *Holarrhena floribunda*: Pregn-4-en-20α-ol-3-one is possibly present in the leaves (Leboeuf *et al*., 1964).
11. *Holarrhena pubescens*: Pubadysone [11α-hydroxy-18,20-oxido-3-oxo-pregna-1,4,17(20)-triene] (**1**) (Siddiqui *et al*., 2001) and pregnenolone (3-hydroxypreg-5-en-20-one) (Zahari and Said, 2013) were isolated from the bark and roots respectively.
12. *Hoodia gordonii* (Masson) Sweet ex Decne.: More than 40 steroidal glycosides were isolated from the plant *viz*. 3β-[β-D-thevetopyranosyl-(1→4)-β-D-cymaropyranosyl-(1→4)-β-D-cymaropyranosyloxy]-12β-tigloyloxy-14β-hydroxypregn-5-en-20-one (**173**), cymaropyranosyl-(1→4)-β-D-cymaropyranosyloxy]-12β-tigloyloxy-14β-hydroxypregn-5-en-20-one, (van Heerden *et al*., 2007), eleven oxypregnane glycosides-hoodigoside A-K (**174-184**) (Pawar *et al*., 2007a), ten pregnane glycosides-hoodigosides L-U (**185- 194**) (Pawar *et al*., 2007b); ten steroidal glycosides, gordonosides A-I, L (**195**) (Dall'Acqua and Innocenti, 2007); seven pregnane glycosides, hoodigosidenV-Z and hoodistanaloside A-B (Shukla *et al.*, 2009); and three others. The backbone chemical structures of all these compounds are the aglycones hoodigogenin A (**196**), calogenin, hoodistanal, dehydro-hoodistanal and isoramanone formed as a result of acid and/or enzymatic hydrolysis (Vermaak *et al.*, 2011).
13. *Hoodia pilifera* (L.f.) Plowes: 3β-[β-D-Thevetopyranosyl-(1→4)-β-D-cymaro-pyranosyl-(1→4)-β-D-cymaropyranosyloxy]-12β-tigloyloxy-14β-hydroxypregn-5-en-20-one and cymaropyranosyl-(1→4)-β-D-cymaropyranosyloxy]-12β-tigloyloxy-14β-hydroxypregn-5-en-20-one were isolated from the plant (van Heerden *et al*., 2007).
14. *Macrosiphonia petraea* (A. St.-Hil.) Kuntze: The roots contain neridienone A (12β-hydroxypregna-4,6,16-triene-3,20-dione) and cybisterol (12β-hydroxypregna-4,6-diene-3,20-dione) (De Assis Junior *et al.*, 2013).
15. *Mandevilla illustris* Woodson: Illustrol (**197**, a 14:15-*seco*-15-norpregnane derivative) (Yunes *et al*., 1993a; Vencato *et al.*, 1999), acetylillustrol (Niero *et al*., 1999) and 2,6-dideoxy-3-*O*-methylpyranosylillustrol (**198**) (Niero *et al*., 2002) were isolated from the rhizomes. A 14:15-seco-15-norpregnane derivative, (3'-14-epoxy-4',15-dioxaandrost-5-en-3β-yl acetate), was also isolated from the plant (Vencato *et al.*, 1999)
16. *Mandevilla pentlandiana*: A pregnane triglycoside, 3β,14β-dihydroxy-21-methoxy-5β-pregnan-20-one-3-*O*-β-D-diginopyranosyl-(1→4)-*O*-β-D-cymaropyranosyl-(1→4)-*O*-β-D-cymaropyranoside, was isolated from the dried roots. 3β,14β,21-Trihydroxy-5β-pregnan-20-one, biosynthetically related to the genin of this glycoside, a precursor of cardenolides, is also produced by the plant (Cabrera *et al.*, 1993c).
17. *Mandevilla velutina***:** A pregnane pentasaccharide, velutinoside (a pentasaccharide derivative of velutinol A, with the unusual sugars oleandrose and digitalose) was isolated

from the plant (Bento *et al.*, 2003). Velutinol A (**199**, (15*R*,16*R*,20*S*)-14,16:15,20:16,21-triepoxy-15,16-seco-14β,17α-pregn-5-ene-3β,15-diol), was also isolated from the rhizomes (Yunes *et al.*, 1993b; Bento *et al.*, 1996).



161 Neridenone A



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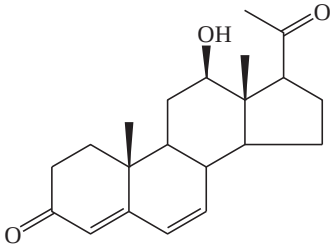

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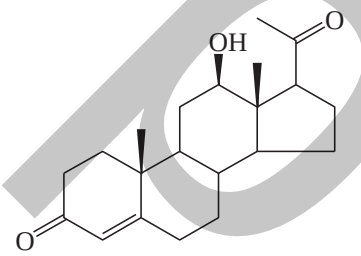

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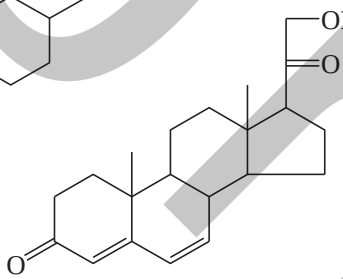

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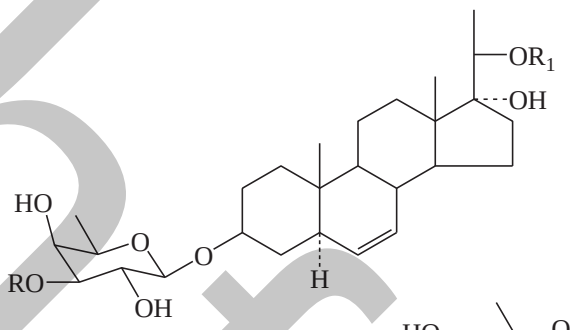
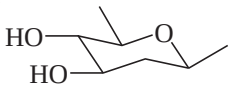
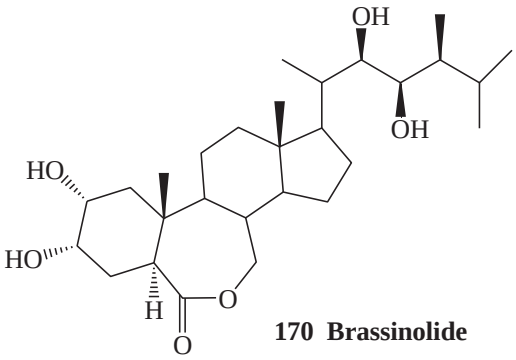


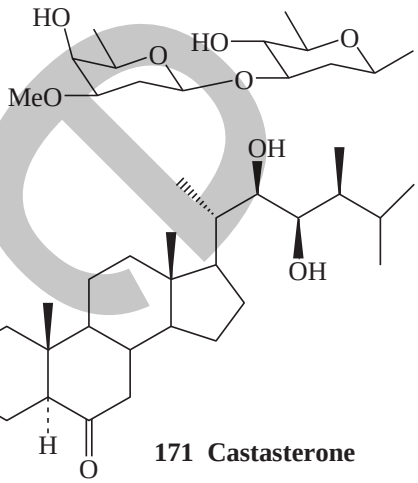
166 R=R_1=H
167 R=Ac,R_1=H

168 R =H,R_1=



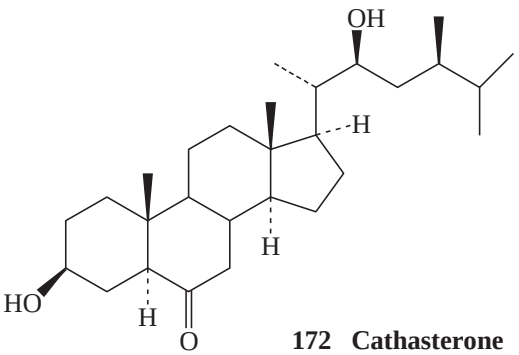


169 R=H, R_1=

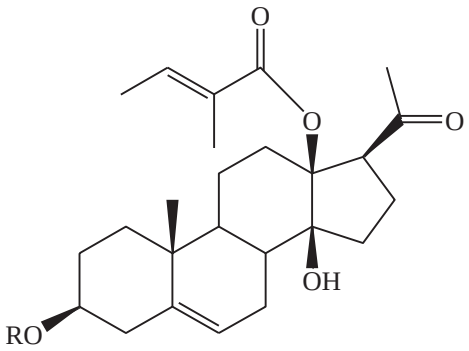


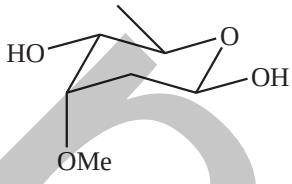
170 Brassinolide

171 Castasterone

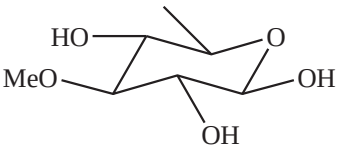


172 Cathasterone

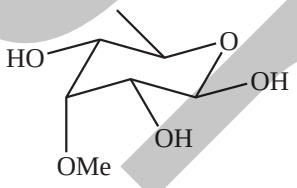




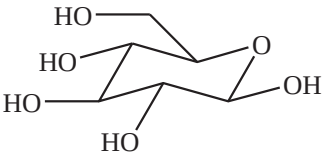
D-Cymarose
(cym)



D-Thevetose
(the)

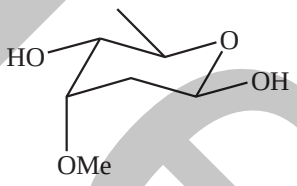


3-O-Methyl-6-deoxy-D-allose
(mda)



D-Glucose
(glu)

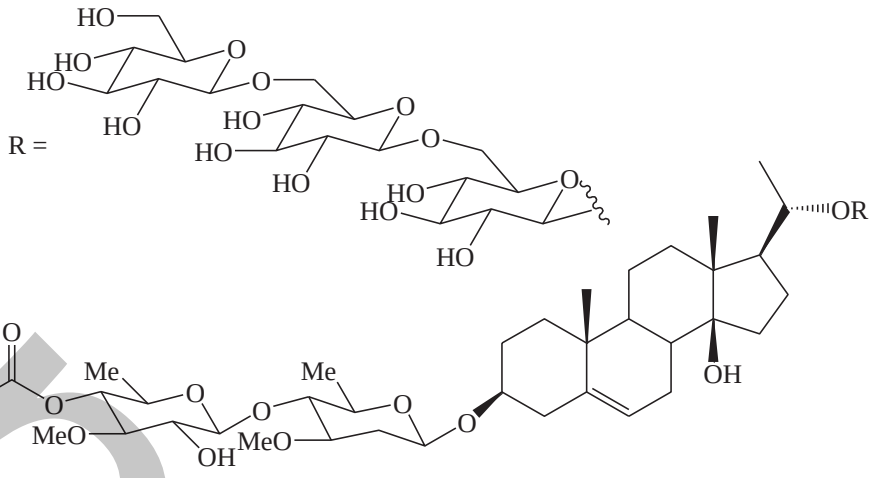
D-Oleandrose
(ole)



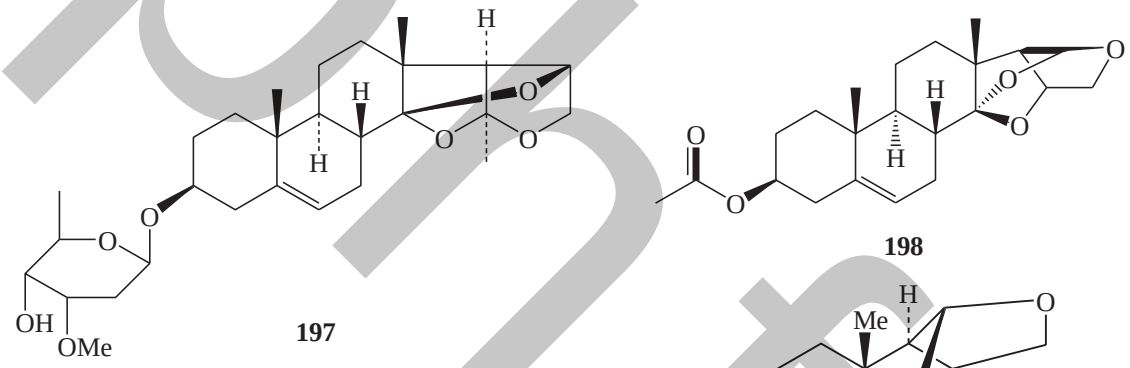
D-Digitoxose
(dig)

Name	R	Name	R
173 P57A53	the-cym-cym	**185 Gordonoside A**	H
174 Hoodigoside A	the-cym	**186 Gordonoside B**	the-ole-cym-cym
175 Hoodigoside B	the-the-cym	**187 Gordonoside C**	*
176 Hoodigoside C	the-cym-cym-cum	**188 Gordonoside D**	dig-ole-cym-cym
177 Hoodigoside D	the-the-cym-cym	**189 Gordonoside E**	ole-ole-cym-cym
178 Hoodigoside E	glu-the-cym-cym	**190 Gordonoside F**	ole-cym-cym-cym
179 Hoodigoside F	glu-ole-the-cym-cym	**191 Gordonoside G**	cym-cym-cym-cym
180 Hoodigoside G	glu-cym-the-cym-cym	**192 Gordonoside H**	*
181 Hoodigoside H	glu-cym-cym-cym-cym	**193 Gordonoside I**	dig-ole-ole-cym-cym
182 Hoodigoside I	glu-ole-cym-cym-cym	**194 Gordonoside L**	ole-cym-cym-cym-cym
183 Hoodigoside J	glu-ole-dig-cym-cym	**196 Hoodigogenin A**	H
184 Hoodigoside K	glu-glu-cym		

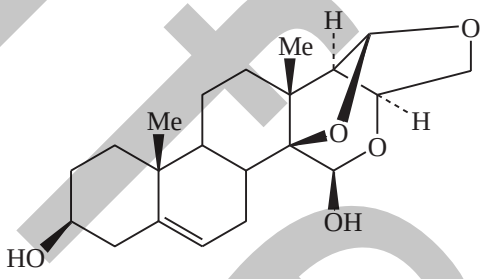
* not mentioned in the article.



195 Hoodigoside L



197 **198**

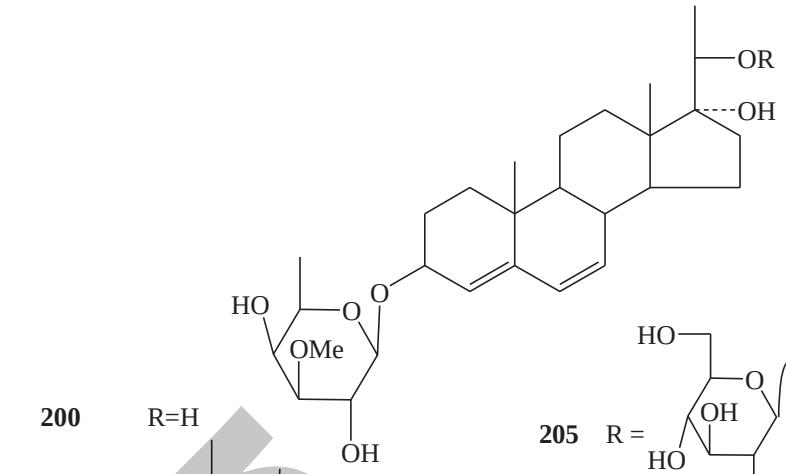


199 Velutinol A

18. *Nerium odorum*: Neridienone A (12β-hydroxypregna-4,6,16-triene-3,20-dione) from the root bark (Yamauchi *et al*., 1974). Three pregnenolone glucosides, the β-D-glucopyranoside, β-D-glucopyranosyl-(1→2)-β-D-glucopyranoside, β-D-gluco-pyranosyl -(1→6)-β-D-glucopyranoside and *bis*-β-D-glucopyranosyl-(1→2, 1→6)-β-D-gluco-pyranoside of pregnenolone were obtained from root and trunk bark of *Nerium odorum* (Yamauchi *et al*., 1972b). 5α-Pregnanolone bis-*O*-β-D-glucosyl-(1→2,1→6)-β-D-glucoside and pregnenolone β-D-apiosyl-(1→6)-β-D-glucoside were identified from the roots (Hanada *et al*., 1992c). Neridienone-A (12β-hydroxy-pregna-4,6,16-triene-3,20-dione), neridienone-B (20β,21-dihydroxy-pregna-4,6-diene-3,12-dione), 12β-hydroxy-pregna-4,6-diene-3,20-dione, 12β-hydroxy-pregn-4-ene-3,20-dione and 12β-hydroxy-16α-methoxy-pregna-4,6-diene-3,20-dione were obtained from the root bark (Abe and Yamauchi, 1976).
19. *Nerium oleander*: Two pregnane glucosides *viz*. 3-*O*-β-gentiobiosyl-3β,14-dihydroxy-5α,14β-pregnan-20-one and 21-*O*-β-D-glucosyl-14.21-dihydroxy-14β-pregn-4-ene-3.20-dione, were isolated from leaves (Abe and Yamauchi,1992a). Neridienone A(12β-

hydroxypregna-4,6,16-triene-3,20-dienone) was identified from the roots (Kumar *et al.*, 2005). Five others were identified from the plant *viz.* 21-hydroxy-pregna-4,6-diene-3,12,20-trione, 20*R*-hydroxypregna-4,6-diene-3,12-dione, 16β,17β-epoxy-12β-hydroxy-pregna-4,6-diene-3,20-dione, 12β-hydroxypregna-4,6,16-triene-3,20-dione (neridienone A), and 20*S*,21-dihydroxypregna-4.6-diene-3.12-dione (neridienone B) (Bai *et al*., 2007).

20. *Pachypodium lamerei* Drake: 3-Hydroxy-pregn-5-en-20-one was identified from the leaves and stems of the plant cultivated in Egypt (El-Kashef *et al.*, 2014).
21. *Paravallaris microphylla*: The leaves contain ketonic steroids *viz.* 3-oxo-4-pregnen-18, (20*S*)-olide, 3-oxo-16ά-hydroxy-4-pregnen-18, (20*S*)-olide, 3-oxo-4,6-pregnadien-18,(20*S*)-olide, 3-oxo-11β-hydroxy-1,4-pregnadien-18, (20*S*)-olide, 3,6-dioxo-4-pregnen-18,(20S)-olide and 3,6-dioxo-5α-pregnan-18,(20*S*)-olide (Husson *et al*., 1971).
22. *Pentalinon andrieuxii* Mueller-Arg. (syn. *Urechites andrieuxii*): Pregnanes e.g. pentalinonside, neridienone and 6,7-dihydroneridienone were isolated from the roots (Pan *et al.*, 2012).
23. *Thevetia neriifolia*: A steroid 4,16-pregnadien-12β-hydroxy-3,20-dione was isolated from the seeds (Siddiqui *et al*., 1992b).A bisdesmosidic tetraoside of 3β,14,21-trihydroxy-5β,14β-pregnan-20-one was identified from the fresh leaves (Abe *et al*., 1994a).
24. *Trachelospermum asiaticum* Nakai: Abe and Yamauchi (1981) reported the isolation of teikaside A (3-*O*-(β-D-digitalosyl)-20-*O*-(β-D-glucosyl-β-D-sarmentosyl)-3β,17α,20α-trihydroxy-5α-pregn-6-ene). Later, 15 bisdesmosidic glycosides were identified from the plant: eight glycosides composed of 3-*O*-β-D-digitalosyl-teikagenin (**200**) (3β,17α,20α-trihydroxy-5α-pregn-6-one), common to teikaside A (teikagenin 3-*O*-β-D-digitalosyl-20-*O*-β-D-glucosyl-β-D-sarmentosyl-β-D-sarmentoside, renamed teikaside A-IIIa) and teikasides A-Ia (**201**, teikagenin 3-*O*-β-D-digitalosyl-20-*O*-β-D-canaroside), teikaside A-1b (**202**, teikagenin 3-*O*-β-D-digitalosyl-20-*O*-β-D-oleandroside), teikaside A-IIa (**203**, teikagenin3-*O*-β-D-digitalosyl-20-*O*-β-D-glucosyl-β-D-glucosyl-β-D-diginoside), teikaside A-IIb (**204**, teikagenin 3-*O*-β-D-digitalosyl-20-*O*-β-D-glucosyl-β-D-oleandroside), teikaside A-IIc (**205**, teikagenin3-*O*-β-D-digitalosyl-20-*O*-β-D-glucosyl-(1→4)-β-D-canaroside), teikaside A-IIIb (**206**, teikagenin 3-*O*-β-D-digitalosyl-20-*O*-β-D-glucosyl-β-D-oleandrosyl-β-D-sarmentoside), teikaside A-IIIc (**207**), teikagenin 3-*O*-β-D-digitalosyl-20-*O*-β-D-glucosyl-β-D-oleandrosyl-β-D-oleandroside and teikaside A-IIId (**208**, teikagenin 3-*O*-β-D-digitalosyl-20-*O*-β-D-glucosyl-β-D-diginosyl-β-D-sarmentoside) (Abe and Yamauchi, 1988a). Seven glycosides, teikasides B and C, having an α-L-sarmentosyl-(1→4)-β-D-digitalosyl moiety at the 3-OH with or without acetyl residues were also isolated *viz.*teikaside C-0 (**209**, teikagenin 3-*O*-(4-*O*-acetyl-α-L-sarmentosyl- (1→4)-β-D-digitaloside)), teikaside C-IIa (**210**, teikagenin 3-*O*-(4-*O*-acetyl-α-L-sarmentosyl- (1→4)-β-D-digitalosyl)-20-*O*-(β-D-glucosyl-β-D-diginoside), teikaside C-IIb (**211**, teikagenin 3-*O*-(4-*O*-acetyl-α-L-sarmentosyl-(1→4)-β-D-digitalosyl)-20-*O*-(β-D-glucosyl-β-D-oleandroside), teikaside C-IIc (**212**, teikagenin 3-*O*-(4-*O*-acetyl-α-L-sarmentosyl-(1→4)-β-D-digitalosyl)-20-*O*-(β-D-glucosyl-(1→4)-β-D-canaroside), teikaside C-IIIa (**213**, teikagenin 3-*O*-(4-*O*-acetyl-α-L-sarmentosyl-(1→4)-β-D digitalosyl)-20-*O*-(β-D-glucosyl-β-D-oleandrosyl-β-D-oleandroside), teikaside C-IVa (**214**, 20-*O*-β-D-cymarosyl-β-D-oleandrosyl-β-D-oleandroside and teikaside B-IVa (**215**) (Abe and Yamauchi, 1988c).
25. *Trachelospermum liukiuense* Hatsusima: Cortexone (**216**) and 8 bisdesmosidic glycosides of teikagenin (having D-digitalose linked to the 20-OH as well as to the 3-OH) *viz.* teikaside AL-Ic (**217**), teikaside BL-Ic (**218**), teikaside AL-IId (**219**), A- Ia, A-Ib, A-IIa and A-IIc (Abe and Yamauchi, 1989a).



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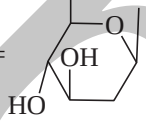

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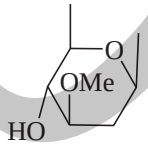

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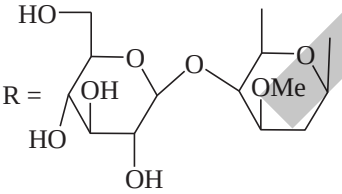

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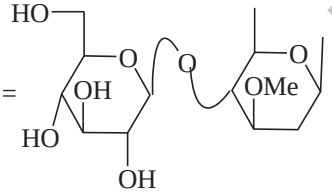

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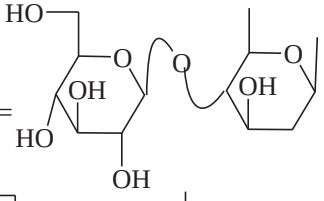

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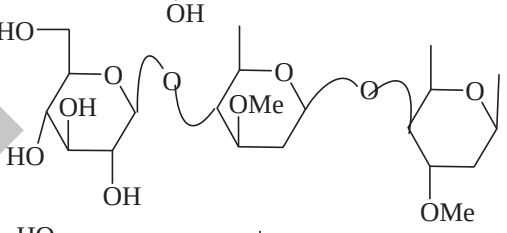

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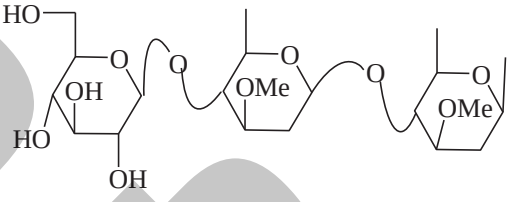

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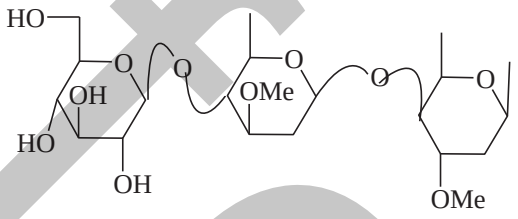
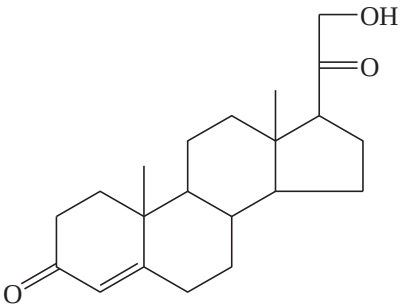
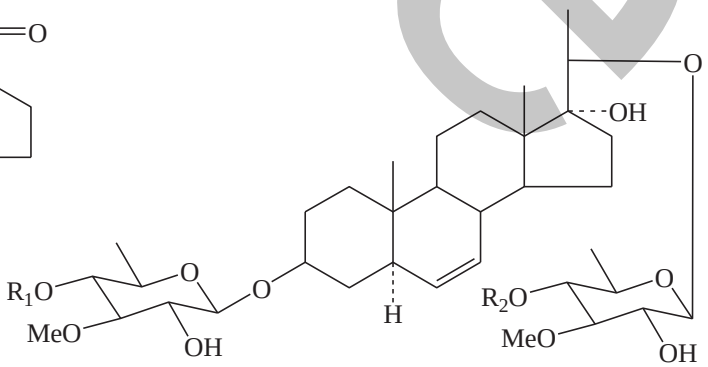


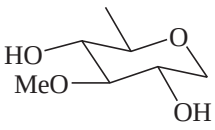


216 Cortexone

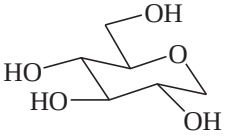


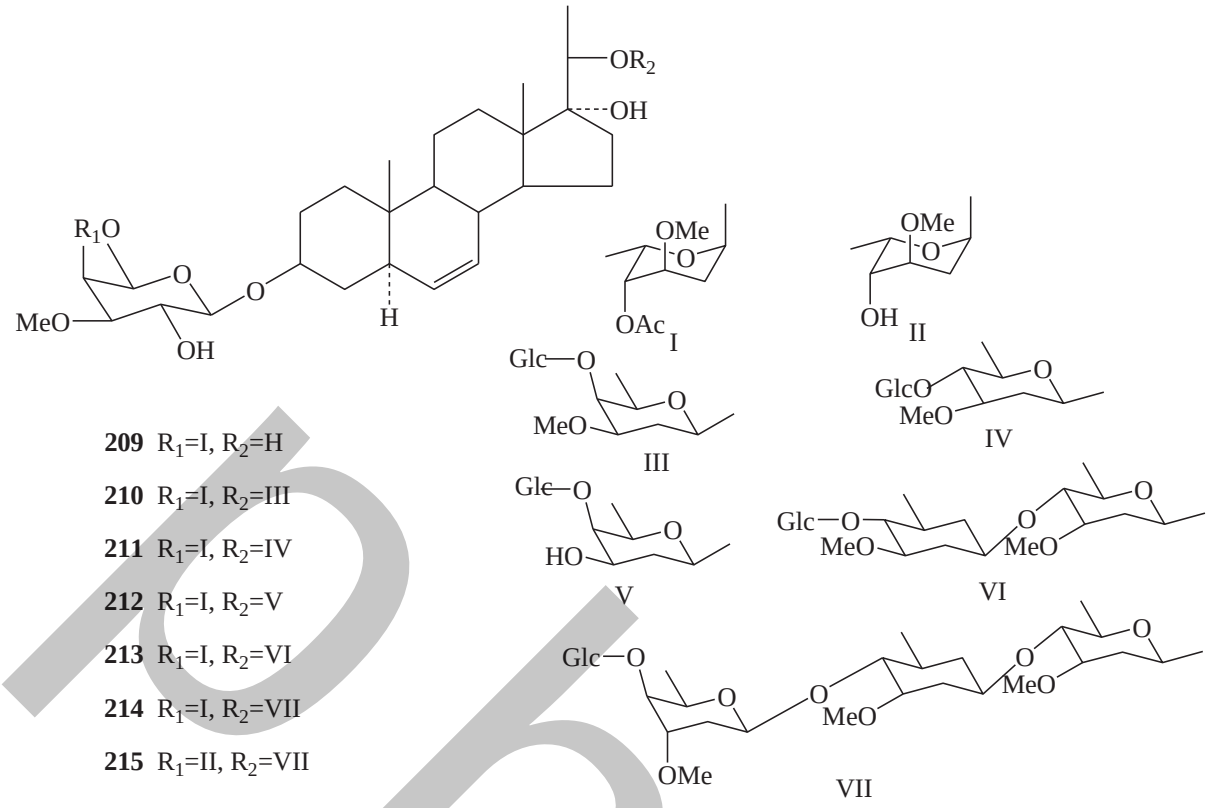
217 $R_1=R_2=H$

218 $R_2=H$, $R_1=$



219 $R_1=H$, $R_2=$





209 R_1=I, R_2=H

210 R_1=I, R_2=III

211 R_1=I, R_2=IV

212 R_1=I, R_2=V

213 R_1=I, R_2=VI

214 R_1=I, R_2=VII

215 R_1=II, R_2=VII

Cardenolides:

Many cardiac glycosides have been isolated from several species of the family. The following are examples of these species and the identified cardenolides:

1. *Acokanthera abyssinica*: Oubain from the seeds (Menziani *et al*., 1964).
2. *Acokanthera friesiorum* Mgf.: Acovenoside A, acolongifloroside E, acolongifloroside H, acofrioside L, acofrioside M, ouabain and a glycoside which gave on hydrolysis 3,5-dianhdro-periplogenin and L-acofriose (3-*O*-methyl-L-rhamnose) from the seeds (Muhr *et al.*, 1954). The root bark contains 0.424% acovenoside A (Bally *et al*., 1952a).
3. *Acokanthera longiflora* Stapf: Acovenoside A, opposide and acolongiflorosides E, G, H, J and K (6-deoxy-α-L-talopyranoside of ouabagenin) from the seeds, stems, root and twigs (Bally *et al*., 1951; Chen *et al*., 1951; Hauschild-Rogat *et al*., 1962; Kingston and Reichstein, 1974).
4. *Acokanthera oblongifolia*: Acospectoside A [1-*O*-acetyl-acobioside A, yielding on hydrolysis anhydroacovenosigenin A, acovenosigenin A, D-glucose, and L-acovenose] (Kapadia, 1969).
5. *Acokanthera oppositifolia*: The seeds contain 19 cardenolides including acovenoside A, acofrioside L, acolongifloroside H, acovenoside C, acolongifloroside K, oubain, oppovenoside, oppofiroside, acotaloside and opposide (Hauschild-Rogat *et al*., 1967a,b).
6. *Acokanthera ouabaio*: Ouabain from the wood (Klein, 1914; Hostettmann *et al*., 2000).
7. *Acokanthera schimperi* (A. DC.) Benth. et Hook. (syns. *Carissa schimperi* A. DC., *Acokanthera ouabaio* Poisson): Ouabain, acoschimperoside N, acoschimperoside P, acolongifloriside H, acoschimperosides ψ-K, N, O, P, Q, S, T, U, V, Y_2 and Z, acovenosides A and C, acolongifloroside K and others from the seeds (Mohr *et al.*, 1957; Thudium *et al.*, 1958; Thudium *et al*., 1959; Cassels, 1985; Kingdon *et. al.*, 2012).
8. *Acokanthera spectabilis* Hook f.: Four glycosides namely acovenoside A, acovenoside C, ouabain and acobiose have been isolated from the plant grown in Egypt (Karawya *et al*.,

1974a,b). The presence of other glycosides has been also reported *e.g.* acospectoside A (Kapadia, 1965), acovenoside C, acolongifloroside K, ouabain (Benmerabet *et al.*, 1974), acobioside A, 14-*O*-acetylacovenoxide C (Pieri *et al.*, 1992 a,b), four 5 β-cardenolides (Hanna *et al.*, 1998) and others (San Martin and Batllori,1966). Two heterosides (Pieri, 1985) and acopieroside II (Pieri and Massiot, 1989) were isolated from the seeds. A heterocyclic compound, spectabiline, was extracted from the wood, leaves, and fruit, is claimed to be of use as a heart tonic (Pieri, 1972). A cardiotonic compound, tentatively called "espectabilina" was obtained from the leaves of this plant (San Martin, 1949).

9. *Acokanthera venenata* G. Don: Venenatin (acovenoside) was early isolated from the stems and bark (Veldsman, 1949a,b). Acovenosides A-C were identified from the seeds (Euw and Reichstein, 1950b; Chen *et al.*, 1951; Mohr and Reichstein, 1951). Six cardenolides were isolated from the leaves. The major compounds were acovenoside A and glucoacovenoside B (Makarevich *et al*., 1987).
10. *Adenium arabicum* Balf f.: Several cardiac glycosidal comounds were detected by TLC, in the plant growing in Saudi Arabia (Al-Sarar *et al.*, 2012).
11. *Adenium boehmianum*: Extraction of whole plant yielded somalin, which existed in 2 forms (Hess *et al.*, 1952).
12. *Adenium coetaneum*: An arrow poison glucoside has been reported in the plant (Krause, 1911).
13. *Adenium honghel*: Adeniine, an energetic heart poison, has been early separated from the plant (Leprince, 1913). The roots and stalks yielded honghelosides A-F, a 16-anhydro-glucoside (Hunger and Reichstein, 1950a), hongkeline (a digitalis heteroside) (Frerejacque and Hasenfratz, 1949), honghelosides A, C, G(somalin) and others (Schindler and Reichstein, 1951a; Hess and Hunger, 1953).
14. *Adenium lugardii*: Undried aerial parts of the plant contain echujin, hongheloside A, somalin and "substance A" (Striebel *et al.*, 1955).
15. *Adenium multiflorum*: The seeds yielded 16-desacetylanhydrohongheloside, 16-anhydro-desglucodigitalinum verum, and others (Hunger and Reichstein, 1950b).
16. *Adenium obesum* Forsskal (syn. *Nerium obesum* Forssk., *Adenium arabicum* Balf. f., *Adenium tricholepis* Chior (desert rose): Hoffmann and Cole (1977) identified 4 cardenolids *viz*. somalin, honghelosides A, 16-acetylstrospeside and honghelin, from the plant. Oleandrigenin β-gentiobiosyl-β-D-thevetoside was the main glycoside among 30 cardiac glycosides detected in roots and stems. Most of the identified cardiac glycosides are D-cymarosides and digitalosides of digitoxigenin and oleandrigenin. So far, 38 cardiac glycosides and 2 cardenolides (aglycones) (Table **6**) have been isolated from the different parts of the plant (roots, stems, leaves and flowers) (Versiani *et al.*, 2014).
17. *Adenium somalense* Balf. fil.: Somalin (digitoxigenin cymaroside) (Muller, 1943, 1944) and a cymarose ether of digitoxigenin from the roots (Hartmann and Schlittler, 1944).
18. *Angadenia berterii*: Oleandrigenin (Pina and Franghaenel, 1971, 1972).
19. *Anodendron affine*: Several cardenolides have been identified from the different parts of the plant:
    a. Stems and leaves: Affinogenin C (**260**), affinogenins D-I-D-V (**261- 265**) (Abe and Yamauchi 1982a), and affinosides S-I-VIII (e.g.**266- 273**) (Abe and Yamauchi, 1983).
    b. Leaves: Affinosides L_a-L_e, (e.g. **274**, **275**) (Abe and Yamauchi, 1985c; Yamauchi and Abe, 1995), 3-*O*-(4,6-dideoxy-3-*O*-methyl-Δ^3-D-hexosulosyl)-affinogenin L_d (affinoside O) (**276**), 3-*O*-(4,6-dideoxy-3-*O*-methyl-D-allosyl)-affinogenin H (affinoside N) (**277**), and Δ^{16}-affinoside M (affinoside I), 3,16-diacetate of 2β,3β,14,16β-tetrahydroxy-11-oxo-5β,14β-card-20(22)-enolide (affinogenin D-VI) (Abe *et al*., 1986) and affinosides Lf and Lg (Abe and Yamauchi, 1993).

Table **6**. Cardiac glycosides isolated from the different parts of *Adenium obesum* (Versiani *et al*., 2014)

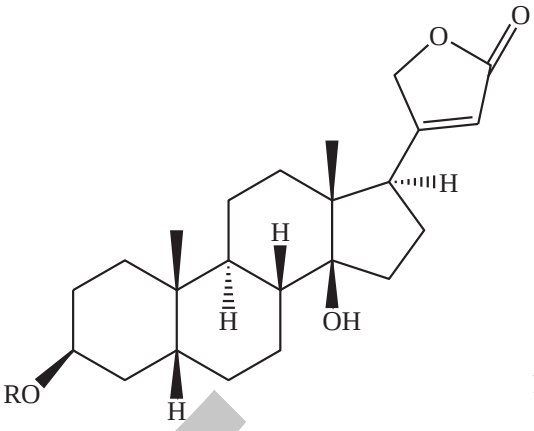
No.	Compounds	Plant part	References
1	Digitoxigenin β-D-cymaroside (somalin) (**220**)	Ap, S, R	Hoffmann and Cole (1977); Yamauchi and Abe (1990a)
2	Oleandrigenin β-D-cymaroside (hongheloside A) (**221**)	Ap, S, R	Hoffmann and Cole(1977); Yamauchi and Abe (1990a)
3	Oleandrigenin β-D-digitaloside (16-*O*-acetylstrospeside, neritaloside) (**222**)	Ap, S, R	Hoffmann and Cole (1977); Yamauchi and Abe(1990a)
4	Digitoxigenin β-D-thevetoside (honghelin) (**223**)	Ap, S, R	Hoffmann and Cole (1977); Yamauchi and Abe (1990a); Arai *et al.* (2011)
5	Δ^{16}-Digitoxigenin β-D-cymaroside (Δ^{16}-somalin) (**224**)	S, R	Yamauchi and Abe (1990a)
6	Oleandrigenin β-D-thevetoside (obeside B) (**225**)	L, R	Yamauchi and Abe (1990a); Arai *et al.* (2011)
7	Gitoxigenin-β-D- thevetoside (obeside C) (**226**)	L, S, R	Yamauchi and Abe (1990a); Arai *et al.* (2011)
8	Δ^{16}-Digitoxigenin β-D-thevetoside (obeside D) (**227**)	S, R	Yamauchi and Abe (1990a)
9	Gitoxigenin β-D-digitaloside (strospeside) (**228**)	R	Yamauchi and Abe (1990a)
10	Oleandrigenin glucoside (**229**)	S, R	Yamauchi and Abe (1990a)
11	Oleandrigenin β-D-glucopyranosyl-(1→4)-β-D-cymaroside (hongheloside C) (**230**)	S, R	Yamauchi and Abe (1990a)
12	Digitoxigenin β-D-glucopyranosyl-(1→4)- β-D-thevetoside (obebioside A) (**231**)	S, R	Yamauchi and Abe (1990a); Arai *et al.* (2011)

Table **6**. Cardiac glycosides isolated from the different parts of *Adenium obesum* (Versiani *et al*., 2014)

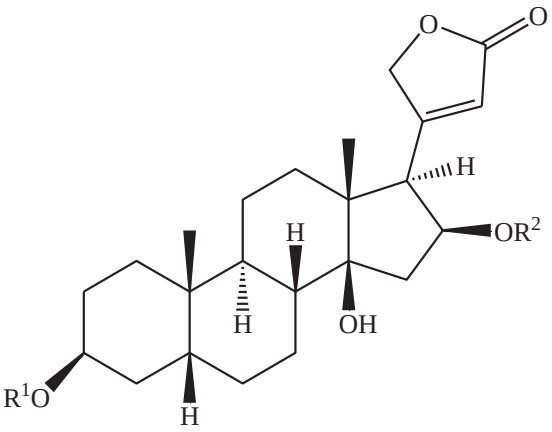
No.	Compounds	Plant part	References
13	Oleandrigcnin β-D-glucopyranosyl-(1→4)- β-D-thevetoside (obebioside B) (**232**)	S, R	Yamauchi and Abe (1990a); Arai *et al.* (2011)
14	Gitoxigcnin β-D-glucopyranosyl-(1→4)- β-D-thevetoside (obebioside C) (**233**)	R.	Yamauchi and Abe (1990a); Arai *et al.* (2011)
15	Δ^{16} -Digitoxigenin β-D-glucopyranosyl-(1→4)- β-D-thevetoside (obebioside D) (**234**)	L, S, R	Yamauchi and Abe (1990a); Arai *et al.* (2011)
16	Digitoxigenin β-D-glucopyranosyl-(1→4)- β-D-digitalosc (odorobioside G) (**235**)	R	Yamauchi and Abe (1990a)
17	Oleandrigenin β-D-glucopyranosyl-(1→4)-β-D-digitalose (**236**)	Ap, S, R	Yamauchi and Abe (1990a); Kiyohara *et al.* (2012)
18	Gitoxigenin β-D-glucopyranosyl-(1→4)-β-D-digitalose (**237**)	R	Yamauchi and Abe (1990a)
19	Δ^{16}-Digitoxigenin β-D-glucopyranosyl-(1→4)-β-D-digitalose (**238**)	S, R	Yamauchi and Abe (1990a)
20	Digitoxigenin β-gentiobiosyl β-D-cymaroside (echujin) (**239**)	S, R	Yamauchi and Abe (1990a)
21	Oleandrigenin β-gentiobiosyl β-D-cymaroside (honghelotrioside A) (**240**)	S, R	Yamauchi and Abe (1990a)
22	Δ16-Digitoxigenin β-gentiobiosyl β-D-cymaroside (Δ^{16}-echujin) (**241**)	R	Yamauchi and Abe (1990a)
23	Digitoxigenin β-gentiobiosyl(1→4)-β-thevotoside (obetrioside A) (**242**)	S, R	Yamauchi and Abe (1990a)
24	Oleandrigenin b-gentiobiosyl(1→4)-β-D-thevotoside (obetrioside B) (**243**)	S, R	Yamauchi and Abe (1990a)

Table **6**. Cardiac glycosides isolated from the different parts of *Adenium obesum* (cont.)
(Versiani *et al*., 2014)

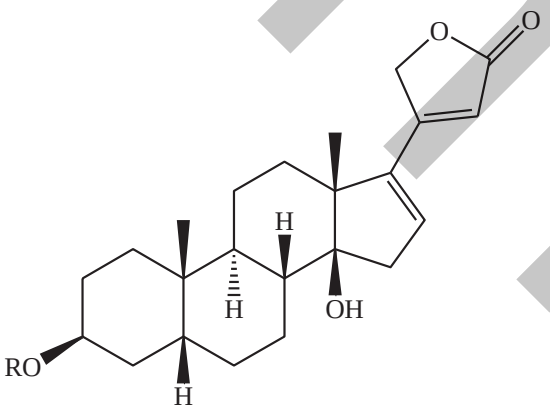
No.	Compound class and name	Plant part	References
25	Digitoxigenin β-gentiobiosyl-β-D-digitaloside (odoroside G) (**244**)	S, R	Yamauchi and Abe (1990a)
26	Oleandrigenin β-gentiobiosyl-β-D-digitaloside (16-*O*-acetylneogitostin) (**245**)	S, R	Yamauchi and Abe (1990a)
27	Oleandrigenin 2'-*O*-acetyl β-D-thevetoside (2'-*O*-acetylobeside B) (**246**)	R, L	Yamauchi and Abe (1990b); Arai *et al.* (2011)
28	Digitoxigenin 2'-*O*-acetyl β-D-thevetoside (2'-*O*-acetylhonghelin) (**247**)	R, L	Yamauchi and Abe (1990b); Arai *et al.* (2011)
29	Oleandrigenin β-D-glucopyranosyl-(1→4)-2'-*O*-acetyl-β-D-thevetoside (**248**)	S, R	Yamauchi and Abe (1990b)
30	Digitoxigenin β-D-glucopyranosyl-(1→4)-2'-*O*-acetyl-β-D-thevetoside (**249**)	S, R	Yamauchi and Abe (1990b)
31	Digitoxigenin (3β,14-dihydroxy-5β-card-20(22)-enolide) (**250**)	L	Arai *et al.* (2011)
32	Gitoxigenin β-D-sarmentoside (**251**)	L	Arai *et al.* (2011)
33	16-Formylgitoxigenin β-D-sarmentoside (**252**)	L	Arai *et al.* (2011)
34	Oleandrigenin β-D-sarmentoside (**253**)	L	Arai *et al.* (2011)
35	Digitoxigenin β-D-sarmentoside (**254**)	L	Arai *et al.* (2011)
36	16-Formylgitoxigenin β-D-thevetoside (**255**)	L	Arai *et al.* (2011)
37	Digitoxigenin β-D-digitaloside (odoroside H) (**256**)	L	Arai *et al.* (2011)
38	Gitoxigenin β-D-glucopyranosyl-(1→4)-β-D-thevetoside (**257**)	S, R	Yamauchi and Abe (1990a)
39	Canariengenin β-D-glucopyranosyl-(1→4)-β-D-thevetoside (**258**)	L	Arai *et al.* (2011)
40	Δ^{16}-3-Acetyldigitoxigenin (16-anhydro-3-acetylgitoxigenin) (**259**)	S	Vethaviyasar and John (1982)



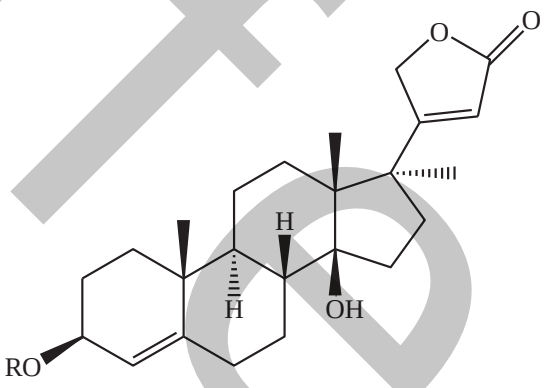
220 R= a **223** R= d
231 R= e **235** R= h
239 R= c **242** R= f
244 R= i **247** R= j
249 R= l **250** R= h
254 R= k **256** R= g



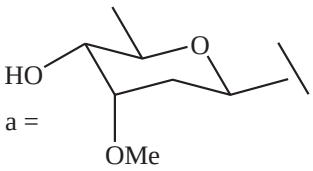
221 R^1=a, R^2=Ac **222** R^1=g, R^2=Ac
225 R^1=d, R^2=Ac **226** R^1=d, R^2=H
228 R^1=g, R^2=H **229** R^1=Glc, R^2=Ac
230 R^1=b, R^2=Ac **232** R^1=e, R^2=Ac
233 R^1=e, R^2=H **236** R^1=h, R^2=Ac
237 R^1=h, R^2=H **240** R^1=c, R^2=Ac
243 R^1=f, R^2=Ac **245** R^1=i, R^2=Ac
246 R^1=j, R^2=Ac **248** R^1=l, R^2=Ac
251 R^1=k, R^2=H **252** R^1=k, R^2=HC(O)
253 R^1=k, R^2=Ac **255** R^1=k, R^2=HC(O)
257 R^1=e, R^2=H



224 R=a **227** R=b
234 R=e **238** R=h
241 R=c



258 R=e



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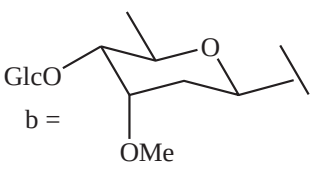

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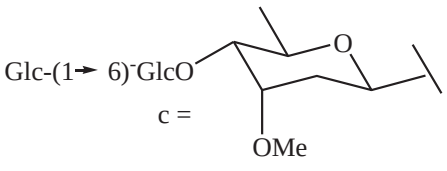

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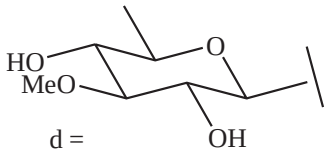

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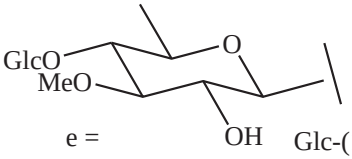

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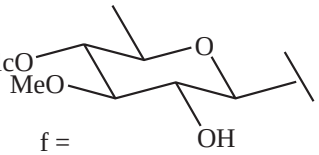

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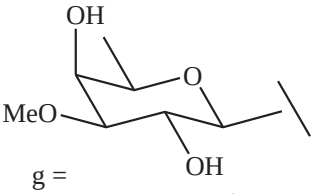

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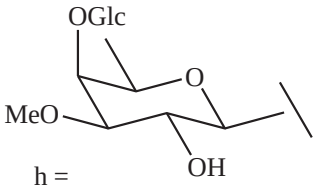

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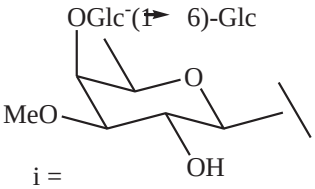
OGlc-(1→6)-Glc



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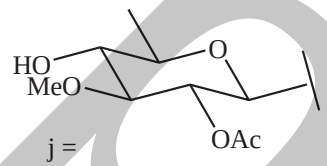

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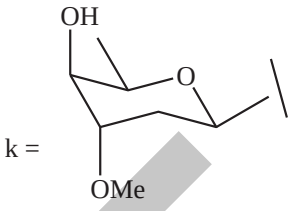

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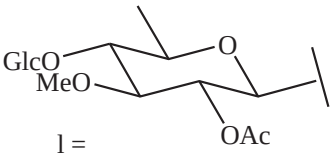

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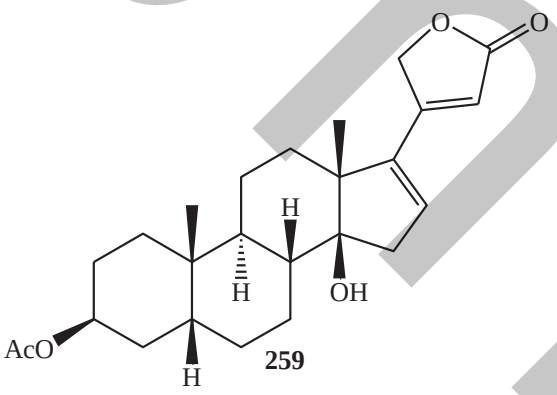

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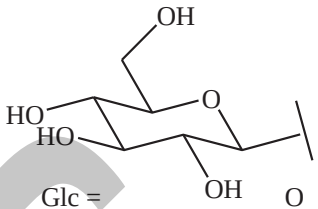

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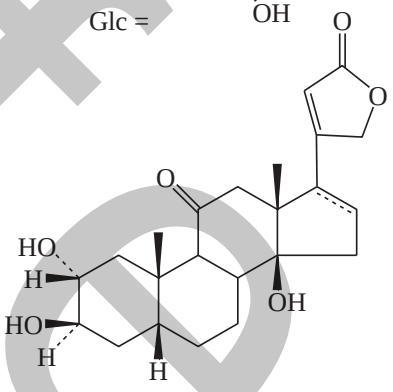
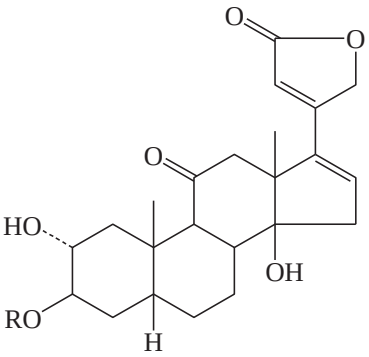


260 Affinogenin C



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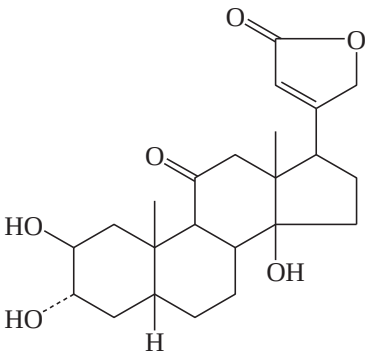
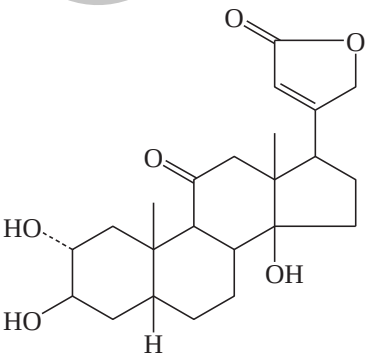
261 Affinogennin D-I

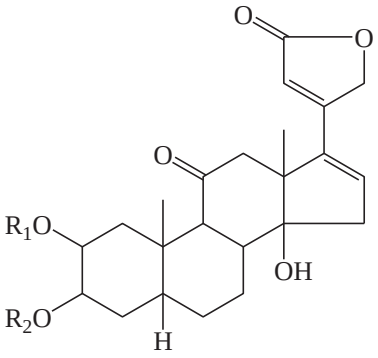


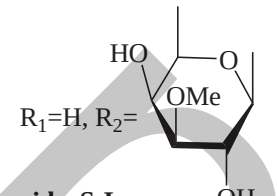
263 Affinogenin D-III



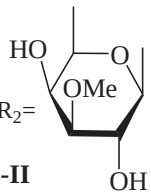
265 Affinogenin D-V

262 Affinogenin D-II R_1=R_2=H
264 Affinogenin D-VI R_1=H, R_2=Ac
270 Affinogenin S-V
R_1=β-D-glocopyranosyl, R_2=H
271 Affinogenin S-VI
R_2=β-D-glocopyranosyl, R_1=H

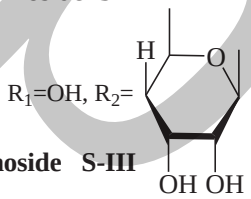




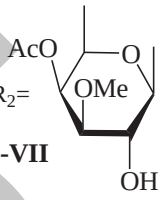
266 Affinoside S-I



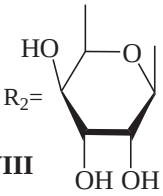
267 Affinoside S-II



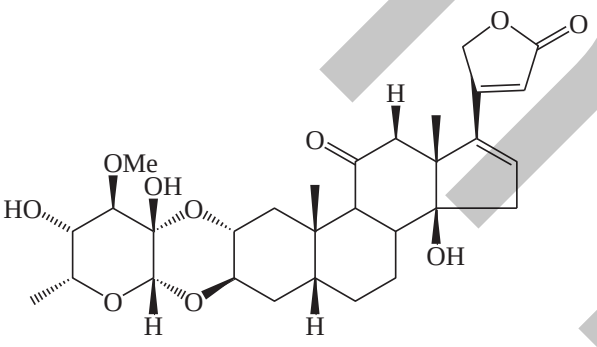
268 Affinoside S-III



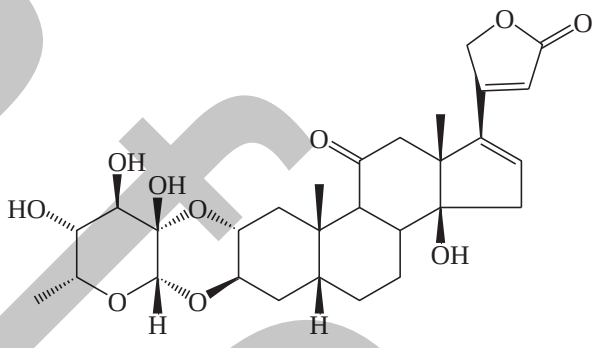
272 Affinoside S-VII



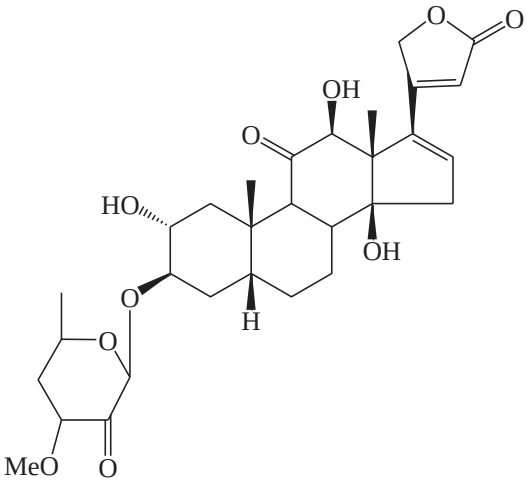
273 Affinoside S-VIII



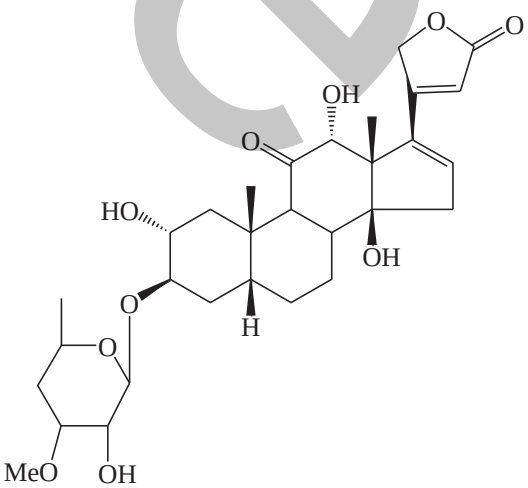
274 Affinoside La



275 Affinoside Le



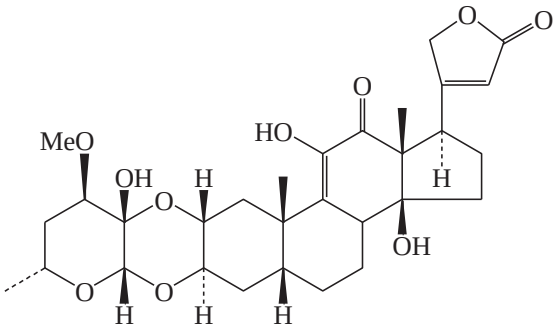
276 Affinoside O



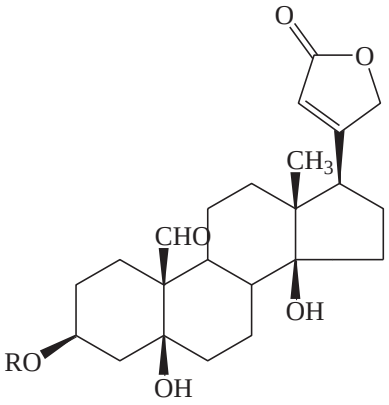
277 Affinoside N

c. Stems and bark: Affinosides A, C, D, E, F, G, H and J, were isolated from the stem and bark. Affinoside B (**278**) and others (Yamauchi *et al*., 1979b).
d. Seeds: Affinoside A, 3'-*epi*-affinoside A, (affinoside M), 3'-demethylaffinoside A (affinoside K) (Abe and Yamauchi, 19885a), affinosides P-T, and others (Hanada *et al*., 1992a).

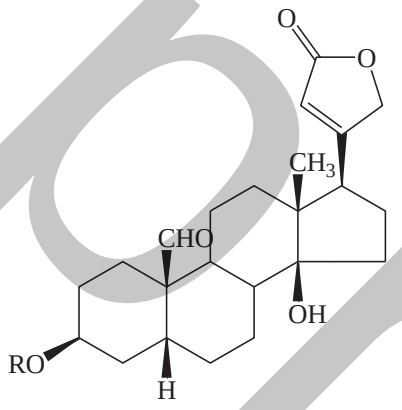
20. *Anodendron paniculatum* (Roxb.) A. DC.: Anodendrosides A-G (glycosides containing unusual sugars) from the wood (Polonia *et al*., 1970; Lichti *et al.*, 1972).
21. *Aouia nitida* (*Thevetia nitida*): Cerberoside, monoacetylcerberoside, cerberin and monoacetylcerebrin from the seeds (Seelkopf, 1974).
22. *Apocynum androsaemifolium*: *k*-Strophanthi and apobioside (cannogenin-(3)-β-D-cymaropyranosyl-(4)-β-D-glucopyranoside) from the roots (Abubakirov and Yamatova, 1960a,b; Yamatova and Abubakirov, 1965; Borikhina and Guseva, 1972. The seed contained 0.40% glycosides (Khodzhaev *et al*., 1968).
23. *Apocynum cannabinum* L.*:* The roots contain apocannoside, strophanthidin (**279**), cannogenin (**280**), cannogenol (**281**), cymarin (**282**, β-D-cymaroside), helveticoside (**283**, β-D-digitoxoside), *k*-strophanthin-β (**284**, β-D-glucosyl-β-D-cymaroside), apocannoside (**285**, β-D-cymaroside), cynocannoside (**286**, β-D-oleandroside), apobioside (**287**, β-D-glucosyl-β-D-cymaroside), cannogenin β-D-glucosyl-β-D-digitaloside (**288**), cannogenin β-cellobiosyl-β-D-cymaroside (**289**), cannogenin β-cellobiosyl-β-D-oleandroside (**290**), cannogenin β-gentiobiosyl-β-D-cymaroside (**291**), cannogenol-β-D-glucosyl-β-D-cymaroside (**292**), (20*S*) and (20*R*)-isomers of 18,20-epoxycymarin (**293**, **294**) and (20*S*)-18,20-epoxycannogenin-β-D-cymaroside (**295**) (Zaitseva and Feofilkatov, 1950, Trabert, 1960a; Kupchan *et al*. 1964; Gerlach *et al*., 1965; Kiselev *et al*., 1975; Abe and Yamauchi, 1994a).
24. *Apocynum lancifolium*: Cymarin (cimarin), strophanthidin and *k*-strophanthin-β from the rizomes and seeds (Hsu and Sun, 1966; Murzagaliev and Tegisbaev, 1975).
25. *Apocynum pictum*: Cimarin and *k*-strophanthin-β from the seeds (Murzagaliev and Tegisbaev, 1975).
26. *Apocynum venetum* L. var. *basikurumon* Hara: Strophanthidin glycosides, basikuloside (strophanthidin 3-*O*-β-D-glucosyl-β-D-cymaroside), apobasinoside, cellostrophanthoside (β-cellbiosyl-cymarin), strophanthidin β-D-digitaloside, strophandin and strophanthidin glucoside from the roots (Abe *et al*., 1988b).
27. *Beaumontia brevituba*: Gentiobiosyl-β-D-cymaroside and gentiobiosyl-α-L-cymaroside of digitoxigenin from the seeds, unripe fruits and leaves; oleandrigenin and /or Δ^{16}-digitoxigenin glycosides from the seeds (Yamauchi *et al*., 1990a) and five cardenolides, digitoxigenin, oleandrigenin, digitoxigenin α-L-cymaroside, digitoxigenin β-gentiobiosyl-α-L-cymaroside, and Δ^{16}-digitoxigenin β-D-glucosyl-α-L-cymaroside from the stems (Kaneda *et al*., 1992).
28. *Beaumontia grandiflora* Wall.: The seeds contain beaumontoside (digitoxigenin-α-L-oleandroside), oleandrin, beauwalloside (oleandrigenin-α-L-cymaroside), wallichoside (digitoxigenin-α-L-cymaroside) and 2 genins digitoxigenin and oleandrigenin (Krasso *et al*., 1963, 1964). The leaves and branches contain digitoxigenin (Kanchanapoom *et al*., 2002). Highest contents of cardenolides were found in flowers (0.48%) followed by leaves (0.312%), flower buds (0.12%), wood (0.1%), and bark (0.038%) of the plant cultivated in Egypt. The cardenolide content revealed a maximum in the leaves at flowering and then decreased to a minimum at the end of the flowering season. The cardenolide content varied with the cultivation site (Sayed *et al*., 1977).



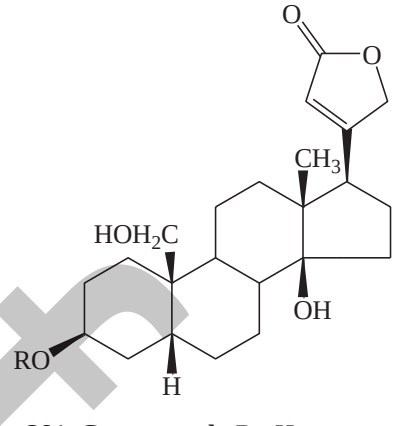
278 Affinoside B



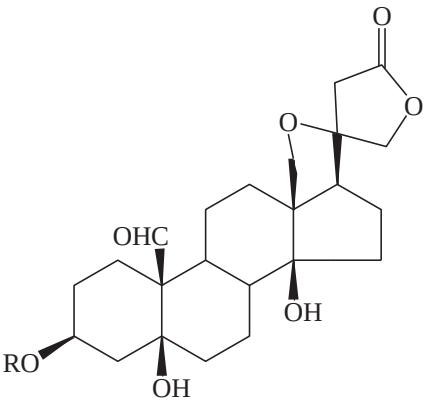
279 Strophanthidin R=H
282 Cymarin R=e
283 Helveticoside R=a
284 K-Strophanthin -β R=f



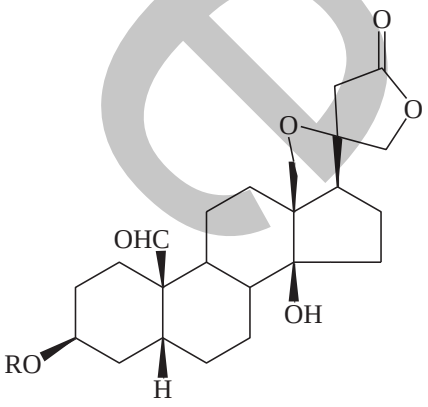
280 Cannogenin R=H
285 Apocannoside R=e
286 Cynocannoside R=b
287 Apobioside R=f
288 Cannogenin-β-D-digitaloside R=d
289 Cannogenin-β-cellobiosyl -β- D-cymaroside R=g
290 Cannogenin-β-cellobiosyl -β-D-oleandroside R=c
291 Cannogenin-β-gentiobiosyl -β-D-cymaroside R=h



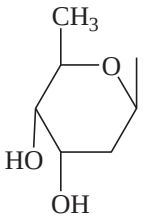
281 Cannogenol R= H
292 Cannogenol -β-D-glucosyl -β -D-cymaroside R= f



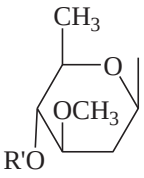
293 R=e (20 *S*)
294 R=e (20 *R*)



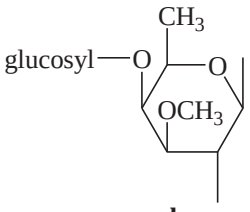
295 R=e (20 *S*)



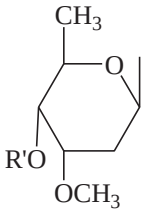
a: β-D-digitoxose



b: R'=H (β- D-oleandrose)
c: R'=β-cellobiosyl

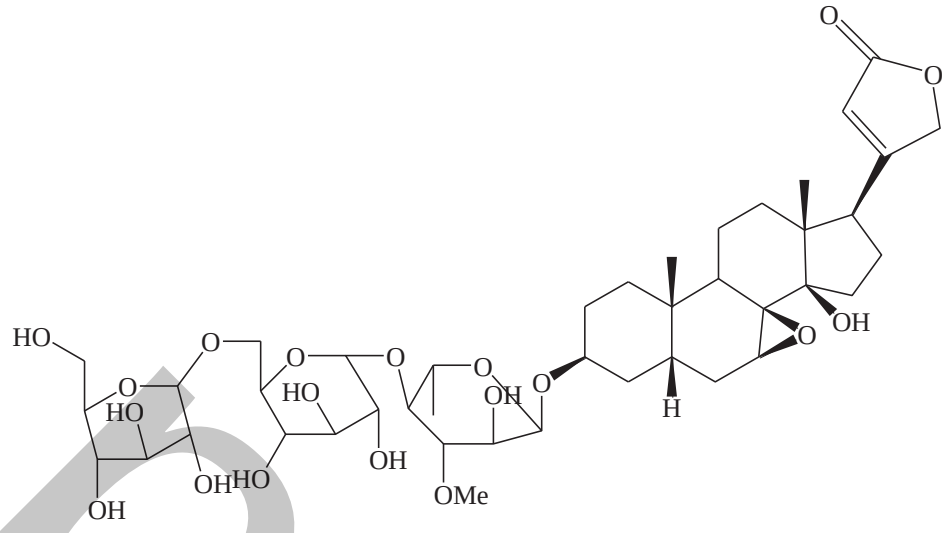


d

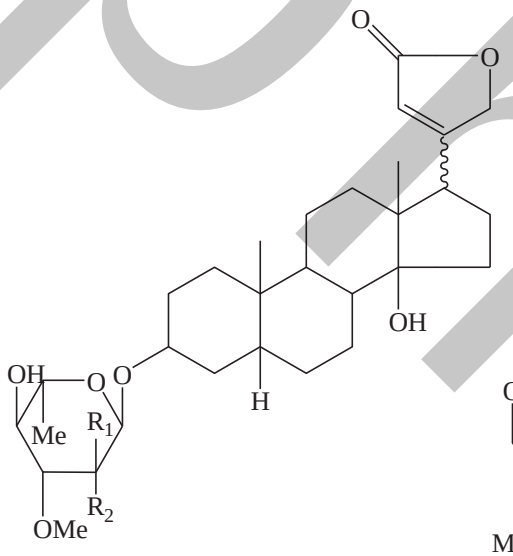


e: R'=H (β-D-cymarose)
f: R'= β-D-glucosyl
g: R'=β-cellobiosyl
h: R'=β-gentiobiosyl

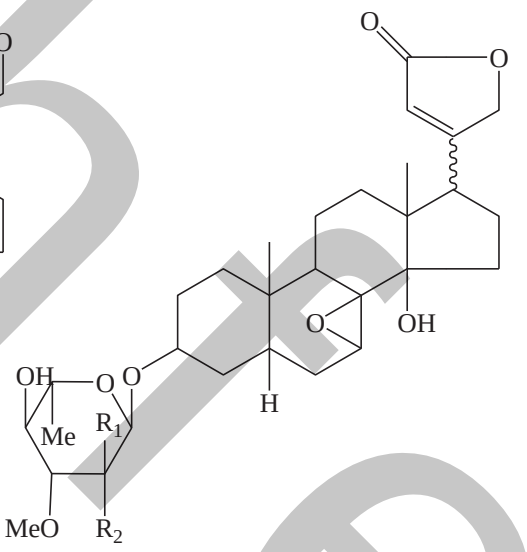
29. *Beaumontia murtonii*: Gentiobiosyl-β-D-cymaroside and gentiobiosyl-α-L-cymaroside of digitoxigenin, oleandrigenin and / or Δ^{16}-digitoxigenin glycosides having the same sugar moieties from the leaves (Yamauchi *et al*., 1990a).
30. *Cerbera dilatata*: Cerbertatin and cerbertin (mono-*O*-acetyl-L-thevetoside of 11β,12β-epoxy-digitoxigenin) and from the seed kernels (Cable *et al*., 1964) (Cable *et. al*., 1965).
31. *Cerbera floribunda*: Cerbertin and cerbertatin from the seed kernels (Cable *et al*., 1964).
32. *Cerbera manghas* L. (Sea mango): From the seeds, tanghinigenin glycoside (**296**) was isolated along with cerberin, neriifolin, thevetin B (Bloch *et al*., 1960) and 2'-*O*-acetyl thevetin B. From the barks of root and stem, gentiobiosyl thevetoside, glucosyl thevetoside, and thevetosides of tanghinigenin and 17β*H*-tanghinigenin were obtained (Abe and Yamauchi, 1977). Neriifolin (**297**), 17α-neriifolin (**298**), deacetyltanghinin (**299**), 17α-deacetyltanghinin (**300**), and six monosides: cerleaside A (**301**), cerdollaside (**302**), 17α-cerdollaside (**303**), solanoside (**304**), 17α-solanoside (**305**) and tanghinigenin α-L-acofrioside (**306**), oleagenin glucosyl-thevetoside (cerleaside B, I), digitoxigenin gentiotriosyl-thevetoside, glucosyl-thevetosides of digitoxigenin and tanghinigenin (Yamauchi *et al*., 1987a,b) (**307**- **316**), cerberin, neriifolin and cerleaside A (Zhang *et al*., 2010c) from the leaves. 17α-Digitoxigenin and apiosyl-glucosyl-thevetoside and cellobiosyl-thevetoside from the stems (Yamauchi *et al*., 1987c). 7,8-Dehydrocerberin (**317**), 17β-neriifolin (**318**), deacetyltanghinin (**319**), tanghinin (**320**), cerberin (**321**), 2'-*O*-acetyl cerleaside A (**322**) (Cheepracha *et al*., 2004) and tanghinigenin (Wang *et al*., 2010a) from the seeds.Three cardenolides, including (−)-17β-neriifolin from the roots (Chang *et al*., 2000). 17-β-Neriifolin and cerberin from the fruits (Cao *et al*., 2013a). A seed of the fresh unripe fruit had concntrations of 49.4, 47.0, 3.5 and 2.3 µg/g (Carlier *et al*., 2014). Viridoside was isolated from the cortex (Zhang *et al*., 2008).
33. *Cerbera odollam*: Cerberin, cerberoside, monoacetylthevetin B, thevetin B (**323**), their 7,8-epoxide derivatives and others from the kernels (Chen and Steldt, 1942; Rangaswami and Rao, 1957; Rao *et al*., 1974; Rao and Rao, 1976; Li *et al*., 1981; Nguyen *et al*., (1993). Oleagenin glucosyl-thevetoside (Cerleaside B, **324**), digitoxigenin gentiotriosyl-thevetoside and others from the leaves (Yamauchi *et al*., 1987a,b). Cerleaside A, 3β-*O*-(2′-*O*-acetyl-l- thevetosyl)-15(14→8)-*abeo*-5β-(8*R*)-14-oxo-card-20(22)-enolide (**322**, 2′-*O*-acetyl cerleaside A), 17α-neriifolin, 17β- neriifolin and cerberin, from the seeds (Laphookhieo *et al*., 2004). The cardenolide content of the plant growing in Egypt, was highest in the leaves, followed by flowers, roots and bark. The wood contained the least amount (Mahran *et al*., 1972). Neriifolin and thevetin B were isolated from leaves, stems, roots, and flowers of the plant growing in Egypt (Mahran *et al*., 1975a).
34. *Cerbera thevetia* (yellow oleander): Cerberin and and thevetin (Pitchandi, 1948; Tewari *et al*., 1971).



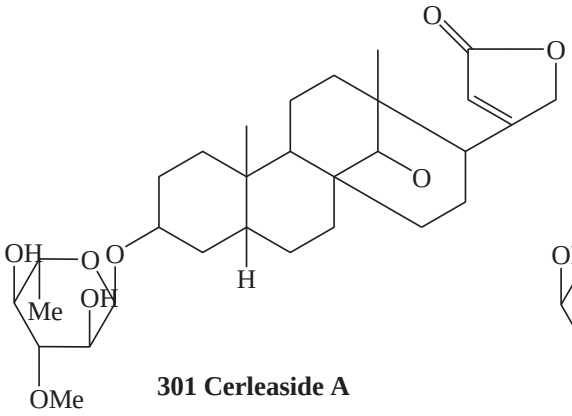
296 Tanghinigenin.



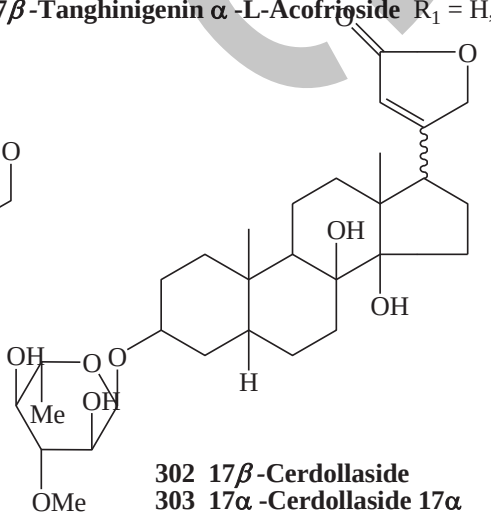
297 17β-Neriifolin R_1 = OH, R_2= H
298 17α -Neriifolin R_1 = OH, R_2= H
304 17β - Cerdollaside R_1 = H, R_2= OH
305 17α -Solanoside R_1 = OH, R_2= OH



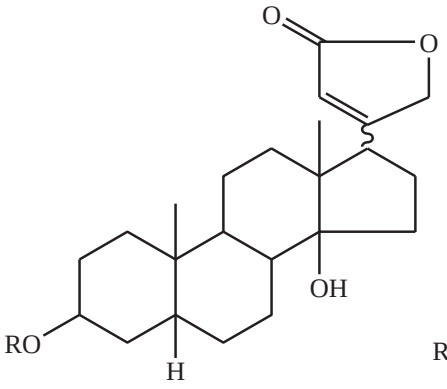
299 17β-Deacetyltanghinin R_1 = OH, R_2= H
300 17α -Deacetyltanghinin R_1 = OH, R_2= H
306 17β-Tanghinigenin α -L-Acofrioside R_1 = H, R_2= OH



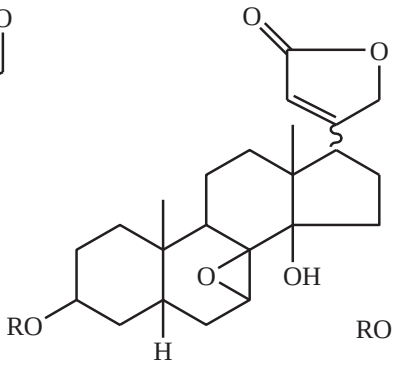
301 Cerleaside A



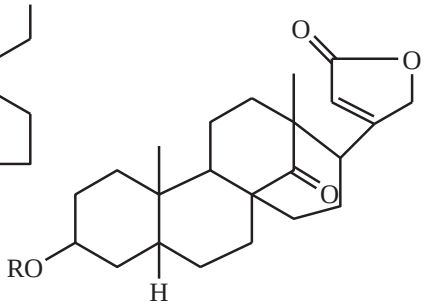
302 17β-Cerdollaside
303 17α -Cerdollaside 17α



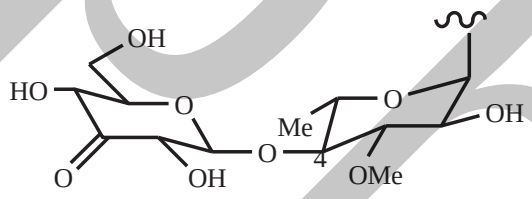
307: 17α, R=a
310: 17*β*, R=c
311: 17*β*, R=b
312: 17α, R=b
315: 17*β*, R=b



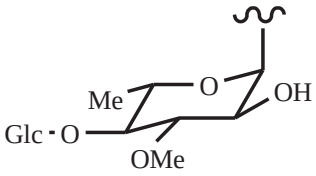
308: 17α, R=a
313: 17*β*, R=b
314: 17α, R=b
316: 17***B***, R=d



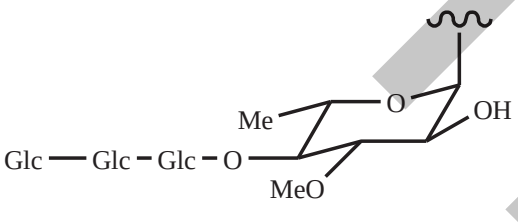
309: R=b



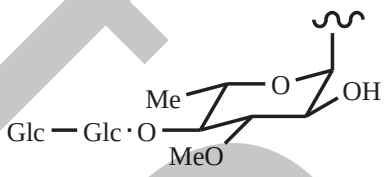
a



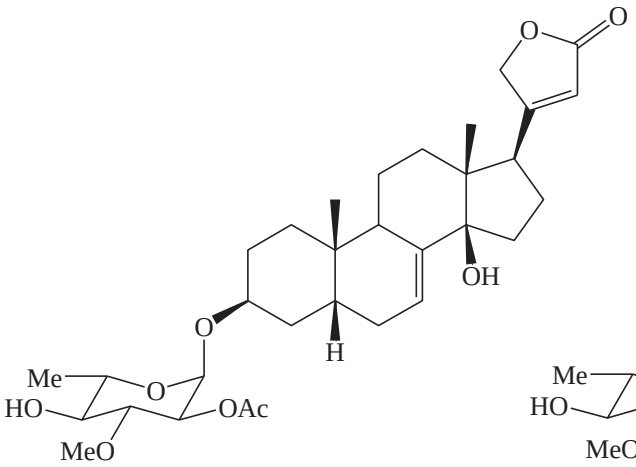
b



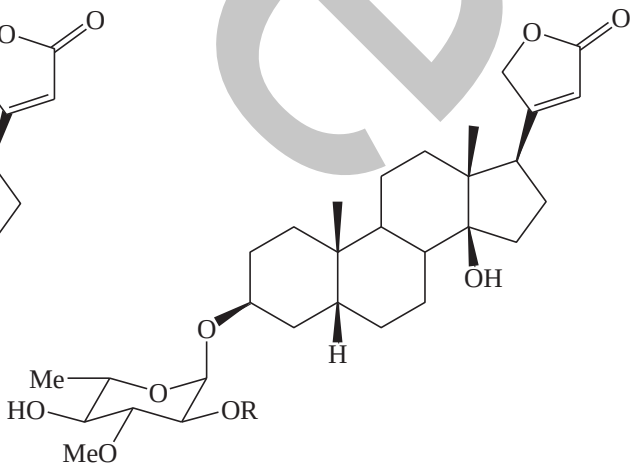
c



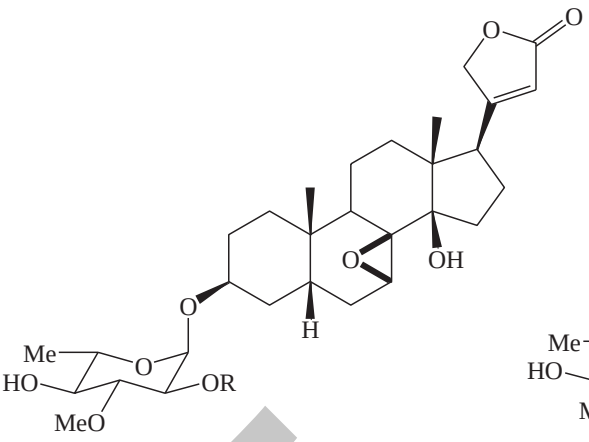
d



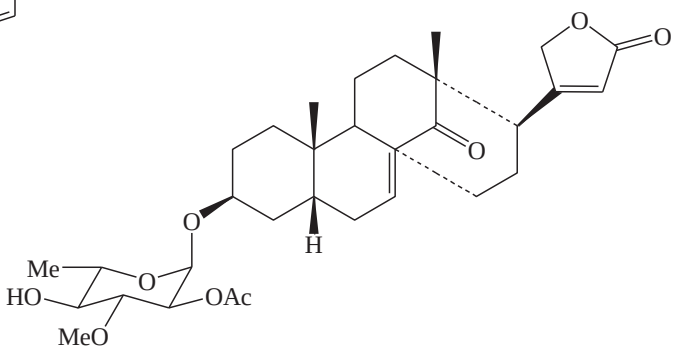
317 7,8-Dehydrocerberin



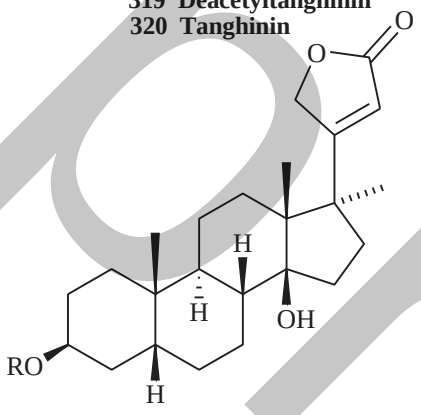
318 17β-Neriifolin R=H
321 Cerberin R=Ac



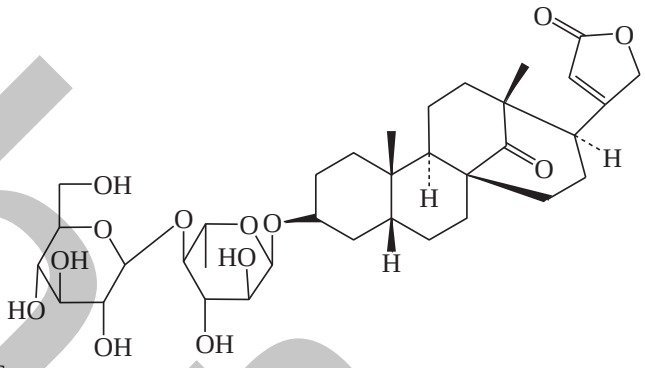
319 Deacetyltanghinin
320 Tanghinin



322 2'-*O*-Acetyl cerleaside



323 Thevetin B R=[β-D-glu (1→6) β-D-gluc-(1→4)-6deoxy 3-*O*–methyl α–Lgluc]

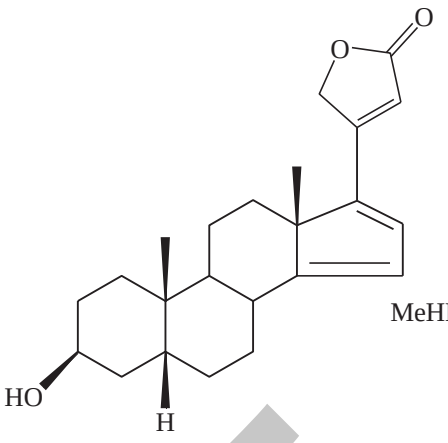


324 Cerleaside B

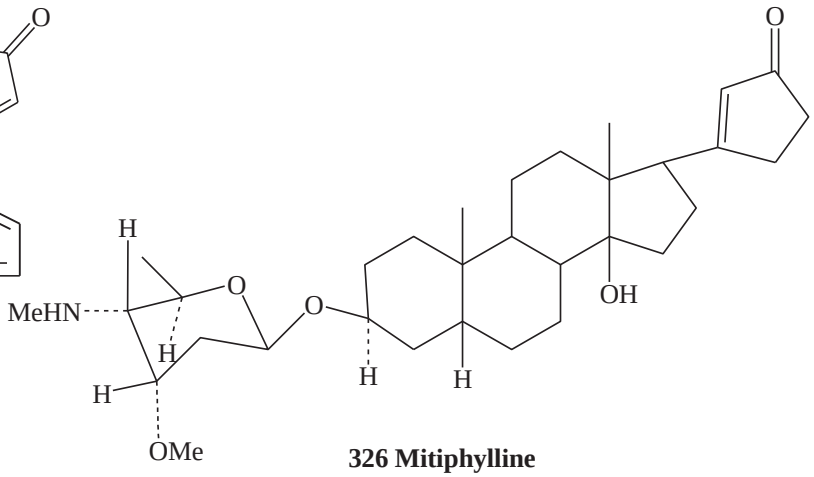
35. *Cerberiopsis candelabrum* Viell. ex Panch. and Seb: Digitonoside, two digitalic glycosides (cerberiopsin I and cerberiopsin II) and candelabrin (Frerejacque, 1970; Frerejacque and Durgeat, 1972, 1973) from the seeds.
36. *Elytropus chilensis*: Two genins, dianhydrogitoxigenin (**325**) and β-anhydrogitoxingenin, artifact produced in the acid hydrolysis) (Castro *et al*., 1980).
37. *Holarrhena mitis*: Mitiphylline (**326**, an 3-aminoglucopyranosyl cardenolide) from the leaves (Janot *et al*., 1968b).
38. *Laseguea erecta*: Digitoxigenin α-L-thevetoside from the stems (Geraldo de Carvalho *et al.*, 2006).
39. *Mandevilla pentlandiana*: From the roots, Thirteen cardenolide-type compounds and free aglycones digitoxigenin and oleandrigenin from the roots (Cabrera *et al*., 1993a).
40. *Melodinus fusiformis*: Oleanderolide from the leaves and seeds (Wang *et al*., 2012a).
41. *Melodinus monogynus*: Jaintigenin, pisigenin, medigenin, digitoxigenin, harinin, jaintin, medinin, gynin, and pisidin from the roots (Bhatnagar and Khare, 1966, 1968).
42. *Nerium indicum* L.: Oleandrin, odoroside H, oleandrigenin 3-*O*-α-L-rhamnopyranoside, uzarigenin and others from the different parts (Lin *et al*., 1975; Mae *et al.*, 2000; Saxena and Albert, 2005; Hasegawa *et al.*, 2007; Wang *et al*., 2009a).
43. *Nerium odorum* L.: Many cardenolides have been isolated from the leaves, bark and seeds e.g. odorosides B, E, H, K-M (Rittel *et al.*, 1953; Satyanarayana *et al*.,1975), oleandrigenin β-gentiobiosyl-(1→4)-β-D-digitaloside (Yamauchi *et al.*, 1976), uzarigenin β-D-digitaloside, uzarigenin 4'-*O*-β-D-glucosyl-β-D-digitaloside, neriumosides A-1, A-2, B-1, B-2 and C-1 (Yamauchi, 1985), yellow pigments with 21-hydroxy-cardenolide

frame work, neriaside (a diginoside of 8,14-*seco*-cardenolide) (Yamauchi and Abe, 1978), digitoxigenin β-gentiotriosyl-(1→4)-β-d-digitaloside, uzarigenin β-gentiobiosyl-(1→4)-β-d-digitaloside, 5α-oleandrigenin glycosides, 40 cardenolide ingredients (Hanada *et al*., 1992c), oleandrin, 16-anhydrogitoxigenin acetate, (Ishidate and Tamura, 1950; Okada, 1953; Matsukuma, 1958), oleandrigenin-β-D-glucosyl-β-D-diginioside, β-gentiobiosyl-α-L-oleandroside (Yamauchi *et al*., 1975), digitoxigenin α-L-oleandroside, 5α-adynerin (Abe and Yamauchi, 1978a), Δ^{16}-adynerin, Δ^{16}-adynerigenin-β-D-digitaloside, 5α-adynerin, neriaside, oleasides A-F, glucosyl-nerigoside, glucosyl-adynerin, gentiobiosyl-odoroside A, gentiobiosyl-olrandrin, gentiobiosyl-neriaside (Yamauchi, 1985) and others (Yamauchi and Ehara, 1972; Abe and Yamauchi, 1992b; Yamauchi *et al*., 1973; Abe and Yamauchi, 1978b). Maximum glycoside content in the leaves was found during the flowering period (June-July) (Guseinova and Ragimov, 1963).

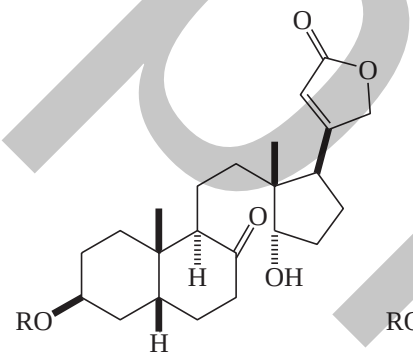
44. *Nerium oleander* L. (oleander): The plant has been shown to have a digitalis-like action and has been regarded as intermediate between *Digitalis* and *Strophanthus* (Rizk and Al-Nowaihi, 1989). The effect is due to the presence of cardiac glycosides. 3β-*O*-[β-D-Glucopyranosyl-(1→4)-β-D-diginopyranosyl]-14α-hydroxy-8-oxo-8,14-*sec*-5β-card-20(22)-enolide (**327**) together with ten cardenolide diglycosides (**328- 337**) were isolated from the air dried leaves (Zhao *et al*., 2011a). Many cardenolides were identified from the different parts (leaves, seeds, stems, roots, flowers and twigs) e.g. oleandrin (**338**), oleandrin glycosides, deacetyloleandrin, adynerin (**339**), neriantin, neritaloside, odoroside-A (**340**), odoroside H (**341**), urechitoxin, strospeside, cortenerin, cornerin, foliandrin, neriin, folinerin and oleandigoside (Varlakov, 1940; Shass, 1941; Schindel and Braun, 1944; Pearson, 1948; Goerlich, 1954, 1961; Tschesche and Grimmer, 1954; Fauconnet and Pouly, 1962; Tschesche *et al*., 1964a; Basilico, 1966; Voicu *et al*., 1971; Fayez and Negm, 1973; Karawya *et al*., 1973b; Siddiqui *et al*., 1997, 2012; Zhao *et al*., 2011a), cardenolides with an unusual framework *viz*. oleasides A-F (**342**, **343**) (Abe and Yamauchi, 1979; Rizk and Al-Nowaihi, 1989). The leaves contain also kaneroside (**344**), neriumoside (**345**) (Siddiqui *et al*., 1986b), neridiginoside (**346)**, nerizoside, neritaloside (Begum *et al*., 1999), neristigmol, dehydroadynerizoside (Siddiqui *et al*., 2006), oleandigoside (Siddiqui *et al*., 2012), cardenolides N-1 (**347**), N-2, N-3, N-4, seven cardenolide monoglycosides (Zhao *et al*, 2007a), cardenolide B-3 (3β-O-[β-D-glucopyranosyl-(1→6)-β-D-glucopyranosyl-(1→4)-β-D-diginopyranosyl]-7β,8-epoxy-14-hydroxy-5β,14β-card-20(22)-enolide (Bai *et al*., 2009), polar cardenolide monoglycosides, (**348**, **349**, **351- 360**), oleagenin (**350**) (Bai *et al*., 2010, 2011a), sixteen cardenolide triglycosides (**367- 382**) (Bai *et al*., 2011b), 3β-hydroxy-5β-carda-8,14,16, 20(22)- tetraenolide (**383**, neriumogenin β), (Huq *et al*., 1998, 1999a), 3β-hydroxy-5α-carda-14(15),20(22)-dienolide (β-anhydroepidigitoxigenin) (**384**), 3β-*O*-(D-digitalosyl)-21-hydroxy-5β-carda-8.14,16,20(22)-tetraenolide (neriumogenin-A-3β-D-digitaloside) (**385**), proceragenin and neridienone A (Huq *et al*., 1999b) and many others (Jäger *et al*., 1959; Turkovic, 1959a,b; Chiarlo, 1964a; Yamauchi *et al*., 1983). The highest content of cardiac glycosides occur in stem bark (0.96%), followed by leaves (0.63%), flowers (0.55%) and stems (0.50%) of the plant growing in Egypt (Karawya *et al*., 1970b). Seeds (0.589%, red flowered) and roots (0.600%, flowering stage) showed the highest percentage of total cardenolides . The highest amount of oleandrin was found in the leaves (0.182%, flowering) and and of adynerin in the roots (0.178%, flowering) and stems (0.124%, flowering). Fruits and seeds were free of adynerin. Oleandrin, adynerin, and total cardenolids were usually higher at all stages of growth in all organs of the plants having red flowers compared with those with white, and were highest in all plants (except fruit and seed) at the flowering stage (April) (Karawya *et al.*, 1973c).



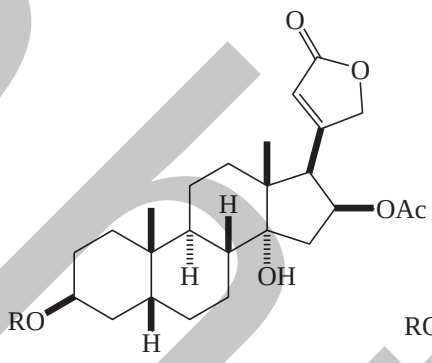
325 Dianhydrogi toxigenin



326 Mitiphylline

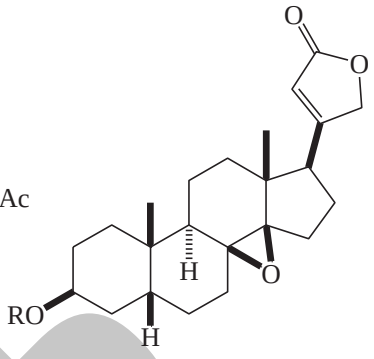


327 R = a_2

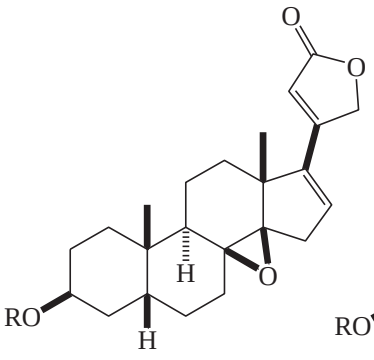


328 R = a_2
329 R = b_2

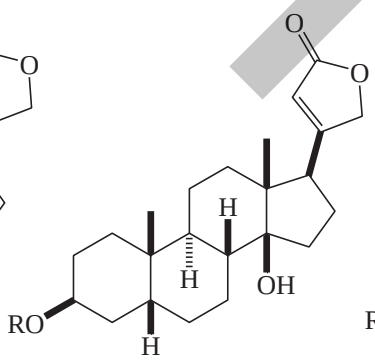
330 R = c_2
331 R = d_2



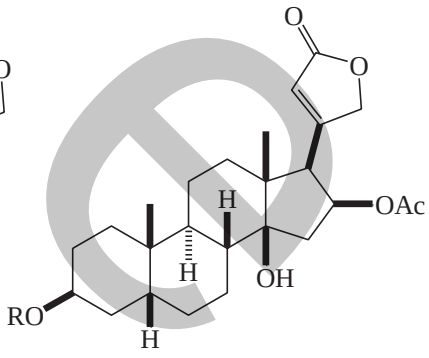
332 R = a_2
333 R = c_2



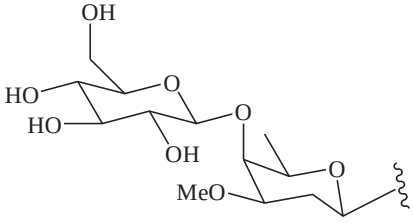
334 R = c_2

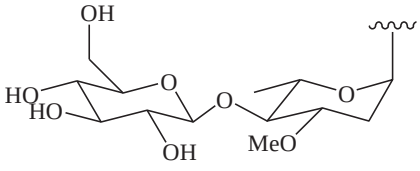


335 R = c_2



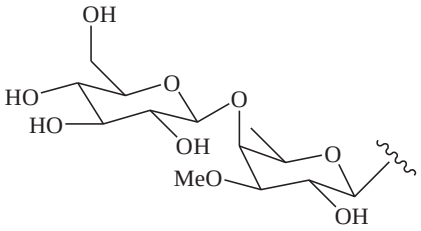
336 R = a_2
337 R = c_2



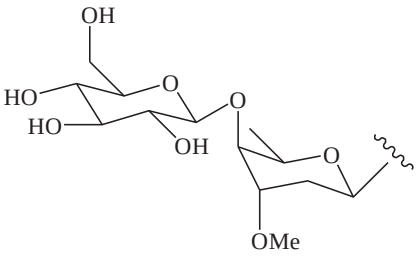


a_2 = *B*-D-glucopyranosyl-(1→ 4)-*B*-D-diginopyranosyl

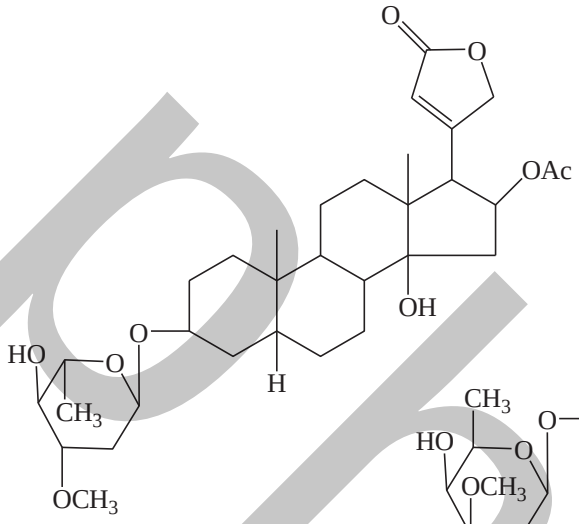
b_2 = *B*-D-glucopyranosyl-(1 →4)-*a*-l-oleandropyranosyl



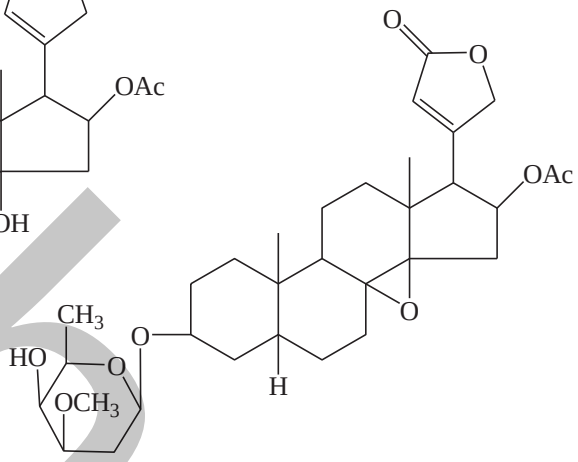
c_2 = *B*-D-glucopyranosyl-(1→4)-*B*-D-digitalopyranosyl



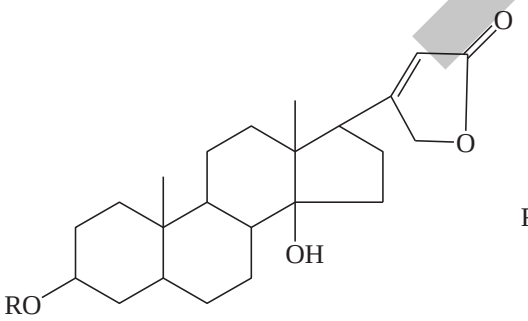
d_2 = *B*-D-glucopyranosyl-(1→4)-*B*-D-sarmentopyranosyl



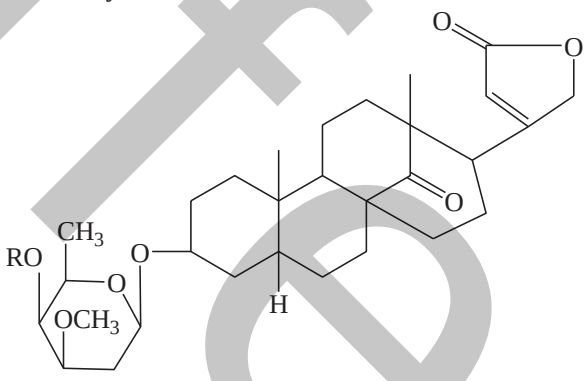
338 Oleandrin



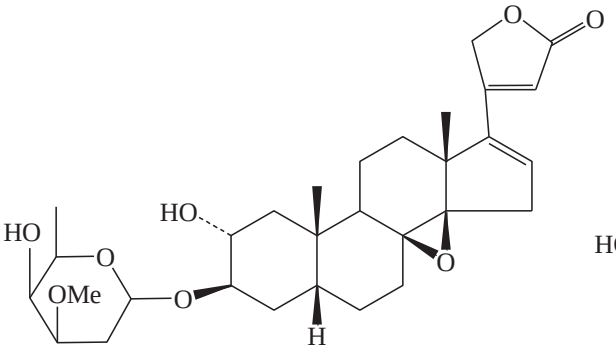
339 Adynerin



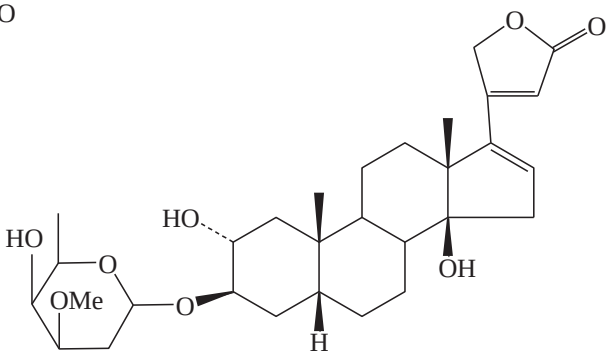
340 Odoroside A R=D-Diginose
341 Odoroside H R=D-Digitalose



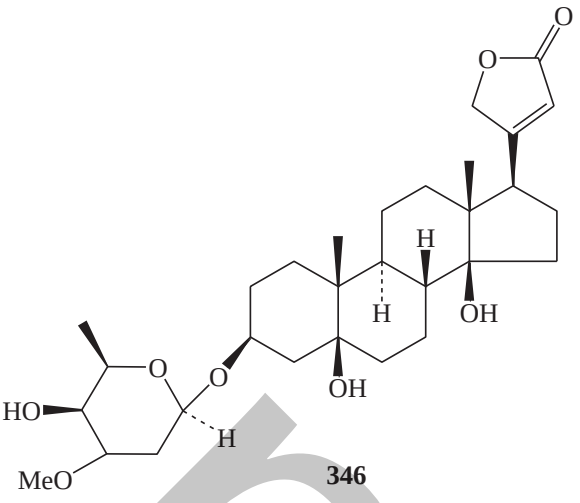
342 Oleaside A R=H
343 Oleaside E R= Gentiobiose



344 Kaneroside



345 Neriumsoide



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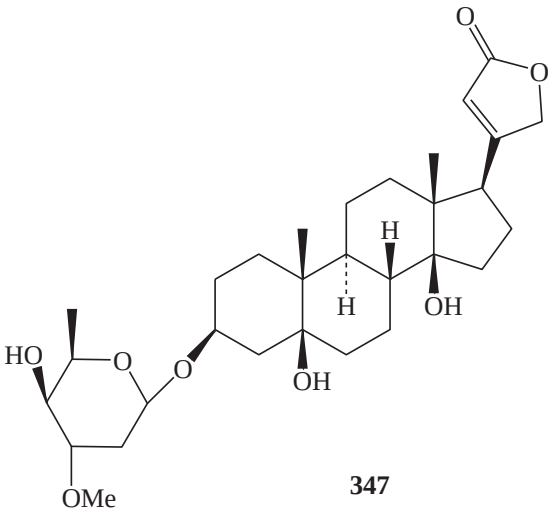

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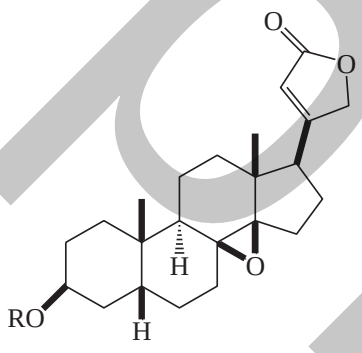
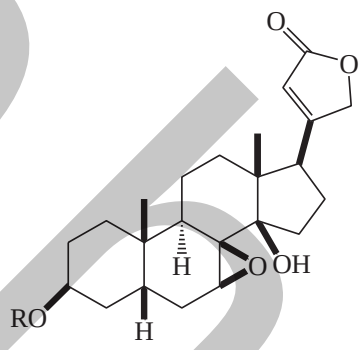
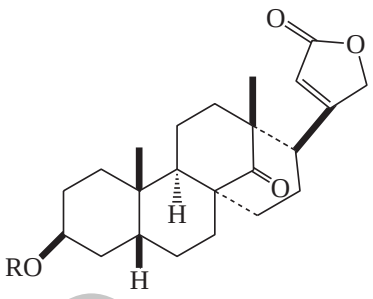


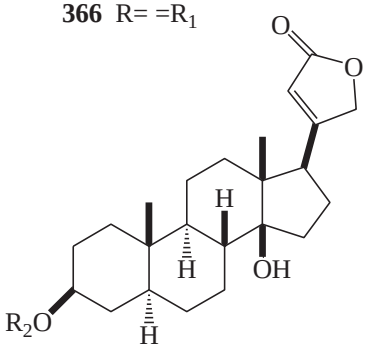
348 R = R_2
366 R= =R_1



349 R =R_1
361 R =H



350 R = H
359 R = R_1



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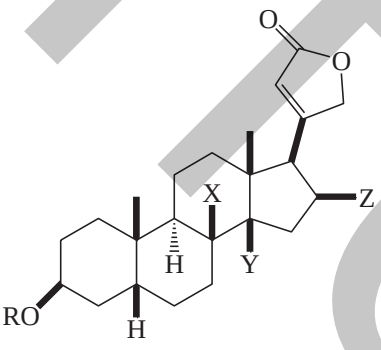
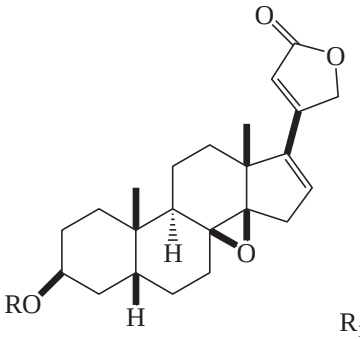
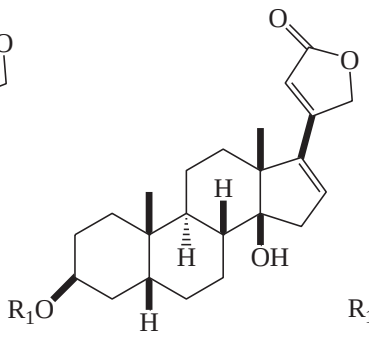


351 R=R_2 X=H Y=OH Z=H
352 R=R_2 X=H Y=OH Z=OAc
353 R=R_3 X=H Y=OH Z=OAc
354 R=R_4 X=H Y=OH Z=OAc
355 R=R_1 X=H Y=OH Z=OH
362 R=R_1 X=OH Y=OH Z=H
363 R=H X=H Y=OH Z=H
364 R=R_1 X=H Y=OH Z=H



357 R = R_2
365 R = R_5



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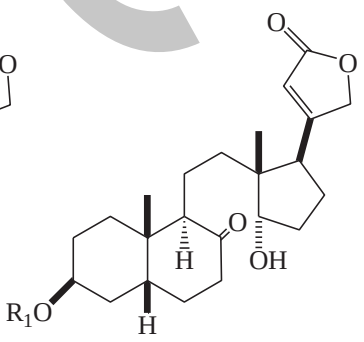
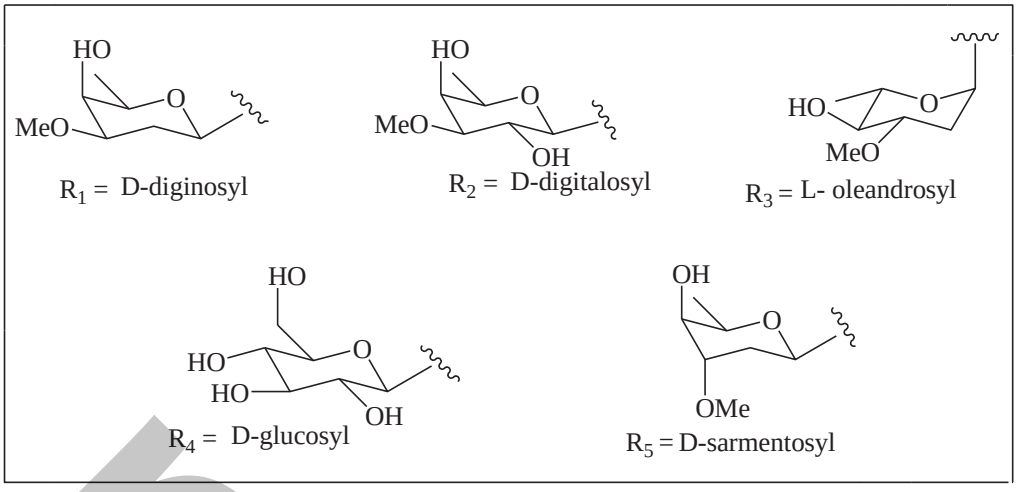
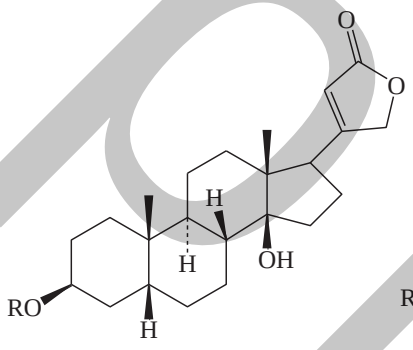


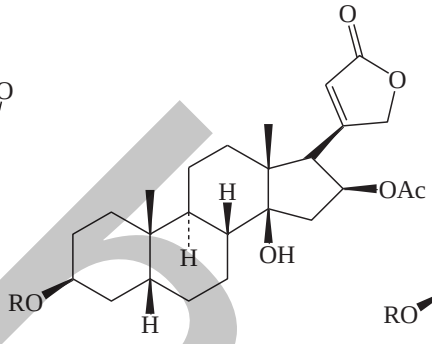
360

R_1, R_2, R_3, R_4 and R_5: see page 87

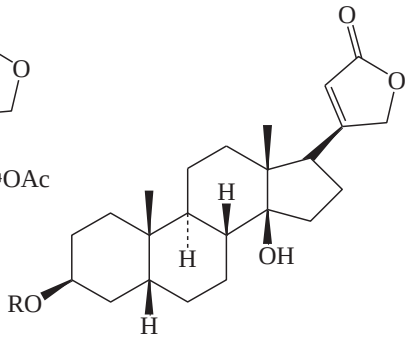




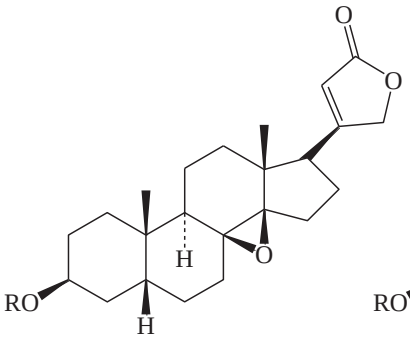
367 R=R_1
368 R=R_2



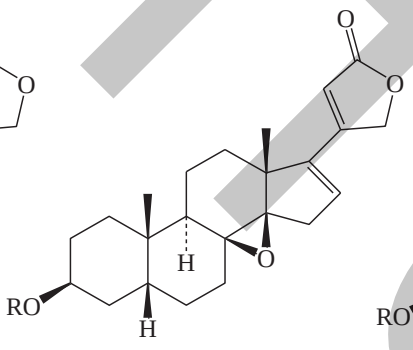
369 R=R_1
370 R=R_2
371 R=R_3



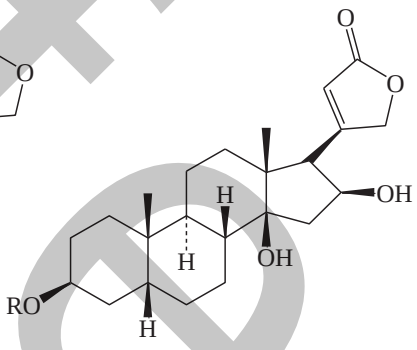
372 R=R_1
373 R=R_2



374 R=R_1
375 R=R_2



376 R=R1
377 R=R2



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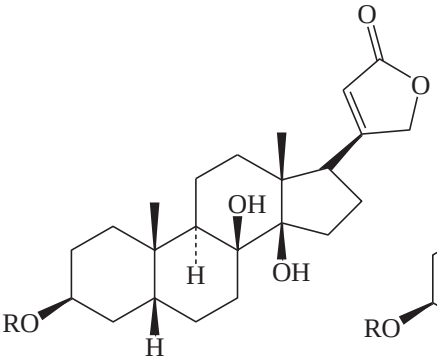
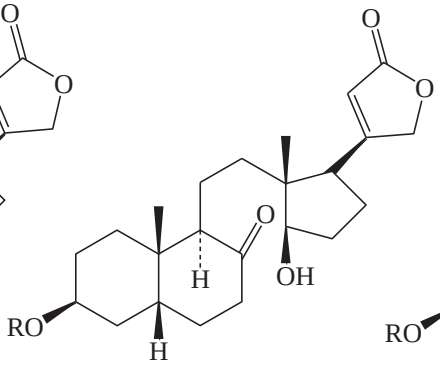
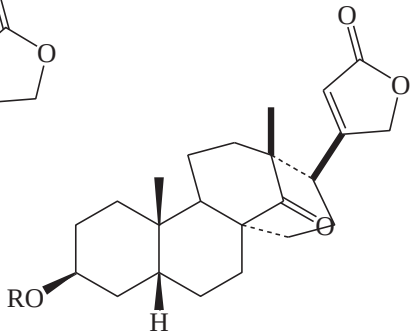


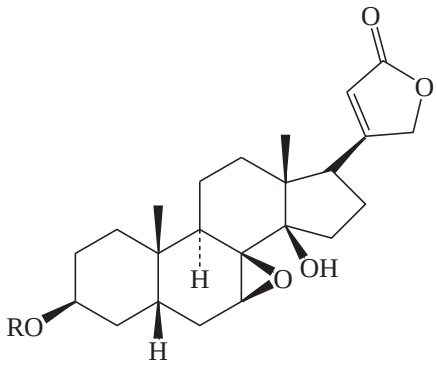
379 R=R_1



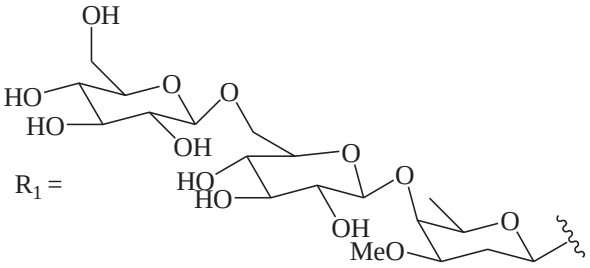
380 R=R_1



381 R=R_1



382 R=R_1



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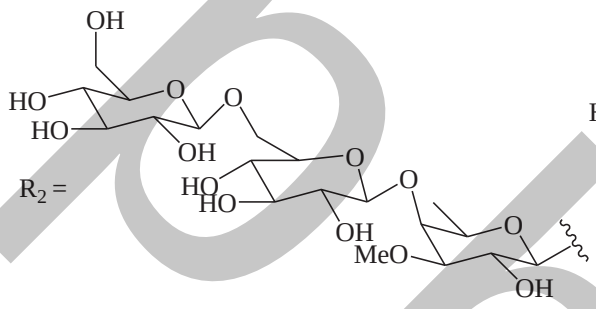
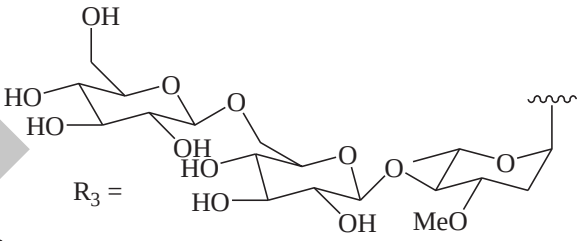


R_2 =



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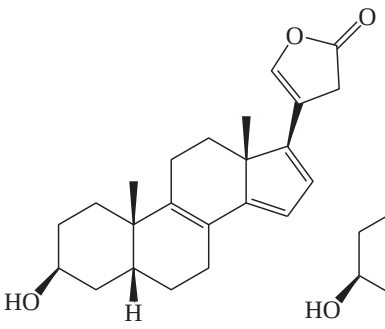

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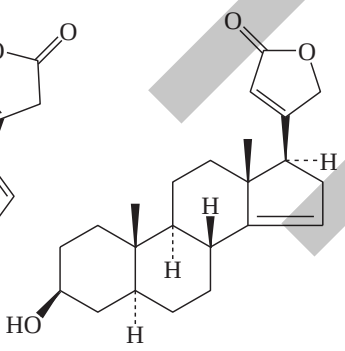

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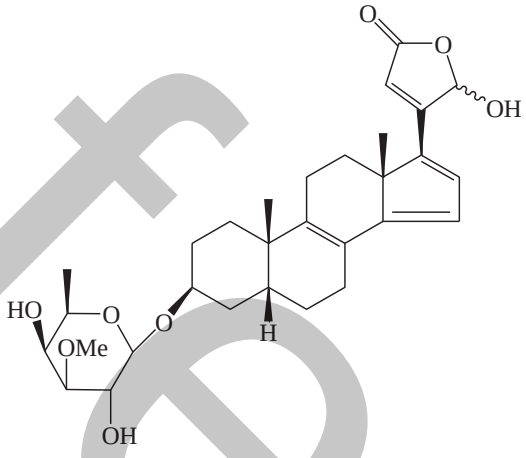
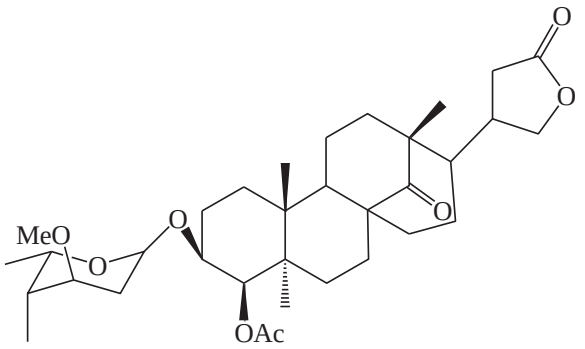
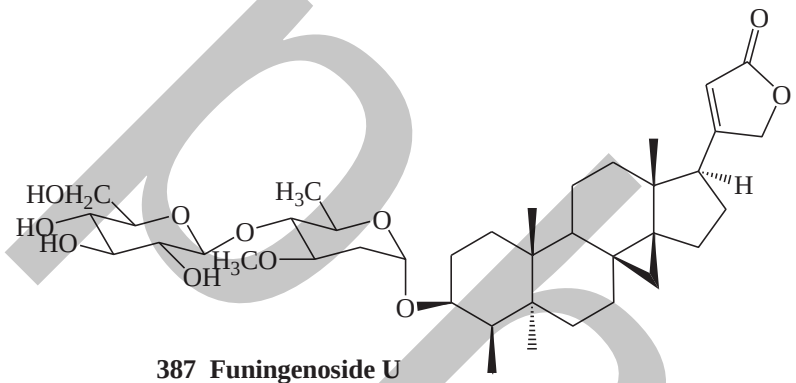


385

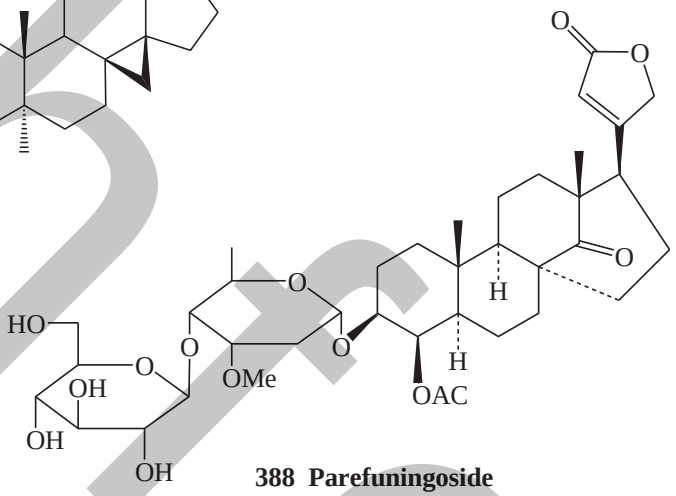
45. *Parepigynum funingesis* Tsiang *et* P.T.Li: Sixteen steroidal glycosides (5α-adynerin-type) with an unusual framework, funingenosides A-P (e.g. E (**386**) (Hua *et al*., 2003a,b, 2004b) and funingenoside U (**387**) (Hua *et al*., 2010) were isolated from the roots. Parefuningoside (**388**) was isolated from the dried aerial part (Cao *et al*., 2004). Six cardiac glycosides, funingenosides B (**389**) and E-I (**390**- **394**), were isolated from the aerial part (Cao and Luo, 2005).
46. *Plumeria obtusa*: Kaneroside and oleandrin from the fresh, undried and uncrushed leaves (Siddiqui *et al.*, 1992a).
47. *Roupellina (Strophanthus) boivinii*: Ten cardenolides, bovinides 1-6 (bovinide A, **395**), digitoxigenin 3-*O*-[*β*-D-glucopyrananosyl-(14)-α-L-acofriopyranoside], corotoxigenin 3-*O*-*β*-D-boivinoside, 17α-corotoxigenin 3-*O*-*β*-D-sarmentoside, and uzarigenin 3-*O*-α-L-rhamnoside (Karkare *et al*., 2007).



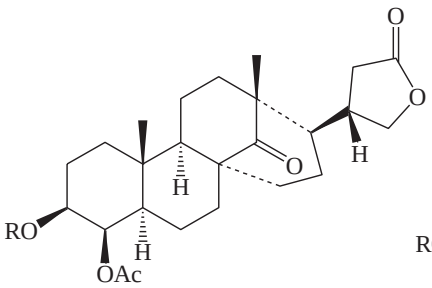
386 Funingenoside E



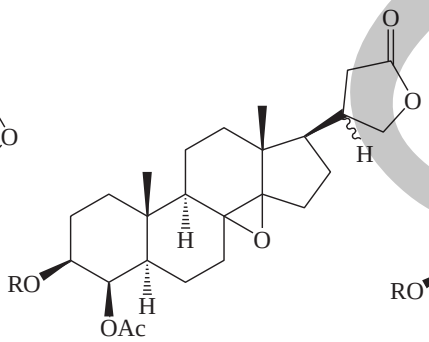
387 Funingenoside U



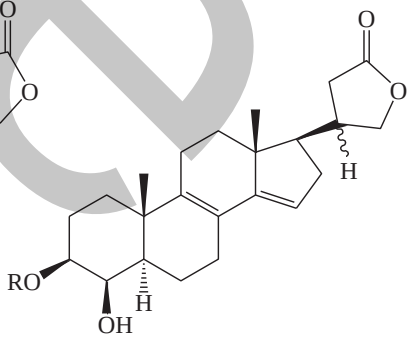
388 Parefuningoside



389: R=R[1]
390: R=R[2]

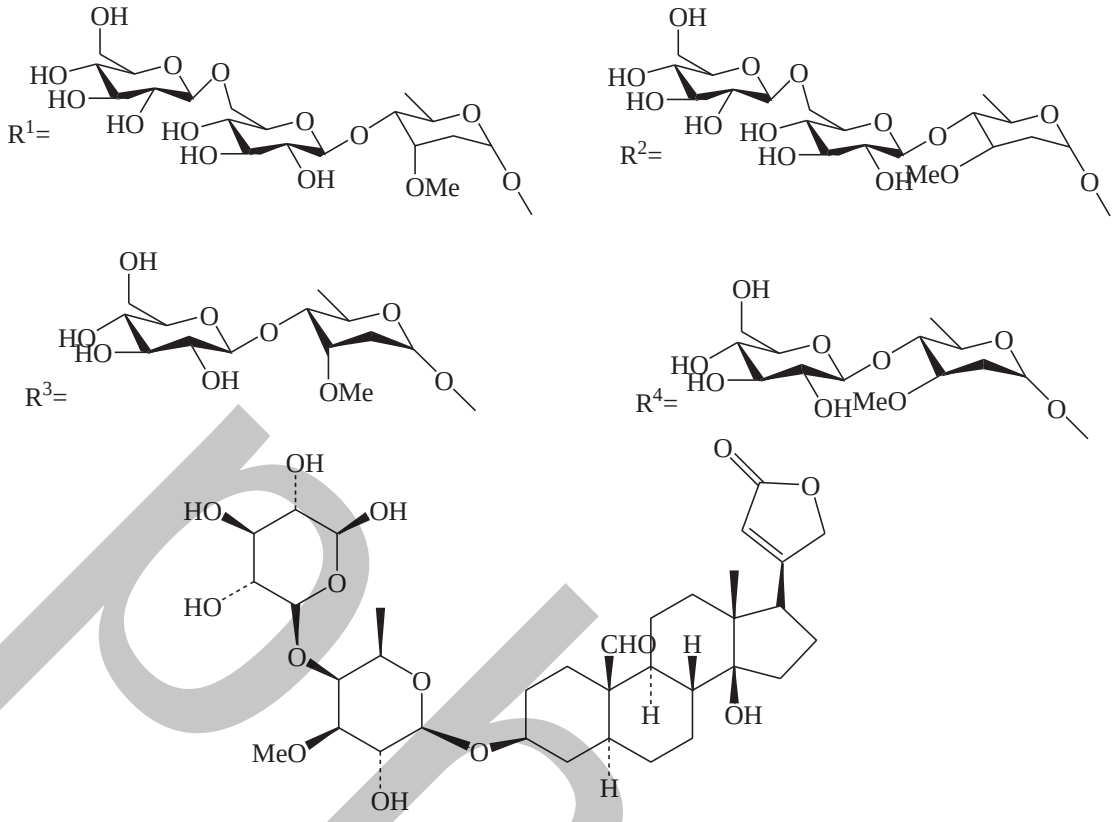


391: R=R[1]
392: R=R[2]



393: R=R[3]
394: R=R[4]

Note: R_1, R_2, R_3 and R_4 in page 87



395 BoivindeA

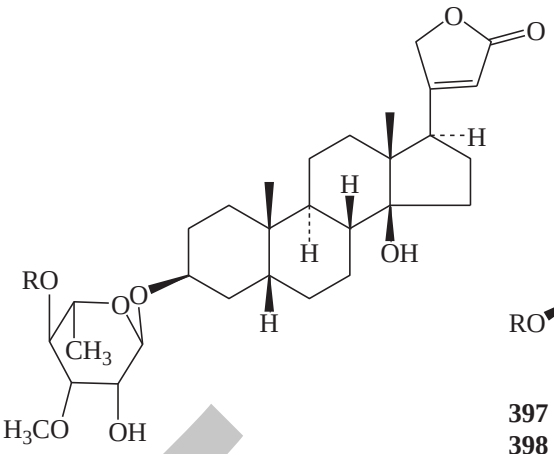
48. *Roupellina boivinii* (Baill.) Pichon (syn. *Strophanthus boivinii* Baill.): Zettoside (uzarigenin 3-*O*-β-D-boivinopyranside) (Russel *et al*., 1961a,b), biovinides A-F, strospeside, anhydrostrospeside and many others (Schindler and Reichstein, 1952b; Karkare *et al.*, 2007) from different parts of the plant (seed, root, bark and wood).
49. *Strophanthus amboensis* (Schinz) Engl. ex Pax.: Kwangoside (sarmentogenin 3-*O*-β-D-diginopyranoside), di-*O*-acetyl-englogenin, intermedioside (sarverogenin D-diginoside), panstroside (β-sarverogenin D-digitaloside), sarveroside (sarverogenin-D-sarmentoside), interoside, leptoside, amboside, ambostroside, quilengoside and others (Salmon *et al*., 1952; Euw *et al*., 1954; Schindler, 1956a-c).
50. *Strophanthus arnoldianus*: Cymarin, cymarol, and k-strophanthoside, emicymarin k-strophanthin-β and others (Ruppol and Turkovic, 1954; Schindler and Reichstein, 1955).
51. *Strophanthus boivinii*: Strospeside, 16-anhydrostrospeside, milloside, paulioside, stroboside and boistroside from the fermented seeds (Schindler and Reichstein, 1952a-c).
52. *Strophanthus caudatus* (Brum. ex L.) Kurz.: Caudoside and divaicoside from the fermented seeds (Schindler and Reichstein, 1954).
53. *Strophanthus congoensis*: Strophanthidol, sarveroside, intermedioside, and panstroside (Rothrock *et al.*, 1950; Schindler and Reichstein, 1956).
54. *Strophanthus courmontii*: Sarveroside, sarmentocymarin, sarmentogenin, and others from the seeds (Euw and Reichstein, 1950e; Rothrock *et al.*, 1950; Schindler and Reichstein, 1951b).
55. *Strophanthus cumingii* A DC.: Strophanthin (Santos, 1939).
56. *Strophanthus dichotomus* DC.:The presence of a powerful cardiac poison in the seeds has been confirmed (Millard, 1936).
57. *Strophanthus divaricatus* (Lour.) Hook. et Arn.: Sinoside, sinostroside, caudoside, ψ-

caudoside, sarmutoside, divaricoside, divostroside, ψ-caudostroside (Schindler and Reichstein, 1953c; Renkonen, 1957; Renkonen *et al.*,1959), divostroside (sarmentogenin 3-*O*-a-L-diginopyranoside), 17β-divostroside (Kawaguchi *et al*., 1993) and others (Huang and Chen, 1958; Chen *et al*., 1987).

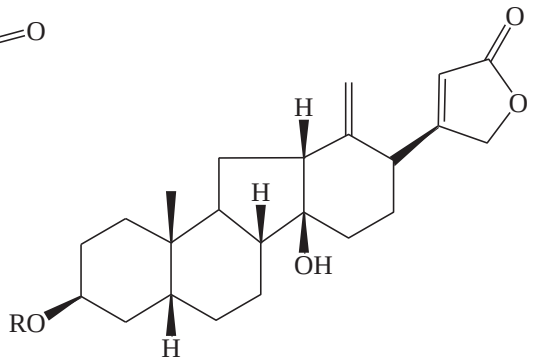
58. *Strophanthus eminii*: Periplocymarin, cymarol, cymarin, emicymarin, alloemicymarin, alloperiplocymarin, periplogenin, strophanthidol, ledienoside and others from the seeds (Lardon, 1950; Zelnik and Schindler, 1957).
59. *Strophanthus gerradi*: Sarvoside, sarmentocymarin, an isomer of sarvoside and others from the seeds (Euw and Reichstein, 1950c).
60. *Strophanthus gracilis*: Strophanthridin, strophanthidol, emicymarin (Aebi and Reichstein, 1951), odoroside H, graciloside and oters (Rosselet and Reichstein,1953).
61. *Strophanthus gratus* (Wall. et Hook.) Baill. (Climbing oleander): Thirty 30 cardenolides, including ouabain, acolongifloroside K, strogoside sarmentoside A, sarmentoside E, sarmentoside D, bipindoside, sarhamnoloside and tholloside from the seeds (Sieburg, 1913; Gomez and Matas, 1950; Laufke, 1960; Jäger *et al*., 1965; Geiger *et al*., 1967).
62. *Strophanthus hispidus*: Cymarin, cymarol, periplocymarin, cymarinic acid, and others from the fermented seeds (Euw and Reichstein, 1950f; Keller and Tamm, 1959).
63. *Strophanthus hypoleucus*: Periplocymarin, cymarol, periplogenin, and emicymarin from the seeds (Euw and Reichstein, 1950d).
64. *Strophanthus intermedius* Pax: Intermedioside, arriagoside, grossweiloside, walloside, cymarin, cymarol, panstroside, christyoside and others from the seeds (Euw *et al*., 1951; Rosselet and Hunger, 1951; Salmon *et al*., 1951; Turkovic, 1954, 1955; Hegedüs *et al*., 1953; Schindler and Reichstein, 1953a ; Hegedüs and Reichstein, 1955).
65. *Strophanthus kombe* Oliv.: More than 30 cardenolides were identified from the seeds, including periplocymarin, cymarin , cymarol, emicymarin, erysimin (helveticoside, strophanthidin 3-β-D-digitoxoside), 7β*H*-helveticoside, periplocin, periplocoside, *k*-strophanthin-β, erysimoside, erysimosol, strophanthotriose and strophanthidol (Kaiser *et al.*, 1959, 1961; Zelnik *et al*., 1960; Makarevich, 1969, 1972; Puchkova *et al*., 1975; Makarevich *et al*., 1993; Makarevich and Kovalev, 2006).
66. *Strophanthus ledienii*: The seeds contain emicymarin, Strophanthidol, strophanthidine, periplogenin (Hess *et al.*, 1951), cymarin, cymarol, periplocymarin, emicymarin, ledienoside and others (Lichti *et al*., 1956a).
67. *Strophanthus letei* Merrill: A saponin somewhat similar to pseudo-strophanthin, but differing from true strophanthin (Wells and Garcia, 1925).
68. *Strophanthus mirabilis*: Periplocymarin, cymarin, cymarol, emicymarin and others (Bally *et al.*, 1952b; Primo and Tamm, 1954).
69. *Strophanthus mortehanii*: Strophanthidol (Rothrock *et al.*, 1950).
70. *Strophanthus nicholsonii*: Periplocymarin, cymarin, cymarol, and emicymarin from the seeds (Euw and Reichstein, 1948)
71. *Strophanthus petersianus*: Sarmentocymarin, pantroside and 3 digitaloid glycosides from fermented seeds (Euw and Reichstein, 1950g; Foppiano and Salmon, 1952).
72. *Strophanthus preussii* Engl. & Pax: Emicin, emicin acetate, periplocymarin, periplocymarin acetate, periplogenin, periplocin tetraacetate, periplocin, alloemicymarin, alloemicymarin acetate, emicymarin acetate, alloperiplogenin, alloperiplogenin acetate and periplogenin acetate from the seeds (Ruppol and Turkovic, 1955, 1957).
73. *Strophanthus sarmentosus* DC. (Arrow-poison): Sarmentoside A, sarmentoside B, sarmentoside D, sarmentoside E, musaroside, sarmentocymarin, intermedioside, inertoside, sarveroside, sarmentogenin, panstroside, leptoside, bipindoside, acarbethoside [sarmentosidic-A acid], bipindaloside, sarmentosidic-A acid methyl ester, lokundjoside,

thollethoside, tholloside, zenkoside, sarhamnoloside, ouabain and others from the seeds of *Strophanthus sarmentosus* var. *glabriflorus*, *Strophanthus sarmentosus* var. *sarmentosus*, *Strophanthus sarmentosus* var. *senegambiae* and *Strophanthus sarmentosus* var. *major* (Buzas *et al*., 1950; Euw *et al*., 1949, 1957; Euw and Reichstein, 1950h, 1952; Callow*et et al*., 1951; Callow and Taylor, 1952; Richter *et al*., 1953; Schnell *et al*., 1953; Schindler and Reichstein, 1953b; Monachino *et al*., 1956; Euk *et al*., 1956; Fechtig *et al*., 1960; Owonubi *et al*., 1997).

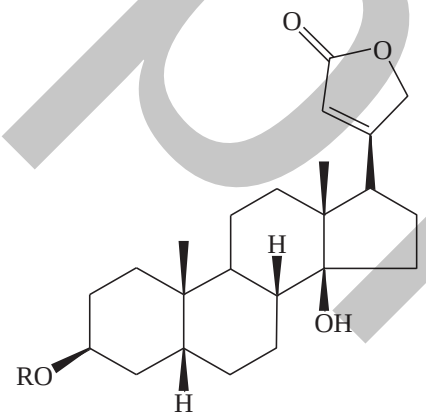
74. *Strophanthus schuchardtii* Pax: Sarveroside, intermedioside, panstroside, sarverogenin, inertoside, leptoside, amboside, quilengoside, and other glycosides from the seeds (Foppiano *et al.*, 1952; Edelmann *et al.*, 1956).
75. *Strophanthus speciosus* (Ward et Harv.) Reber.: Two cardiac glycosides, named substance No. 763 (later identified as strospeside) and substance No. 764 from the fermented seeds (Euw and Reichstein, 1950a; Schindler and Reichstein, 1952b).
76. *Strophanthus thollonii* Franch.: Sarmentoside E, sarmentoside A, sarmentoside D, ouabain, lokundjoside, thollethoside, tholloside, tetra-*O*-acetyl cyclosemiacetal, zenkoside and others from the seeds (Weiss *et al.*, 1957; Weiss *et al.*, 1958).
77. *Strophanthus tholloni* var. *gardeniiflorus*: Sarmentoside A, sarmentoside E, sarnovide and panstroside from the fermented seeds (Euw *et al.*, 1955).
78. *Strophanthus vanderijstii* Staner: Callengoside, desaroside, kisantoside, vanderoside, sarmentocymarin, kwangoside, emicymarin, sarnovide, odoroside H, digistroside and others from the seeds (Lichti *et al.*, 1956b; Brenneisen *et al*., 1964a,b).
79. *Strophanthus welwitschii:* Intermedioside and panstroside from the seeds (Euw *et al.*, 1952).
80. *Strophanthus wightianus* Wall.: Caudoside and divaicoside from the seeds (Rangaswami *et al*., 1953).
81. *Tabernaemontana heyneana*: Two cardiac glycosides in the fruits (Pillai, 1955b).
82. *Tanghinia venenifera*: Tanghinin, desacetyltanghinin and veneniferin from the seeds (Frerejacque and Hasenfratz, 1946).
83. *Thevetia ahouia* (L.) A. DC. : More than 20 cardenolides, including *C-nor*-D-homo cardenolide glycosides, from the leaves, wood and twigs: 3'-*O*-methylevomonoside (**396**), thevetiogenin 3-*O*-β-gentiobiosyl-(1→4)-α-L-rhamnopyranoside (**403**), thevetiogenin 3-*O*-β-D-glucopyranosyl-(1→4)-α-L-rhamnopyranoside (**400**), digitoxigenin 3-*O*-β-D-glucopyranosyl-(1→4)-α-L-acofriopyranoside (**411**), digitoxigenin 3-*O*-β-D-glucopyranosyl-(1→4)-2'-O-acetyl-α-L-thevetopyranoside, thevetiosides A (**398**), B (**399**), C (**401**), D (**402**), F (**404**), H (**405**), I (**397**), evomonoside (**406**), neriifolin (**407**), 2'-acetyl-neriifolin, solanoside (**408**), thevetin B (**414**), cerberin (**409**), evonoside (**417**), digitoxigenin 3-*O*-β-gentiobiosyl-(1→4)-α-L-acofrioside (**415**) and digitoxigenin 3-*O*-β-D-glucosyl-(1→4)-α-L-thevtoside (**410**) (Jolad *et al*., 1981; Endo *et al*., 1997).
84. *Thevetia neriifolia* Juss: Thevetiosides A-G, α-L-rhamnosides of digitoxigenin, cannogenin, thevetiogenin, neriifoside, peruvoside, ruvoside, thevetin, neriifolin, neriifoside, acetylneriifolin, thevefoline, theveneriine, glycosides of uzarigenin and others from the leaves and seeds (Frerejacque, 1947, 1956; Helfenberger and Reichstein, 1948; Baisse, 1952; Rangaswami and Rao, 1958, 1961; Rao *et al*., 1967; Abe *et al*., 1992a,b 1994a; Siddiqui *et al*., 1992b; Begum *et al*., 1993a). Mahran *et al*. (1970) isolated thevetin A, thevetin B and neriifolin from the plant growing in Egypt. Three cardenolides digitoxigenin, neriifolin and evomonoside were also iaolated from the roots of *Thevetia neriifolia*, cultivated in Egypt (El Tanbouly *et al*., 2000). Digitoxigenin and thevetin B were identified in *in vivo* and *in vitro* from immature seeds culture (Taha *et al*., 2010).



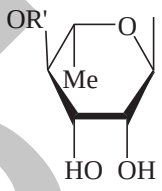
396 3/-*O*-**Methylevomonoside**



397 Thevetioside I R=a_1
398 Thevetioside A R=b_1
399 Thevetioside B R=c_1
400: R=a-2
401 Thevetioside C R=b_2
402: R=c-2 D
403: R=a-3 glu
404 Thevetioside F R=b_3
405 Thevetioside H R=c_1

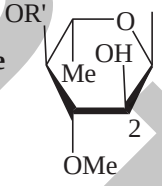


406 Evomonoside R=rhannoside
407 Neriifolin R=β-D-gluco pyranosyl
408 Solanoside R=((6-deoxy-3-*O*-Methylα-L-mannopyranosyl) oxy
409: R=b-4
410: R=b-2
411: R=c-2
412: R=b-5
413: R=a-3
414: R=b-3
415: R=c-3
416: R=b-6

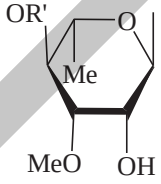


a-1 :R'=H (a-L-rhamnosyl)
a-2 :R'=β-D-glucosyl
a-3 :R'=gentiobiosyl

α-L-the



b-1 :R'=H (α-L-thevetosyl)
b-2 :R'=β-Dglucosyl
b-3 :R'=β-gentiobiosyl
b-4 :R'=H 2'-*O*-acetyl
b-5 : R'=β-D-glucosyl 2'-*O*-aoetyl
b-6 : R'=β-gentiobiosyl 2'-*O*-aoetyl

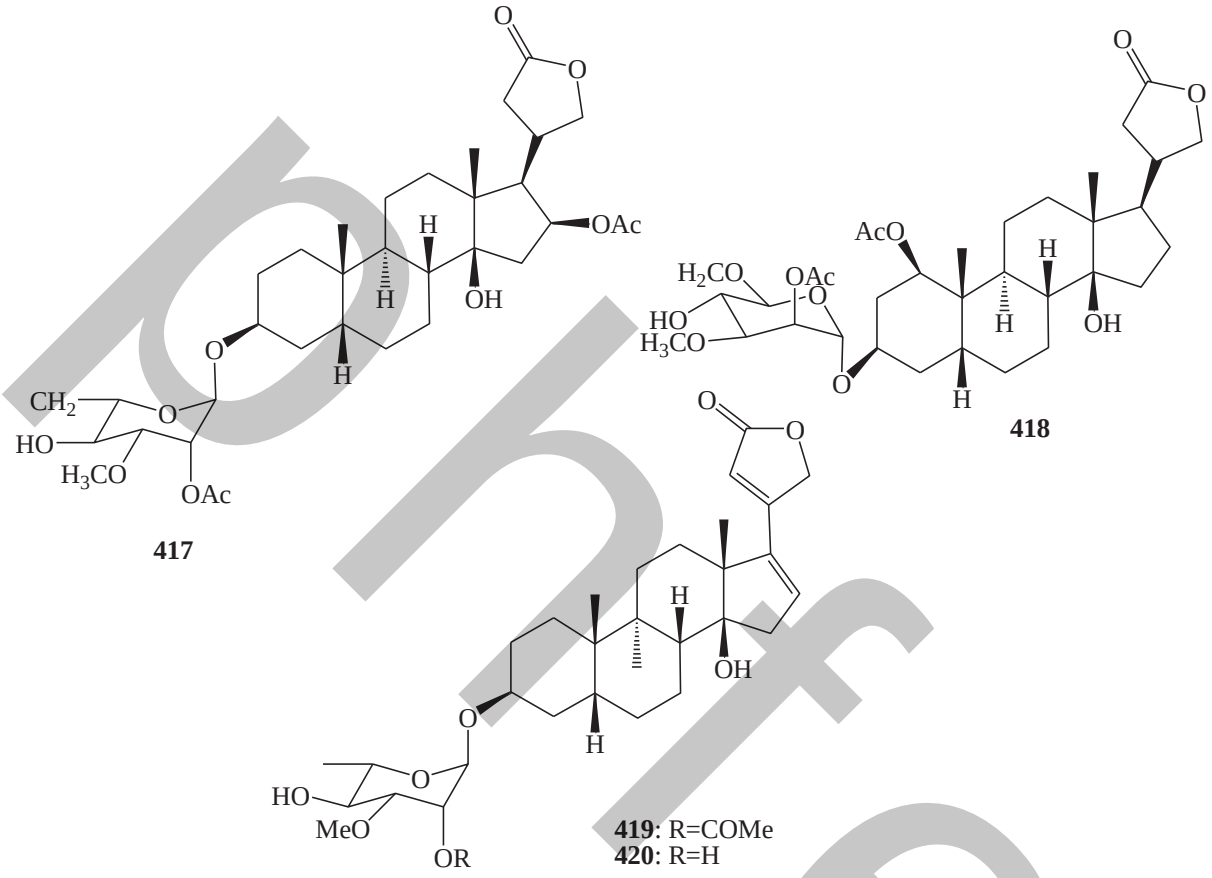


c-1 :R'=H (a-L-acofriosyl)
c-2 :R'=β-D-glucosyl
c-3 :R'=β-gentiobiosyl

85. *Thevetia ovata* A. DC.: Thevetin A, thevetin B, peruvoside and theveridoside from the seeds (Kyerematen *et al*., 1985).
86. *Thevetia peruviana* (Pers.) Merr. (Yellow oleander): Thevetin, thevetin A, thevetin C, thevetoxin, cerberoside, neriifolin, cerberin (monoacetylneriifolin), ruvoside, perusitin, glucoperuvoside, thevebioside, neriifolin, thevefolin and others from the seeds (Bisset, 1962; Portilla G., 1954; Cosme *et al*., 1958; Rangaswami and Rao, 1959; Lang and Sun, 1964; Sun and Libizov, 1964; Huang *et al*., 1965; Voigtländer *et al*., 1969; Said and Rahman, 1986; Jin *et al*., 1988; Miyagawa *et al*., 2009; Kohls *et al*., 2012).
87. *Thevetia thevetioide*s: Thevetoside, thevetoside acetate, digitoxigenin, thevetin B and others (Cruz *et al*., 1979; Perez-Amador *et al*., 1993). Both digitoxigenin and thevetin B were identified from *in vivo* and *in vitro* immature seeds culture (Taha *et al*., 2010).
88. *Trachomitum sarmatiense*: Cymarin, *k*-strophanthin-β, apobioside, apocannoside and a nonidentified compound from the roots (Waclaw-Rozkrutowa, 1975).
89. *Vallaris glabra* Ktz. (Bread flower): Acoschimpereoside 2'-acetate (**417**) and (**418**) from

the leaves (Rifai *et al*., 2011).

90. *Vallaris solanacea* (Roth) O. K.: Vallaroside (digitoxigenin-α-L-vallaropyranoside), solanoside (digitoxigenin-α-L-acofriopyranoside), vallarosolanoside (oleandrigenin-α-L-vallaropyranoside),16-deacetyl-16-anhydro-acoschimperoside P and others from the seeds (Kaufmann, 1965; Kaufmann *et al.*, 1965); *O*-acetyl-solanoside (*O*-acetyl acofreosyl-digitoxigenin) (Vohra *et al*., 1966), vallarisoside (**419**), and 3β-*O*-(α-acofriosyl)-16-anhydrogitoxigenin (**420**) (Ahmed *et al*., 2010a) from the aerial parts.



Flavonoids

Duret and Paris (1970) studied the polyphenols of 4 species of *Rauwolfia* and reported the homogeneity of the family Apocynaceae in regard to flavonoid composition. As in the related family Asclepiadaceae, only flavonols were found. Flavones were absent. The heterosides of the flavonols consisted of derivatives. of kaempferol and quercitol. In spite of the similarity of *Rauwolfia* to other Apocynaceae in regard to flavonoids, there are small differences from one species to another concerning the derivatives of kaempferol and quercitol which are present (Duret and Paris, 1970).

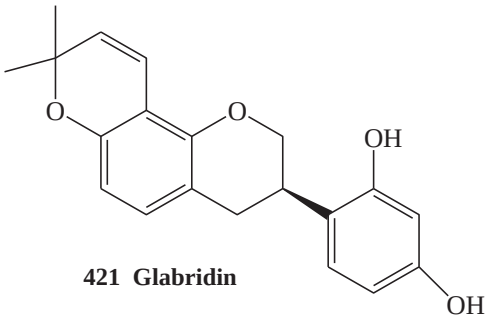
The distribution of various flavonoids and phenolic acids in the leaves of 22 plants belonging to Apocynaceae [*Carissa congesta, Allamanda cathartica, Allamanda violacea, Thevetia peruviana, Rauwolfia tetraphylla, Cerbera odollum, Kopsia fruticosa, Catharanthus pusillus, Catharanthus roseus, Plumeria rubra f. acuminata, Alstonia scholaris, Holarrhena antidysenterica, Tabernaemontana divaricata, Vallaris solanacea, Wrightia tinctoria, Wrightia tomentosa, Nerium indicum, Strophanthus wallichii, Beaumontia grandiflora, Aganosma caryophyllata, Ichnocarpus frutescens and Roupellia grata* was systematically studied. Kaempferol was more frequent in the subfamily Plumeroideae and glycoflavones,

leucoanthocyanins, and gentisic and sinapic acids were present in the subfamily Echitoideae. These chemical evidences clearly show that the 2 subfamilies are natural groups (Daniel and Sabnis, 1978).

Paris and Duret (1974) examined the flavonoids of leaves of 15 Apocynaceae from different geographic sources. Overall, the flavonoid compounds of all the Apocynaceae examined were quite uniform regardless of geographic rigin (Ivory Coast, Madagascar, France, Guiana, New Caledonia, Guadeloupe). Kaempferol and quercetol were uniformly present. Among the monosides, isoquercitroside was widely distributed. Among the biosides, rutinoside was found in almost all the species, frequently accompanied by nicotifloroside. Robinoside was identified in some species. Some small differences were encountered within a genus (e.g., *Amsonia tabernaemontana* vs. *Amsonia ciliata*) and within varieties of a given apecies (e.g., varieties of *Cabucala madagascariensis*). In general, the flavonoid contents of the leaves were low. Exceptions were *Nerium oleander* (1 to 3%, depending on the stage at which collected), *Amsonia tabernaemontana* (5%), *Echitella lisianthiflora* (3%), and *Himatanthus articulatus*, *Baissea leonensis*, and *Strophanthus hispidus* (the last 3~1%) (Paris and Duret, 1974). The total flavonoid content of leaves in *Apocynum venetum* L. and *Poacynum hendersonii* (Hook. f.) Woodson was 2.6 % and 2.2 %, respectively, however that of flowers was significantly lower than that of leaves, which was approximately 0.5 % (Deng *et al*., 2012). The hyperoside content in the leaves of *Poacynum hendersonii* is about 0.24%, while almost no hyperoside is found in the flowers, stems or roots. Similarly, the total flavonoid content in the leaves is also higher, about 3.54%, while those are lower in the flowers, stems and roots (Shi *et al*., 2009). The quercetin content in both *Apocynum venetum* and *Poacynum hendersonii* reached its highest level in summer and its lowest in autumn (Ma *et al*., 2003). The amounts of flavonoids, hyperoside and isoquercitrin in leaves of *Apocynum venetum* and *Apocynum venetum* var. *basikurumon*, used as an anti-aging agent, and of isoquercitrin and quercetin 3-O-sophoroside in leaves of its substitute, *Poacynum hendersonii*, were relatively large (0.2-0.8%) (Nishibe *et al*. 1994). Examples of the flavonoids, isolated from some species of the family are shown in Table **7**.

Adenium obesum flowers anthocyanins were identified as cyanidin 3-*O*-(4-α-L-rhamnosyl)-β-D-galactopyranoside (Pale *et al*., 2004). Anthocyanidins were isolated from from orange-red flowers of *Catharanthus roseus* cv 'Equator Deep Apricot', and identified as rosinidin 3-*O*-[6-*O*-(α-rhamnopyranosyl)-β-galactopyranoside] (1), and also 7-*O*-methylcyanidin 3-*O*-[6-*O*-(α-rhamnopyranosyl)-β-galactopyranoside]. (2) by chemmical and spectroscopic methods. Pigment 1 was found to be a major anthocyanin in the flowers of this cultivar. By contrast, the distribution of rosinidin glycosides is very limited in plants, and reported only in the flowers of *Primula*. Pigment 2 was found in smaller concentrations, but its aglycon, 7-*O*-methyl-cyanidin, has been reported only once before, from the fruit of mango (Toki *et al*., 2008).

Two anthocyanins were isolated from ornamental reddish flowers of *Plumeria rubra viz.* cyanidin 3-*O*-β-(2"-glucopyranosyl-*O*-β-galactopyranoside) and cyanidin-3-*O*-β-galacto-pyranoside (20%) (Byamukama *et al*., 2011).



421 Glabridin

Table **7**. Flavonoids of some species of the family Apocynaceae

Species	Plant Part	Flavonoids	References
1. *Adenium obesum*	…..	3-*O*-Methylkaempferol and 3,3′-bis (*O*- methyl) quercetin	Hoffmann and Cole (1977)
2. *Aganosma caryophyllata*	F	Quercetin, rutin, hyperin, isoquercetin (quercetin 3-*O*-glucoside), quercetin 3-arabinoside	Sekhar *et al.* (1985)
	L	Kaempferol, kaempferol 3-arabinoside, kaempferol 3-galactoside, quercetin and quercetin 3-arabinoside	Ramana *et al*. (1985)
3. *Aganosma dichotoma*	…..	Quercetin and rutin	Subramanian *et al*. (2014)
4. *Allamanda blanchetii*	F	Taxifolin (kaempferol 3-*O*-galactoside)	Ganapaty *et al*. (1989)
5. *Allamanda cathartica*	P	Quercetin 3-*O*-(6″-*O*-acetyl) neohesperidoside	Manogaran and Sulochana (2005)
	F	Kaempferol, quercitrin (quercetin 3-*O*-rhamnoside), quercetin and hesperitin	Tiwari *et al*. (1979); Subramanian and Swamy (1963); Hema and Krishnaveni (2014)
	St	Glabridin (**421**), kaempferol and naringenin	Yamauchi *et al.* (2011)
6. *Allamamanda neriifolia*		Nicotiflorin (kaempferol 3-*O*-rutinoside)	Yu *et al*. (2010)
7. *Allamanda schotii*	F	Kaempferol, quercetin and rutin	Ganapaty and Rao (1988)
8. *Alstonia deplanchei*	L	Heterosides of isorhamnetol, quercetol and kaempferol	Duret and Paris (1972 a)
9. *Alstonia macrophylla*	L	Tricin-4'-*O*-β-L-arabinoside, vitexin and myricetin-3'- rhamnoside-3-*O*-galactoside	Parveen *et al.* (2010)
10. *Alstonia scholaris*	St	Formononetin 7-O-β-D-apiofuranosyl-(1→6)-β-D-glucopyranoside and biochanin A 7-O-β-D-apiofuranosyl-(1→6)-β-D-glucopyranoside	Thomas *et al*. (2008)
	L	Isorhamnetin 3-*O*-β-D-galactopyranoside, isorhamnetin 3-*O*-β-D-glucopyranoside, kaempferol 3-*O*-β-D- glucopyranside, kaempferol 3-*O*-(2 glc-rhamnosylrutionside), isorhamnetin, kaempferol, 7, 3′-4′-trimethoxyl-5- hydroxyflavone and 3,5, 7,4′-tetrahydroxy flavone-3-*O*-β-D-glucosidekaempferol, quercetin, isorhamnetin, kaempferol-3-	Desoky (1999); Jong- Anurakkun *et al*. (2007); Du *et al.* (2007a) Hui *et al.* (2009); El-Askary *et al.* (2013)

Table 7- Flavonoids of some species of the family Apocynaceae (cont.)

Species	Plant Part	Flavonoids	References
		O-β-D-galactopyranoside, quercetin-3-*O*-β-D-galactopyranoside, isorhamnetin-3-*O*-β-D-galactopyranoside, kaempferol-3-*O*-β-D-xylopyranosyl-(2→1)-*O*-β-D-galactopyranoside, quercetin-3-*O*-β-D-xylopyranosyl-(1'''→2'')-*O*-β-D-galactopyranoside and isoquercitrin	
		Epicatechin	
	Ap	Formononetin 7-*O*-β-D-apiofuranosyl-(1→6)- β-D-glucopyranoside	Thara and Zuhra (2013)
	S	and biochanin A 7-*O*-β-D-apiofuranosyl- (1→6)-β-D-glucopyranoside	Thomas *et al.* (2008)
	R	Isookanin 7-*O*-rhamnoside (8,3,4'-trihydroxyflavanone-7-*O*, α-L-rhamnopyranoside)	Chauhan *et al*. (1985)
11. *Alstonia undulata*	L	Heterosides of isorhamnetol and kaempferol	Duret and Paris (1972a)
12. *Amsonia ciliata*		Tamarixetin 3-*O*-arabinoside, tamarixetin 3-*O*-galactoside, isorhamnetin 3-*O*-galactoside, kaempferol 3-*O*-galactoside, querctin 3-*O*-glactoside, quercetin 3-*O*-arabinoside, and quercetin 3-*O*-galactoside	Urbatsch and Mabry (1974)
13. *Amsonia tabernaemontana*	…..	Rutin and kaempferol 3-glucorhamnoside	Lutomski and Nowicka (1972); Lutomski and Okulicz- Kozaryn (1972)
	L	Rutin	Zsadon *et al.* (1973d, 1974c)
14. *Anodendron affine*	St	Wogonin	Inagaki *et al*. (1971a)
	L	Kaempferol and astragalin, nicotiflorin, rutin and quercetin 3-*O*-(2''-galacosyl) glucoside	Shima *et al*. (1971a, 1972a); Sakushima *et al*. (1985)
15. *Apocynum hendersonii*	L	Astragalin, baimaside (quercetin 3-*O*-sophoroside **422**) and isoquercitrin (isoquercetin), Quercetin-3-*O*-glucuronide, quercetin-3-*O*-α-L- arabinofuranoside, quercetin-3-*O*-arabinofuranoside, 3′,8″-biapigenin, amentoflavone (**423),** quercetin-3-*O*-maltoside, quercetin-3-*O*-rutinoside	Hu *et al.* (1988); Zhang *et al.* (2009c)

Table 7. Flavonoids of some species of the family Apocynaceae (cont.)

Species	Plant Part	Flavonoids	References
16. *Apocynum lancifolium*	H	Quercetin, neo-isorutin and quercetin 3-glucopyranoside	Murzagaliev *et al.* (1972, 1973); Murzagaliev and Tegisbaev (1975)
17. *Apocynum pictum*	H	Queretin, quercetin 3α-D-glucofuranoside and quercetin 3β-D-glucopyranoside	Murzagaliev *et al.* (1972, 1973); Murzagaliev and Tegisbaev (1975)
18. *Apocynum venetum*	L	Quercetin, isoquercetin, hyperin, (hyperoside), quercetin 3-*O*-(6″-malonyl)-β-D-glucoside, quercetin 3-*O*-(6″-*O*-malonyl)-β-D-galactoside, astragalin, kaempferol, flavan-3-ols (catechin, epicatechin, gallocatechin and epigallocatechin), phenylpropanoid-substituted flavan-3-ols (apocyanins A-D, catechin-[8,7-e]-4α-(3,4-dihydroxyphenyl)-dihydro-2(3H)-pyranone and cinchonain I1), cinchonain Ia plumbocatechin A, 8-*O*-methylretusin, kaempferol 3-*O*-(6″-*O*-acetyl)-β-D-galactopyranoside, trifolin, isoquercetin 6''-*O*-acetate, rutin, isoquercetrin, quercetin 3-*O*-β-D-glucosyl (2→1)-β-D-gulucoside, quercetin-3-*O*-glucuronide, kaempferol 3-*O*-β-D-glucoside, amentoflavone (3′,8″-biapigenin), avicularin (quercetin-3-*O*-α-L-arabinofuranoside), acetylated isoquercetin, acetylated hyperoside, and trifolin (kaempferol 3-*O*-β-D-galactoside), kaempferol-3-*O*-galactoside kaempferol-3-*O*-(6''-*O*-acetyl)-β-D-glucopyranoside, quercetin-3-*O*-(6''-*O*-acetyl)-β-D-glucopyranoside, quercetin-3-*O*-(6''-*O*-acetyl)-β-D-galactopyranoside and kaempferol-7-*O*-α-L-rhamnopyranoside	Wang *et al.* (1985); Chen and Liu (1991); Fan *et al.* (1999); Xiong *et al*. (2000) Li and Yuan (2006); Cheng *et al*. (2007), Kamata *et al*. (2008); Zhang *et al*. (2009c, 2010b, 2011b), Kong *et al*., (2014); Zhou *et al*.; (2011); Yan *et al* (2012)
	F	Kaempferol, kaempferol 3-*O*-glucoside, quercetin, quercetin 3-*O*-glucoside and rutin	Chen *et al*. (2005); Cai *et al*. (2007a)
	B	Hyperoside, isoquercitrin, kaempferol and luteolin	Li *et al*, (2011)
	L,Pt, Sd,St	Kampferol 3-*O*-(2,6-di-*O*-rhamnosyl-galactoside)-7-*O*-hexoside, kampferol 3-*O*-(6-*O*-rhamnosyl-galactoside)-7-*O*-galactoside,	Ferreres *et al*. (2008)

Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

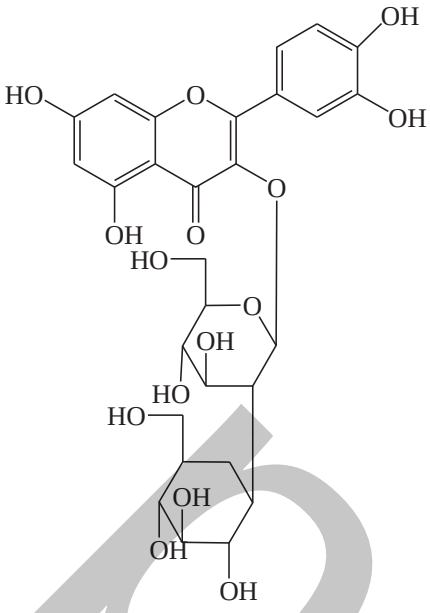
Species	Plant Part	Flavonoids	References
		kampferol 3-*O*-(6-*O*-rhamnosyl-galactoside)-7-*O*-glucoside, quercetin 3-*O*-(2,6-di-*O*-rhamnosyl-galactoside), quercetin 3-*O*-(2,6-di-*O*-rhamnosyl-glucoside), kaempferol 3-*O*-(2,6-di-*O*-rhamnosyl-galactoside), kaempferol 3-*O*-(2,6-di-*O*-rhamnosyl-gluoside), quercetin 3-*O*-(6-*O*-rhamnosyl-galactosyl, isorhamnetin 3-*O*-(2,6-di-*O*-rhamnosyl-galactoside), quercetin 3-*O*-(6-*O*-rhamnosyl-gluoside), isorhamnetin 3-*O*-(2,6-di-*O*-rhamnosyl-gluoside), kaempferol 3-*O*-(6-*O*-rhamnosyl-galactoside), kaempferol 3-*O*-(6-*O*-rhamnosyl-gluoside) and isorhamnetin 3-*O*-(6-*O*-rhamnosyl-galactoside)	
	…..	Quercetin-3-*O*-β-D-glc(2 → 1)-β-D-glucoside, rutin, isoquercetin, kaempferol-3-*O*-β-D-glucoside, quercetin-3-*O*-(6''-O-malonyl)-β-D-glucoside, quercetin and kaempferol	Yan *et al*. (2012a)
19. *Apocynum venetum* var. *basikurumon*	….	Isoquercitrin and hyperoside	Sakushima *et al.* (1978)
20. *Aspidosperma macrocarpon*	L	Rutin	Bannwart *et al*. (2013)
21. *Aspidosperma quebracho- blanco*	L	Isorhamnetin-3-*O*-rhamnosylglucoside, quetrcetin-3-*O*-rhamnosyl-glucoside, quercetin-3-*O*-xylosylgalactoside, kaempferol-3-*O*-rhamnosylglucoside, isorhamnetin-3-*O*-rhamnosyldiglucoside, quercetin-3-*O*-rhamnosyldiglucoside, quercetin-3-*O*-xylosyl-galactosylglucoside and kaempferol-3-*O*-rhamnosyldiglucoside.	Peletto and Del Pero (1995)
22. *Aspidosperma Tomentosum*	….	Isorhamnetin	Bezerra de Aquino *et al*. (2013)
23. *Baissea leonensis*	L	Isoquercitroside and astragaloside	Duret and Paris (1972b)

Table 7. Flavonoids of some species of the family Apocynaceae (cont.)

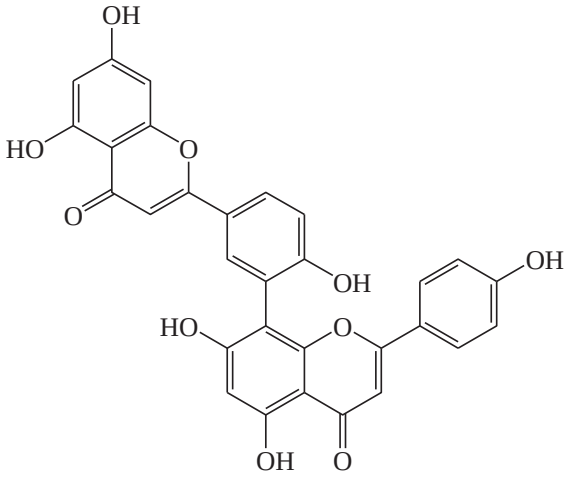
Species	Plant Part	Flavonoids	References
24. *Beaumontia grandiflora*	Ap	Kaempferol 3-*O*-glucoside, kaempferol 3-*O*-rutinoside, quercetin, quercetin 3-*O*-galactoside, diosmetin 7-*O*-rhamnoside and kaempferol 3-3-*O*-neohesperidoside	Kanchanapoom *et al*. (2002), Abdelshafeek *et al.* (2010)
25. *Catharanthus roseus*	St	Syringetin 3-*O*-robinobioside and others	Brun *et al.* (1999)
	Pt	Kaempferol, quercetin and tricin	Vimala and Jain (2001)
	Hr	3′,4′-Di-*O*-methylquercetin-7-*O*-[(4″→13‴)-2‴,6‴,10‴,14‴-tetramethylhexadec-13‴-ol-14‴-enyl]-β-D-glucopyranoside, 4′-*O*-methylkaempferol-3-*O*-[(4″→13‴)-2‴,6‴,10‴,14‴-tetramethylhexadecan-13‴- olyl]-β-D-glucopyranoside, 3′,4′-di-*O*-methylbutin-7-*O*-[(6″→1‴)-3‴,11‴-dimethyl-7‴-methylene-dodeca-3‴,10‴-dienyl]-β-D-glucopyranoside, and 4′-*O*- methyl-butin-7-*O*-[(6″→1‴)-3‴,11‴-dimethyl-7‴-hydroxymethylene-dodecanyl]-β-D- glucopyranoside	Chung *et al.* (2009)
	L	Kaempferol 3-*O*-α-L-rhamnopyranosyl-(1→2)-α-L-rhamnopyranosyl-(1→6)-β-D-galactopyranoside (mauritianin), quercetin 3-*O*-α-L-rhamnopyranosyl-(1→2)-α-L-rhamnopyranosyl-(1→6)-β-D-galactopyranoside, quercetin, and rutin	Nishibe *et al*. (1996); Roy and Chatterjee (2010); Rao and Ahmed (2013)
26. *Cerbera manghas*	L	Rutin, nicotiflorin (kaempferol 3-rutinoside), manghaslin (quercetin, 3-*O*-L-rhamnosyl- (1→2)-*O*-[L-rhamnosyl-(1→6)-D-glucoside) and clitorin (kaempferol 3-*O*-L-rhamnosyl-(1→2)-*O*-[L- rhamnosyl-(1→6)-D-glucoside) and 3-*O*-(2^G-rhamnosylrutinosyl)-7-*O*-β-glucosylquercetin	Sakushima *et al.* (1976, 1980a, b)
	St	Naringenin, naringenin 7-glucoside, aromadendrin and (+)-dihydroquercetin	Yu *et al*. (2009)
27. *Cerberiopsis candelabra*	L	Rutin	Frerejacque (1970)
28. *Chonemorpha griffithii*	Ap	Apigenin and lueolin	Bai *et al*. (2013)

Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

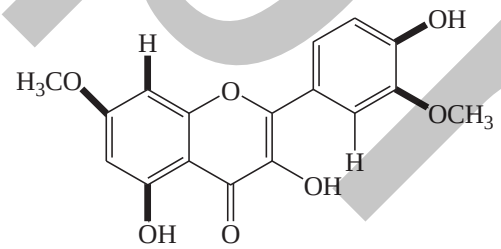
Species	Plant Part	Flavonoids	References
29. *Dipladenia maritiana*	Ap	Kaempferol, kaempferol 3-*O*-β-D-glucopyranoside, quercetin 7-*O*-β-D-glucopyranoside, quercetin 7-*O*-β-D-galactopyranoside, and epicatchin	Geraldo de Carvalho *et al.* (2001)
30. *Dyera costulata*	L	Rhamnazin (**424**) and quercetin 3-*O*-α-L-rhamnopyranoside	Subhadhirasakul *et al.* (2003)
31. *Ecdysanthera rosea*	….	Ayanin (**425**, quercetin 3,7,4'-trimethyl ether), casticin (**426**, vitexicarpin, 3',5-Dihydroxy-3,4',6,7-tetramethoxyflavone) and kaempferol 3-*O*-L-rhamnoside	Zhu *et al.* (2011a)
32. *Echites hirsuta*	Wp	Aromadendrin (dihydrokaempferol), kaempferol and naringenin	Chien *et al.* (1979)
33. *Epigynum auritum*	Rz	Epigeoside (catechin 3-*O*-α-D-glucopyranosyl-(1→6)-β-D-glucopyranoside (**427**), and catechin 3-*O*-α-L-rhamnopyranosyl-(1→4)-β-D-glucopyranosyl- (1→6)-β-D-glucopyranoside)	Jin and Mu (1990,1991)
34. *Ervatamia coronaria*	F	Kaempferol	Farooq *et al.* (1959)
35. *Ervatamia officinalis*	L,St	Calycosin (**428**) and luteolin	Zhu *et al.* (2011c)
36. *Formosia benthamiana*	L	Kaempferol, kaempferol 3 *O*-β-D-glucoside, quercetin and quercetin 3 *O*-β-D-glucoside	Chang *et al.* (1990)
37. *Himatanthus sucuuba*	B	Biochanin A (**429**) (5,7-dihydroxy-4′-methoxyisoflavone), dihydrobiachanin A (**430**), dalbergiodin (**431**), naringenin, ferreirin and dihydrocajanin (**432**)	Waltenberger *et al.* (2011a)
	La	Myricetin and quercitrin	Silva *et al.* (2010)
38. *Holarrhena crassifolia*	L	Isoquercitrin, robinin, (kaempferol 3-*O*-robinoside-7-*O*-rhamnoside, kaempferol 3-*O*-galactorhamnoside-7-*O*-rhamnoside), rutin, kaempferol and quercetol glycosides	Paris and Duret (1973)
39. *Holarrhena floribunda*	L	Quercetol 3- glucoside (named hollarhenoside and isoquercitroside), robin, rutin, kaempferol and quercetol glycosides	Paris and Foucaud (1959); Paris and Duret (1973)



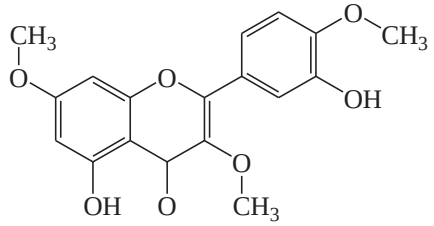
422 Baimaside



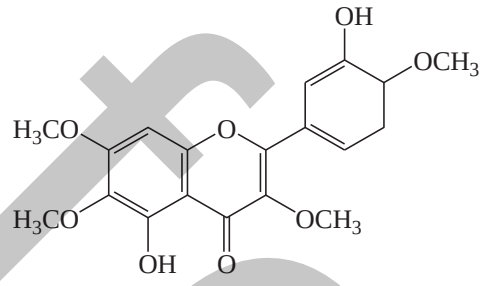
423 Amentoflavone



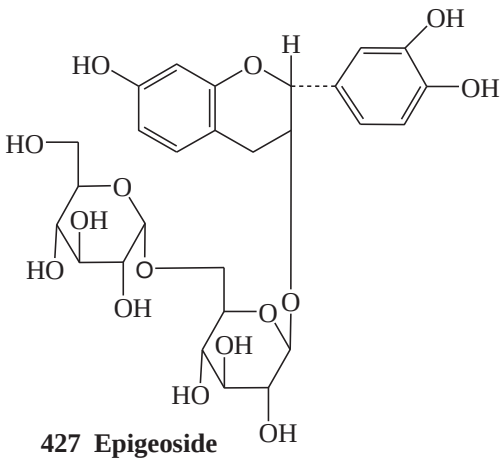
424 Rhamnazin



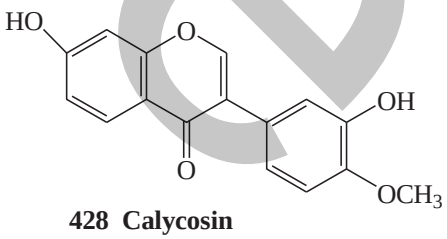
425 Ayanin



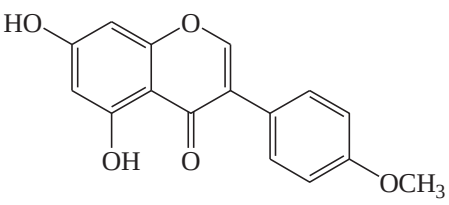
426 Casticin



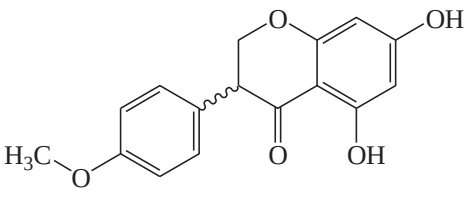
427 Epigeoside



428 Calycosin



429 Biochanin A



430 Dihydrobiochanin A

Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

Species	Plant Part	Flavonoids	References
40. *Holarrhena mitis*	L	Isoquercitrin, robinin, rutin, kaempferol and quercetol glycosides	Paris and Duret (1973)
41. *Holarrhena pubescens*	L	Naringenin and naringenin 7-*O*-β-D-glucoside	Tuntiwachwuttikul *et al.* (2007)
42. *Hunteria zeylanica*	L	Kaempferol-3-*O*-β-D-glucoside	Xie *et al.* (2013)
43. *Ichnocarpus frutescens*	L	Apigenin, luteolin, kaempferol, trifolin (kaempferol 3-*O*-galactoside), vitexin and isovitexin	Daniel and Sabnis (1978); Khan *et al.*(1995)
	F	Quercetin and quercetin 3-*O*-β-D-glucoside	Singh and singh (1987)
	….	Kaempferol and kaempferol 3-glucoside	Verma *et al*. (1988)
44. *Landolphia dawei*	L, St	Quercetin and rutin	Michel and Sleem (2003)
45. *Landolphia kirkii*	L	Kaempferol 5-rhamnoside, mearnsitrin (myricetin 4′-methylether-*O*-rhamnoside) and myricitrin (myricetin 3-*O*-rhamnoside)	Gabetta *et al.* (1973)
46. *Laseguea erecta*	F	Quercetin and quercetin 3-*O*-α-L-arabinopyranoside	Geraldo de Carvalho *et al.* (2007)
47. *Macrosiphonia longiflora*	….	Naringin, rutin, myricetin, morin, quercetin, (±)-naringenin and luteolin	da Silva *et al*. (2014)
48. *Melodinus fusiformis*	L,T	Astragalin	Wang *et al*. (2012a)
49. *Melodinus hemsleyanus*	L,T	Cirsilinol (**433**) and latifolin (**434**)	Zhang *et al*. (2013a)
50. *Melodiuns suaveolens*	L, Tw	(+)-Liquiritigenin	Tong *et al*. (2013)
51. *Nerium indicum*	F	Kaempferol 3-glycoside	Lin *et al.* (1975)
52. *Nerium odorum*	Rb	Kaempferol	Satyanarayana *et al.* (1975)
	L	Quercetin 3-*O*-robinobioside and rutin	Hao *et al.* (2013)

Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

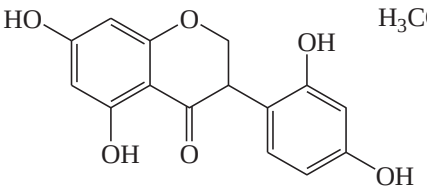
Species	Plant Part	Flavonoids	References
53. *Nerium oleander*	L	Quercetin, rutin, quercitrin (quercetin 3-*O*-rhamnoside), isoquercitrin (quercetin 3-*O*-glucopyranoside) and kaempferol 3-rhamnoglucoside, quercetin-5-*O*-[α-L-rhamnopyranosyl-(1 → 6)]-β-D-glucopyranoside and kaempferol-5-*O*-[α-L-rhamnopyranosyl-(1 → 6)-β-D-glucopyranoside	Wagner and Luck (1955); Hoerhammer *et al.*, (1956); Hoerhammer and Wagner (1957); Goerlich, 1961; Dominguez *et al.* (1967); Hiermann *et al.* (1982); Siddiqui *et al.* (2012)
	Ap	Luteolin 4'-methyl ether, luteolin-7-*O*-glucouronid, apigenin-7-*O*-galactoside and isorhamnetin-3-*O*-galactoside and isorhamnetin-3-*O*-galactoside	Shams *et al.* (2012)
54. *Ochrosia nakaiana*	L	Astragalin, isoquercitrin, kaempferol nicotiflorin and rutin	Sakushima *et al.* (1980c)
55. *Poacynum pictum*	L	Quercetin 3-*O*-glucoside, quercetin 3-*O*-rutinoside, quercetin 3-sophoroside, quercetin 3-*O*-(2^G-glucosyl-rutinoside) and hyperin (quercetin 3-*O*-galactoside)	Nishibe *et al*. (2001a); Zhang *et al*. (2009d)
56. *Plumeria acutifolia*	F	Hyperoside and rutin	El-Sherbeni *et al.* (2012)
57. *Plumeria alba*	Dp	Rutin	Harrison *et al.* (1973)
	F	Rutin, hyperoside and kaempferol	Gunasingh and Nagarajan (1980); Santhi (2009)
58. *Plumeria obtusa*	Ap	Glochiflavanoside B	(Saleem *et al.*, 2011)
59. *Plumeria rubra*	St	Quercetin, quercetrin and rutin	Mahran *et al.* (1974a)
	Stb	Plumerubroside, (**435**, a flavan 3-ol glycoside)	Kardono *et al*. (1990b)
	L	Rutin	Mahran *et al.* (1974a)
	….	Rubranonoside (7-*O*-α-L-rhamnopyranosyl-4'-*O*-β-D-gluco-pyranosylnaringenin)	(Akhtar *et al.*, 2013)
60. *Plumeria rubra* var.*alba*	St	Quercetin, quercetrin and rutin	Mahran *et al.* (1974a)
	L	Rutin and quercetin	Mahran *et al.* (1974a)

Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

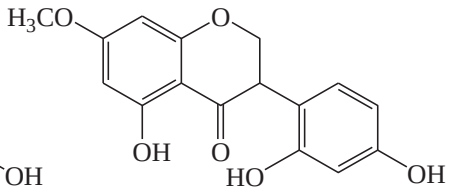
Species	Plant Part	Flavonoids	References
61. *Poacynum hendersonii*	Ap	Quercetin-3-*O*-sophoroside, isoquercitrin and isoquercitrin-6'-*O*-malonate	Shi *et al.* (2012)
	F	Kaempferol, kaempferol 3-*O*-β-D-glucopyranoside, 6''-*O*-acetylastragalin, Kaempferol 3-*O*-sophoroside, kaempferol 3-*O*-β-D-glucopyranosyl-(1→4)-β-D-glucopyranoside, quercetin, quercetin 3-*O*-β-D-glucopyranoside, quercetin 3-*O*- sophoroside, quercetin 3-*O*-β-D-glucopyranosyl-(1→4)-β-D-glucopyranoside	Morikawa *et al.* (2012)
	Dp	Eriodictyol-7-*O*-β-D-glucoside, quercetin, isoquercitrin, hendersoside, rutin, kaempferol, trifolin , astragalin and isorhamnetin-3-*O*-β-D-glucoside	Wei *et al*. (2008)
	L	Quercetin, quercetin 3-*O*-glucoside, quercetin 3-*O*-sophoroside, isorhamnetin 3-*O*-glucoside, quercetin 3-*O*-sophoroside and isorhamnetin 3-*O*-glucoside	Lei *et al*. (1995); Zhang *et al.* (2006a)
62. *Rauwolfia serpentina*	L,R,Stb	Rutin	Bhardwaj (1988)
63. *Rauwolfia verticillata*	L	Robinin	Chiang *et al*. (1963)
64. *Rauwolfia vomitoria*	L	Astragalin, nicotiflorin, kaempferol and quercetin	Paris and Etchepare (1967); Malik and Afza (1983)
65. *Tabernaemontana catharinensis*	StB	Rutin, quercetin and kaempferol	Boligon *et al*. (2014)
	Br, Fr	Rutin	Piana *et al*. (2014)
66. *Tabernaemontana divaricata*	R,St	Calycosin [3',7-dihydroxy-4'-methoxyisoflavone, 3'-hydroxyformononetin], formononetin and farnisin [**436**, 3',7-dihydroxy-4'-methoxyflavone]	(Liang *et al*., 2006b)
67. *Thevetia neriifolia*	F	Thevefolin (= tamarixetin 3-*O*-digalactoside), quercetin 3-galactoside, quercetin 3-digalactoside and tamarixetin 3-galactoside	Gunasegaran and Nair (1981)

Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

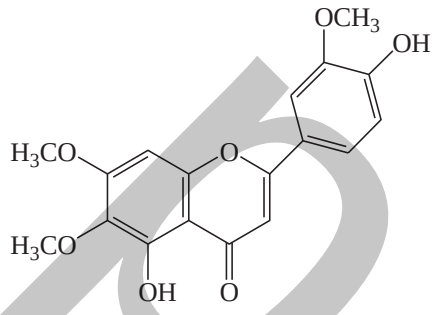
Species	Plant Part	Flavonoids	References
68. *Thevetia peruviana*	F	Kaempferol and quercetin	Rao *et al.* (1975); Thilagavathi *et al*. (2010)
	Pr	Hesperitin 7- glucoside	Rao *et al.* (1975)
	L	Kaempferol 3-glucosyl(1→4) [6‴-sinapoylglucosyl] (1→2)galactoside, kaempferol 3-[2‴′-sinapoylglucosyl] (1→4)[6‴-sinapoylglucosyl](1→2)galactoside, kaempferol and quercetin 3-[6‴-sinapoylglucosyl] (1→2)galactosides, kaempferol, quercetin 3-glucosyl(1→2)galactosides, (2*R*) and (2*S*)-5-*O*-β-D-glucopyranosyl-7,4′-dihydroxy-3′,5′-dimethoxyflavanone [peruvianoside I (**437**), peruvianoside II (**438**)] and quercetin 3-*O*-{β-D-glucopyranosyl-(1→2)-[α-L-rhamnopyranosyl-(1→6)]-β-D-galacto-pyranoside} (peruvianoside III, (**439**)	Abe *et al.* (1995b); Tewtrakul *et al.* (2002)
	…. S	Apigenin-5-methyl ether	Voigtlaender and Balsam (1970); Rao and Narayanan (1973)
69. *Trachelospermum asiaticum* var. *intermedium*	L	Apigenin, apigenin 7-glucoside, luteolin, luteolin 7-glucoside and luteolin 4′-glucoside Apigenin 7-gentiobioside, rhoifolin and luetolin 7-neohesperidoside	Inagaki *et al.* (1973); Sakushima *et al.* (1973)
	F	Apigenin 7-*O*-glucoside, luteolin 7-*O*-glucoside, luteolin 4-*O*-glucoside, rhoifolin (apigenin 7-*O*-neohesperidoside), kaempferol 3-*O*-glucoside and quercitrin	Hosoi *et al*. (2008)
70. *Trachelospermum axillare*	L	Apigenin, apigenin 7-*O*-β-gentiobioside, apigenin 7- *O*-β-D-glucoside, apigenin 7-*O*-β-neohesperidoside, apigenin 7-*O*-β-rutinoside, luteolin, luteolin 7-*O*-β-gentiobioside, luteolin 7- *O*-β-D-glucoside, luteolin 4'- *O*-β-D-glucoside and quercetin 3-*O*-β-D-glucoside	(Nishibe *et al.*, 2000)
71. *Trachelospermum difforme*	L	Several flavonol glycosides	Sakushima *et al.* (1982)



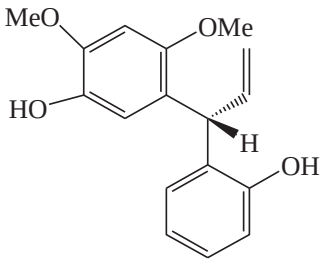
431 Dalbergioidin



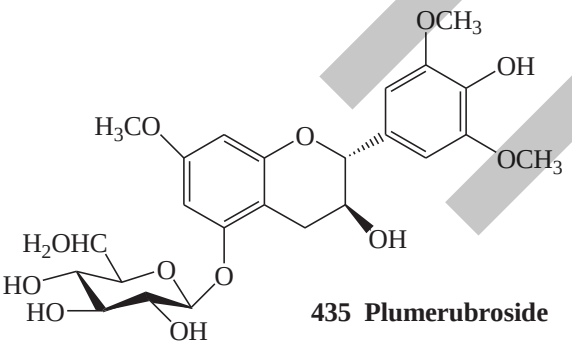
432 Dihydrocajanin



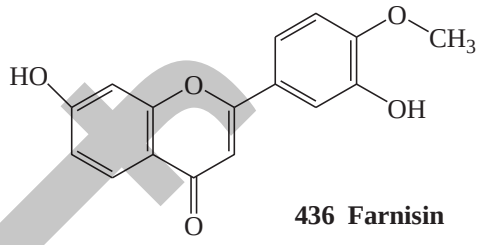
433 Cirsilinol



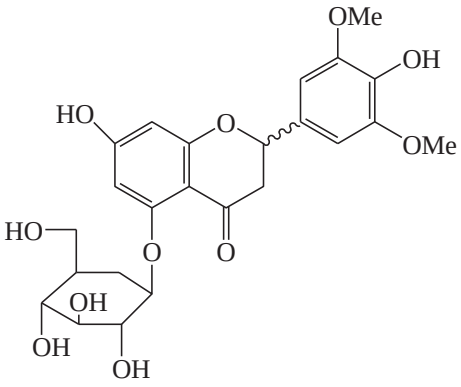
434 Latifolin



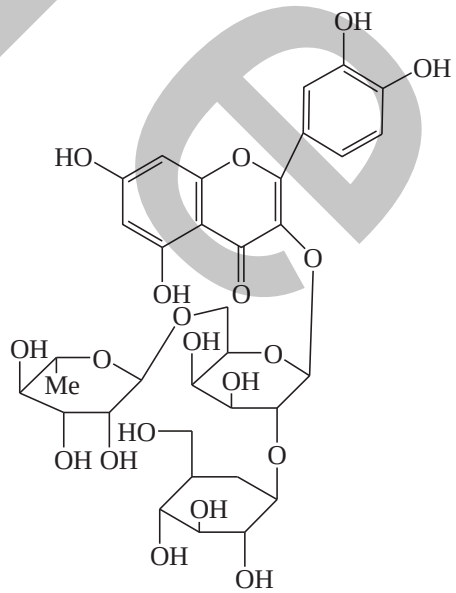
435 Plumerubroside



436 Farnisin



437 2R-Peruvianoside I
438 2S-Peruvianoside II



439 Peruvianoside III

Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

Species	Plant Part	Flavonoids	References
72. *Trachelospermum fragrans*	L	Astilbin (taxifolin 3-*O*-rhamnoside), hyperin, quercetin and quercitrin	Rao and Rao (1977)
73. *Trachelospermum gracilipes*		Apigenin-7-*O*-neohesperidoside, apigenin-7-*O*-glucoside, apigenin-7-*O*-glucoside, apigenin-7-*O*-diglucoside and apigenin-7-*O*-rutinoside	Lin *et al*. (1992a)
74. *Trachelospermum jasminoides*	Ap	3',7-Dimethoxyisoflavanone-4', 5-di-*O*-β-D-glucopyranoside, luteolin-4'-*O*-β-D-rutinoside, and luteolin-7-*O*-β-D-glucopyranoside	Zhang *et al.* (2013g)
		Chrysoeriol-7-*O*-β-D-glucoside, luteolin-7-*O*-β-gentiobioside, luteolin-7-*O*-β-D-glucoside, apigenin-7-*O*-neohesperidoside, apigenin, apigenin 7-*O*-β-glucoside, naringin and 6,8-di-*C*-glucopyanosylapigenin	Sakushima *et al.* (2002); Jing *et al*. (2012); Tan *et al*. (2010e); Yuan *et al*. (2010)
	L	Apigenin, apigenin 7-*O*-gentiobioside, cosmociin, luteolin, luteolin 4′-*O*-glucoside, luteolin 7-*O*-glucoside , luteolin 7-*O*- gentiobioside and rhoifolin (apigenin 7-*O*-rhamnoglucoside, apigenin 7-*O*-neohesperidoside) (**440**)	Fu *et al.* (2008)
75. *Trachelospermum jasminoides var. pubescens*	L	Taxifolin 3-*O*-arabinoside, (2*R*,3*R*)-taxifolin 3-*O*-arabinoside, taxifolin 3-glucoside, taxifolin and quercetin 3-arabinoside, astragalin, isoquercitrin and cosmosiin (apigenin 7-*O*-glucoside)	Sakushima and Nishibe (1988); Hosoi *et al*. (2006)
76. *Vinca erecta*	Ap	Kaempferol and robinin (**441**)	Akhmedzhanova (1986)
77. *Vinca herbacea*	….	Quercetin and rutin	Nishibe *et al.* (1998)
78. *Vinca major*	L	Rutin, Kaempferol 3-rutinoside and robinin (Kaempferol-3-*O*-galacto-rhamnoside-7-*O*-rhamnoside)	Kowalewski and Kowalska (1966); Şöhretoğlu *et al*. (2013)

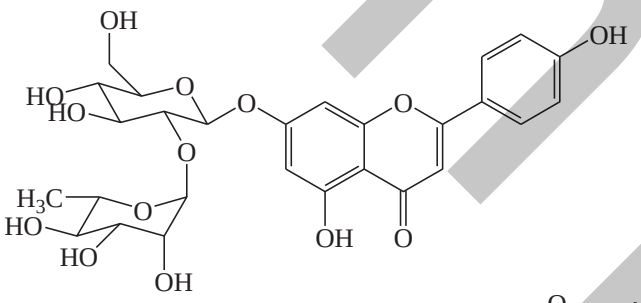
Table **7**. Flavonoids of some species of the family Apocynaceae (cont.)

Species	Plant Part	Flavonoids	References
79. *Vinca minor*	Wp	Kaempferol, quercetin derivatives containing glucose and rhamnose and robinin	Szostak and Kowalewski (1969)
	L	Quercetin 3-rhamnoglucoside-7β-glucoside, kaempferol 3-rhamnogluco-7-glucoside, kaempferol 3-rhamnogluco 7-galactoside, querecetin 3- rutino-7-glucoside and quercetin 3-rhamnogluco-7-glucoside and kaempferol 3-*O*-α-L-rhamno-pyranosyl-(1→6)-β-D-glucopyranoside-7-*O*-β-D-glucopyranoside	Raynaud *et al.* (1970); Szostak and Kowalewski (1975); Nishibe *et al* (1996)
80. *Voacanga africana*	L	Heterosides of quercetol and kaempferol	Duret *et al*. (1972a)
81. *Voacanga thouarsii*	L	Heterosides of quercetol and kaempferol	Duret *et al*. (1972a)
82. *Winchia calophylla*	Stb	Immaculoside (5, 8-dimethoxy 7-*O*-β-D-glucopyranosyl flavone)	Chen *et al*. (2012)
83. *Wrightia coccinea*	….	Rutin	Muruganandam *et al*. (2000)
84. *Wrightia tinctoria*	L	Rutin	Muruganandam *et al*. (2000)
	S	Wrightiadione (an isoflavone)	Lin *et al.* (1992b)
	F	Quercetin and rutin	Sethurman *et al.* (1984)
	B	Quercetin	Bigoniya *et al*. (2013)
85. *Wrightia tomentosa*	L	Rutin	Muruganandam *et al*. (2000)

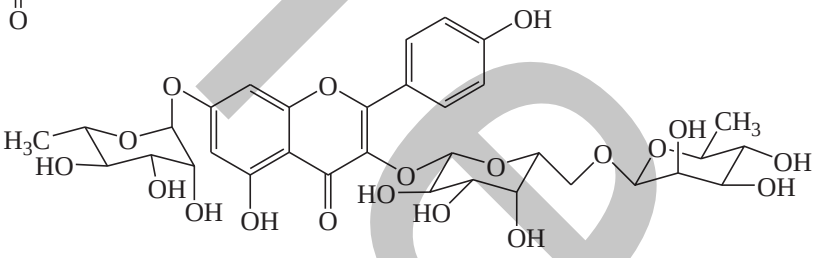
Ap: aerial parts; Br: branches; Dp: different parts; F: flowers; Fr: fruit; H: herb; Hr: hairy roots; L: leaves; La: latex; P: pods; Pr: fruit pericarp; Pt: petals; Rb: root bark; Rz: rhizome; S: seeds; St: stems; Stb: stem bark; Tw: twigs; Wp: whole plant.

Diglycoside based on malvidin was identified from the plant (Krishnamoorthy and Seshadri, 1962). Four delphinidin glycosides were found in the bluish-purple flowers of *Vinca major*. Among them were identified as vincanin A (delphindin 3-robinobioside-5-rhamnoside) (**442**) and vincanin B (delphinidin 3-robinobioside) (**443**) (Ishikura and Minekeshi, 1978).

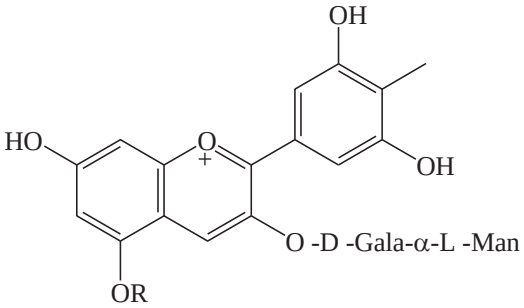
In addition, proanthocyanidins have been identified in few species. One trimeric proanthocyanidin, epicatechin-(2β→*O*→7.4β→6)-epicatechin-(2β→*O*→7,4β→8)-epicatechin (**444**) and two tetrameric proanthocyanidins, epicatechin-(2β→*O*→7.4β→8)-[epicatechin-(4β→6)]-epicatechin-(4β→8)-epicatechin, named as parameritannin A-1 (**445**), and epicatechin-(2β→*O*→5.4β→6)-[epicatechin-(2β→*O*→7.4β→8)]-epicatechin-(4β→8)-epicatechin, named as parameritannin A-2 (**446**), have been isolated from the bark of *Parameria laevigata* Moldenke along with the two dimers, proanthocyanidin A-2 (**447**) and proathocyanidin A-6 (**448**), and two trimers, cinnamtannin B-1 (**449**) and aesculitannin B(**450**) (Kamiya *et al*., 2001). Parameritannin A-3 (**451**), a tetrameric A-type proanthocyanidin, along with cinnamtannin β-2, pavetannin C-1 and cinnamtannin D-1 were isolated from the bark of *Parameria leavigata* (Kamiya *et al*., 2003). Two A-type proanthocyanidins have been isolated from *Ecdysanthera utilis* and identified as epicatechin-(4β→8.2β→*O*→7)-eoicatechin-(4β→8)-epicatechin and epicatechin-(4β→8)-epicatechin-(4β→8.2β→*O*→7)-epicatechin-(4β→8)-epicatechin. The structure-related components epicatechin, procyanidin B2, proanthocyanidin A1, proanthocyanidin A2, and aesculitannin C were also isolated (Lin *et al*., 2002b).



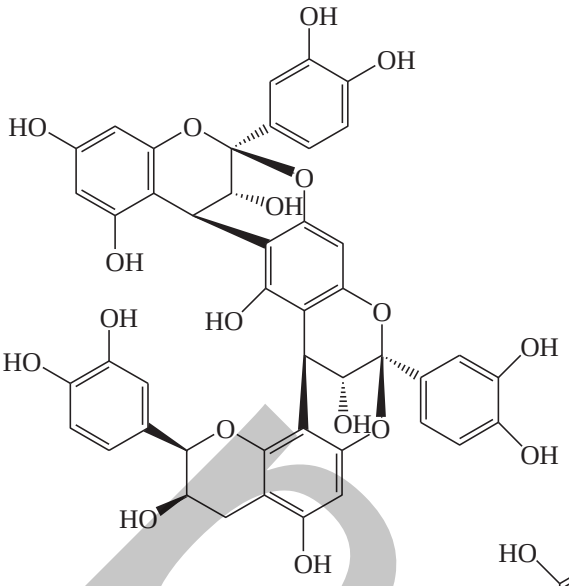
440 Rhoifolin



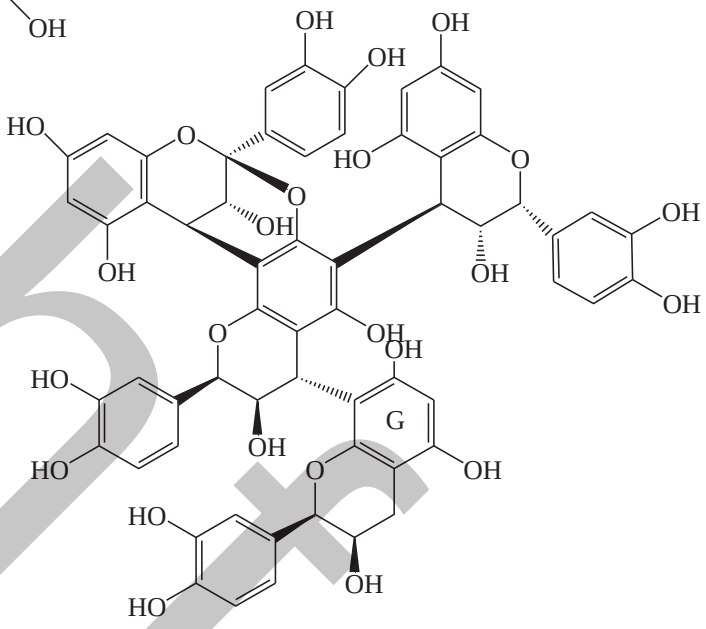
441 Robinin



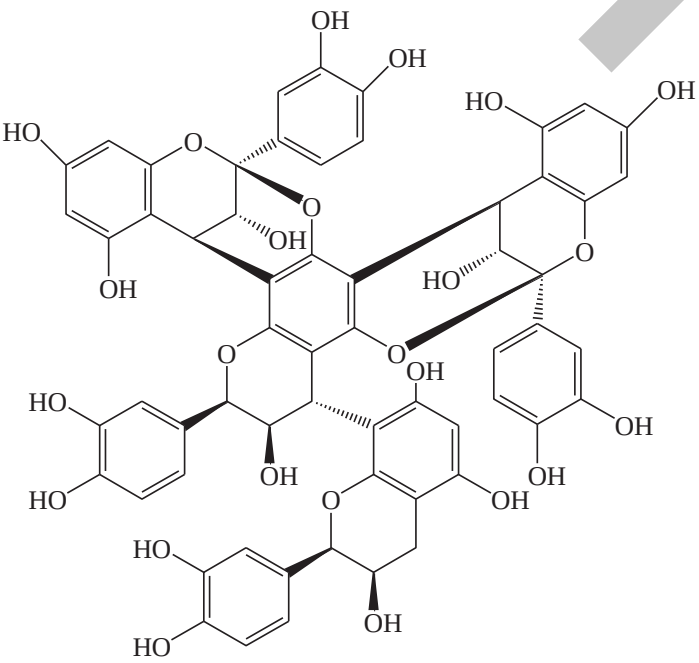
442 Vincanin A R= α-L-Rhmnosyl
443 Vincanin B R=H



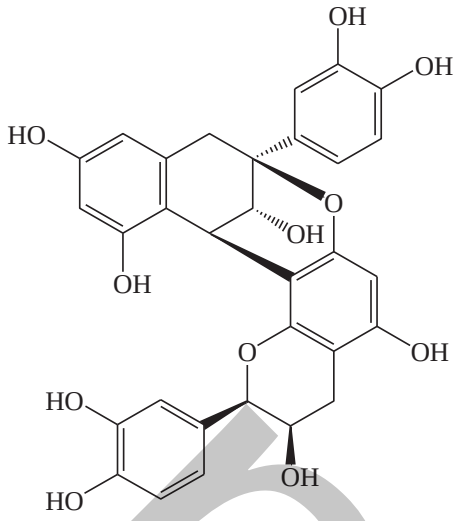
444



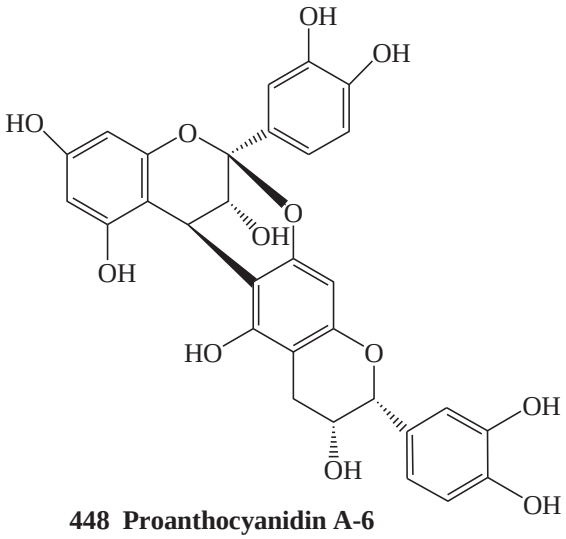
445 Parameritannin A-1



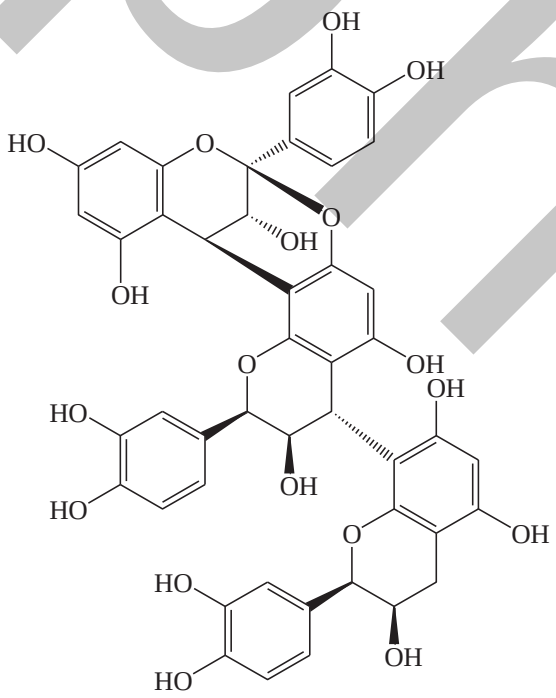
446 Parameritannin A-2



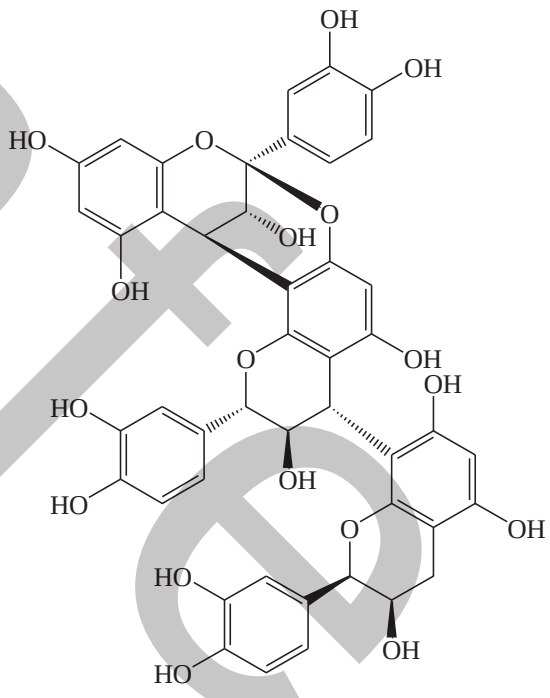
447 Proanthocyanidin A-2



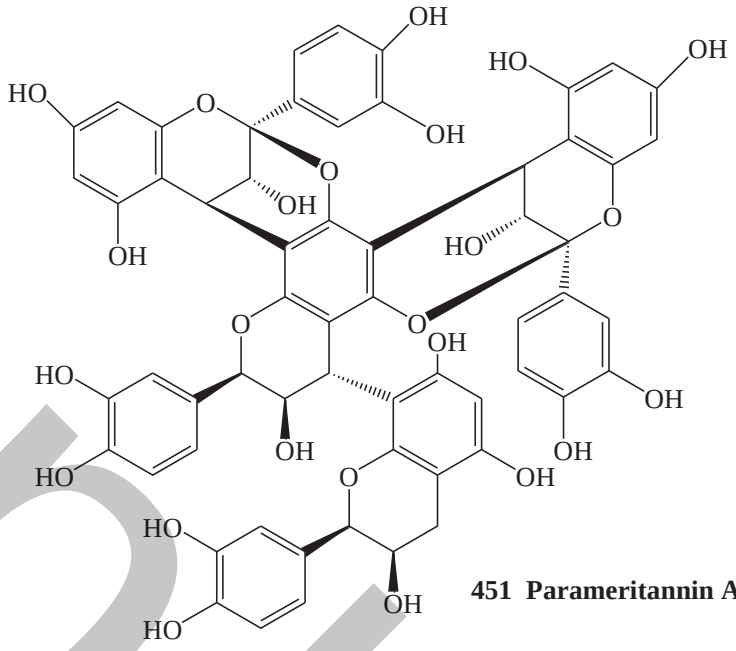
448 Proanthocyanidin A-6



449 Cinnamtannin B-1



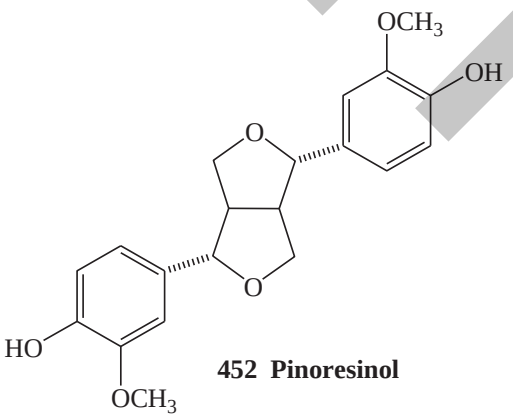
450 Aesculitannin B



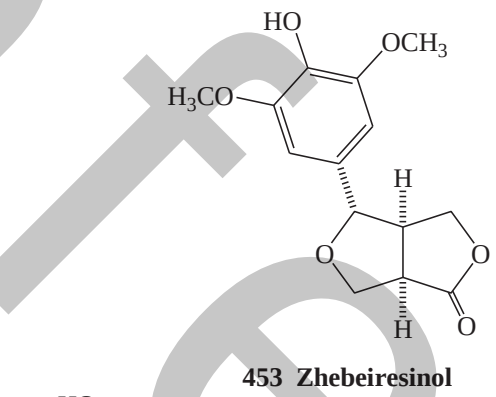
451 Parameritannin A-3

Lignans

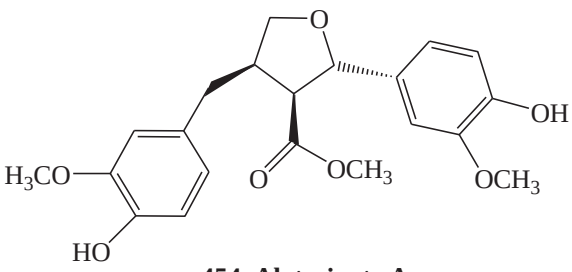
Sesqui-, sester- and trilignans principally composed of olivil complex lignans (cerberalignans) were isolated from *Cerbera* species. Several others have been isolated from the family; examples of these are shown in Table **8**.



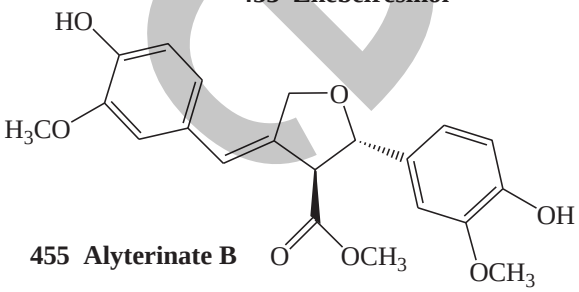
452 Pinoresinol



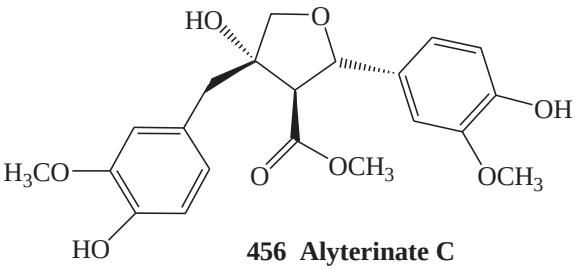
453 Zhebeiresinol



454 Alyterinate A



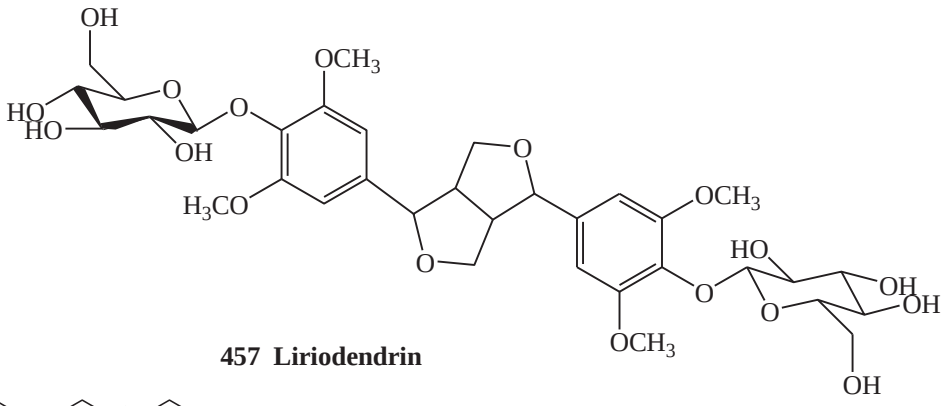
455 Alyterinate B



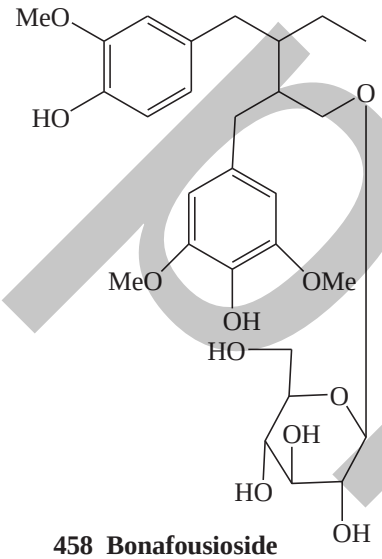
456 Alyterinate C

Table **8**. Lignans of some species of the family Apocynaceae

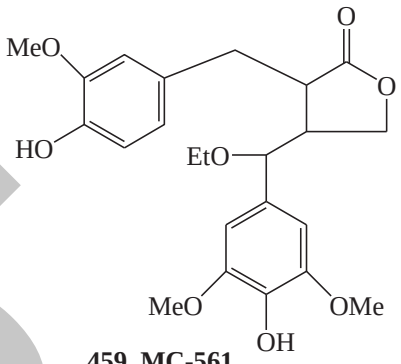
Species	Plant Part	Lignans	References
1. *Allamanda cathartica*	St	1-[3-(4-Allyl-2,6-dimethoxyphenoxy)-4-methoxyphenyl]propane-1,2-diol	Yamauchi *et al.* (2011)
2. *Allamanda neriifolia*		Pinoresinol, medioresinol, syringaresinol and their glucosides, 9α-hydroxypinoresinol and 9α-hydroxymedioresinol.	Abe and Yamauchi (1988b)
3. *Allamanda schottii*	St	Pinoresinol	Anderson *et al.* (1988)
4. *Alyxia reinwardtii*	B St	(+)-Pinoresinol (**452**) and (+)-pinoresinol β-Dp-glucopyranoside (+)-Pinoresinol and zhebeiresino (**453**)	Kitagawa *et al.* (1988) Rao *et al.* (2012); Rattanapan *et al.*(2012)
5. *Alyxia schlechteri*	R	Alyterinates A–C (**454-456**, lignan esters)	Sriphana *et al.* (2013)
6. *Alyxia sinensis*	....	Liriodendrin (**457**) and pinoresinol di-*O*-β-D-glucopyranoside	Wang *et al.* (2002b)
7. *Alstonia scholaris*	L	(-)-Lyoniresinol 3-*O*-β-D-glucopyranoside	Jong-Anurakkun *et al.* (2007)
8. *Aspidosperma marcgravanum*	W	(-)-Lirioresinol C and *O,O*-dimethyllioresinol B	Arndt *et al.* (1967)
9. *Beaumontia brevituba*	S	Syringaresinol β-D-glucoside	Kaneda *et al.* (1992)
10. *Beaumontia grandiflora*	Ap	(+)-Syringaresinol 3-*O*-β-D-glucopyranoside	Kanchanapoom *et al.* (2002)
11. *Bonafousia macrocalyx*	B	Bonafousioside (**458**)	Garnier *et al.* (1988)
12. *Cerbera manghas*	St	Cerberalignans D-I, J (olivil-4.0.8″-*threo*-guaiacylglycerol), K (olivil-5.′5″-cycloolivil), L (**460**, olivil-5.5″-cycloolivil), M (olivil-5.5″-olivil-43′.0.84′-*threo*-guaiacylglycerol), and N (olivil-5′.5″-olivil-4‴.0.84′-*threo*-guaiacylglycerol), olivil (**461**), cycloolivil (**462**), three olivil dimmers: 5',5'''-bis-olivil, 5,5''-bis-olivil and 5,5'-bis-olivil (**463-465**), 4,4',9,7'-tetrahydroxy-3,3'-dimethoxy-7,9'-epoxylignan	Abe *et al.* (1988c, 1989a); Yu *et al.* (2009)



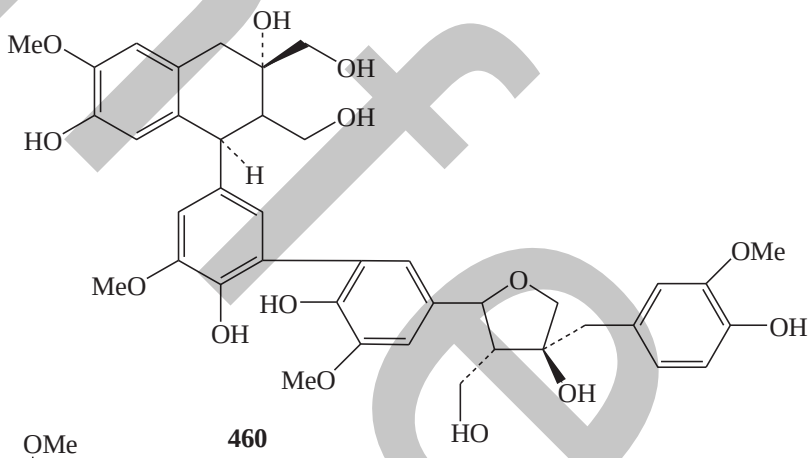
457 Liriodendrin



458 Bonafousioside



459 MC-561



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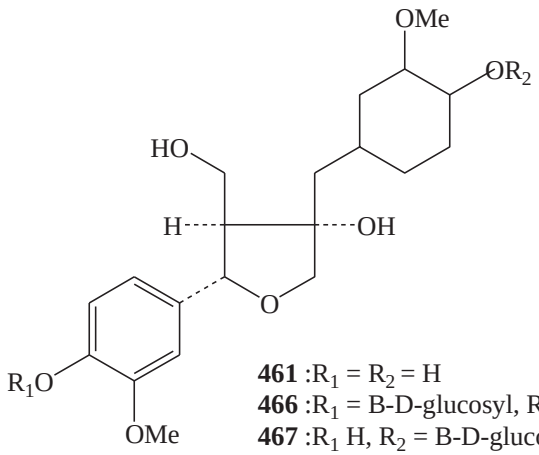
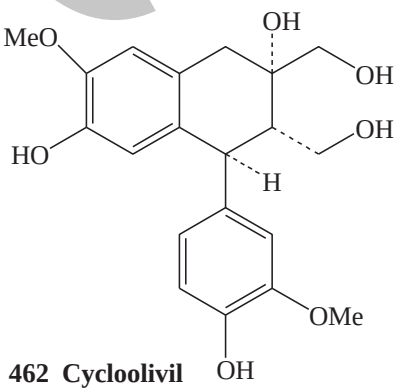


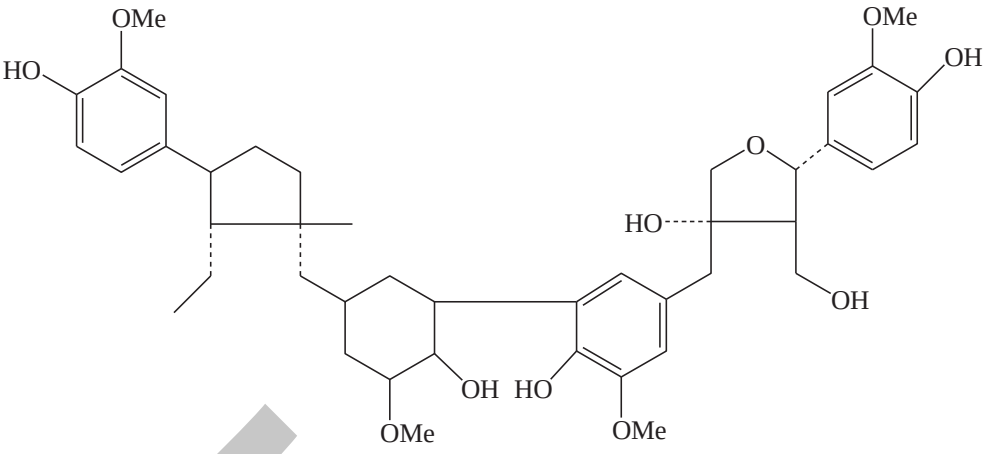
461 :R_1 = R_2 = H
466 :R_1 = B-D-glucosyl, R_2=H
467 :R_1 H, R_2 = B-D-glucosyl



462 Cycloolivil

Table **8**. Lignans of some species of the family Apocynaceae (cont.)

Species	Plant Part	Lignans	References
	L	Olivil 4-*O*-β-D-glucoside (**466)** and olivil 4'-*O*-β-D-glucoside (**467)**	Abe *et al*. (1988d)
	R	(-)-Olivil and (-)-cycloolivil	Chang *et al*. (2000)
	Wp	Cycloolivil	Wang *et al*. (2007)
13. *Cerbera odollum*	St	Cerberalignans D-I, olivil 4-*O*-glucoside, olivil 4′-*O*-glucoside and dimers of olivil (5,6,7)	Abe *et al*. (1988d, 1989a)
14. *Chonemorpha griffithii*	Ap	5'-Methoxy-7'-oxomatairesinol, (+)-(7*R*,8*R*,7'*R*)-lyoniresinol, balanophonin, (+)-lariciresinol, (+)-syringaresinol, and (-)-(7*R*,8*S*)-dihydrodehydrodiconiferyl alcohol	Bai *et al*. (2013)
15. *Chonemorpha macrophylla*	.....	A lignan dervative MC-561 (**459**)	Hamaguchi *et al*. (1993)
16. *Ecdysanthera rosea*	Ap	*ent*-Isolariciresinol, (-)-2α-*O*-(β-D-glucopyranosyl) lyoniresinol and (+)-lyoniresinol	Zhu *et al*. (2010)
17. *Ervatamia hainanensis*	L,T	8α-Hydroxypinoresinol, (+)-syringaresinol and ervatamisin [(-)-(7*R*,7'*R*,7"*R*,8*S*,8'*S*,8"*S*)- 4',4"- dihydroxy-3,3',3",5-tetramethoxy-7,9',7',9- diepoxy-4,8"-oxy-8,8'-sesquineolignan-7",9"-diol]	Yang *et al.* (2013)
	….	Isolariciresinol 9-*O*-β-D-glucopyranoside	Tan *et al.* (2003)
18. *Ervatamia yunnanesis*		Pinoresinol and syringaresinol	Luo *et al*. (2002)
19. *Himatanthus fallax*		Matairesinol, pinoresinol and (7*R*)-methoxy-8-*epi*-matairesinol	Abdel-Kader *et al*. (1997)
20. *Himatanthus sucuuba*	B	Pinoresinol	Waltenberger *et al*. (2011a)
21. *Hunteria zeylanica*	L	(+)-Syringaresinol-4, 4'-*O*-bis-β-D-glucopyranoside	Xie *et al.* (2013)
22. *Laseguea erecta*	St	Pinoresinol	Geraldo de Carvalho *et al.* (2006)
23. *Macrosiphonia petraea*	R	Pinoresinol and 8α-hydroxypinoresinol	De Assis Junior *et al.*, 2013
24. *Melodinus fusiformis*	L,T	(+)-Pinoresinol, 8α-hydroxypinoresinol, syringaresinol, (+)-1-hydroxyresinol and (+)-fraxiresinol	Wang *et al*. (2012a)



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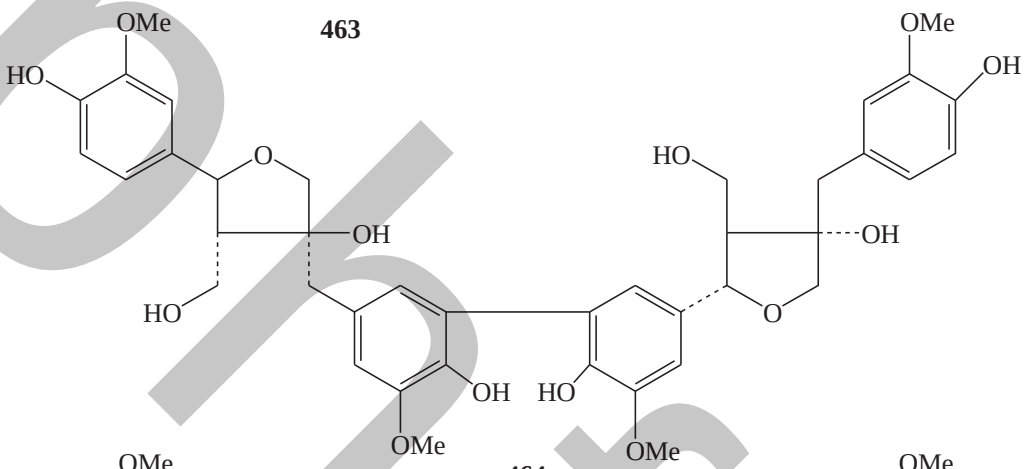

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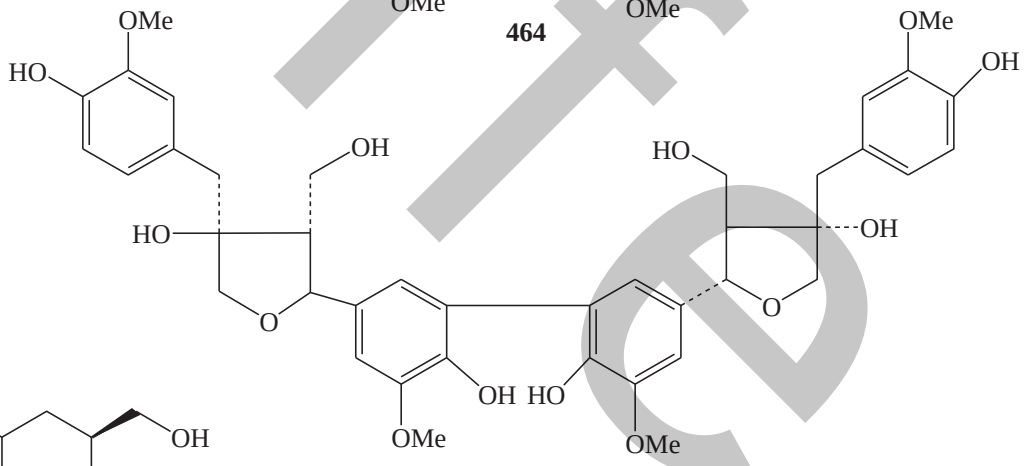
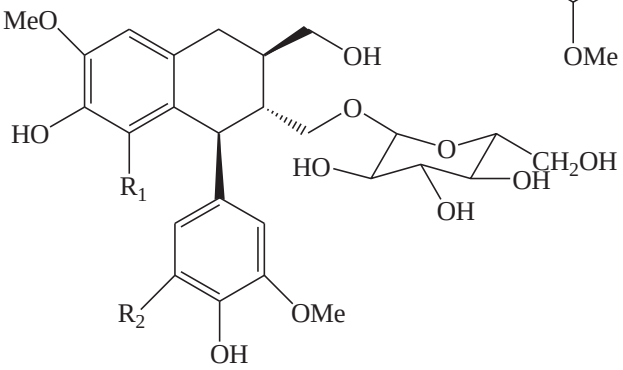


465



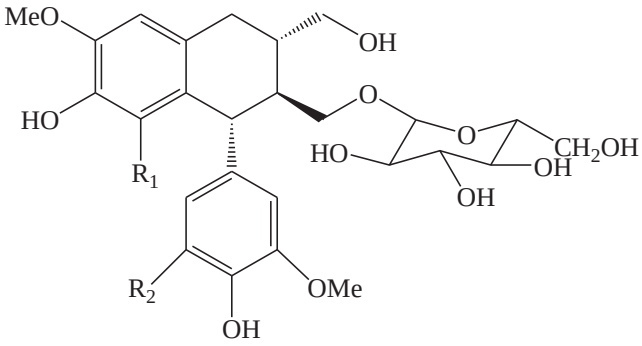
	R1	R2
468:	H	-OMe
469:	H	H
470:	-OMe	-OMe

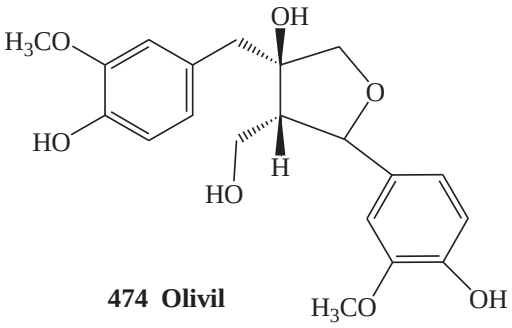
Table **8**. Lignans of some species of the family Apocynaceae (cont.)

Species	Plant Part	Lignans	References
25. *Melodinus suaveolens*	L,Tw	(+)-Isolariciresinol ((+)-cyclolariciresinol)	Tong *et al*. (2013)
26. *Parsonia laevigata*		*bis*-*O*-Rhamnosides of lariciresinol, 5, 5′-dimethoxylariciresinol, *seco*-isolariciresinol and pinoresinolapiosyl (1→2) glucoside	Abe and Yamauchi (1989b)
27. *Plumeria rubra*	B	Liriodendrin	Zaheer *et al.* (2010)
28. *Poacyanum hendersonii*	L	Syringaresinol, syringarsinol β-D-glucoside and pinoresinol 4-*O*-glucoside	Lei *et al.* (1995); Zhang *et al.* (2006a)
	F	(+)-Pinoresinol 4-*O*-β-D-glucopyranoside	Morikawa *et al.* (2012)
29. *Poacynum pictum*	L	Syringaresinol-β-D-glucopyranoside and syringaresinol di-*O*-β-D-glucopyranoside (liriodendrin),	Du *et al.* (2006); Zhang *et al.* (2009d)
30. *Rauwolfia yunnanensis*	R	Syringaresinol	Geng and Liu (2008)
31. *Stemmadenia minima*		(+)-5'-Methoxyisolariciresinol 3α-*O*-β-D-glucopyranoside (**468**), (+)-isolariciresinol 3α-*O*-β-D-glucopyranoside (**469**), (+)-lyoniresinol 3α-*O*-β-D-glucopyranoside (**470**), (-)-lyoniresinol 3α-*O*-β-D-glucopyranoside (**471**), (-)-5'-methoxyisolariciresinol 3α-*O*-β-D-glucopyranoside (**472**) and (-)-isolariciresinol 3α-*O*-β-D-glucopyranoside (**473**)	Achenbach *et al.* (1992)
32. *Strophanthus gratus*	Stb	Olivil (**474**), pinoresinol and 8-hydroxypinoresinol (**476**)	Cowan *et al*. (2001)
33. *Tabernaemontana cymosa*	…	(+)-lyoniresinol (**475**), (+)-5,5'-dimethoxy-9-*O*-(β-D-glucopyranosyl) lariciresinol, (+)-3α-*O*-(β-*O*-glucopyranosyl)-lyoniresinol, (-)-3α-*O*-(β-*O*-glucopyranosyl)-lyoniresinol, (-)-2α-*O*-(β-D-glucopyranosyl)-lyoniresinol, (-)-3α-*O*-(β-D-glucopyranosyl)-5'-methoxyisolariciresinol, (+)-8,8'-dimethoxy- 1-*O*-(β-D-glucopyranosyl)seco-isolariciresinol	Achenbach *et al*. (1997)
34. *Trachelospermum asiaticum*		Trachelosiaside (matairesinol 5′-*C*-β-D-glucoside), arctigenin, many glucosides and gentiobiosides of arctigenin, matairesinol, trachelogenin and nortrachelogenin (**477**)	Abe and Yamauchi (1986); Awale *et al* (2014)

Table **8**. Lignans of some species of the family Apocynaceae (cont.)

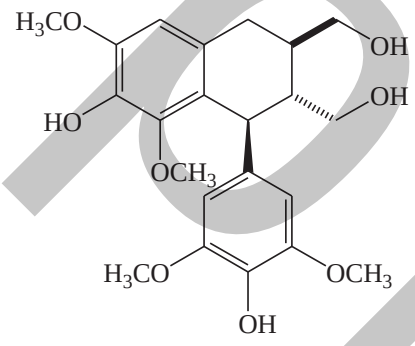
Species	Plant Part	Lignans	References
35. *Tarchelospermum asiaticum var. intermedium*	St	Matairesinoside (**478**) (matairesinol 4-′β-D-glucoside), tracheloside (**479**), matairesinol, arctigenin (**480**), trachelognin, nortrachelogenin, arctigenin 4′-β-gentiobioside (**481**), nortrachelogenin 4,4′-di-β-D-glucopyranoside, nortracheloside (**482**), arctiin (**483**) and (2*R*,3*R*)-2,4′′-hydroxy-3′′-methoxybenzyl-3′,4′,5′-trimethoxybenzyl-butyrolactone (**484**), matairesinol-4,4'-di-*O*-β-D-glucopyranoside and nortrachelogenin-4,4'-di-*O*-β-D-glucospyranoside	Inagaki *et al*. (1968, 1971b,1972b) Nishibe *et al*. (1971a,1973a-d,1981); Miyazaki *et al*. (1958) Nishibe *et al*. (1972, 1973i)
36. *Trachelospermun axillare*	B	Traxillaside (**485**), arctigenin, traxillagenin, trachelogenin, matairesinol, nortrachelogenin, arctiin, tracheloside, matairesinoside and nortracheloside	Nishibe *et al*. (1993)
37. *Trachelospermum foetidum*		Arctigenin 4′-β-gentiobioside (**486**), matairesinoside and tracheloside	Nishibe *et al*. (1973e)
38. *Trachelospermum gracilipes*		Arctiin (arctigenin 4′-*O*-β-D-glucoside), matairesinoside (matairesinol 4'-*O*-β-D-glucoside) and trachelosiasoide (matairesinol 5'-*C*-β-D-glucoside)	Lin *et al*. (1993a)
39. *Trachelospermum jasminoides*	Ap …	Tracheloside and nortrachelogenin 5'-*C*-β-glucopyranoside Arctiin, arctigenin, arctigenin-4'-*O*-β-gentiobioside, matairesinol-4'-*O*-β-gentiobioside, traxillagenin, traxillaside, 4-demethyltraxillagenin, trachelogenin, trachelogenin-4'-*O*-β-gentiobioside, nortrachelogenin, nortrachelogenin-5'-*C*-β- glucoside, nortrachelogenin-8'-*O*-β-glucoside, tracheloside, nortracheloside, matairesinoside and tanegoside A	Zhang *et al*. (2013g) Gao *et al*. (2011); Jing *et al*. (2012)
	L, St	Nortrachelogenin 8′-*O*-β-D-glucopyranoside, nortrachelogenin 5′-*C*-β-D- glucopyranoside, trachelogenin amide, nortracheloside, trachelogenin, tracheloside, 4′-O-β-gentiobioside, 5-methoxy-tracheloside and 5-methoxytrachelogenin	Jing *et al*. (2011); Tan *et al*. (2005b)



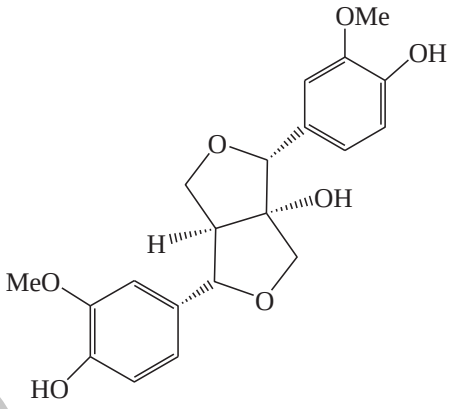


474 Olivil

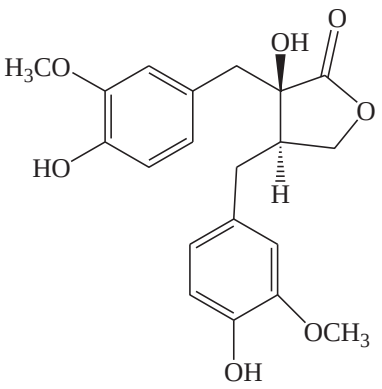
	R1	R2
471:	-OMe	-OMe
472:	H	-OMe
473:	H	H



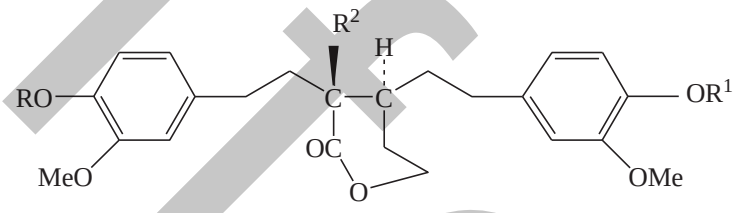
475 (+) Lyoniresinol



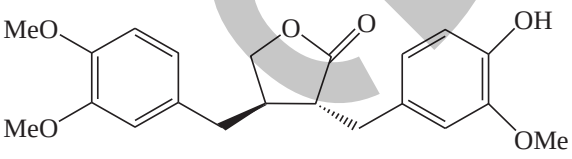
476 8-Hydroxy pinoresinal R =OH



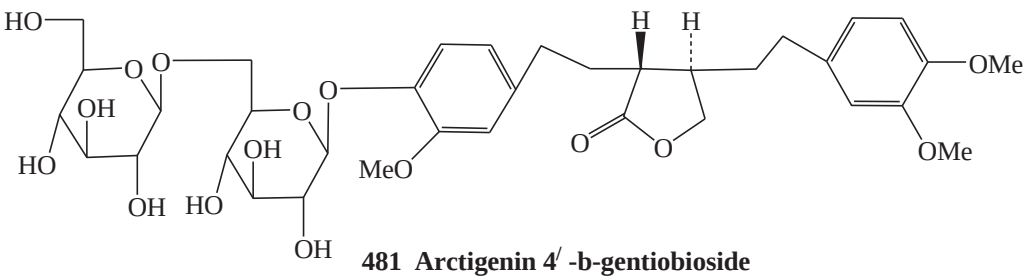
477 (-)Nortrachelogenin



478 II -Matairesinoside R=glucosyl, R^1 =H, R^2 =Me
479 III-Tracheloside R=glucosyl, R^1 =CH_3, R^2 =H
482 IV-Nortracheloside R =glucosyl, R^1 =H, R^2 =OH
483 I-Arctiin R=glucosyl, R^1 =Me, R^2 =H



480 Arctigenin

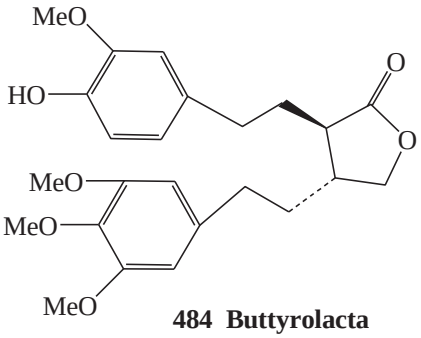


481 Arctigenin 4/ -b-gentiobioside

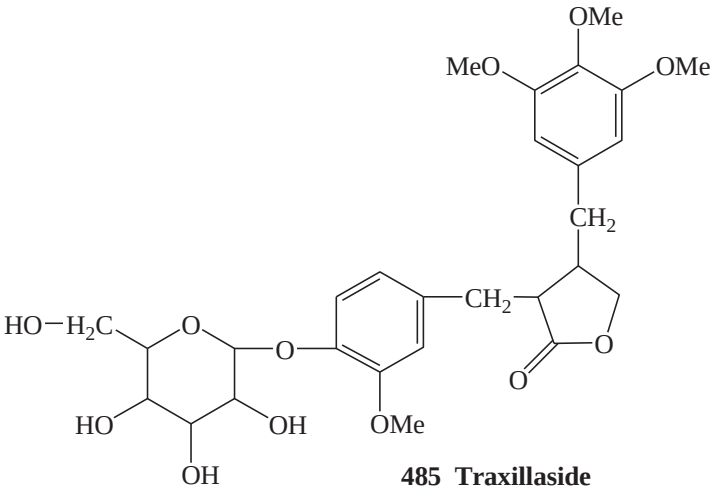
Table **8**. Lignans of some species of the family Apocynaceae (cont.)

Species	Plant Part	Lignans	References
40. *Trachelospermum jasminoides var. heterophllum*		Arctigenin-4′-gentiobioside, tracheloside and 2 optical isomers of tracheloside	Li *et al*. (1994b)
41. *Trachelospermum jasminoides* var. *pubescens*	St	Arctiin, matairesinoside, tracheloside and nortracheloside	Nishibe *et al.* (1973j)
42. *Trachelospermum liukiuense*		Arctigenin 4′-β-gentiobioside, matairesinoside, tracheloside, nortracheloside, tanegosides A (**487**), B (**488**) and (C) (**489**) 4-*O*-glucosylmatairesinoside, dihydroconiferyl alcohol-4′-*O*-glucoside, arctiin and 8,8′-bisdihydrosyringenin glucoside	Nishibe *et al*. (1973e); Abe and Yamauchi (1990)
43. *Trachelospermum lucidum*	L	Matairesionoside-4-*O*-β-D-glucoside, apocynotrachelogenin *5′-O*-β-D-glucoside, rafanotrachelogenin 4-*O*-β-D-glucopyranoside, trachelosiaside, and matairesinol *C*-glycoside	Ahmad *et al*. (2005a); Kousar *et al*. (2008)
44. *Vinca major*	L	Syringaresinol 4-*O*-β-D-glucopyranoside	Şöhretoğlu *et al.* (2013)
45. *Vinca minor*	Tc	Liriosinol B (**490**)	Garnier *et al.* (1975)
46. *Winchia calophylla*	St, B	Sesamin and (-)-lyoniresinol	Zhu *et al*. (2005)

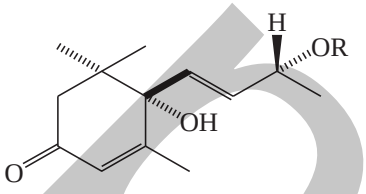
Ap; aerial parts; B: bark; L: leaves; La: latex; St: stems; Stb: stem bark; Tc: tissue culture, Tw: twigs



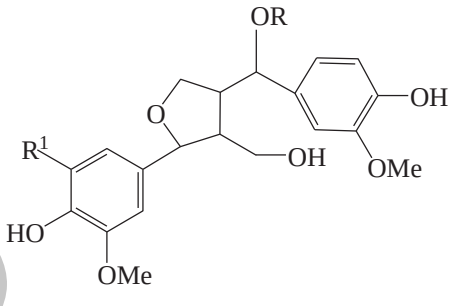
484 Buttyrolacta



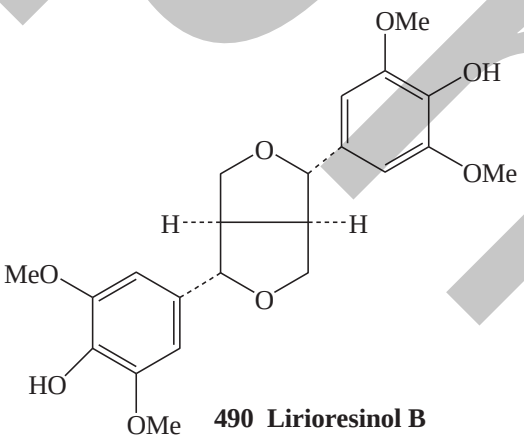
485 Traxillaside



486 Roseoside R=b-D-Glu $(OH)_4$



487 I -Tanegosides A, R=β-D-glocosyl, R^1 =H
488 11 -Tanegosides B, R=β-D-glocosyl, R^1 =H
489 111-Tanegosides C, R=β-D-glocosyl, R^1 =OMe



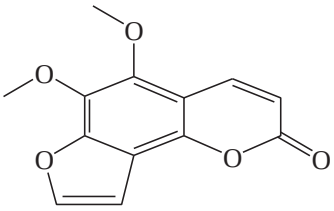
490 Lirioresinol B

Coumarins

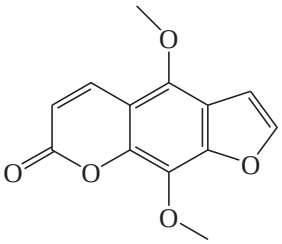
Coumarins have been identified from several species of the family; examples of these are the following:

1. *Allamanda blanchetti*: Umkalin (5,6-dimethoxy-7-hydroxycoumarin) from the root bark (Bhattacharyya and De Morais, 1986).
2. *Allamanda doniana*: Scopoletin from the woods and roots (Harumi *et al.*, 1995).
3. *Allamanda schottii*: Scoparone and scopoletin from the stems (Anderson *et al*., 1988).
4. *Allamanda violacea* A. DC.: 5,6-Dimethoxycoumarin from the flowers (Sethi *et al*., 2013).
5. *Alstonia mairei*: Pimpinellin (**491**), isopimpinellin (**492**) and toddalolactone (**493**) from the roots and bark (Ye *et al*., 1989).
6. *Alstonia yunnanensis*: Methyl 3,4,5-trimethoxycinnamate from the roots (Chen *et al*., 1985).
7. *Alyxia insularis* Kanehira & Sasaki: Coumarin, 8-hydroycoumarin and umbelliferone (Huang *et al*., 1990a; Wang *et al*., 1993).
8. *Alyxia lucida*: Coumarin, 3-hydroxycoumarin, 8-hydroxycoumarin, 5-hydroxycoumarin and scopoletin (Sadavongvivad and Supavilai,1977).

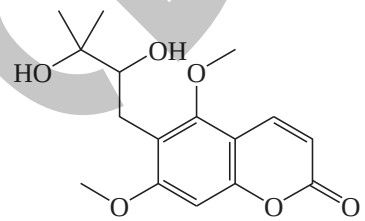
9. *Alyxia reinwardtii*: Coumarin, 3-hydroxycoumarin, 6-hydroxycoumarin, 8-hydroxy-coumarin and scopoletin from the stems (Rattanapan *et al*., 2012).
10. *Alyxia reinwardtii* var. *lucida*: Two 3-hydroxycoumarin glycosides I and II from the inner bark (Lin *et al*., 1993b).
11. *Alyxia sinensis*: Coumarin, aesculin (esculin) (**494**), flaxetin and scopoletin (Wang *et al*., 2002b).
12. *Anodendron affine*: A benzopyran compound, 2,2-dimethyl-2*H*-1-benzopyran-6-carboxylic acid (2,2-dimethyl-2*H*-chromene-6-carboxylic acid (Shima *et al.*, 1971e).
13. *Apocynum venetum*: Esculin, esculetin, isofraxidin and scopoletin from the flowers, leaves and bark (Chen and Liu, 1991; Cai *et al*., 2007a; Li *et al*., 2011; Kong *et al*., 2013).
14. *Baissea leonesis*: The leaves contain baisseoside which yielded on hydrolysis esculetol, rhamnose and glucose (Pousset *et al*., 1970).
15. *Beaumontia grandiflora* Wall.: Scopolin and scopoletin (Kanchanapoom *et al*., 2002).
16. *Cerbera manghas*: Two furocoumarins, nodakenin (**495**) and isoimperatorin (Wang *et al.*, 2007).
17. *Echites hirsuta*: Fraxetin (Chien *et al*., 1979).
18. *Ecdysanthera rosea*: Scopoletin from the stems (Lin *et al.*, 2002a).
19. *Ervatamia hainanensis*: 8-Hydroxy-6-methoxy-3-*n*-pentylisocoumarin (Jin *et al*., 2008) and toddalolactone from leaves and twigs (Yang *et al*., 2013).
20. *Landolphia dewei* Stapf: Scopoletin was isolated from the plant cultivated in Egypt (Michel and Sleem, 2003).
21. *Laseguea erecta*: Scopoletin from the stems (Geraldo de Carvalho *et al*., 2006).
22. *Nerium odorum*: Scopoletin and scopolin (Rittel *et al*., 1953).
23. *Pentalinon andrieuxii* Mueller-Argoviensis (syn. *Urechites andrieuxii*): Three coumarins, serborosin (**496**), xanthoxyletin (**497**) and xanthyletin (**498**) from the roots (Pan *et al*., 2012).
24. *Plumeria obtusa*: Scopoletin from the leaves (Siddiqui *et al*., 1992a).
25. *Plumeria rubra*: Scopoletin (Kuigoua *et al.*, 2010; Shinde *et al*., 2014).
26. *Poacynum pictum* (Schrenk) Baill: Isoscopoletin from the leaves (Zhang *et al*., 2009d).
27. *Trachelospermum asiaticum* var. *intermedium*: Scopoletin from the stems (Nishibe *et al*., 1981).
28. *Trachelosperomum jasminoides*: Scopoletin (Yuan *et al*., 2010).
29. *Voacanga africana*: 8-Hydroxy-6-methoxy-3-pentylisocoumarin from the bark (Dan *et al.*, 2013). Precocene I (7-methoxy-2,2-dimethylchromene) represented 95.2% of the volatile oil (Ehiabhi *et al*., 2006).



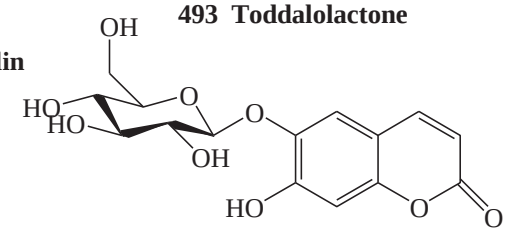
491 Pimpinellin



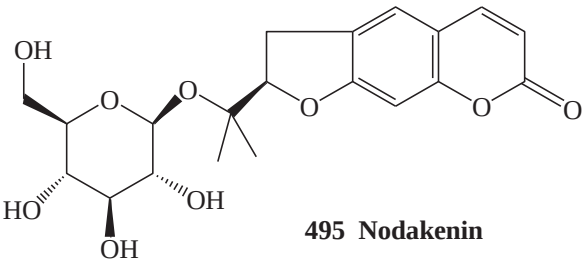
492 Isopimpinellin



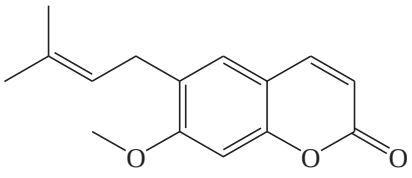
493 Toddalolactone



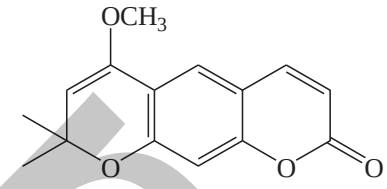
494 Aesculin



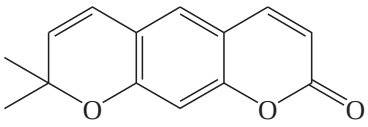
495 Nodakenin



496 Serborsosin



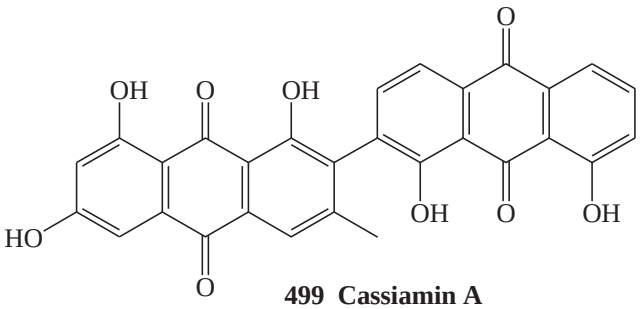
497 Xanthoxyletin



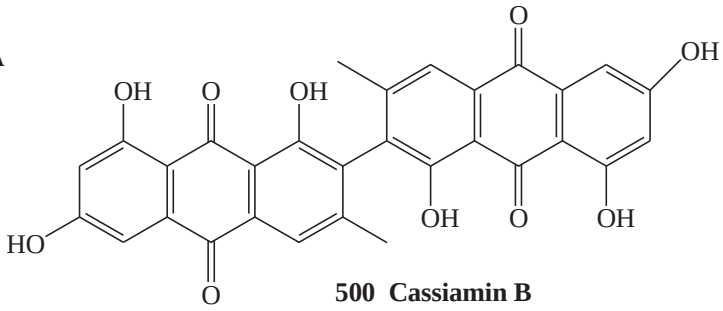
498 Xanthyletin

Quinones

Three anthraquinones, physicon, emodin and chrysophanol were isolated from the stems of *Alyxia sinensis* (Wang *et al.* (2002b). Emodin was isolated from*Trachelospermum jasminoids* (Zhang *et al.*, 2012b). 2-Acetyl-3-hydroxy-1,4-naphthoquinone was identified from the leaves and stems of *Pachypodium lamerei* Drake, cultivated in Egypt (El-Kashef *et al.*, 2014). 2,6-Dimethoxybenzoquinone was identified from the roots of *Rauwolfia vomitoria* (Kupchan and Obasi, 1960). *Plumeria rubra* contains 2,6-dimethoxy-*p*-benzoquinone (Kuigoua *et al.*, 2010) and 2,5-dimethoxy-*p*-benzoquinone (Shinde *et al.*, 2014). *p*-Hydroxyphenyl-*O*-β-D-primeveroside (a glycoside formed from hydroquinone) was isolated from cell suspension cultures of *Rauwolfia serpentina* (Lutterbach *et al.*, 1993). Two dimeric anthraquinones, cassiamin A (**499**) and cassiamin B (**500**), were isolated from the stem bark of *Schizozygia coffaeoides* (Atilaw *et al.*, 2014). Hydroquinone was identified from the leaves of *Wrightia tinctoria* R. Br. (Jose and Joji, 2014). A hydroquinone diglycoside acyl ester, ecdysanrosin A was isolated from the aerial parts of *Ecdysanthera rosea* (Zhu *et al.*, 2010).



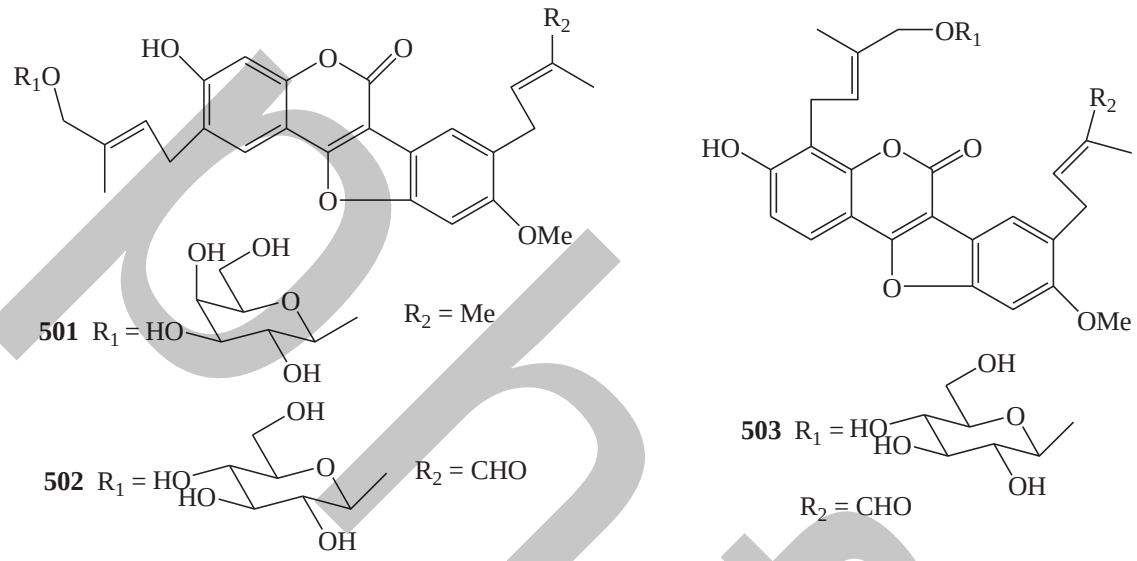
499 Cassiamin A



500 Cassiamin B

Coumestans

Coumestans (phytoestrogens, which are oxidation products of pterocarpan that are similar to coumarin, "derivatives of isoflavones"), mostly found in the Leguminosae, have been isolated from *Picralima nitida*. The roots of *Picralima nitida* yielded three coumestan glycosides, 3-hydroxy-9- methoxy-2- [2'(*E*)-3'- methyl-4'-*O*-β-galactopyranosylbutenyl]-8-isoprenylcoumestan (**501**), 3-hydroxy- 9-methoxy-2- [2'(*E*)-3'-methyl-4'-*O*-β-glucopyranosyl-butenyl]-8-[2''(*E*)-3''-methyl-4''-oxobutenyl]coumestan (**502**), and 3-hydroxy-9-methoxy-4-[2'(*E*)-3'-methyl-4'-*O*-β-glucopyranosylbutenyl]-8-[2''(*E*)-3''-methyl-4''-oxobutenyl] coumestan (**503**) (Kouam *et al.*, 2011).



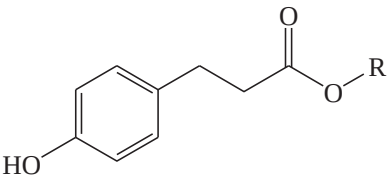
Organic Acids & Phenolic compounds

The Apocynaceae belonging to the Echitoideae tribes, have a polyphenol composition similar to that of Plumierioideae. The main phenolic acids encountered were protocatechuic and *p*-coumaric acid and the flavonoids were represented by flavonols derived from kaempferol and quercetol (Duret and Paris, 1972). The following are examples of organic acids and phenolic compounds, other than flavonoids and lignans, identified from some Apocynaceae species:

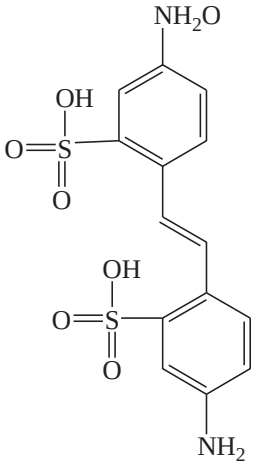
1. *Aganosma caryophyllata*: Ferulic and vanillic acids from flowers and leaves (Ramana *et al.*, 1985; Serkhar *et al.*, 1985).
2. *Alafia multiflora* Stapf.: Vanillic acid from the latex (Balansard *et al.*, 1980).
3. *Allamanda neriifolia* Hook (Yellow bell): Four long chain 4-hydroxycinnamate esters (**504**-**507**) from the flowers (Ragasa and Alimboyoguen, 2013).
4. *Allamanda violaceae* A. DC.: Hexadec-2-enylsuccinic anhydride and 1,2-benzene dicarboxylic,bis(2-ethylhexyl)ester from the flowers (Sethi *et al.*, 2013).
5. *Alstonia angustiloba*: 3-*O*-Caffeoylquinic acid, 4-*O-caffeoylquinic* acid and 5-*O*-caffeoylquinic acid from the leaves (Wong *et al.*, 2014a).
6. *Alstonia scholaris*: 1-Hydroxy-3,5-dimethoxyxanthone (Du *et* al., 2007), chlorogenic acid and caffeic acid from the leaves (E-Askary *et al.*, 2013).
7. *Alstonia venenata* R. Br.: Phenol, 4-propyl-; 1,2-benzenedicarboxylic acid, mono(2-ethylhexyl) ester and didodecyl phthalate from the leaves (Sutha *et al*., 2012).
8. *Alyxia reinwardtii*: *p*-Hydroxybenzoic acid from the stems (Rao *et al*., 2012; Rattanapan *et al*., 2012).
9. *Amsonia sinensis*: Amsonic acid (**508**) and *trans*-sinapic acid methyl ester (Wang and

Feng, 2003).

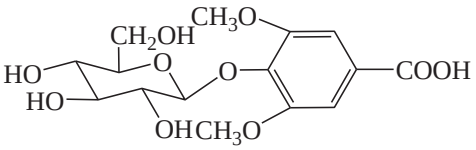
10. *Anodendron affine* Druce: Glucosyringic acid (**509**) (4-β-D-glucopyranosyloxy-3,5-dimethoxy-benzoic acid, 4-hydroxy-3-(3-methyl-2-butenyl)benzoic acid (**510**), anodendroic acid [**511**, 2-(1-hydroxy-1-methylethyl)-2,3-dihydrobenzofuran-5-carboxylic acid] from the stems (Shima *et al*., 1971c,d, 1972b); esters of 4-*O*-glucosyl-3,5-diprenyl-4-hydroxybenzoic acid (4-*O*-glucosylnervogenic acid) with carbohydrates such as sucrose, 1,3-di-*O*-methyl-*myo*-inositol (dambonitol) and glucose, named anodendrosins A-I (e.g. anodendrosin A (**512**, 1,3-di-*O*-methyl-6-*O*-(4-*O*-β-D-glucopyranosyl-3,5-diprenyl-4-hydroxybenzoyl)-*myo*-inositol) and others (**513**- **516**) (Abe and Yamauchi, 1985b), nine homologous compounds (e.g. anodendrsin J (**517**), anodendrosin K (**518**) and 7 others (**519**- **525**) mainly from from the seeds (Hanada *et al*., 1992b,d); chlorogenic acid and its methyl ester from the leaves (Sakushima *et al*., 1985).
11. *Anodendron formicinum* (Tsiang & P. T. Li) D. J. Middleton: Formicinuoside A (**526**), formicinuoside B (**527**), formicinuoside C (**528**), 4-hydroxy-3-prenylbenzoic acid, 4-(*O*-β-D-glucopyranosyl)-3-prenylbenzoic acid methyl ester (**530**), 4-(*O*-β-D-glucopyranosyl)-3-prenylbenzoic acid (**531**), canthoside C (**532**) and anodendrosin E from the stems (Qin *et al*., 2014).
12. *Apocynum androsaemifolium*: Acetovanillone (**533**) from the roots (Abubakirov and Yamatova, 1960b).
13. *Apocynum cannabinum*: Acetovanillone (apocynin, 4'-hydroxy-3'-methoxyacetophenone) and *p*-hydroxyacetophenone from the roots (Trabert, 1960b; Murzagaliev *et al*., 1973).
14. *Apocynum pictum*: Apocynin, a naturally occurring methoxy-substituted catechol, from the roots (Murzagaliev *et al*., 1973).
15. *Apocynum venetum*: Vanillic acid, isovanillic acid, chlorogenic acid, methyl chlorogenate, protocatechuic acid (**529**), caffeic acid, 3-*O*-caffeoylquinic acid, tyrosol [4-(2-hydroxyethyl) phenol], benzyl-*O*-β-D-glucopyranoside, 2-phenylethyl-*O*-β-D-glucopyranoside, 1-β-*O*-benzoyl-D-glucopyranoside from the leaves and flowers (Chen *et al*., 2005; An *et al*., 2013; Kong *et al*., 2013); hyperforin [**536**, a prenylated phloroglucinol derivative] from the herb (Song and Huang, 2012), 3,4-dihydroxybenzoic acid Me ester, 3,5-dihydroxy-benzaldehyde, and 3,4-dihydroxybenzoic acid from the bark (Li *et al*., 2011). The proanthocyanidins in the plant from different habitats ranged from 2.16% to 10.95% (Guang *et al*., 2009). The leaves contain ~ 4.90% gallotannins (Jiang and Liu, 1988). The seeds also contained a large amount of tannins (11.7%) (Peive, 1930). *p*-Hydroxy-acetophenone and acetovanillone were identified from the underground parts (Sancin, 1971).
16. *Apocynum venetum* var. *basikurumon*: *p*-Hydroxyacetophenone from the roots (Imai and Ikeda, 1957), succinic acid and chlorogenic acid from the leaves (Sakushima *et al*., 1978).
17. *Aspidosperma formasanum*: Lichexanthone from the plant (Garcia M. and Brown, 1976).
18. *Aspidosperma macrocarpon*: 5-*O*-Caffeoylquinic acid and 3,5-*O*-dicaffeoylquinic acid from the leaves (Bannwart *et al.*, 2013).
19. *Aspidosperma polyneuron*: The bark contains tannin 0.492% (Floriani, 1930a).
20. *Aspidosperma quebracho blanco* (White quebracho): The wood contains 3% tannin bark 4% and the leaves 27.5% (Norton, 1916).
21. *Beaumontia grandiflora*: 2-Hydroxybenzoic acid (Wang *et al*., 2009c).
22. *Catharanthus roseus*: Chlorogenic acid from the leaves (Nishibe *et al*., 1996); lanast-5,8-dien-3β-ol-27-oic acid-3β-D-glucopyranosyl (4'-1")-10",11"-dimethoxy-anthracene, 2-methoxy-6 (*n*-nonacontan-5",6"-dionyl)- 11-hydroxy-13-methyl- 11β-rhamnopyranoside



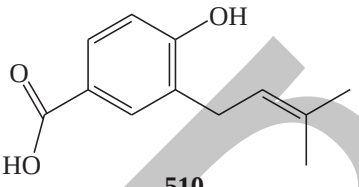
504 R=-$(CH_2)_8CH{=}CH(CH_2)_{11}CH_3$
505 R=-$(CH_2)_{21}CH_3$
506 R=-$(CH_2)_8CH{=}CH(CH_2)_{13}CH_3$
507 R=-$(CH_2)_{23}CH_3$



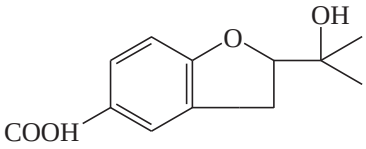
508 (E)-Amsonic acid



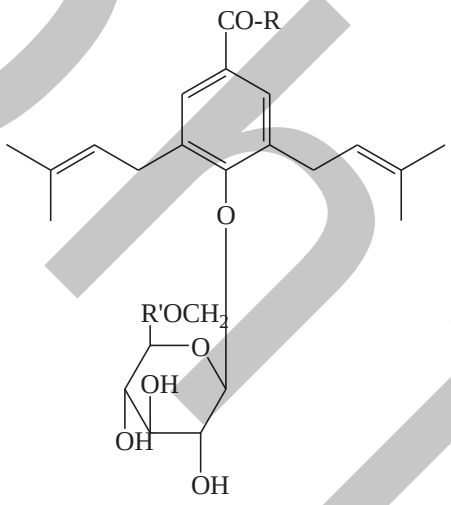
509 Glucosyringic acid

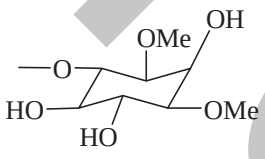


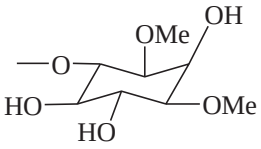
510



511 Anodendroic acid

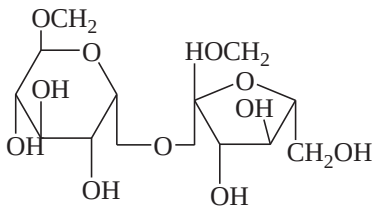


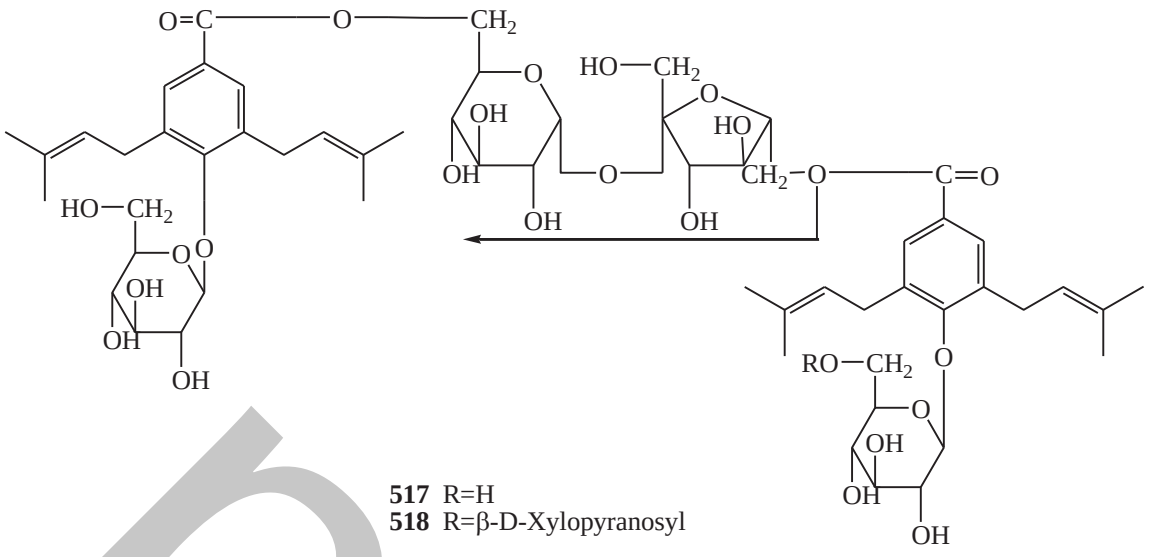
512 Anodendrosin A R=  ; R' =H

513 Anodendrosin C R=  ; R' =β-D-Xylopyranosyl

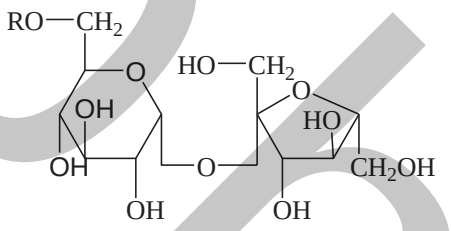
514 Anodendrosin B R =β-D-Glucopyranosyl; R' =H

515 Anodendrosin D R =β-D-Glucopyranosyl; R' =β-D-Xylopyranosyl

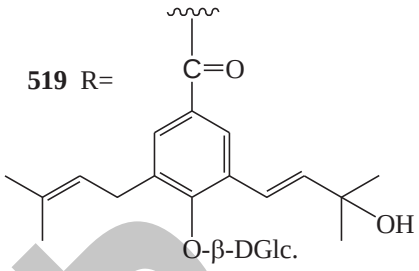
516 Anodendrosin E R=  ; R'=H

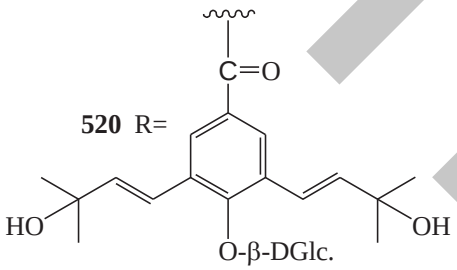


517 R=H
518 R=β-D-Xylopyranosyl

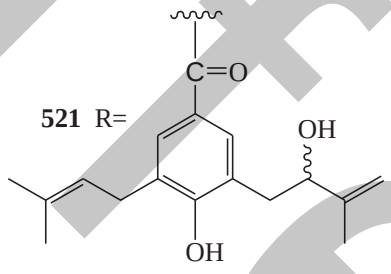


519 R=

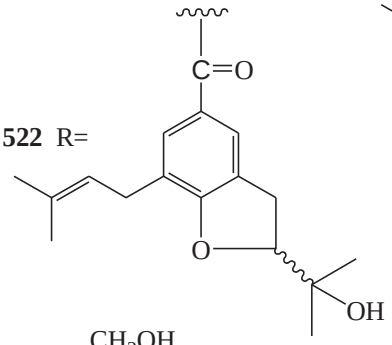




520 R=



521 R=



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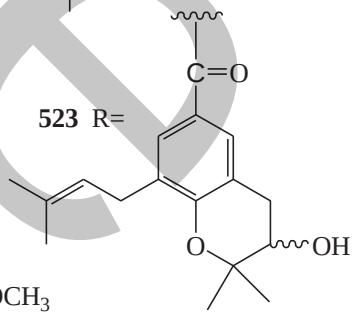
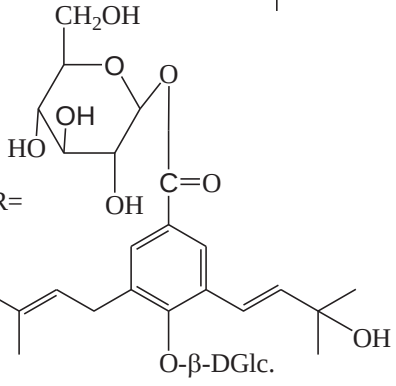
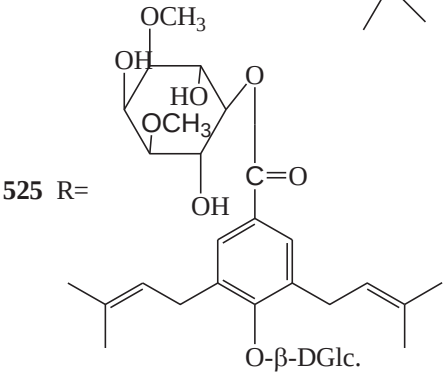


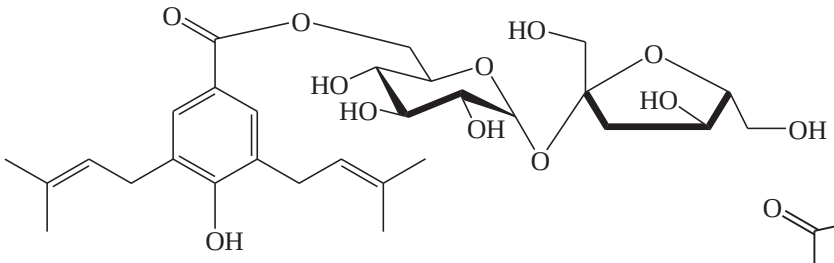
523 R=



524 R=



525 R=



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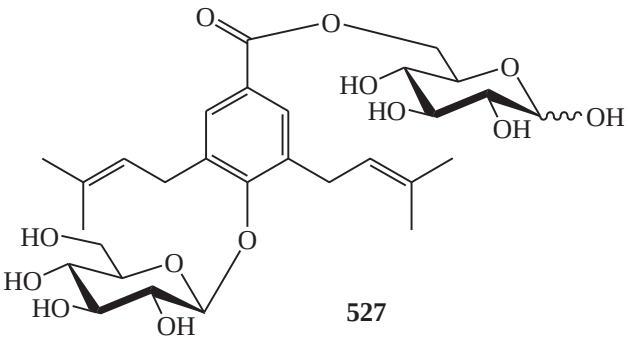

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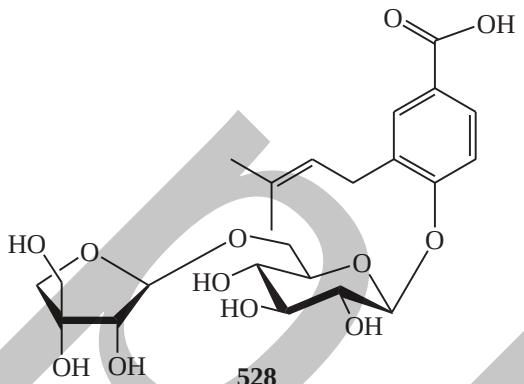

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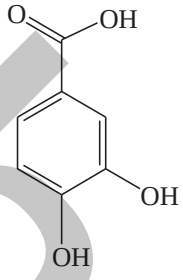
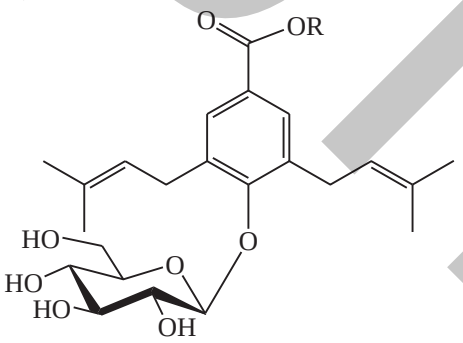
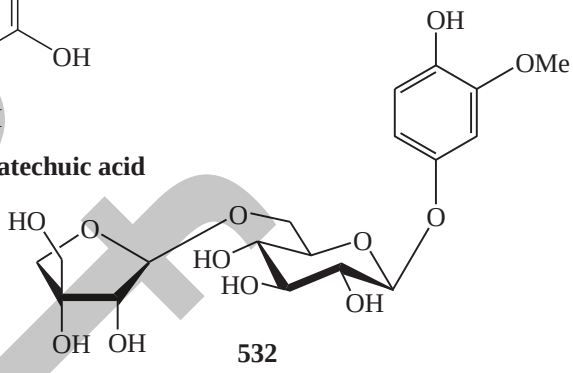


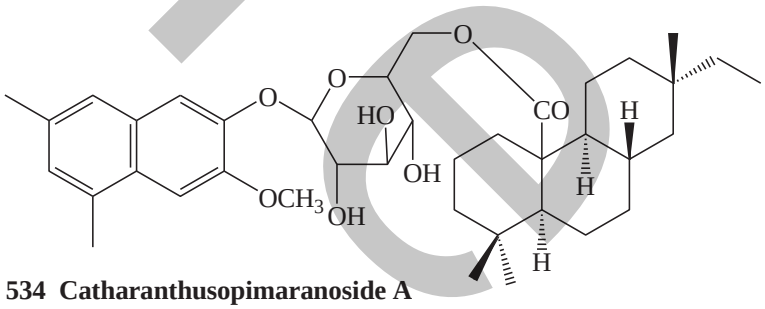
529 Protocatechuic acid



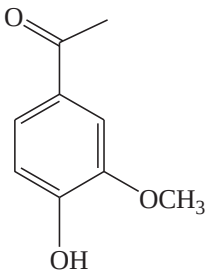
530 R=Me **531** R=H



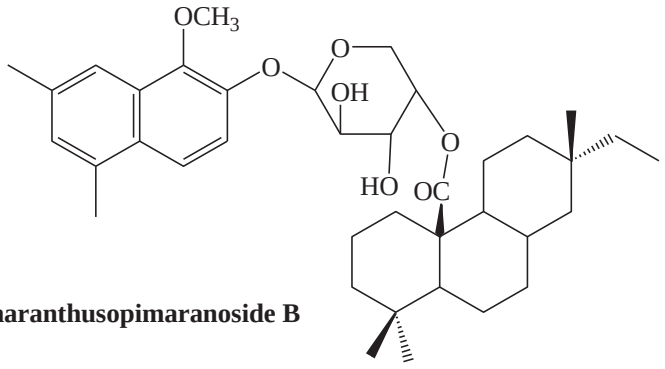
532



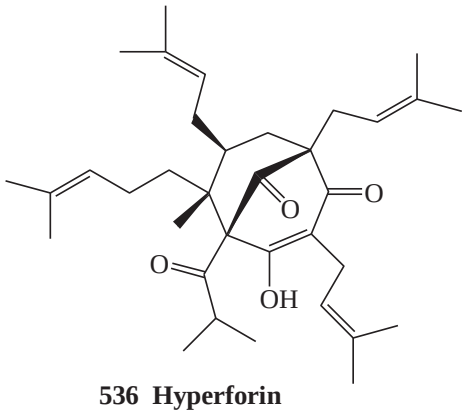
534 Catharanthusopimaranoside A



533 Acetovanillone



535 Catharanthusopimaranoside B



536 Hyperforin

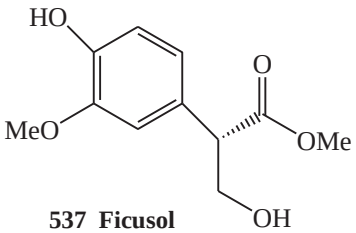
anthracene, catharanthusopimaranosides A and B (**534, 535**) from the hairy root cultures (Chung *et al*., 2007c, 2008a); 3-*O*-caffeoylquinic acid, 3-*O*-caffeoylquinic acid and 3-*O*-caffeoylquinic acid from the leaves and stems (Ferreres *et al*., 2008). High density cultures of *C. roseus* produced 1.54 g vanillin glucoside per L suspension culture (6% of the dry wt.) within 24 h corresponding to a yield of 60% (Sommer *et al.*, 1997). Oxalic, *cis*-aconitic, citric, pyruvic, malic and fumaric acids were detected in the roots (Pereira *et al*., 2010a). Besides alkaloids, the plant produces a wide spectrum of phenolic compounds, such as 2,3-dihydroxybenzoic acid, as well as phenylpropanoids such as cinnamic acid derivatives, flavonoids and anthocyanins. As reviewed by Mustafa and Verpoorte (2007), the following phenolic compounds (other than flavonoids, mentioned in Table 11) were identified from the different parts (aerial parts, leaves, stems and flowers) and cell suspension culture: benzoic acid, 2,3-dihydroxybenzoic acid, 2,3-dihydroxybenzoic acid glucoside, 2,5-dihydroxybenzoic acid, 2,5-dihydroxybenzoic acid glucoside, salicylic acid, salicylic acid glucoside, gallic acid, glucovanillin, vanillic acid, glucovanillic acid, vanillyl alcohol, vanillyl alcohol-phenyl-glucoside, *trans*-cinnamic acid, hydroxytyrosol (**536**, 4-(2-hydroxyethyl)-1,2-benzenediol), ferulic acid, chlorogenic acid, malvidin, malvidin 3-*O*-glucosides, malvidin 3-*O*-(6-*O*-*p*-coumaroyl), petunidin, petunidin 3-*O*-glucosides, petinidin 3-*O*-(6-*O*-*p*-coumaroyl), hirsutidin (an *O*-methylated anthocyanidin), hirsutidin 3-*O*-glucosides and hirsutidin petinidin 3-*O*-(6-*O*-*p*-coumaroyl). The production of anthocyanin in the flowers from both field-grown and regenerated by somatic embryogenesis plants and cell cultures were also described (Piovan and Filippini, 2007). The anthocyanins in the suspension cultures were compared with those biosynthetized in the flowers both of regenerated by somatic embryogenesis and field-grown plants. Six anthocyanins were identified in all the examined samples, three 3-*O*-glucosides and three 3-*O*-(6-*O*-*p*-coumaroyl) glucosides of petunidin, malvidin and hirsutidin. The anthocyanin relative content was similar for cell suspensions and flowers from regenerated plants but different from field-grown plant flowers; instead, the total content was almost the same for the two flower types and higher compared to suspension culture content (Filippini *et al.*, 2003).

23. *Cerbera manghas* L.: Salicylic acid from the cortex (Zhang *et al.*, 2008), stem and bark (Li *et al.*, 2010b), 1,3-bis(*m*-carboxyphenyl)-propan-2-one, 2-(*m*-carboxyphenyl)-3-(*m*-carboxylbenzyl) succinic acid (Zhang *et al*., 2009b), two phenylpropionic acid derivates, cerberic acids A and B (Zhang *et al.*, 2010e) from the bark; benzoic acid, vanillic acid, vanillin, *p*-hydroxybenzaldehyde, isophthalaldehydic acid, β-hydroxy-propiovanillone, ficusol (**537**), evofolin B, 3,4'-dihydroxypropiophenone, *p*-hydroxybenzoic acid, protocatechuic acid from the fruits (Cao *et al.*, 2013), *p*-hydroxybenzaldehyde, *m*-

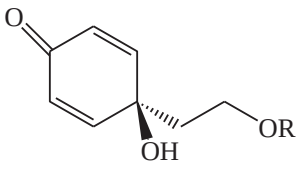
carboxyphenylacetic acid, *p*-hydroxybenzoic acid, protocatechuic acid, *p*-hydroxy-cinnamic acid, isophthalic acid, vanillic acid, succinic acid from the leaves (Zhang *et al*., 2010c,d), coniferaldehyde, ethyl (2*E*)-3-(4-methoxyphenyl)-2-propenoate and *p*-hydroxy-phenylethyl anisate (Wang *et al*., 2007) and (3*R*)-des-*O*-methyllasiodiplodin (Wang *et al*., 2010b).

24. *Cerbera odollam* Gaertn.: 2,6-Dihydroxy-4-methoxy benzoic acid and 2-hydroxy-4-methoxy-6-Me benzoic acid from the stem bark (Hasan *et al*., 20111).
25. *Chonemorpha griffithii* Hook. f. (syn. *Chonemorpha valvata* Chatterjee): Tararic acid, methyl orsellinate, *cis*-hydroxymellein and *trans*-hydroxymellein from the aerial parts (Bai *et al*., 2013).
26. *Dyera costulata*: 5-*O*-Caffeoylquinic acid from the leaves (Wong *et al*., 2014a).
27. *Ecdysanthera rosea*: 5-*O*-Caffeoylquinic acid, methyl 5-*O*-caffeoyl quinate, butyl 5-*O*-caffeoyl quinate (Lin *et al*., 2002a), tianshic acid (Zhu *et al*., 2010), tartaric acid and malic acid from the aerial parts (Lin *et al*., 2002a).
28. *Ecdysanthera utilis*: Two proanthocyanidins, epicatechin-(4β→8,2β→*O*→7)-epicatechin-(4β→8)-epicatechin and epicatechin-(4β→8)-epicatechin-(4β→8,2β→*O*→7)-epicatechin -(4β→8)-epicatechin; epicatechin, procyanidin B2, proanthocyanidin A1, proantho-cyanidin A2, and aesculitannin C (Lin *et al*., 2002b).
29. *Epigynum auritum*: Catechin-3-*O*-α-L-rhamnopyranosyl-(1→4)-β-D-glucopyranosyl-(1→6)-β-D-glucopyranoside from the rhizomes (Jin and Mu, 1991).
30. *Ervatamia coronaria*: Vanillic, gentisic, syringic, 4-hydroxybenzoic and salicyclic acids (Henriques *et al*., 1996).
31. *Ervatamia hainanensis*: *threo*-2,3-*bis*-(4-Hydroxy-3-methoxyphenyl)-3-methoxy-propanol from the leaves and twigs (Yang *et al*., 2013).
32. *Himatanthus sucuuba*: Two lichen depsides, confluentic acid and 2'-*O*-methyl-perlatolic acid, vanillic acid, *p*-coumaric acid, *p*-hydroxybenzoic acid from the bark (Endo *et al*., 1994) and gallic acid acid from the latex (Silva *et al*., 2010).
33. *Holarrhena antidysentrica*: 5-Caffeoylquinic acid (chlorogenic acid) from the seeds (Kumar *et al*., 2013b).
34. *Holarrhena* species: *p*-Hydroxybenzoic acid, protocatechuic acid and *p*-coumaric acid from the leaves of *Holarrhena crassifolia*, *Holarrhena floribunda* and *Holarrhena mitis* (Paris and Duret, 1973).
35. *Hunteria zeylanica*: (±)-*erythro*-Guaiacylglycerol, (±)-*threo*-guaiacylglycerol, 1,3,5-trimethoxybenzene, glucosyringic acid, 2, 6-dimethoxy-4-hydroxyphenol-1-*O*-β-D-glucopyranoside and 3, 5-dimethoxy-benzyl alcohol 4-*O*-β-D-glucopyranoside from the leaves (Xie *et al*., 2013).
36. *Ichnocarpus frutescens* R. Br.: Vanillic acid, syringic acid, sinapic acid and protocatechuic acid from the leaves (Daniel and Sabnis, 1978; Chaudhary *et al*., 2012; Singh and Singh, 2012).
37. *Kopsia fruticosa*: 3-*O*-Caffeoylquinic acid, 4-*O*-caffeoylquinic acid and 5-*O*-caffeoylquinic acid from the leaves (Wong *et al*., 2014a).
38. *Kopsia hainanensis*: Dihydrodehydrodiconiferyl alcohol from the leaves and twigs (Yang *et al*., 2012c).
39. *Macrosiphonia longiflora* (Desf.) Mull. Arg: Ellagic acid (da Silva *et al*., 2014).
40. *Melodinus fusiformis*: Dibutyl phthalate, butyl isobutyl phthalate, *bis*-(2-ethylhexyl)-tetraphthalate and 2-hydroxybenzoic acid from the leaves (Wang *et al*., 2012a).
41. *Melodinus hemsleyanus*: Dibutylterephthalate from the leaves (Zhang *et al*., 2013a).
42. *Melodinus suaveolens*: Salicylic acid and 2,3-dihydroxy-1-(4-hydroxy-3-methoxy-phenyl)-propan-1-one from the leaves and twigs (Tong *et al*., 2013).

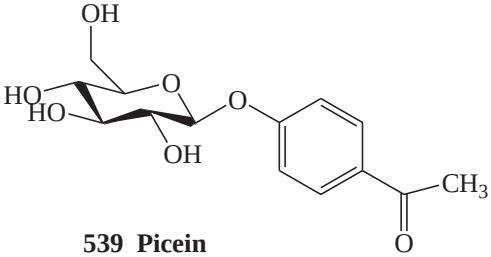
43. *Nerium indicum*: 3-*O*-Caffeoylquinic acid and 5-*O*-caffeoylquinic acid from the leaves (Ishikawa *et al.*, 2007).
44. *Nerium odorum*: 4-Hydroxyacetophenone and 2,4-dihydroxyacetophenone from the dried root bark (Yamauchi *et al*., 1972a).
45. *Nerium oleander*: 3-*O*-Caffeoylquinic, 4-*O*-caffeoylquinic and 5-*O*-caffeoylquinic acids from te leaves (Wong *et al.*, 2014a).
46. *Ochrosia nakaiana* (Koidz.) Koidz. ex H. Hara: Chlorogenic acid from the leaves (Sakushima *et al*., 1980c).
47. *Ochrosia oppositifolia*: Two ferulic acid esters namely (*E*)-methyl 3-(4'-hydroxy-3',5' dimethoxyphenyl) acrylate and (*E*)-methyl 18-(*E*)-3-(4'-hydroxy-3'methoxyphenyl)-acryloyloxy octadec-3-enoate (Nasab *et al*., 2011).
48. *Parameria laevigata* Moldenke: Three trimeric proanthocyanidins, cinnamtannin B-1, aesculitannin B and epicatechin-(2β→*O*→7, 4β→6)-epicatechin-(2β→*O*→7, 4β→8)-epicatechin, four tetrameric proanthocyanidins, epicatechin-(2β→*O*→7, 4β→8)-[epicatechin-(4β→6)]-epicatechin-(4β→8)-epicatechin, named as parameritannin A-1, and epicatechin-(2β→*O*→5, 4β→6)-[epicatechin-(2β→*O*→7, 4β→8)]-epicatechin-(4β→8)-epicatechin, named as parameritannin A-2, parameritannin A-3, two dimers, proanthocyanidin A-2 and proanthocyanidin A-6 from the bark (Kamiya *et al*., 2001, Murakami-Nakai *et al.*, 2005).
49. *Parahancornia amapa*: Cornoside (**538**) and other phenylethanoid derivatives from the latex (De Carvalho *et al*., 2008).
50. *Peschiera australis*: Vanillic acid, syringic acid, gentisic acid and salicylic acid (Rates *et al*., 1993).
51. *Plumeria bicolor*: Two ferulic acid esters, 34-hydroxytetratriacontanyl *trans*-ferulate and 34-acetyloxytetratriacontanyl *trans*-ferulate from the stem bark (Dobhal *et al*., 1999).
52. *Plumeria obtusa*: The leaves contain 3-*O*-caffeoylquinic acid or neochlorogenic acid, 4-*O*-caffeoylquinic acid or cryptochlorogenic acid and 5-*O*-caffeoylquinic acid or chlorogenic acid (Wong *et al.*, 2014a), *rel*-(3*R*,3'*S*,4*R*,4'*S*)-3,3',4,4'-tetrahydro-6,6'-dimethoxy[3,3'-bi-2*H*-benzopyran]-4,4'-diol, and methyl coumarate from the aerial parts (Saleem *et al.*, 2011).
53. *Plumeria rubra*: 4-Hydroxyacetophenone (Hamburger *et al*., 1991) from the heartwood, *p*-*E*-coumaric acid and 2,4,6-trimethoxyaniline from the stem bark (Kuigoua *et al.*, 2010).
54. *Poacynum hendersonii*: Phenethyl alcohol β-D-xylopyranosyl-(1→6)-β-D-glucopyranoside, methyl salicylate β-D-glucopyranoside, methyl salicylate primeveroside, picein (**539**), 4-hydroxybenzoic acid 4-*O*-β-D-glucopyranoside, 1-feruloyl-β-D-glucopyranose, (*E*)-ferulic acid 4-*O*-β-D-glucopyranoside, *cis*-*p*-coumaric acid 4-*O*-β-D-glucopyranoside and (7*S*,8*R*)- dihydrodehydroconiferyl alcohol, from the flowers (Morikawa *et al*., 2012) and gallic acid (Wei *et al*., 2008).
55. *Tabernaemontana catharinensis* A. DC.: Caffeic acid, chlorogenic acid and gallic acid in the stem bark (Boligon *et al*., 2014), branches and fruits (Piana *et al.*, 2014).



537 Ficusol

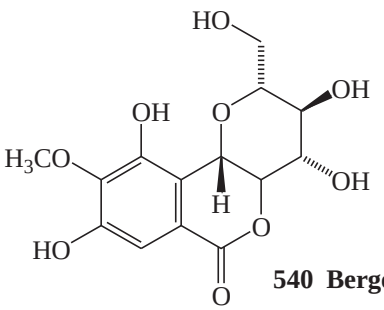


538 Carnoside R=gluc

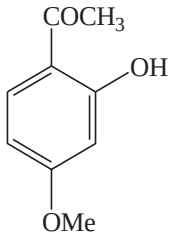


539 Picein

56. *Tabernaemontana cymosa*: 3-*O*-(β-D-Glucopyranosyl)-5-*O*-methylgallic acid from the leaves (Achenbach *et al*., 1997).
57. *Tabernaemontana divaricata*: Benzoic acid (Pratchayasakul *et al.*, 2008); Coniferyl alcohol and sinapyl alcohol in cell suspension cultures (Dagnino *et al*., 1991).
58. *Tabernaemontana glandulosa*: Phenylpropanoids from the leaves and stems (Achenbach *et al.*, 1994).
59. *Thevetia neriifolia*: Two phenylpropanoids, methyl β-(2-hydroxy-4-carboxy)phenyl-acetate and β-(2-hydroxy-4-carboxy)phenylacetic acid from the flowers (Gunasegaran and Nair, 1983).
60. *Trachelospermum asiaticum* var. *intermedium* :Vanillic acid (Nishibe *et al*., 1981).
61. *Trachelospermum jasminoides* (Lindl.) Lem.: Salicylic acid (Guo *et al.*, 2009), bergenin (**540**, a *C*-glucoside of 4-*O*-methyl gallic acid) (Jing *et al*., 2012).
62. *Thevetia neriifolia*:Two phenylpropanoids, methyl β-(2-hydroxy-4-carboxy)phenyllactate and β-(2-hydroxy-4-carboxy)phenyllactic acid from the flowers (Gunasegaran and Nair, 1983).
63. *Vallaris glabra*: 3-*O*-Caffeoylquinic acid, 4-*O*-caffeoylquinic acid and 5-*O*-caffeoyl-quinic acid from the leaves (Wong *et al.*, 2014b).
64. *Vallaris solanacea* Kuntze (syn. *Vallaris heynei*): Benzyl 2-*O*-β-apiofuranosyl-(1→2)-β-D-glucopyranosyl-2,6-dihydroxy-benzoate from the aerial parts (Ahmed *et al*., 2010a).
65. *Vinca major*: Chlorogenic acid from the leaves (Şöhretoğlu *et al*., 2013).
66. *Winchia calophylla* A. DC.: Paeonol (**541**) (2-hydroxy-4-methoxyacetophenone), 4-hydroxy-3-methoxybenzoic acid, 3,4-dihydroxybenzoic acid and 2,3-dihydroxybenzoic acid (**542**) (Zhu *et al.*, 2005) and winchiepoxide (a derivative of tetrahydroxy-cyclohexane-carboxylic acid) from the stem bark (Zhu *et al*., 2004a).
67. *Wrightia tinctoria* R. Br.: Ferulic acid (**543**) in the bark (Bigoniya *et al*., 2013) and chlorogenic acid from the seeds (Amin *et al*., 2013).
68. *Wrightia tomentosa*: A xanthonoid compound, mangiferin (**544**), from the roots (Nagarajan *et al*., 2012).
69. *Wrightia* species: Indigotin (indigo dye, indigo blue) indirubin (indigo red, indigopurpurin), tryptanthrin (couroupitine A), isatin (1*H*-indole-2,3-dione), anthranillate, were isolated as major constituents of *Wrightia tinctoria* and *Wrightia tomentosa*. Anthranillate was the major constituent of *Wrightia coccinea*. Indigotin was found in fresh plant material, and indirubin was an artifact formed during drying (Muruganandam *et al*., 2000).



540 Bergenin



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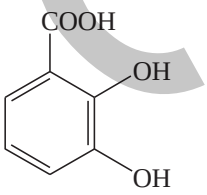

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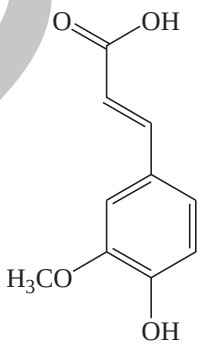
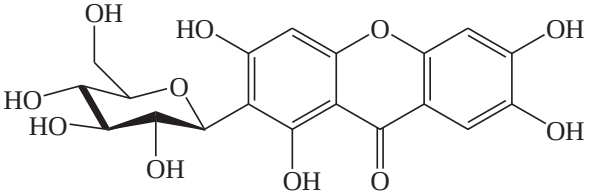


543 Ferulic acid

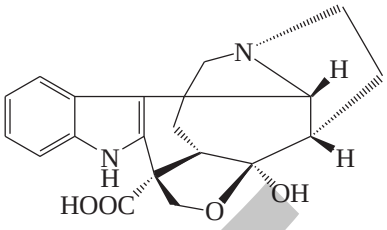


544 Mangiferin

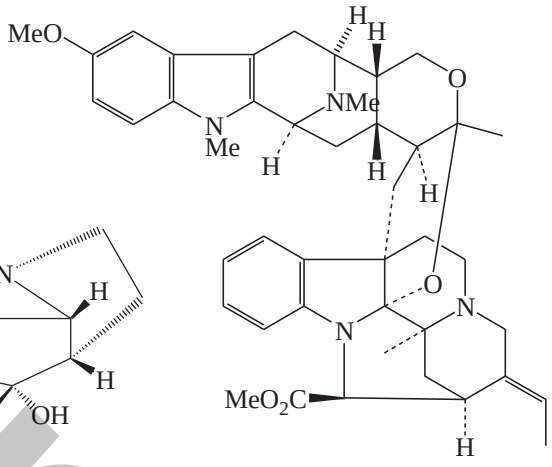
Alkaloids

The indole alkaloids as systematic markers of the Apocynaceae have been studied (Bolzani *et al*., 1984). However, the presence of other classes of alkaloids, though not many, was also reported. Pyrrolizidine alklaoids, typical of many Boraginaceae, Compositae and Leguminosae, have been isolated from some genera of the family Apocynaceae e.g. *Alfia*, *Anodendron*, *Parsonia*, *Strophanthus* and *Urechites* (Rizk, 1991). Also, isolated from plants of the family, steroidal alkaloids from some genera e.g. *Chonemorpha*, *Funtumia*, quinoline alkaloids from *Kopsia*, *Melodinus*; spermidine alkaloids from *Oncinotis* (as mentioned below), pyrrolizidine alkaloids from *Parsonia*; carboline alkaloids from *Amsonia tabernaemontana* and *Apocynum cannabinum* and others. It is not the aim of the authors (in this chapter) to review the occurrence of alkaloids of the family Apocynaceae, but to give examples of the isolated alkaloids from the different genera. There are several reviews about the occurence of the alkaloids in the family, as well as their biological activities (e.g. Bisset, 1958; Raffauf, 1964; Cerny and Sorm, 1967. Ganguly, 1969; Goutarel, 1971; Laine and Goutarel, 1972, 1976; Balsevich, 1988; Budman, 1992 Van Tellingen *et al*., 1992). Pereira *et al*. (2007) reviewed the occurrence of 247 indole alkaloids in more than 50 *Aspidosperma* species. Also, Guimerãs *et al.* (2012) reviewed the ^{1}H and ^{13}C-NMR data up to 2011, describing the skeleton of 35 different plumeran indole alkaloids in *Aspidosperma* species, from a group of 46 of them. Also, a chemotaxonomic review of 15 *Kopsia* species (regarding their alkaloids) has been reported (Sévenet *et al*., 1994). According to Raffauf (1996), nearly 1000 alkaloids have been isolated from species of the family Apocynaceae. Since then hundreds more of the alkaloids have been identified from plants of this family. The following are examples of the alkaloids identified from some species (and not all species) of the family Apocynaceae:

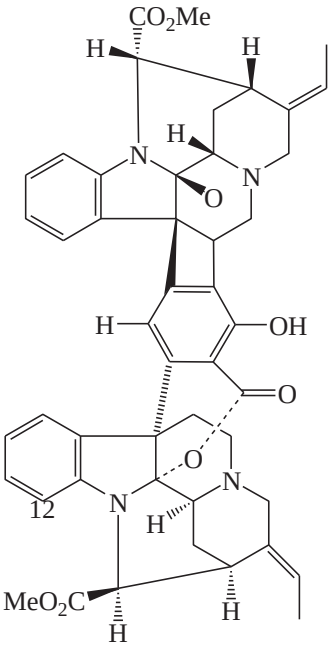
1. *Alafia multiflora* Stapf: Alafine (a pyrrolizidine alkaloid) from the seeds (Païs *et al*., 1971).
2. *Alstonia actinophylla:* Actinophyllic acid (**545**) from the leaves (Carroll *et al*., 2005).
3. *Alstonia angustifolia* Wall: Yohimbine, pleiocarpamine, fluorocarpamine, cathafoline, cabucraline, vincamajine, normacusine B, lochnerine, affinisine, akuammicine, antirhine, alstonisine, alstonerine, alstophylline, macralstonine, villalstonine, tetrahydrocantleyine, 19,20-dehydro-10-methoxytalcarpine, hydroxystrictamine, villalstonine *N*-4′-oxide, 10-methoxy villalstonine (**546)**, *N*(b)-demethylalstogustine *N*-oxide (**547**) (Ghedira *et al*., 1988, Hu *et al.*, 1989a), bipleiophylline (Kam *et al*., 2008), alstogustine, 19-*epi*-alstogustine (Hu *et al.*, 1989b), alstopirocine (**548**), pleiomaltinine (**549**), pleiomalicine (**550**) (Tan *et al.*, 2010b), perhentisine A (**551**), perhentisine B (**552**), perhentisine C (**553**), lumutinine E (**554**), villalstonidine A (**555**), villalstonidine B (**556**), villalstonidine C (**557**), villalstonidine D (**558**) and villalstonidine E (**559**), bibleiophylline, perhentinine (**560**), perhentidines A-C, anhydromacralstonine, villalstonine, macrocarpamine (Tan *et al*., 2013), *N*(4)-methyltalpinine and many others from different parts of the plant (Zeches *et al*., 1987; Said *et al*., 1992; Wright *et al*., 1992; Kam *et al*., 1997d; Tan *et al*., 2011a, 2012; Pan *et al*., 2014).
4. *Alstonia angustifolia* var. *latifolia*: Alstolactone, affinisine oxindole, lagumicine, 10-methoxycathafoline *N*(4)-oxide and others from the leaves (Kam and Choo, 2004a).
5. *Alstonia angustiloba*: Angustilodine, angustilocine, alstilobanines A-E, angustilobine C (**561**), andransinine (**562**, possibly an artifact), alstolucine, 19,20-*E*-vallesamine, *O*-acetylvallesamine, angustilobine A, angustilobine B, condylocarpine, vincamine, 16*R*,19*E*-isositsirkine, angustiphylline, 6,7-*seco*-angustilobine B, yunnanensine, undulifoline, 20-*S*-tubotaiwine, venoterpine, cantleyinen and others from the leaves and stem bark (Kam and Choo, 2004b; Koyama *et al*., 2008; Ku *et al*., 2011; Low *et al*., 2014).



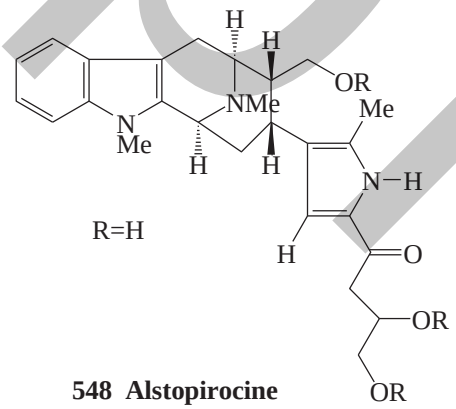
545 Actinophyllic acid



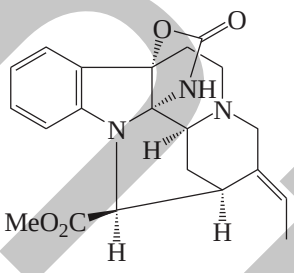
546



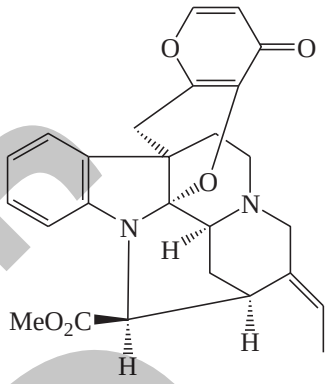
547 *N*(b)-Demethylastogustine-*N*-oxide



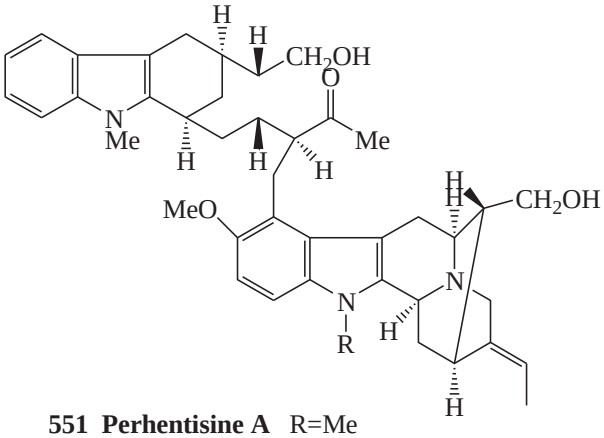
548 Alstopirocine



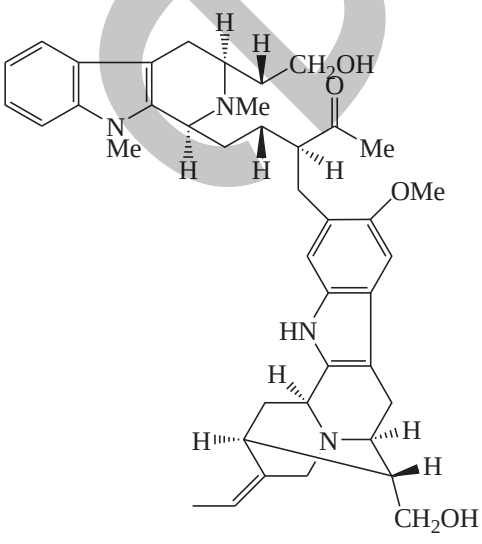
549 Pleiomaltinine



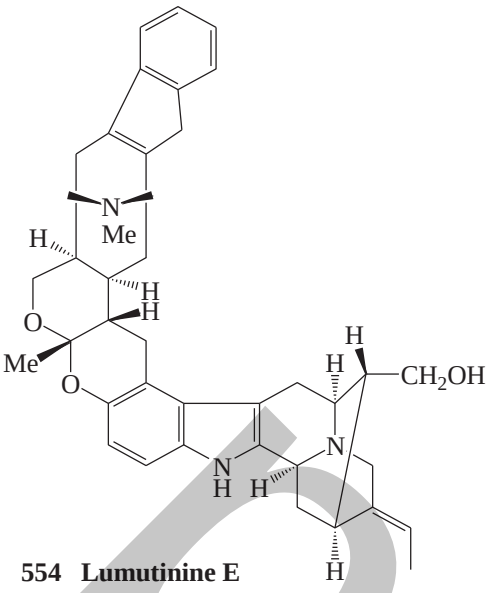
550 Pleiomalicine



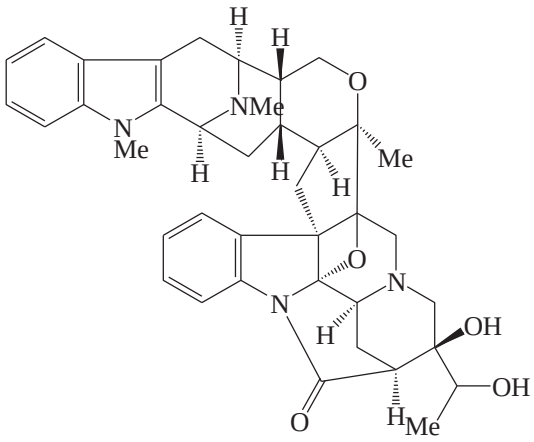
551 Perhentisine A R=Me
552 Perhentisine B R=H



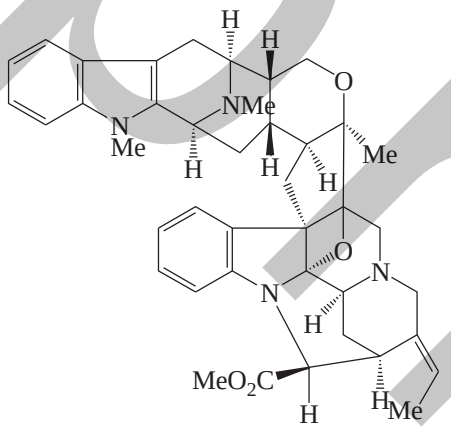
553 Perhentisine C



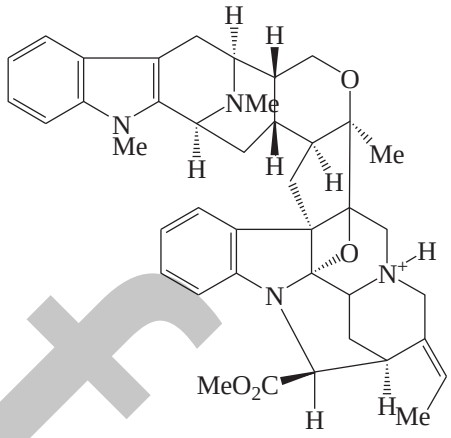
554 Lumutinine E



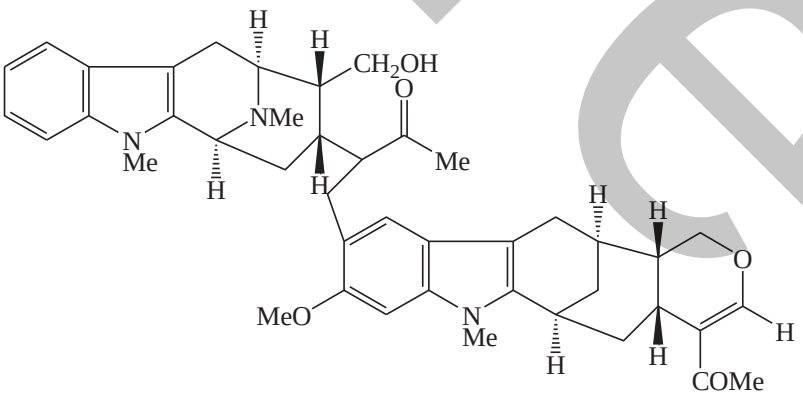
555 Villalstonidine A



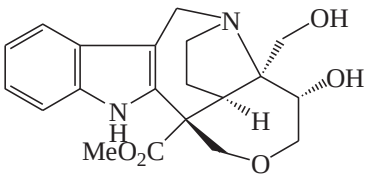
556 Villalstonidine B R_1=CH_2OH, R_2 = Me
557 Villalstonidine C R_1=H, R_2 =CH_2OH



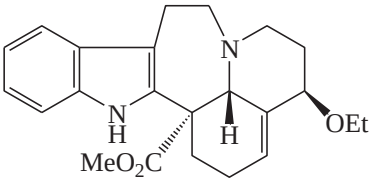
558 Villalstonidine D R=Me
559 Villalstonidine E R=CH_2CL



560 Perhentinine

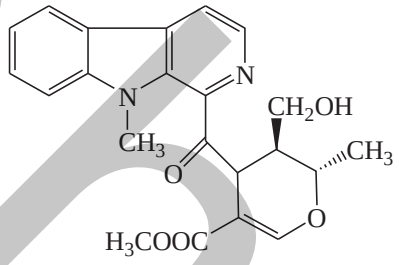


561 Angustilobine C



562 Andransinine

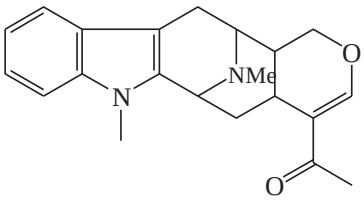
6. *Alstonia boonei* De Wild: Akuammidine, voacangine, echitamine, echitamidine, *N*α-formylechitamidine and *N*α-formyl-12-methoxyechitamidine from the leaves and stem bark (Croquelois *et al*., 1972; Oguakwa *et al.*, 1983; Oguakwa, 1984; Adotey *et al*., 2012).
7. *Alstonia boulindaensis* Boiteau: Lanciferine, 10-methoxylanciferine, 10-hydroxy-lanciferine and others from the aerial parts (Lewin *et al*., 1978).
8. *Alstonia congensis* Engler: Echitamine, echitamidine, nor-echitamine, 17-acetoxy-nor-echitamine, akuammidine, akuammicine, 12-methoxyakuammicine, tubotaiwine, 12-methoxytubotaiwine, angustilobines A and B, 6,7-*seco*-angustilobines A and B, angustilobine B-*N*(4)-oxide (Goodson and Henry, 1925; Prista *et al.*, 1965; Caron *et al*., 1989), rhazine (Banerji and Jana, 1986) and others from different parts of the plant.
9. *Alstonia constricta* F. Muell. (Bitter bark, Quinine tree, Peruvian bark, Australian fever bark): Reserpine, alstonidine, alstonine, α-yohimbine (rauwolscine), alstonilidine, alstoniline, vincamedine, vincamajine, 1-carbomethoxycarboline, quebrachidine and 14-ketoalstonidine (**563**), from the stem and root barks (Hawkins and Elderfield, 1942; Crow and Greet, 1955; Svoboda, 1957; Crow *et al.*, 1970; Allam *et al*., 1987).



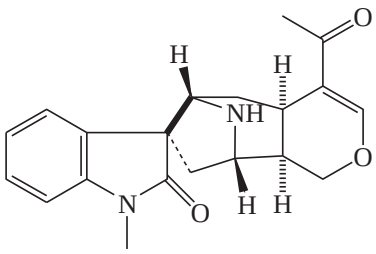
563 14-Ketoalstonidine

10. *Alstonia coriacea* Panther ex S. Moore: Gentianine, 10-methoxy deplancheine, vincamajine, desmethylquaternine, corialstonine and cabucraline from the stem bark (Cherif *et al*., 1987, 1989).
11. *Alstonia deplanchei*: Pleiocraline and deplancheine from the stem and bark (Das *et al.*, 1977; Besselievre *et al*., 1980).
12. *Alstonia glabriflora*: Alstophylline and macralstonine from the bark (Hart *et al*., 1972).
13. *Alstonia glaucescens*: N_b-demethylechitamine, 17-*O*-acetyl-N_b-demethyl-echitamine, echitamidine *N*-oxide, echitaminic acid, echitamidine, 20-epi-19ξ-echitamidine, and echitamine from the stem bark (Keawpradub *et al*., 1992, 1994).
14. *Alstonia lanceolata*: Akuammicine, lochnericine, gentianine, picraline, 10,11-dimethoxy-1-methyldeacetylpicraline, pseudoakuammigine, compactinervine, cathafoline, lanceomigine, lanceomigine-*N*(4)-oxide and others from the stem bark (Vercauteren *et al*., 1981a).
15. *Alstonia lanceolifera*: Lanciferine and its 10-methoxy and 10-hydroxy derivaytives, *O*-trimethoxycinnamoyl-vincamajine, akuammiline, *O*-trimethoxy-cinnamoyl-10-methoxy-vincamajine, *O*-trimethoxycinnamoyl-10-hydroxyvincamajine, *O*-trimethoxy-benzoyl-hydroxyvincamajine, 10-methoxyvincamajine, picraline, 10,11-dimethoxy-1-methyl-deacetyl picraline benzoate, 10,11-dimethoxy-1-methyl-deacetyl picraline 3',4',5'-tri-methoxybenzoate, 10,11-dimethoxy-1-methyl-deacetyl picraline, (-)-lochnericine, 10,11-dimethoxy-1-methyldeacetylpicraline 3',4',5'-tri-methoxybenzoate, 10-methoxy-*nor*-C-fluorocurarine, 11-methoxyakuatiammicine, 10-methoxycompactinervine and 11-methoxycompactinervine and others from the aerial parts (mainly leaves and stem bark) (Lewin *et al*., 1975a,b; Ravao *et al*., 1982; Petitfrere-Auvray *et al.*, 1981).

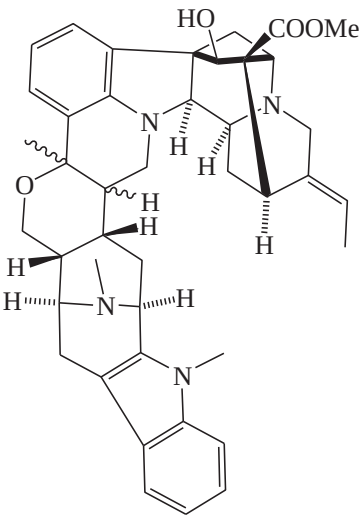
16. *Alstonia legouixiae*: Voachalotine, vincamajine, quaternine, and *N*(a)-demethylquaternine from the trunk and root barks (Lewin *et. al.*, 1981).
17. *Alstonia lenormandii*: Picraline, 10,11-dimethoxy-1-methylpicraline, 10,11-dimethoxy-1-methyldeacetylpicraline, akuammiline, lochnericine, 11-methoxyakuammicine, 12-methoxycompactinervine, gentianine 3',4',5'-trimethoxycinnamamide and others from the leaves and from the stem bark of two varieties of *Alstonia lenormandii* var. *lenormandii* and *Alstonia lenormandii* var. *minutifolia* (Legseir *et al*., 1986).
18. *Alstonia macrophylla* Wall: Affinisine, alstolagumine, alstonerinal, alstonerine, alstomaline, alstonamide, alstonisine, isoalstonisine, alstonal, alstonoxine C, alstomacrophylline, alstomacroline, alstomacroine, alstoumerine, alistonoxione D, alstophylline, alstofolinine, alstiphyllanines A-I, alstoniaphyllines A-C, alstozine *N*-oxide, alstopicralamine, alstophylline, cabucraline, cathafoline, lagumidine, lochnerine, lumutinines A-D, demethoxyalstonamide, pleicarpamine, 10-methoxyaffinisine, 10-methoxycathafoline, 16-hydroxyalstonal, demethoxy-alstophylline, macrocarpamine, macrosalhine, macralstonine, anhydro-macralstonine, macrophylline, picrinine, talcarpine, (-)-strictaminolamine, 10-hydroxy-strictamine, 11-methoxyakuammicine, 6-oxoalstophyllal, macrocarpine D, macrodasine H, pleiocarpamine, quebrachidine, villalstonine, villastonine *N*-oxide, vincamajine, 19-hydroxy-vincamajine, vincorine, 17-carboxylcompactivervine *N*-oxide and 17-carboxylalstovine *N*-oxide and others from leaf, stem, stem-bark and root-bark (Manas-Santos and Santos, 1936; Chatterjee *et al.*, 1961a; Kishi *et al.*, 1965, 1966; Khan *et al.*, 1967b; Manalo, 1967, 1968; Mukherjee *et al*., 1969; Banerji *et al*., 1972; Banerji and Chakrabarty, 1973; Mayerl *et al*., 1978; Ratnayake *et al*., 1987; Atta-ur-Rahman *et al.*, 1987f, 1988f-h, 1990a,b, 1991b,c, 1994; Arambewela *et al*., 1990; Abe *et al.*, 1994b,c; Wong *et al*., 1996; Keawpradub and Houghton, 1997; Keawpradub *et al*., 1997, 1999a,b; Kam *et al*., 1999a, 2004a; Kam and Choo, 2000, 2004c; Hirasawa *et al*., 2009a; Arai *et al*., 2010, 2012; Changwichit *et al*., 2011; Lim *et al*., 2011-2014; Deguchi *et al*., 2012; Cheenpracha *et al*., 2013).
19. *Alstonia mairei*: 5-Hydroxy-4,8-dimethoxyfuroquinoline, skimmianine, maireines A and B and others from the leaves, twigs, roots and bark (Ye *et al*., 1989; Cai *et al*., 2010a).
20. *Alstonia muelleriana* Domin: Alstonerine (**564**), alstonisine (**565**), alstonsidine (**566**), macralstonine (**567**), villalstonine (**568**), quebrachidine, vinervinine, pleiocarpamine, 11-methoxyakuammicine (**569**) and others from the bark (Cook *et al*., 1969; Cook and Le Quesne, 1971a,b, 1975; Elderfield and Gilman, 1972; Burke *et al*., 1973).
21. *Alstonia neriifolia*: Nerifoline and echitamine chloride from the stem bark (Chatterjee and Ghosal, 1960).
22. *Alstonia odontophora* Boiteau: Vincamajine, 11-methoxyakuammicine, quebrachidine, pleiocarpamine, antirhine, pleiocorine, pleiocraline and *N*(1')-demethylpleiocorine from the leaves and stem bark (Vercauteren *et al*., 1979).
23. *Alstonia plumosa* Labill. var. *communis* Boiteau: Fluorocarpamine, pleiocarpamine, alstovine, cabucraline, cathafoline, caberine, quaternoxine, caberoline, quaternoline (raucubaine), strictamine, pleiocraline, pleiocorine, cabucraline 10-carboxaldehyde, 2,7-dihydroxypleiocarpamine, plumocraline, deoxy-cabufiline and nordeoxycabufiline and others from the root and stem barks (Jacquier *et al*., 1982; Massiot *et al*., 1981).
24. *Alstonia pneumatophora*: Vallesamine, *O*-acetylvallesamine, alpneumines A-H (**570**-**577**), alsmaphorazines A and B (**578**, **579**) and alsmaphorazines C-E (Zeches *et al*., 1987; Koyama *et al*., 2010a,b, 2012).
25. *Alstonia quaternata*: 11-Methoxy-*epi*-3α-yohimbine, quaternine (10,11-dimethoxy-picrinine), quaternoxine and others (Mamatas-Kalamaras *et al*., 1975b).



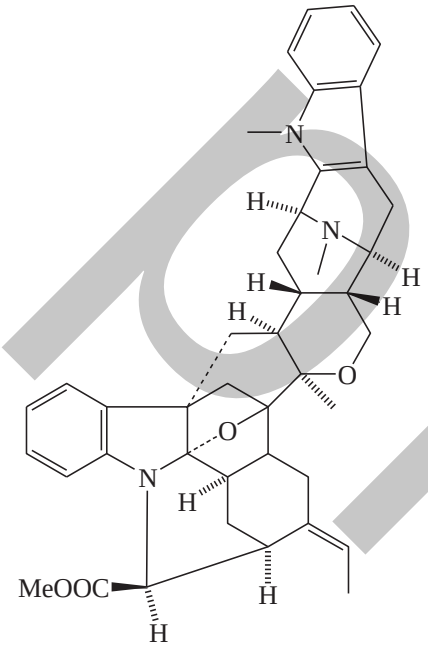
564 Alstonerine



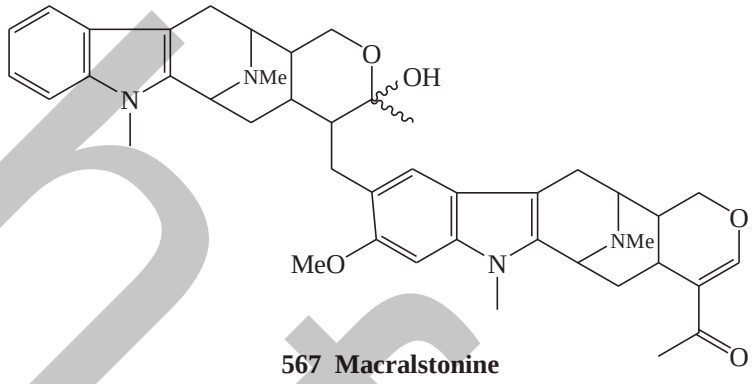
565 Alstonisine



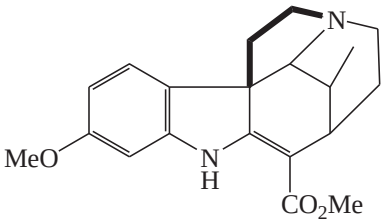
566 Alstonsidine



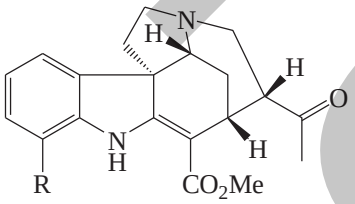
568 Villalstonine



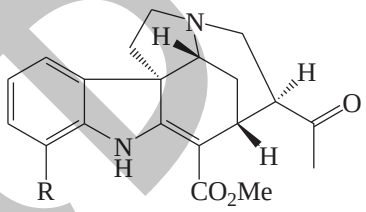
567 Macralstonine



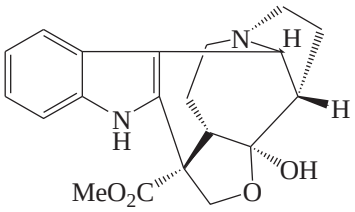
569



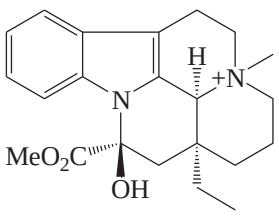
570 Alpneumine A OH, N(4)oxide
571 Alpneumine B OH
572 Alpneumine C H, N(4)oxide



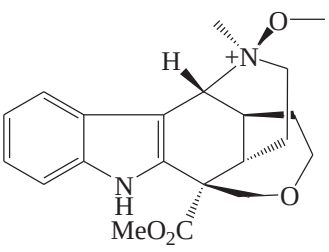
573 Alpneumine D R=OH
574 Alpneumine E R=H



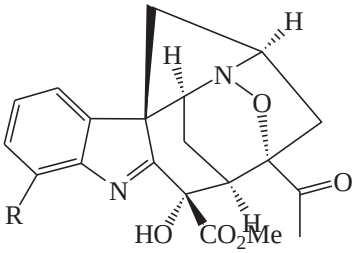
575 Alpneumine F



576 Alpneumine G

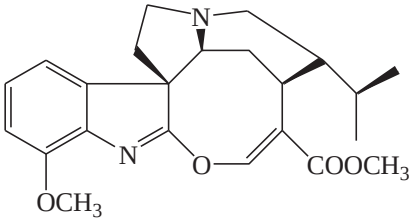


577 Alpneumine H

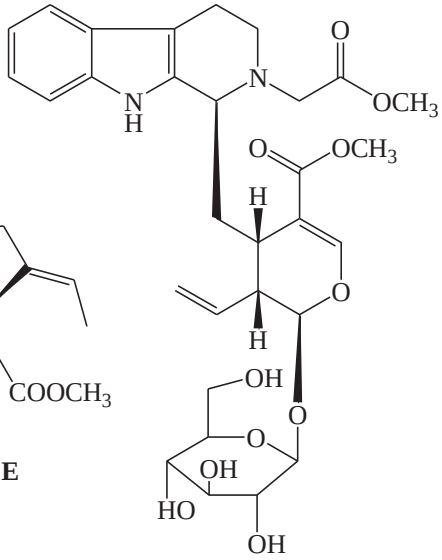


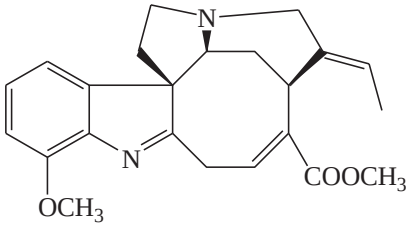
578 Alsmaphorazine A R = OH
579 Alsmaphorazine B R = H

26. *Alstonia rostrata* (*Winchia calophylla*): Alstrostines C-F (**580**-**583**), 19,20-dihydro-akummicine, echitamidine, 12-methoxyechitamidine, vallesiachotamine, iso-vallesiachotamine, deacetyl-akummiline, akuammidine, undulifoline, tabersonine and others from the leaves and twigs (Cai *et al.*, 2011a; Bao *et al*., 2012).
27. *Alstonia rupestris* Kerr: Scholarisins I-VII (**584**-**590**), (3*R*,5*S*,7*R*,15*R*,16*R*,19*E*)-scholarisine F (**591**), 3-*epi*-dihydrocorymine (**592**), and (*E*)-16-formyl-5α-methoxy-strictamine (**593**) from the leaves (Wang *et al*., 2013a).
28. *Alstonia scholaris* R. Br.: Alstolactines A-C, picrinine (**594**), N^1-methoxymethyl picrinine, picralinal (**595**), nareline (**596**), pseudoakuammigine, alschomine (**597**), alstonerine, isoalschomine (**598**), scholarine (**599**), alstonamine, sitsirikine, rhazimanine, lagunamine (19-hydroxytubotaiwine), angustilobine B acid, losbanine, tubotaiwine and its oxide, 6,7-*seco*-angustilobine B, 19-epischolaricine, N^b-methyl-scholaricine, N^a-methylburnamine, vallesamine (19,20-*Z*-vallesamine (**600**) and 19,20*E*-vallesamine **601**), nareline ethyl ether, 5-*epi*-nareline ethyl ether, scholarine-*N*(4)-oxide, nareline methyl ether, scholaricine, akuammidine, akuammidine *N*-oxide, rhazine, 5-methoxystrictamine, manilamine 19,20-(*E*)-vallesamine, angustilobine B N^4-oxide, (19,20)-*E*-alstoscholarine, (19,20)-*Z*-alstoscholarine, 5-methoxy-aspidophylline, scholarisine A, leuconolam, mataranines A and B (**602**,**603**), scholarisine I (**604**), (±)-scholarisine II (**605**), sarpagine, *N*(4) dimethyl-echitamine, echitamidine (**606**), alistonitrine A, a glucoside of venoterpine (**607**), akuammiginone (**608**), echitamidine-*N*-oxide 19-*O*-β-D-glucopyranoside (**609**), echitaminic acid (**610**), echitamidine *N*-oxide (**611**), N^b-demethylalstogustine *N*-oxide (**612**), akuammicine *N*-oxide (**613**), and N^b-demethylalstogustine (**614**), scholarisines B-G and others from the different parts of the plant (leaf, bark, fruit, flower and root) (Siddappa, 1945; Chatterjee *et al.*, 1965b, 1969a; Talapatra and Talapatra, 1967; Gale *et al*., 1970; Rastogi *et al*., 1970; Stekol'nikov, 1970; Boonchuay and Court, 1976b; Dutta *et al*., 1976; Banerji and Banerji, 1977; Morita *et al*., 1977; Biswas and Saharia, 1978; Banerji and Siddhanta, 1981; Banerji *et al*., 1984; Atta-ur-Rhaman *et al*., 1985a, 1986b, ; Atta-ur-Rahman and Alvi, 1987; Abe *et al*., 1989b,c; Yamauchi *et al*., 1990c,d; Kam *et al*., 1997a; Salim *et al*., 2004a; Wongseripipatana *et al*., 2004; Macabeo *et al*., 2005, 2006; Zhou *et al*., 2005; Cai *et al*., 2007b, Du *et al*., 2007b; 2008a,b, 2010b; Feng *et al.*, 2009a, 2013; Hirasawa *et al*., 2009b; Jain *et al.*, 2009a,b; Wang *et al*., 2009b; Yang *et al*., 2014; Zhang *et al.*, 2014b; Zhu *et al*., 2014).
29. *Alstonia somersetensis* F. M. Bailey: Macralstonidine and villalstonine (Sharp, 1934).
30. *Alstonia spatulata*: Twenty-five alkaloids including alstolobine A and strychnan type (e.g. alstolucines A-E) from the leaf and stem-bark (Tan *et al*., 2010c).
31. *Alstonia spectabilis*: Pleiocarpamine, vincamagine, quebrachidine, villalstonine, macralstonidine and N^1-methylsarpagine from the bark (Hart *et al*., 1972).

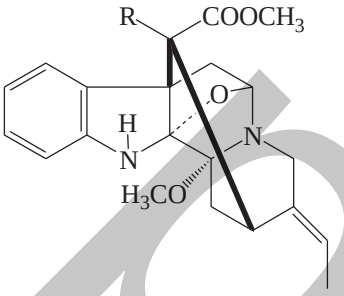


580 Alstrostine C R=OH
581 Alstrostine D R=O

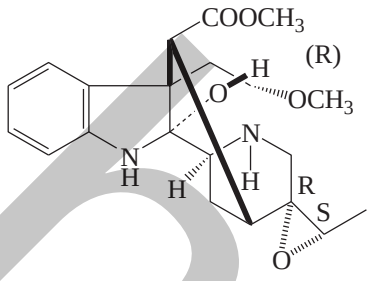




582 Alstrostine E

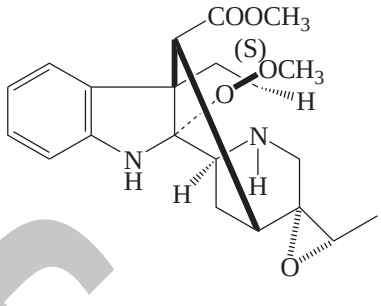


584 Scholarisin I R=COH
585 Scholarisin II R=CH_2OH
586 Scholarisin III R=CH_2OAc
591 Scholarisin F R=H

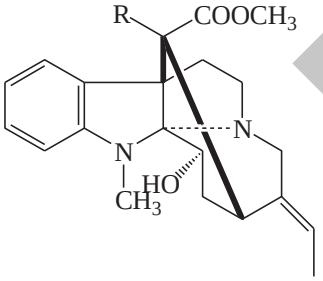


587 Scholarisin IV

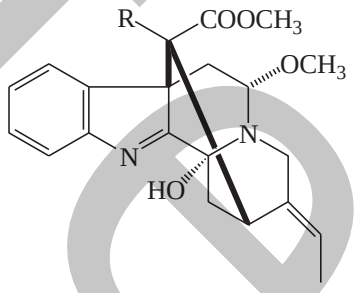
583 Alstrostine F



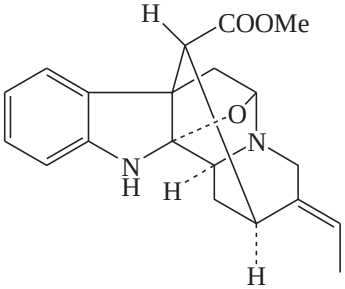
588 Scholarisin V



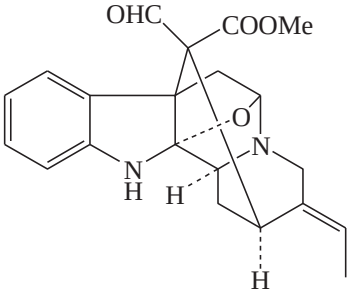
589 Scholarisin VI R=CHO
592 3-epi-dihydro-corymine R=CH_2OH



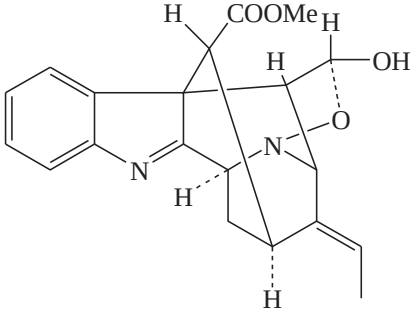
590 Scholarisin VII R=CH_2OH
593 (E)-16-formyl -5a-methoxystrictamine R=CHO



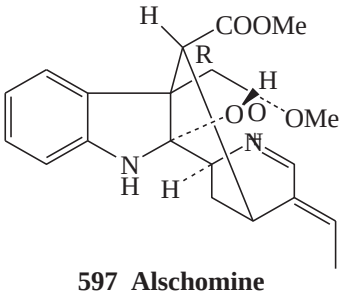
594 Picrinine



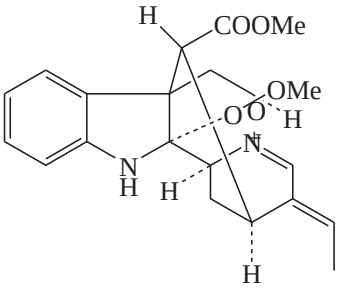
595 Picralinal



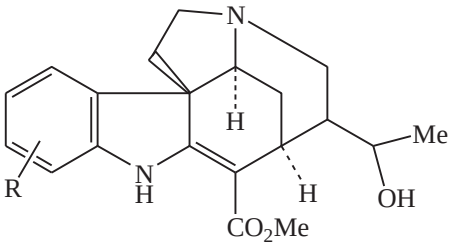
596 Nareline



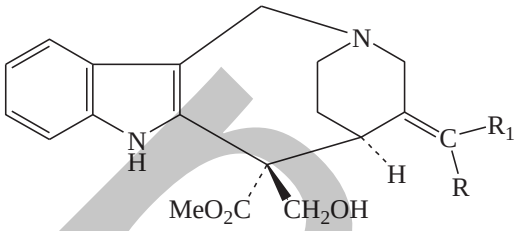
597 Alschomine



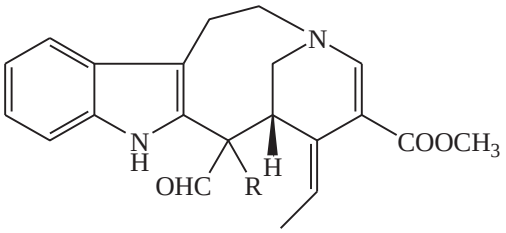
598 Isoalschomine



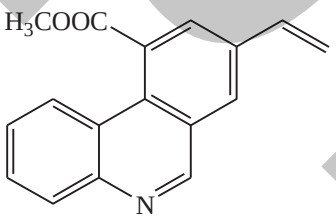
599 Scholarine, R=OMe
606 Echitamidine, R=H



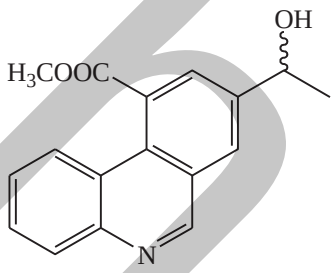
600 19,20-Z-Vallesamine R=H, R_1=Me
601 19,20-E-Vallesamine R=H, R_1=Me



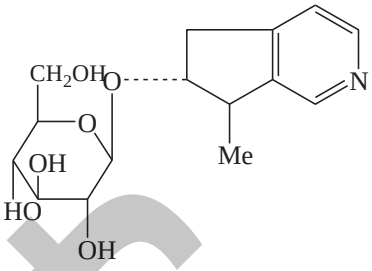
602 Mataranine A, R=Hβ
603 Mataranine B, R=Hα



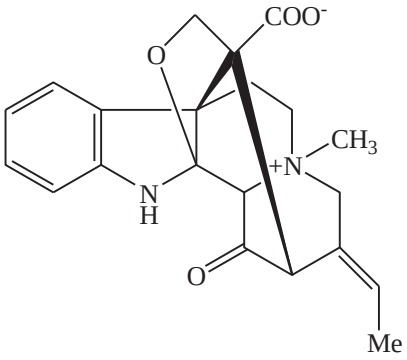
604 Scholarisines I



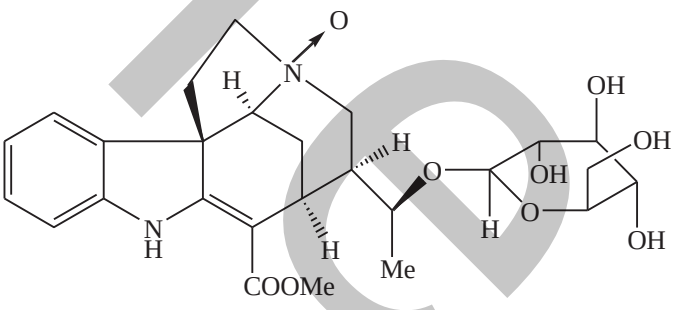
605 Scholarisines II



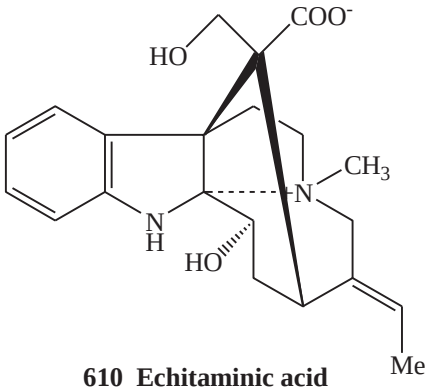
607 Glucoside of venoterpine



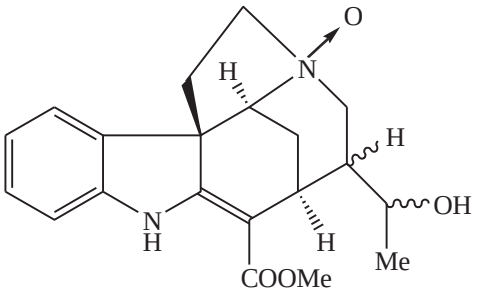
608 Akuammiginone



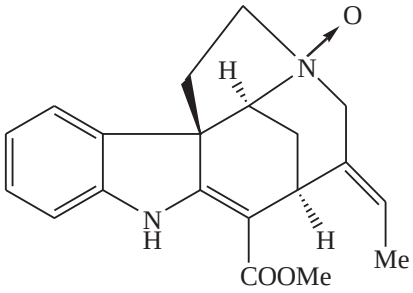
609 Echitamidine-N-oxide 19-O-β-D-glucopyranoside



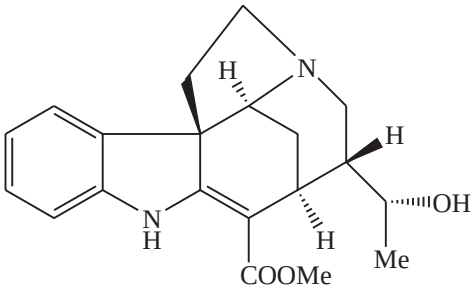
610 Echitaminic acid



611 Echitamidine N-oxide C-19(S), C-20(S)
612 N-demethylalstogustine N-oxide C-19(R), C-20(R)

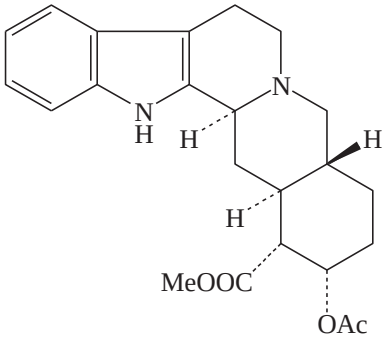


613 Akuammicine N-oxide



614 N-demethylalstogustine

32. *Alstonia sphaerocapitata***:** Vincamedine, 10-methoxyvincamedine, Z-isositsirikine, akuammicine, quaternoline, 11-methoxyakuammicine, tubotaiwine, cabucraline, cathafoline, caberoline, vincoridine, quebrachidine, quaternoxine, nor *C*-fluorocurarine, desoxycabufiline, nordesoxycabufiline, undulatine, and deformoundulatine and others from the leaves, fruits, stem bark and roots (Caron *et al*., 1984; Nuzillard *et al*., 1989).
33. *Alstonia undulata*: Vincamedine, alstonidine, 11-methoxyakuammicine, deplancheine, fluorocarpamine, pleiocarpamine, cabucraline, desoxycabufiline, cabucraline-*N*(4)-oxide, gentiacraline, vincorine, cathafoline, pericyclivine, gentiacraline, voachalotinal, 17ξ-hydroxydehydrovoachalotine, 10-hydroxypericyclivine, 10-methoxypericyclivine, *N*(1)-methyl-10-methoxypericyclivine and others from the leaves and root bark (Guillaume *et al*., 1984; Morfaux *et al*., 1989; Pinchon *et al*., 1990).
34. *Alstonia undulifolia*: (+)-Tetrahydrocantleyine, (-)-cantleyine, echitamine, *nor*-echitamine, (-)-akuammicine, pleiocarpamine, echitamidine, undulifoline and others from the stem bark (Massiot *et al*., 1992).
35. *Alstonia venenata* R. Br.: Venenatine, isovenenatine alstovenine, Δ^3-alstovenine, echitovenidine, 16-epialstovenine, reserpine, kopsinine, veneserpine, venoxidine, vincadifformine, venotropine, echitoserpine, 5,22-dioxokopsan, alstolenine, anhydro-alstonatine, (-)-echitoveniline, (-)-11-methoxyechitoveniline, (-)-11-methoxy-echitovenedine, echitoserpidine, 19,20-dihydropolyneuridine and others from the bark, fruit and leaf (Ray and Chatterjee, 1963, 1968; Govindachari *et al*., 1964, 1965a; Das *et al*., 1965, 1966; Chatterjee *et al*., 1965a, 1969b, 1978a,c, 1979, 1981; Ray and Dutta, 1973; Majumder and Dinda, 1974b; Majumder *et al*., 1974a, 1979b, 1981; Dutta and Ray, 1975; Chatterjee and Mukhopadhyay, 1977; Banerjii *et al*., 1982; Majumder and Basu, 1982; Singh *et al*., 1999).
36. *Alstonia verticillosa* F. Muell: Echitamine (Sharp, 1934).
37. *Alstonia villosa* Blum: Yohimbine-17-*O*-acetate (**615**), vincamajine (**616**), vincamajine-17-*O*-3',4',5'-trimethoxybenzoate (**617**), N_4-oxide of (**618**), 19,20α-epoxy-11-methoxy-akuammicine (**619**), quaternine (**620**), norquaternine (**621**), 10-methoxy-N_1-methyl-burnamine-17-*O*-veratrate (**622**), 10-methoxy-N_1-methyl-burnamine-17-*O*-benzoate (**623**), 5α,10,11-trimethoxystrictamine (**624**), (19*Z*)-picralinal (**625**), (19*Z*)-burnamine-17-*O*-3',4'-trimcthoxybcnzoate (**626**), (19*Z*)-16-formyl-5α-methoxystrictamine (**627**), 5α,10-dimethoxystrictamine (**628**), 17-deaeetyl-5α,10-dimethoxyakuammiline-17-*O*-3',4',5'-trimethoxybenzoate (**629**), 17-deacetyl-5α,10-dimethoxyakuammiline-17-*O*-benzoate (**630**) and, (19Z)-5α-methoxyrhuzirnine (**631**) from the leaves (Abe *et al*., 1998).
38. *Alstonia vitiensis* var. *novo ebudica monachino*: Pleiocarpamine, vincorine, cabucraline, alstovine and quaternoxine (Mamatas-Kalamaras *et al*., 1975a).



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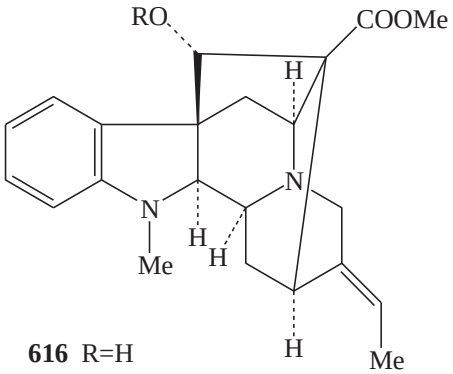
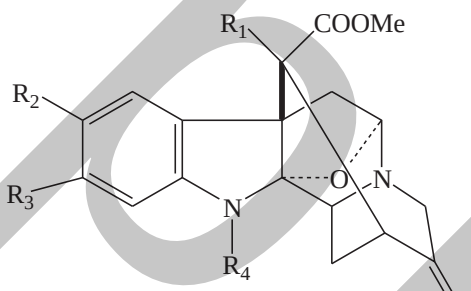
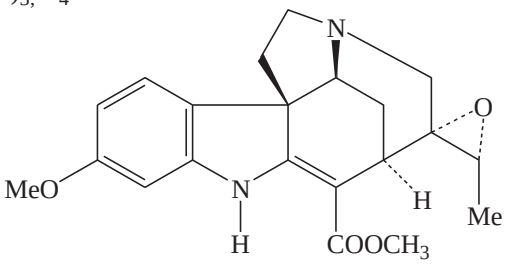


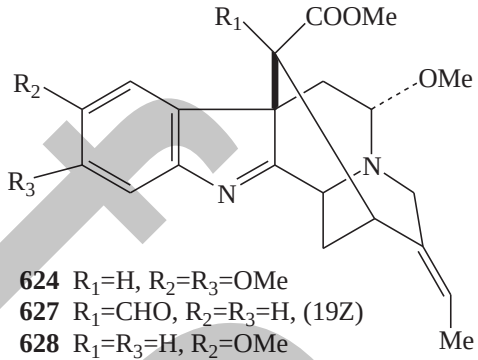
616 R=H
617 R=Benzoyl(OMe)$_3$
618 R=Benzoyl(OMe)$_3$, N$_4$-oxide



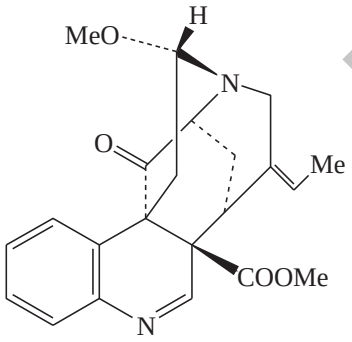
620 R_1=H, R_2=R_3=OMe, R_4=Me
621 R_1=R_4=H, R_2=R_3=OMe
622 R_1=CH2O-Benzoyl(OMe)$_2$, R_2=OMe, R_3=H, R_4=Me
623 R_1=CH2O-Benzoyl R_2=OMe, R_3=H, R_4=Me
625 R_1=CHO, R_2=R_3=R_4=H, (19Z)
626 R_1=CH_2O-Benzoyl(OMe)$_3$, R_2=R_3=R_4=H, (19Z)



619



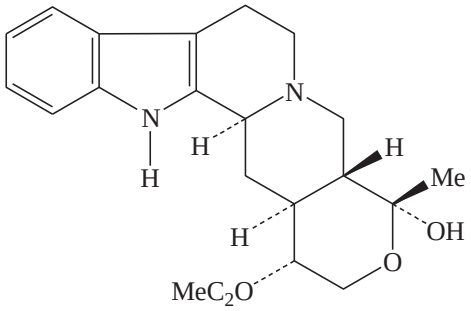
624 R_1=H, R_2=R_3=OMe
627 R_1=CHO, R_2=R_3=H, (19Z)
628 R_1=R_3=H, R_2=OMe
629 R_1=CH_2O-Benzoyl(OMe)$_3$, R_2=OMe, R_3=H
630 R_1=CH_2O-Benzoyl, R_2=OMe R_3=H



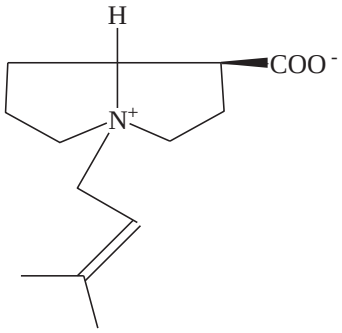
631

39. *Alstonia yunnanensis* Diels: Tetrahydroalstonine, perakine, vellosimine, normacusine B, sarpagine, lochnerinine, 11-methoxy-19-hydroxytabersonine, pseudoakuammigine, picrinine, deacetylpicraline 3,4,5-trimethoxybenzoate, corynanthine, yohimbine, 17-acetylsarpagine, 16-episarpagine, alstoyunines A-H, perakine *N*(4)-oxide, raucaffrinoline *N*(4)-oxide, vinorine, vinorine and others (Chen *et al.*, 1981a, 1986; Weiming *et al*., 1983; Chen *et al*., 1985 Feng *et al*., 2009c; Cao *et al*., 2012).
40. *Ambelania occidentalis*: Vincamine and 14-*epi*-vincamine from the aerial parts (Ayyad *et al*., 2012).

41. *Amsonia angustifolia* Michx.: (+)-Eburnamenine, (−)-eburnamine, (+)-eburnamonine, (+)-isoeburnamine, rhazidine, (−)-tabersonine, vincamine, vincadifformine-N^b-oxide, (±)-10-oxovincadifformine, tetrahydroalstonine, (±)-vincadine, 3,4-epoxyallocatharanthine, (+)-epivincamine, tetrahydroalstonine, Δ^{14}-vincamine and others from the leaves, stems and seeds (Zabolotnaya *et al.*, 1964; Clauder *et al*., 1973; Kocsis *et al*., 1974, 1978 Tomczyk and Kisiel, 1980).
42. *Amsonia brevifolia*: 17-Demothoxy corynoxine B, 17demothoxy isorhynchophilline and others from the whole plant (Sharma *et al*., 1988).
43. *Amsonia elliptica* Roem et Schult.: Ellipticine, β-yohimbine, yohimbine, antirhine, antirhine methochloride, tetrahydrosecamine, vallesiachotamine, pleiocarpamine, 17α-*O*-methyl-yohimbine., tabersonine, tetrahydro-alstonine, Δ^{14}-vincamine, 16-epi-Δ^{14}-vincamine, 3-oxo-tabersonine, 16-carbomethoxy-16-hydroxy-14,15-epoxy-3-oxo-1,2-dehydroaspidospermidine, tabersonine N_b-oxide, 17-oxoyohimbine and others from roots, seeds and whole plant (Kimoto and Inoue, 1942; Kimoto and Honjo, 1943; Imai and Ogiso, 1955, 1958; Kimoto and Okamoto, 1955; Kimoto *et al*., 1959; Sakai *et al*., 1973; Aimi *et al*., 1978; Sauerwein and Shimomura, 1990,1991).
44. *Amsonia illustris*: (+)-Eburnamonine (Zabolotnaya *et al.*, 1964).
45. *Amsonia sinensis*: Amsosinine (**632**), tabersonine, vincadifformine, lochnericine, β-yohimbine, isoeburnamine, minovicinine, picrinine, strictamine, rhazidigenine, rhazimine, vincanidine and others (Liu *et al*., 1991a,b; Wang and Feng, 2003).
46. *Amsonia tabernaemontana* Walt.: Eburnamine, (+)-eburnamonine, iso-eburnamine, (+)-1,2-dehydroaspidospermine, (-)-quebrachamine, (-)-tetrahydroalstonine, (+)-akuammidine, tetrahydrosecamine, (+)-dihydro-19,20-condylocarpine, tabersonine, lochnericine, vincadine, (+)-6,7-dehydrovincadine, (-)-epivincadine, (+)-vincadifformine, (-)-vincadifformine, (+)-(-)-*nor*-*C*-fluorocurarine, harmolol, harmine, tetrahydroharman and others from leaves, stalks, seeds and roots (Janot *et al*., 1954a; Plat *et al*., 1962a; Zabolotnaya *et al*., 1964; Lutomski *et al*., 1967; Lutomski and Nowicka, 1968; Zsadon and Hubay, 1969; Panas *et al*., 1972a,b; Zsadon and Kaposi, 1970, 1972; Zsadon and Tamas, 1972; Zsadon *et al*.,1970, 1971a-c, 1973c,d, 1974a-c, 1975a-c, 1978).
47. *Anacampta angulata* (Mart.) MGF: Voacristine hydroxyindolenine from the trunk bark (Garnier *et al*., 1984a).
48. *Anacampta macrocalyx* (syn. *Tabernaemontana macrocalyx* Müll. Arg.: Coronaridine and tabersonine from the seeds (Bruneton *et al*., 1979).
49. *Anartia meyeri* (*Tabernaemontana meyeri*): 11-Hydroxycoronaridine, 11-hydroxy-heyneanine, 10-hydroxyheyneanine, 19-epiheyneanine, angustine, 16-epipleiocarparmine, tubotaiwine, conopharyngine, jollyanine, voacangine, isovoacangine, heyneanine, ibophyllidine, 7-hydroxyindolenine coronaridine, coronaridine, and eglandine from the leaves, stalks and roots (Ladhar *et al.*, 1981).
50. *Anodendron affine* Druce: Two zwitterionic alkaloids, anodendrine (**633**, *N*-isopropenyl-laburnic acid) and alloanodendrine (*N*-isopropenyl (+)-isoretonecanolic acid) from the aerial parts (Sasaki and Hirata, 1969, 1970).
51. *Apocynum cannabinum*: Harmolol from the roots (Lutomski *et al*., 1967).
52. *Aspidosperma album* (Vahl) Benoist ex Pichon: (+)-Sitsirkine, (+)-16-episitsirkine, kromantine, aspidoalbine, cromantine, aspidocarpine, aspidolimidine, aspidolimidinol, *N*-propionyl-*N*-deacetylaspidolimidine, and others from the seeds and bark (Ferrari *et al*., 1963; Relyveld, 1963a,b; Ferrari and Marion, 1964; Urrea *et al*., 1978).
53. *Aspidosperma auriculatum* Markgr.: Reserpine and dihydrocorynantheol (Gilbert *et al*., 1965).



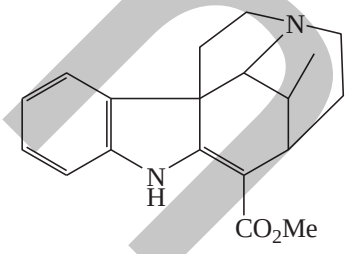
632 Amsosinine



633 Anodendrine

54. *Aspidosperma australe*: Aspidospermine, olivacine, (±)-guatambuine, (+)-guatambuine, (-)-guatambuine and uleine (Orazi, 1946; Ondetti and Deulofeu, 1959-1961).
55. *Aspidosperma campus-belus*: Olivacine (Garcia M. and Brown, 1976).
56. *Aspidosperma carapanauba*: Carapanaubine (Gilbert *et al*., 1963).
57. *Aspidosperma chakense*: Quebrachamine, spegazzinine and spegazzinidine from the bark (Orazi *et al*., 1956; Djerassi *et al.*, 1962a).
58. *Aspidosperma compactinervium*: Compactinervine and *N*-acetyl-11-hydroxy-aspidospermatine from the bark (Gilbert *et al.*, 1965).
59. *Aspidosperma cruenta*: Obscurinervine and obscurinervidine (Harper *et al.*, 1993).
60. *Aspidosperma cuspa* (Kunth) Blake: Burnamine, aspidodasycarpine, kopsanone, epikopsanol, kopsanol, picraline, 16-*epi*-isositsirikine**,** aspidocarpine and others (Burnell and Medina, 1968; Simões and Gilbert, 1976; Simões *et al.*1976; Perez *et al*., 2012).
61. *Aspidosperma cylindrocarpon* Muell.Arg: 11-Methoxylimapodine, cylindrocarpinol, *N*-formylcilindrocarpinol, *N*-acetyl-cylindrocarpinol, cylindrocarine, cylindrocarpidine, cylindrocarpine, *N*-Methyl-cylindrocarine, *N*-benzoylcylindrocarine, 12-demethoxy-*N*-acetylcylindrocarine, *N*-hydroxycinnamoyl-19-hydroxycylindrocarine, *N*-formyl-19-hydroxycylindrocarine, cylindrocarine and others (Djerassi *et al.*, 1960; Gilbert *et al*., 1960; Milborrow and Djerassi, 1969; Guimerãs *et al.*, 2013).
62. *Aspidosperma dasycarpon* A. DC.: Uleine, 1,13-dihydro-13-hydroxyuleine, (+)-apparicine, dasycarpidone, (+)-guatambuine, des-*N*-methyldasycarpidone, dehydrodes-*N*-methyluleine, dasycarpidol and aspidodasycarpine (Joule *et al.*, 1965).
63. *Aspidosperma desmanthum* Benth ex. Mull Arg.: Aspidoalbine and aspidocarpine (Garcia M. and Brown, 1976; Henrique *et al.*, 2010).
64. *Aspidosperma discolor* A. DC.: Reserpiline, isoreserpiline, isoreserpiline-ψ-indoxyl, yohimbine, β-yohimbine demethoxy-palosin, demethoxyaspidospermine, 10-methoxy-geissoschizol, 10-methoxy-dihydrocorynantheol and others (Ferreira *et al.*, 1963; Dastoor and Schmid, 1963; Dastoor *et al*., 1967).
65. *Aspidosperma dispermum*: Aspidodispermine and desoxyaspidodispermine (Pereira *et. al.*, 2007).
66. *Aspidosperma duckei*: Kopsanone, kopsanol, epikopsanol and epikopsanol-10-lactam (Ferreira *et al*., 1966).
67. *Aspidosperma eburneum*: (-)-Aparicine, olivacine, uleine, 3-*epi*-uleine, *N*-acetyl-aspidospermine, (-)-β-yohimbine, (+)-des-*O*-nethylaspidospermine, yohimbine and others (Antonaccio *et al.*,1962; Gilbert *et al.*, 1965; Pereira *et al*., 2007).
68. *Aspidosperma exalatum*: Aspidospermidine, demethoxy-aspidospermine, limaspermine, fendlerine *O*-demethylpalosine, demethoxypalosine, harman 3-carboxylic acid and others from the seeds and bark (Sanchez *et al*., 1971; Medina and Hurtado, 1977).

69. *Aspidosperma excelsum*: Aspidexcelcine, aspidexeine, aspidoasycarpine, α-yohimbine, yohimbine, *O*-acetylyohimbine, 11-methoxytubotaiwine, ochrolifuanine A, excelsinidine, tetrahydrosecamine, 16-demethoxy-carbonyltetrahydrosecamine, 16-hydroxytetrahydro-secamine and others (Relyveld, 1964, 1965; Benoin*et al.*, 1967; Burnell and Nguyen-Thi-Sen, 1971; Verpoorte *et al*., 1983; Layne *et al*., 2007).
70. *Aspidosperma fendleri*: Fendlispermine, fendlerine, quebrachamine, and aspidolimidine and others from the fruit root bark (Burnell *et al*., 1964a,b, 1966; Medina *et al.*, 1973).
71. *Aspidosperma formasanum*: Uleine, 3-epiuleine, 1,3-dihydro-13-hydroxyuleine and (+)-aspidocarpine (Garcia M. and Brown, 1976).
72. *Aspidosperma gilbertii*: Gilbertin and *N*,*N*-dimethyltetrahydro-ellipticinium hydroxide (Miranda and Blechert, 1982; Duarte and Conde Miranda, 1983).
73. *Aspidosperma gomezianum* A. DC.: (-)-Aparicine, uleine, 3-*epi*-uleine and *N*-acetylaspidospermine (Gilbert *et al.*, 1965; Pereira *et al*., 2007).
74. *Aspidosperma illustra*: β-Yoimbine and 1,2-dehydroaspidospermidine from the stem bark and leaves (Barbosa *et al.*, 2010).
75. *Aspidosperma limae* Woods: Aspidocarpine, aspidolimine, aspidolimidine, limapodine, limatine, 11-methoxylimatine, limatinine, 11-methoxylimatinine, limaspermine, tubotaiwine (**634**), 3'-methoxylimapodine and others (Gilbert *et al*., 1962a; Pinar and Schmid, 1963, 1967; Pinar *et al*., 1962, 1965).

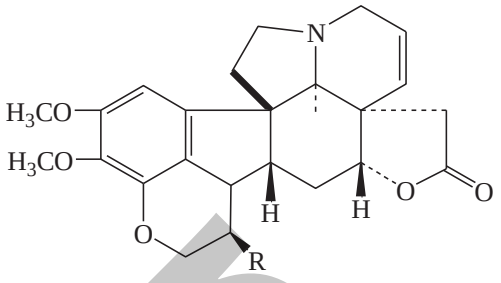


634 Tubotaiwine

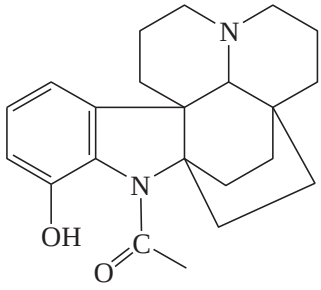
76. *Aspidosperma longepetiolatum*: Guatambuine and guatambuinine from the bark and roots (Bettolo and Carvalho-Ferreira, 1959; Ferreira *et al*., 1959).
77. *Aspidosperma macrocarpon* Mart.: Ervinceine, (-)-vincadifformine, kopsanone, kopsinine, kopsanol kopsanone and 18-epikopsanol from the seed, leaves and stem bark (Mitaine *et al*., 1996; Bannwart *et al*., 2013).
78. *Aspidosperma marcgravianum* Woodson: Aricine, aspidocarpine, reserpiline, (-)-demethoxyaspidospermine, dihydrocorynantheol, 16-*epi*-3*S*,4*S*-isositsirkine *N*-oxide, 18-oxohaplocidine, 18,19-dihdroantirhine, isogeissoschizol, 10-methoxy-isogeissoschizol, isantirhine, 4',5',6',17-tetrahydro(*R*) usambarensine *N*-oxide, dihydrocorynantheol, tetrahydro-secamine and others from the stem bark, root bark, leaves and wood (Gilbert *et al.*, 1962b; Arndt *et al*., 1967; Verpoorte *et al*., 1982 Robert *et al*., 1983a).
79. *Aspidosperma megalocarpon* Muell. Arg.: Fendlerine, aspidoalbine, aspidocarpine and aspidolimidine from the trunk and root barks (Mitaine *et al*., 1998).
80. *Aspidosperma melanocalyx* Muell-Arg.: Demethylaspidocarpine and others from the bark (Miranda and Gilbert, 1969).
81. *Aspidosperma multiflorum*: (-)-Aparicine, copsinine, uleine and 3-*epi*-uleine (Gilbert *et al.*, 1965; Pereira *et al.*, 2007).
82. *Aspidosperma neblinae*: Neblinine, pyrifolidine, deacetylpyrifolidine, aspidospermine, aspidocarpine, eburnamonine, demethylaspidospermine, aspidospermidine, 1,2-dehydro-aspidospermidine and demethoxyaspidospermine (Thomas *et al.*, 1969).

83. *Aspidosperma nigricans*: Guatambuine, (+)-olivacine *N*-oxide, (+)- uleine, dihydrouleine and others (Gilbert *et al.*, 1965; Arndt *et al.*, 1967; Pereira *et al.*, 2007).
84. *Aspidosperma nitidum*: 10-Methoxydihydrocorynantheol, braznitidumine, and harman-3-carboxylic acid from the stem bark (Arndt *et al.*, 1967; Pereira *et al.*, 2006a,c).
85. *Aspidosperma oblongum*: Thirty five alkaloids have been obtained from the seeds e.g. aspidocarpine, β-yohimbine, yohimbine, aricine, tetrahydroalstonine, α-yohimbine, methoxy-10-corynanthine, aspidodasycarpine, isositsirikine, methoxy-10-isositsirikine, cantleyine, antirhine, vallesiachotamine, vallesamine, alloyohimbine, corynanthine, *epi*-17-alloyohimbine, 19,20-dehydro-β-yohimbine, 3,4-dehydro-β-yohimbine, β-yohimbine oxindole, β-yohimbine pseudoindoxyle, β-yohimbine *N*-oxide, 10-methoxy-β-yohimbine, β-yohimbine *N*-oxide, 10-methoxy-β-yohimbine,10-methoxy-α-yohimbine, 19,20-dehydro-α-yohimbine, aricine pseudoindoxyle, methoxy antirhine, 10-methoxy sitsirikine, 3,4,5,6-tetradehydro-sitsirikine, and others (Palmer, 1961; Spiteller and Spiteller-Friedmann, 1962, 1963; Gilbert *et al.*, 1965; Robert *et al*., 1983b).
86. *Aspidosperma obscurinervium* Azembuja: (+)-Aspidocarpine, aspidolimine, obscurinervine (**635**), obscurinervidine(**636**), dihydroobscurinervidine (**637**) and dihydro-obscurinervine (**638**), from the bark (Brown and Djerassi, 1964; Kahrl *et al*., 1971).
87. *Aspidosperma olivaceum* Mull. Arg.: Aspidoscarpine, uleine, apparicine, *N*-methyl-tetrahydrolivacine, and olivacine from the leaves and bark (Schmutz and Hunziker, 1958a; Chierrito *et al*., 2014).
88. *Aspidosperma parvifolium* A. DC.: Uleine, epiuleine, apparicine and desmethyluleine from the stem bark (Jácome *et al*., 2004).
89. *Aspidosperma peroba* F. Allem ex Sald.: Mecusine B and alkaloid Q_2 from the stem bark (Fish *et al*., 1964; Quaisuddin, 1974, 1980).
90. *Aspidosperma polyneuron*: Müll. Arg.: Aspidospermine, quebrachamine, perobine, normacusine B, polyneuridine, palosine, a glycoside of harman-3-carboxylic acid and others (Antonaccio, 1957; Schmutz and Lehner, 1959; Taylor *et al.*, 1959; Antonaccio and Budzikiewicz, 1962; Antonaccio *et al*., 1962; Paladini *et al*., 1962; dos Santos *et al*., 2008). The cortex contained 2% of alkaloid (Floriani, 1930b).
91. *Aspidosperma populifolium*: Copsinine, *N*-formyl-16,17-dimethoxy-aspidofractinine, 17-methoxy-aspidofractinine and others (Gilbert *et al.*, 1965; Pereira *et al*., 2007).
92. *Aspidosperma pruinosum*: Yohimbine, β-yohimbine, 10-methoxy-yohimbine, 10-methoxy-4-methylgeissoschizol, normacusine B, compactinervine, 10-methoxy-dihydrocorynantheol and others from the bark (Nunes *et al.*, 1992; Taveira, 1992).
93. *Aspidosperma pyricollum*: Uleine, (+)-stemmadenine, (-)-apparicine, dimethyl-aspidospermine, yohimbine, β-yohimbine, 19-dehydroyohimbine and dasycarpidone from the bark and fruit (Arndt and Djerassi, 1965; Arndt *et al*., 1967).
94. *Aspidosperma pyrifolium* Mart.: Aspidofiline (**639**), aspidofractinine, pyrifoline (**640**), pyrifolidine (**641**), refractidine, (-)-vincadifformine, halocline, palosine, vallesine, (-)-aspidospermine, aspidospermidine, akuammicine, tubotaiwine, aspidofractinine and *N*-formylaspidofractinine, 15-demethoxypyrifoline, dehydroxyhaplocidine and others (Antonaccio, 1960; Gilbert *et al*., 1960, 1962c; Serur and Matos, 1981; Craveiro *et al*., 1983; Mitaine *et al*., 1996; de Araujo *et al*., 2007; Xavier de Araujo *et al*., 2007).
95. *Aspidosperma quebracho-blanco* Schlecht.: Akuammidine, aspidospermine, rhazidine, aspidospermatine, quebrachamine, quebrachine, quebrachacidine, (-)-pyrifolidine, rhazinilam and others from the leaves and bark (Labriola, 1939; Tunmann and Rachor, 1960; Biemann *et al*., 1961, 1963; Schnoes *et al.*, 1962; Markey *et al*., 1967; Tunmann and Wolf, 1969; Lyon *et al*., 1973). Aspidochibine, 3-oxo-14,15-dehydrorhazinilam, 11-hydroxy-tubotaiwine and 1,6-propano-3-ethylideno-1,4-piperazine-2,5-dione were

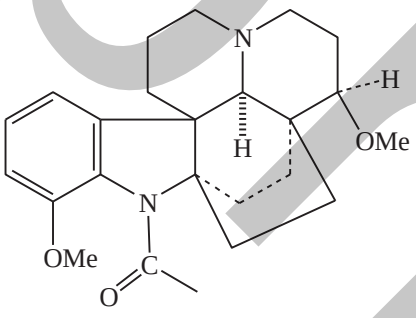
isolated from cultured cells (Aimi *et al*., 1991,1994). The total alkaloids of bark of *Aspidosperma quebracho-blanco* Schlecht. f. *pendulae* Speg. amounts to 4.098% (Floriani, 1938). *Aspidosperma quebracho blanco* subsp. f. *pendulae* contained aspidospermicine (Dominguez, 1932).



635 Obscurinervine R=C_2H_5
636 Obscurinervine R=CH_3
637 6,7-dihydro Obscurinervine R=C_2H_5
638 6,7-dihydro Obscurinervine R=CH_3



639 Aspidofiline



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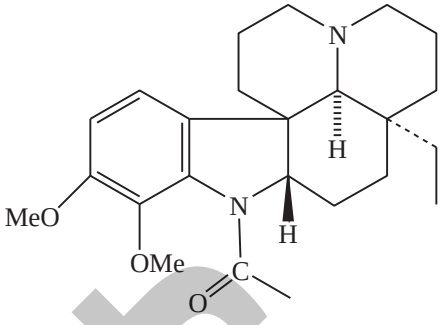
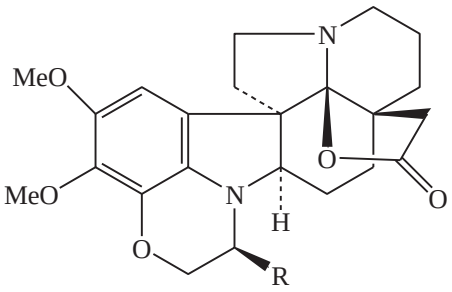


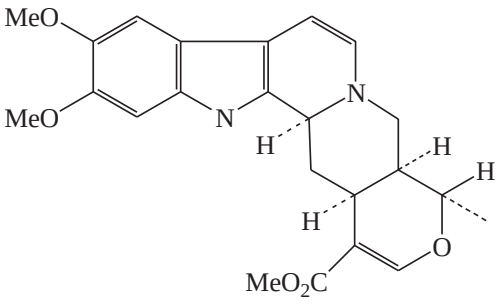
641

96. *Aspidosperma quirandy* Hassler: Aspidospermine, aspidosamine, haslerine, quirandine and others from the bark (Floriani, 1929, 1935).
97. *Aspidosperma ramifolium* Mull. Arg.: Ramiflorine A, ramiflorine B, β-yohimbine and 10-methoxygeissoschizol from the bark and seeds (Fatima *et al*., 1996).
98. *Aspidosperma refractum*: Refractine (Gilbert *et al*., 1960).
99. *Aspidosperma rhombeosignatum*: Limaspermidine, aspidospermine, aspidospermidine, demethoxypalosine, harman 3-carboxylic acid ethyl ester from the bark and others (Medina and Di Genova, 1979).
100. *Aspidosperma rigidum* Rusby: Picraline, 3α-aricine, (-)-carapanaubine, reserpiline, 3β-reserpiline, carboxine A, carboxine B, isocarboxine, carapanaubine, isocaranaubine, haplocidine and others (Arndt *et al*., 1967; Reina *et al*., 2011; Vieira *et al*., 2013).
101. *Aspidosperma sandwithianum* Markgr.: Quebrachamine (Relyveld, 1963c).
102. *Aspidosperma schultesii* Woodson: 18-Oxo-aspidoalbine, 18-oxo-*O*-methylaspidolobine and 11-hydroxytubotaiwine from the bark (Reina *et al*., 2011).
103. *Aspidosperma sessiliflorum*: (-)-Aspidospermine (Bolzani*et al*., 1987; Perreira *et al*., 2007).
104. *Aspidosperma spegazzinii*: Ajmaline and 2 quaternary alkaloids: N_b-metho derivative of akuammidine and spegatrine (N_b-methyl sarpagine) (Orazi *et al*., 1966).

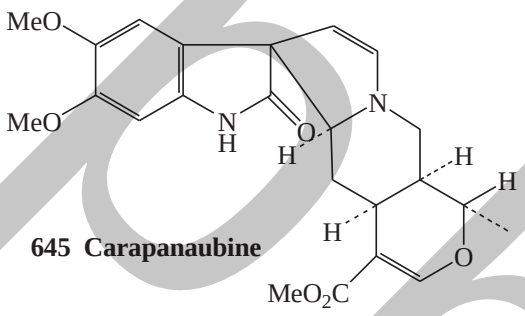
105. *Aspidosperma spruceanum* Benth. ex Mull. Arg.: Aspidospermidine, aspidocarpine, aspidolimine, fendlerine, aspidolimidine, obscurinervidine, spruceanumine A (**642**), spruceanumine B (**643**), and others from the stem bark and seeds (Oliveira *et al*., 2009).
106. *Aspidosperma subincanum* Mart: Subincanadines A-G1, subincanine, pausperadine A, 1,2-dihydroellipticine, ellipticine methonitrate and others (Büchi *et al.*, 1961; Gaskell and Joule, 1970; Kobayashi *et al.*, 2002; Ishiyama *et al*., 2005).
107. *Aspidosperma tomentosum* Mart.: Uleine and (+)-12-hydroxy-*N*-acetyl-aspidospermatidine (Arndt *et al*., 1967).
108. *Aspidosperma ulei* Markgr.: Dihydroellipticine, uleine, 1,2-dihydroellipticine, 19(*E*)-hunteracine, yohimbine, 20-epi-dasycarpidone, olivacine, *N*-demethyluleine and 20(*E*)-*nor*-subincanadine E and others from the different parts of the plant (Schmutz and Hunziker, 1957, 1958b; Lehner and Schmutz, 1961; dos Santos Torres *et al*., 2013).
109. *Aspidosperma vargasii* A. DC.: (±)-Guatambuine, 9-methoxyolivacine, ellipticine and *N*-methyltetrahydroellipticine(Henriqu *et al.*, 2010; Burnell and Della Casa, 1967).
110. *Aspidosperma verbascifolium*: Kopsanone, kopsanol, 3'-epikopsanol, 10-oxo-3'-*epi*-kopsanol and N^{α}-formylkopsanol (Braekman *et al*., 1969a).
111. *Beaumontia grandiflora:* A steroidal alkaloid, beaumontamine (3β,14β-dihydroxy-20-amino-17α-pregn-5-ene) from the stems (Ma *et al.*, 2009).
112. *Bleekeria vitiensis*: Bleekerine (**644**), carapanaubine (**645**), holeinine (**646**), isoreserpiline (**647**), isoreserpiline-Ψ-indoxyl (**648**), ellipticine and 9-methoxyellipticine (**649**) (Kilminster *et al.*, 1972; Sainsbury and Webb, 1972; Kanji and Sinsbury, 1974).
113. *Bonafousia macrocalyx:* Coronaridine, voacangine, heyneanine, voacangarine and several others (Garnier *et al*., 1984b,c).
114. *Bonafousia tetrastachya* (Humboldt et Kunth) Markgraf: Bonafousine (**650**), isobonafousine (**651**), geissoschizine, (-)-12-hydroxyvincadifformine, tetrastachyne, tetrastachynine and others (Damak *et al*., 1976a-c, 1980, 1981).
115. *Cabucala caudat*a: Cabufiline from the leaves (Massiot*et al.*, 1982).
116. *Cabucala cryptophlebia* (Baker) Pichon: Cabucine, 10,11-dimethoxymitraphylline, and others (Annon, 1972a; Hannart, 1972; Rasoanaivo *et al.*, 2001).
117. *Cabucala erythrocapra* var. *erythrocarpa*: Caberine, caberoline, (-)-cabucine, (-)-quebrachidine, (-)-ochropamine, (-)-akuammicine, (-)-akuammine, (-)-lochnerinine, cabucinine, (-)-aricine, (-)-minovincine, cabuamine and others (Douzoua *et al*., 1974) from the stems and foliage of the plant (Mansour *et al.*, 1974).
118. *Cabucala fasiculata*: Cabucine, (-)-carapanaubine, (-)-lochnerinine (-)-caberine, (-)-*O*-methylakuammine, cabucinine, (+)-rauvoxinine, (-)-cabucraline, caboxine A (**652**) isocaboxine A (**653**), isocarboxine B (**654**) and others from the different parts of the plant (Titeux *et al*., 1974, 1975a).
119. *Cabucala intermedia*: Dimethoxyoxindole derivative (Anon, 1972b).
120. *Cabucala madgascariensis* Pich.: 10-Methoxahmalicine, reserpine, cabucine and cabucinine from the woody stalks, branches and root bark (Groebel *et al.*, 1970; Douzoua *et al*., 1972).
121. *Cabucala madgascariensis* (DC.) Mgf., var. *amygdalifolia* Mgf.: Carapanaubine, rauvoxinine, 10,11-dimethoxyisomitraphylline and 10-methoxahmalicine from the aerial part (Kan-Fan *et al*., 1972).
122. *Cabucala striolata*: Ajmalicine, ajmalicinine, 10,11-dimethoxyajmalicine, 10,11-dimethoxyajmalicinine, cabucine, cabucinine, quebrachidine and reserpine from the root bark (Bombardelli *et al*., 1974a) and ochropamine from the leaves (Hannart, 1973).
123. *Cabucala torulosa* Pichon: (-)-Aricine, (-)-cabucine, (-)-vaincamjine , (+)-quebrachidine and (-)-cabucraline from the leaves, stem and root bark (Titeux *et al*., 1975b).



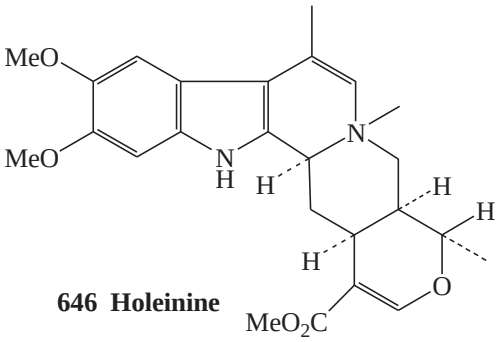
642 Spruceanumine A R=CH_3
643 Spruceanumine B R=C_2H_5



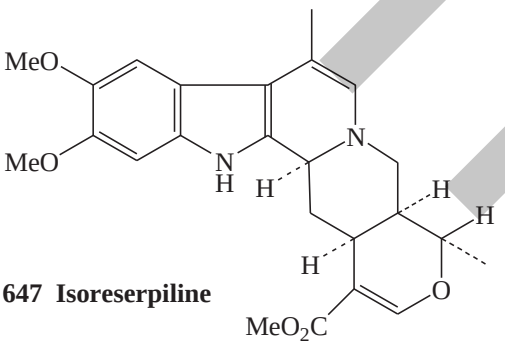
644 Bleekerine



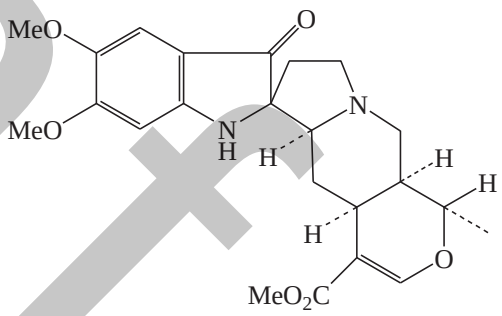
645 Carapanaubine



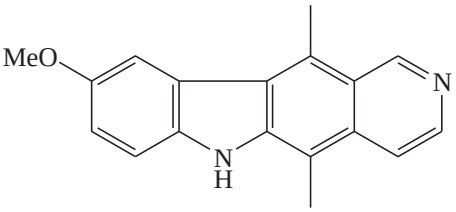
646 Holeinine



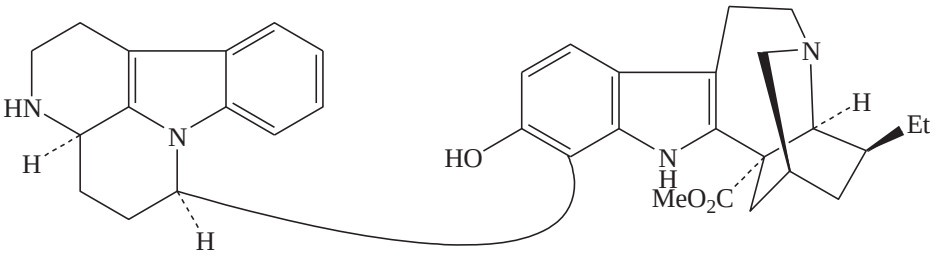
647 Isoreserpiline



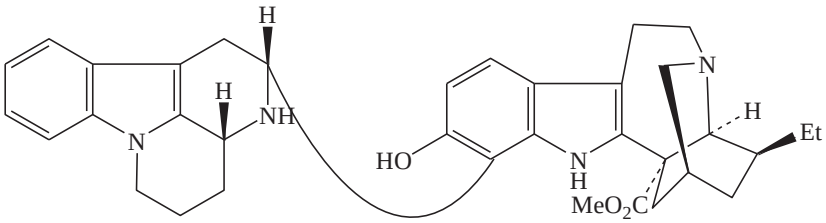
648 Isoreserpiline-Ψ-indoxyl



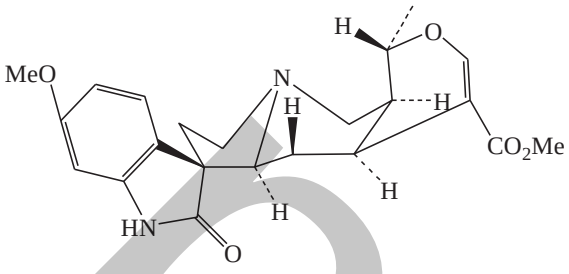
649 9-Methoxyellipticine



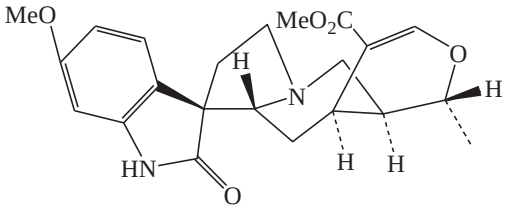
650 Bonafousine



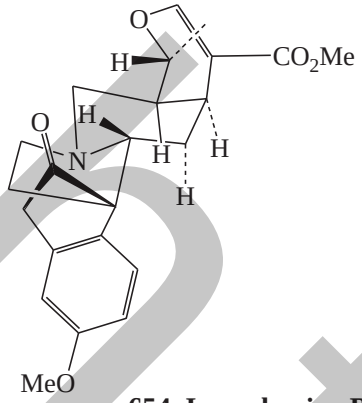
651 Isobonafousine



652 Caboxine A

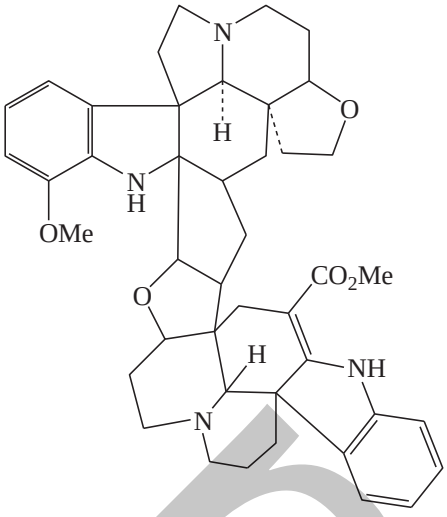


653 Isocaboxine A

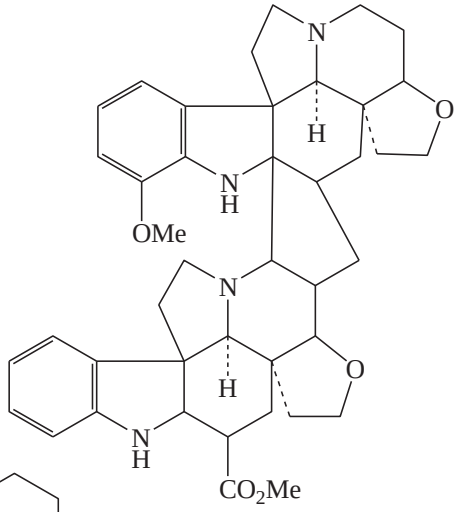


654 Isocarboxine B

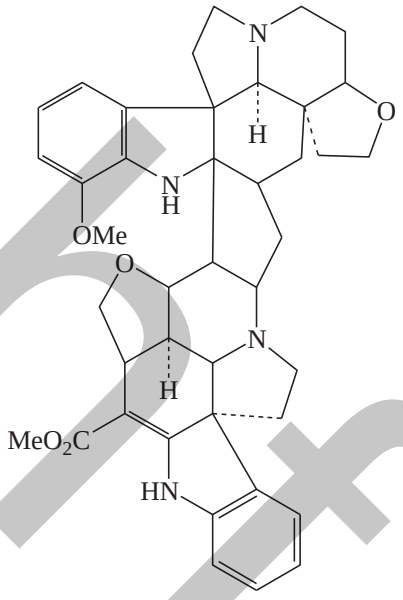
124. *Callichilia barteri* (Hook.f.) Pichon: Beninine (**655**), callichline (**656**), vobtusine (**657**) and lonicerine (16-*epi*-aspidodasycarpine) (Agwada *et al*., 1967; Naranjo *et al*., 1970).
125. *Callichilia stenocepala*: An alkaloid, $C_{42}H_{48}N_4O_6$, having 2 basic centers (Patel *et al*., 1961).
126. *Callichilia subsessilis*: Vobtusine and callichiline (Goutarel *et al*., 1959).
127. *Capuronetta elegans* Mgf: Capuronine and two derived from cleavamine from the leaves and stem bark (Chardon-Loriaux *et al*., 1978; Riche, 1980).
128. *Catharanthus lanceus* Boj. ex A. DC. (syn. *Vinca lancea*, *Lochnera lancea*): Ajmalicine, perivine, yohimbine, pericyclivine, vindoline, lochnerinine, periformyline, vindolinine, pericalline, perimivine, catharanthine, cathalanceine, cathanneine, catharine, lancine, ammocalline, vinosidine, hörhammericine, hörhammerinine, vincoline, leurosine and others from the leaves and roots (Blomster *et al*., 1964, 1967, 1968; Loub *et al*., 1964; Farnsworth, 1972; Farnsworth *et al*., 1964a,b, 1966, 1967, 1968b; Abraham *et al*., 1965, 1967; Maloney *et al*., 1965, 1968; Aynilian *et al*., 1972).
129. *Catharanthus libanotica*: Vincoline (Aynilian *et al*., 1974).
130. *Catharanthus longifolius* Pich.: Ajmalicine, desacetylvindoline, calongine, cathovaline, monovincinine, echitovenine, vindorosine, vindolinine, perivine, catharanthine, δ-yohimbine, normacusine B, pericyclivine, akuammidine, akuammicine, vindorosine, vindoline, pericalline, antirhine, leurosine, vincaleucoblastine, vindolicine, catharine, catharicine and others (Rasoanaivo *et al*., 1972, 1973; Rabaron *et al*., 1973a; Potier *et al*., 1973, 1974).



655 Beninine



656 Callichline

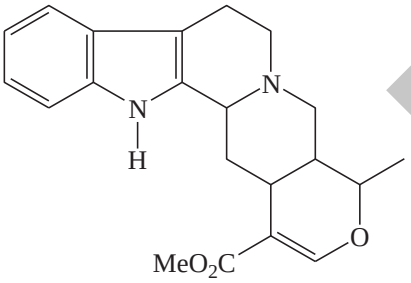


657 Vobtusine

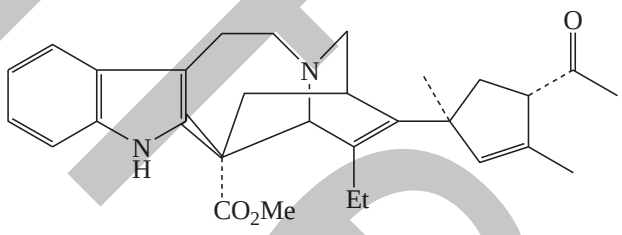
131. *Catharanthus ovalis* Mgf.: Kitraline, kitramine, alstonine, venalstonine, venalstonidine, vinolinine, vindolicine, vincaleucoblastine, leurosine, catharine, catharanthine, coronaridine, cathovaline, serpentine, vindoline, vincovaline, pericalline, caberine, vindorosine, vindoline and others (Langlois and Potier, 1971, 1972a,b; Langlois *et al*., 1979, 1980; Andriamialisoa *et al*., 1976; Chiaroni *et al*., 1976; Saxton, 1998).
132. *Catharanthus pusillus*: Ajmalacine, vindorosine, leurosine, vindoline, catharanthine and lochnerinine (Tin-Wa *et al*., 1968;).The plant contained 0.49% crude alkaloids (Fylypiw *et al*., 1965).
133. *Catharanthus roseus* Don. (*Vinca rosea* L.) (Madagascar periwinkle): There are several reviews dealing with the phytochemistry and pharmacology of *Catharanthus roseus*. According to the reviews of van der Heijden *et al.* (2004) and Aslam *et al.* (2010), the plant contains about 130 indole alkaloids of which 25 are dimeric in nature. The plant is also rich in bisindole alkaloids, most of them containing vindoline or catharanthine moiety. Both the commercially important alkaloids of vinblastine and vincristine have a large dimeric asymmetric structure composed of a dihydroindole nucleus (vindoline ring) and an indole nucleus, linked by a carbon-carbon bond. Vinblastine and vincristine (used in cancer treatment) are present in very low concentrations. However, more other alkaloids have been identified. The isolation of over 165 alkaloids, several of which

display anticancer activity, have been so far reported: ajmalicine (**658**) [3-*epi*-ajmalicine], ajmalicine pseudoindoxyl, ajmalicine-7-hydroxyindolenine, 19-*epi*-3-*iso*-ajmalicine, akuammicine, 12-hydroxyakuammicine, alioline (**659**), xylosyloxy-akuammicine, akuammiline, antirhine, *O*-deacetylakuammiline, akuammigine, 10-hydroxydeformodihydropseudoakuammigine-10-*O*-α-L-arabinopyranoside, 10-hydroxy-deacetyl-akuammiline, akuammine, alstonine, ammocalline, ammorosine, apparicine, bannucine, β-carboline, caroside, carosine, cathalanceine, catharanthamine, catharanthine (**660**), catharicine, catharine, catharoseumine, catharosine, cathenamine, cathindine, cathovaline, cavincidine, cavincine, cleavamine, coronaridine, corynanthine, cycloleurosine, cyclovinblastine A, cyclovinblastine B, 4-deacetoxycyclovinblastine, 17-deacetoxycyclovinblastine, 14′,15′-didehydrocyclovinblastine, deacetoxyvindoline, deacetylvindoline, dihydroantirhine, (-)-dihydrocorynantheol, dihydrositsirikine, 19(*S*)-epimisiline, fluorocarpamine-*N*-oxide, gomaline (**661**), hörhammericine, 11-methoxy-hörhammericine, 18-hydroxystrictamine, isoleurosine, 10-hydroxy-cathafoline10-*O*-α-L-arabinopyranoside, isositsirkine [19,20-*cis*-16(*R*)-isositsirikine, 19,20-*trans*-16(*R*)-isositsirikine, 19,20-*trans*-16(*S*)-isositsirikine], isovallesiachotamine, leurocolombine, leurosidine N_b-oxide, 4'-deoxyleurosidine N'_b-oxide, leurosidine, 4'-deoxyleurosidine, leurosine, 17-deacetoxyleurosine, 5'-oxoleurosine, leurosine N_b'-oxide, leurosinine, leurosinone (**662**), leurosivine, lochnericine, lochnerine, lochnerine *N*-oxide, 21-hydroxycyclolochnerine, lochnerinine, lochneririne, lochnerivine, lochrovicine, lochrovidine, lochrovine, lohnerine, maandrosine, 10-methoxyaffinisine-*N*(4)-oxide, methyl vingramine (**663**), minovincine, minovincinine, mitraphylline, *N*-demethyl-vinblastine, neoleurocristine, neoleurosidine, neoleurosidine N_b-oxide, normacusine B *N*-oxide, 10-methoxy-normacusine B, pericyclivine, perimivine, perividine, perivine, perosine, pleiocarpamine, pleurosine, preakuammicine, pseudovinca, rosamine (**664**), roseadine, roseamine, rosicine (**665**), rovindine, serpentine, serpentinic acid, sitsirikine, strictosidine, strictosidine lactam, tabersonine, 11-methoxytabersonine, 19-acetoxy-11-hydroxy-tabersonine, 19-hydroxy-11-methoxy-tabersonine, tetrahydroalstonine, N_b-acetyl tryptamine, *N*,*N*-dimethyl tryptamine, tubotaiwine, vallesiachotamine, venalstonine, vidolicine, vinamidine, 15'*R*-hydroxyvinamidine, vinaphamine, vinaspine, vinblastine (**666**), [20'-*epi*-vinblastine], 17-desacetoxy-vinblastine-N_b-oxide, 20'-deoxyvinblastine-N_b-oxide, 3',4'-anhydro-vinblastine, 4-deacetoxyvinblastine, 4'-deoxyvinblastine, 14'-hydroxy-vinblastine, 15'hydroxyvinblastine, vinblastine N'_b-oxide, vincadifformine, vincaleukoblastine, vincamicine, vincanamidine, 17-deacetoxy-vinamidine, vincamine, (-)-vincapusine, vincarodine, vincathicine, vincolidine, *O*-deacetyl-vindolidine, vincoline, vincristine (**667**), vindolicine, vindolidine, vindoline, vindolinine [19(*R*)-vindolinine, 19(*S*)-vindolinine, 19-*epi*-vindolinine], 15(*S*)-hydroxy-14,15-dihydrovindolinine, vindolinine B, vindolinine N_b-oxide [16-*epi*-19-*S*-vindolinine-*N*-oxide, 19-*epi*-vindolinine *N*-oxide], vindorosine, vinervine, vingramine (**668**), vinoblastine, vinosidine, vinsedicine, vinsedine, yohimbine, 3-*epi*-α-yohimbine, 18β-hydroxy-3-*epi*-α-yohimbine (e.g. Svoboda *et al*., 1962, 1964; Gorman and Neuss, 1963; Moza and Trojanek, 1965; Kutney and Browen, 1963, 1966; Gorman and Sweeny, 1964; Svoboda, 1963, Ciulei *et al*., 1965; Creasey, 1975; Svoboda and Blake, 1975; Tafur *et al*., 1975; Cuellar and O'Farril-Tejera, 1976a; Ali *et al*., 1979; Cordell, 1981b; Atta-ur-Rahman and Bashir, 1983; Atta-ur-Rahman *et al*., 1983a 1984a-c, 1986a, 1988a; Ali, 1990; Jossang *et al*., 1998; Habib-ur-Rahman and Atta-ur-Rahman, 2005; Mai *et al*., 2006; Zhong *et al*., 2010; Wang *et al*., 2011a; 2012d,e, 2014b ; Zhang *et al*., 2013c,d) and two pairs of epimeric indole alkaloids with a chlorine atom (Wang *et al*., 2011b). The alkaloids are

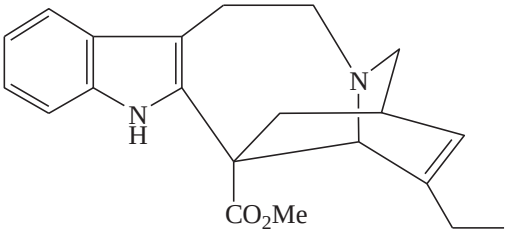
well distributed in the whole plant. The alkaloid content of the plant varies considedrably in various parts; the maximum being in the root bark which ranges from 0.15 to 1.34% and even up to 1.79% in some strains (Aslam *et al.*, 2010). Total alkaloids in different parts of the plant, were 2.230% in roots, 0.411% in stems, 1.098% in leaves, 0.503% in flowers and 0.013% in seeds (Yang *et al.*, 2008). The total alkaloids of the roots of the plant, growing in India, was 1.3% and that of ajmalicine and serpentine 5.7% (Ramesh *et al.*, 1982). The contents of vinblastine, catharanthine and vindoline in the plant from 8 areas in Hainan province, varied greatly e.g. 4.9-48.4 μg/g, 0.028-0.591 mg/g and 0.255-2.77 mg/g, respectively (Yan *et al.*, 2007). The vindoline content in periwinkle samples of Guangzhou (China) varied greatly in one year. The vindoline content in stem was raised from October to February and fell from February to September. In leaf, the vindoline content was up from October to March and down from April to September. The vindoline content in flower and fruit were more complex compared to stem and leaf. The maximum vindoline contents in stem, leaf, flower and fruit were in February, March, June and April, respectively (Zhou *et al.*, 2012).The plant from Vietnam and Bulgaria contained vinblastine 0.005-0.038, vindoline 0.105-0.339, and catharanthine 0.044-0.231% (Tam *et al*., 1995). Vinblastine and vincristine (the antileukemic agents) were isolated, in a pure form, from the plant cultivated in Egypt (Shams *et al.*, 2009). Callus tissue of *Vinca rosea* demonstrated capacity to biosynthesize ajmalicine, catharanthine, lochnericine, vinblastine and vindoline (Andreeva and Bereznegovskaya, 1977). There are several reports on the production of several alkaloids from *C. roseus* by the tissue culture (e.g. Zenk *et al.*, 1977; Constabel *et al.*, 1982; Moreno *et al.*, 1995; Zhao *et al.*, 2001; Ataei-Azimi *et al.*, 2008; Verma *et al.*, 2012; Ahmad *et al*., 2013).



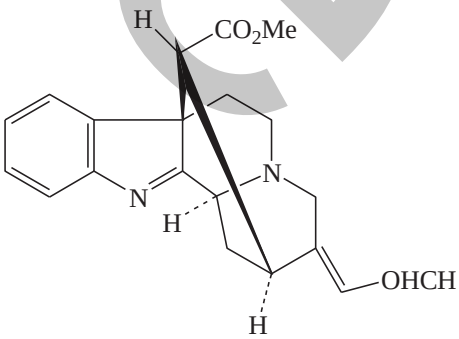
658 Ajmalicine



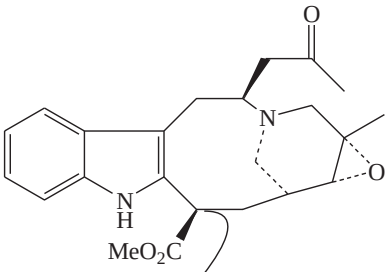
659 Alioline

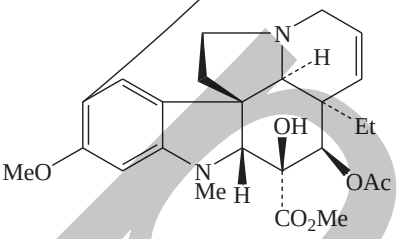


660 Catharanthine

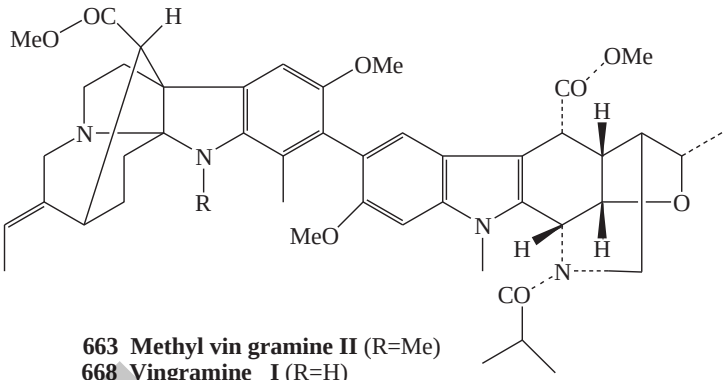


661 Gomaline

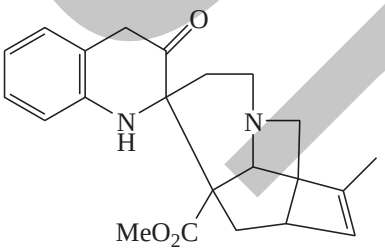




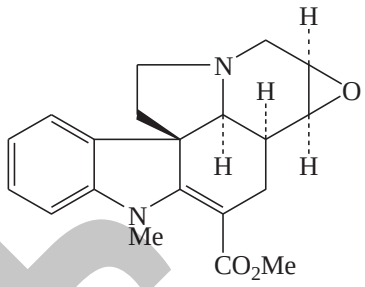
662 Leurosinone



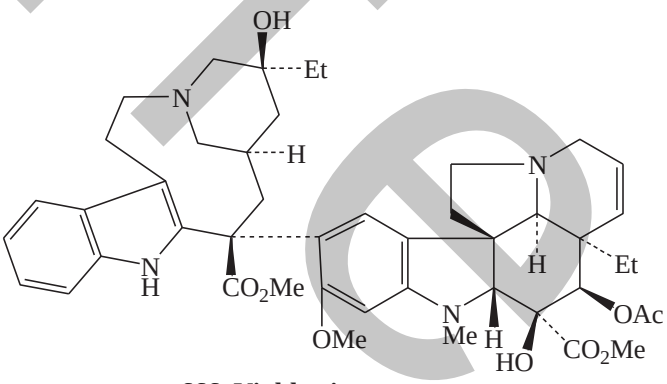
663 Methyl vin gramine II (R=Me)
668 Vingramine I (R=H)



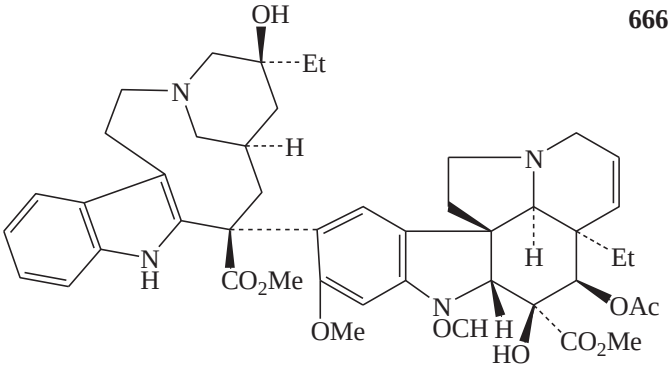
664 Rosamine



665 Rosicine



666 Vinblastine

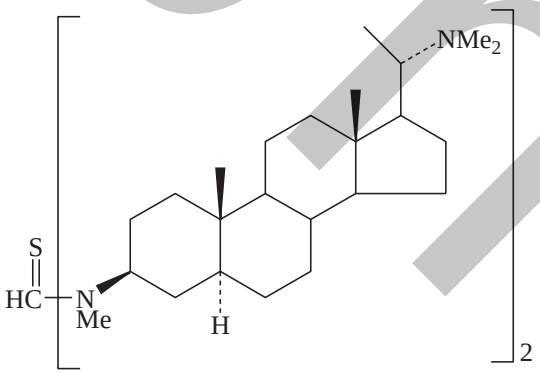


667 Vincristine

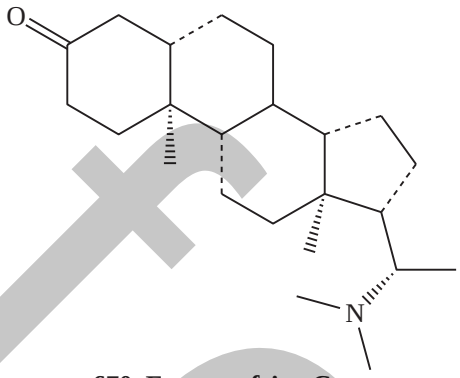
134. *Catharanthus trichophyllus*: Ajmalicine, akuammicine, pericalline, pseudoyohimbine, tetrahydroalstonine, vindoline vindolinine, lochnericine, horhammericine, (-)-minovincine, minovincinine, (-)-echitovenine, cathaphylline, leurosine, vindorosine, vincaleukoblastine, vincarodine, periformyline, pericyclivine, and trichophylline from root and aerial part (Kim *et al*., 1970; Segelman and Farnsworth, 1974; Cordell and Farnsworth, 1976; Mukhopadhyay and Cordell, 1981; Mukhopadhyay *et al*., 1983a).
135. *Chonemorpha grandiflora* (Rotyh) M. R. and S. M. Almeida (syn. *Chonemorpha fragrans* (Moon) Alston; *Chonemorpha macrophylla* G. Don): Chenomorphine, *N*-formylchonemorphine, camptothecin, japindine (**669**, a sulphur containing dimeric base) and funtumafrine C (**670**) from the roots, stems and callus cultures (Chatterjee and Das, 1959; Chatterjee and Banerji, 1972; Banerji *et al*., 1973, 1978; Chatterjee *et al*., 1987; Kulkarni *et al*., 2010). The root bark of *Chonemorpha macrophylla* contains 3.03% total alkaloids, consisting mainly of chonemorphine (Das and Pillay, 1954).
136. *Chonemorpha penangensis* Ridl.: Chonemorphine (**671**) (Chatterjee and Das, 1959).
137. *Comularia camerunensis*: Eburnamenine, eburnamine, isoeburnamine, pleiocarpine and pleiocarpinine from the root bark (Bruneton, 1982).
138. *Conopharyngia durissima* Stapf.: Coronaridine (**672**) coronaridine hydroxyindolenine (**673**), 12,13-dimethoxycoronaridine, isoquinuclidine, akuammiline, conodurine, conduramine, conopharyngine, tabersonine (**674**), anhydrovobasindol, isovoacangine and others from the root and stem barks (Renner *et al*., 1959; Renner and Prins, 1962a,b; Das *et al*., 1967; Hootele *et al*., 1967a; Dugan *et al*., 1969).
139. *Conopharyngia johnstonii* Stapf: Tubotaiwine and tubotaiwine-N-oxide from the root bark (Pinar *et al*., 1972).
140. *Conopharyngia jollyana*: Jollyanine, 19-oxoconopharyngine, 19-oxocoronaridine and 20-hydroxy-19-oxocoronaridine (Hootele*et al.*, 1964, 1967b; Hootele and Pecher, 1968).
141. *Conopharyngia longiflora*: Conoflorine and probably isovoacangine (Dugan *et al*., 1967; Lopes, 1967).
142. *Conopharyngia pachysiphon*: Conopharyngine and 20α-amino-3β-hydroxy-5-pregnene-β-D-glucoside was isolated from the root (Dickel*et al.*, 1959; Lucas and Dickel, 1962).
143. *Craspidospermum verticillatum* Bojer ex A. DC.: Craspidospermine, 11-methoxy-(-)-tabersonine, venalstonine, 11-hydroxy-(-)-tabersonine, Δ^{14}-vincine and $\Delta^{14\text{-}16}$-epivincine (Kan-Fan *et al*., 1968, 1971, 1976).
144. *Craspidosperma verticillatum* var. *petiolare* Andrangine, andranginine, venalstonine deformylstemmadenine, condylocarpine, 11-methoxy-tabersonine and stemmadenine from the leaves (Kan-Fan *et al*., 1974).
145. *Crioceras dipladeniiflorus*: Andrangine, criophylline, Δ^{14}-vincamine, 12-methoxy-Δ^{14}-vincamine (**675**), tabersonine, ditabersonine,voaphylline, vobtusine, voaphylline, criocerine (**676**) and others (Bruneton *et al.*, 1973a,b, 1974, 1975).
146. *Crioceras longiflorus*: Vobtusine, 14-dehydrovincamine, and 16-*epi*-14-dehydro-vincamine from the root bark (Cave *et al*., 1971).
147. *Cyclocotyla congolensis* Stapf: Eburnamine and eburnamonine from the root bark (DeLaude and Huls, 1978).
148. *Daturicarpa elliptica* Stapf: Ibogaine, iboxygaine, ibogaline, ipophyllidine and voacangine from the root and stem (Bruneton *et al*., 1976a).
149. *Dictyophleba lucida*: Dictyophlebine, dictyodiamine, dictyolucidine and dictyolucidamine (Khuong-Huu-Qui *et al*., 1965b; Janot *et al*., 1966).
150. *Diplorhyncus condylocarpon* (Muell. Arg.) Pichon ssp. *mossambicensis* (Benth.) Duvign. (Syn: *Diplorhynchus angolensis* Biittner, *Diplorhyncus* angustifolia Stapf.): Yohimbine, β-yohimbine, tombozine (normacusine B), stemmadenine, condylocarpin,

norfluorocurarine and mossambine (diplorrhyncine) from the root bark (Stauffacher, 1961; Monseur *et al*., 1962; Hedberg *et al*., 1982).

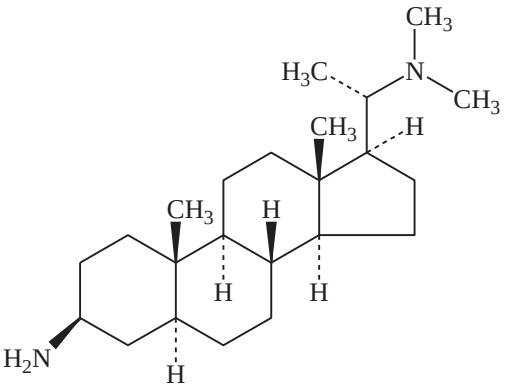
151. *Dyera costulata*: Ochrolifuanines (e.g. **677**), E and F, and the 18-dehydro-ochrolifuanines A, E and F from the leaves (Mirand *et al*., 1983).
152. *Elytropus chilensis*: Holarrhenin, holarrhimine and others (Chavez *et al*., 1951; Ibanez *et al*., 1952; Vera *et al*., 1953).
153. *Ervatamia chinensis*: Ervachinines A-E, rutaecarpine, evocarpine, and 1-methyl-2-[(*Z*)-6-undecenyl]-4(1*H*)-quinolone, and others from the whole plant (Guo *et al*., 2012a,b).
154. *Ervatamia coronaria* Stapf (syn: *Taberaemontana divaricata*): Apparicine, hecubine (**678**), voaphylline (**679**), hyderabadine (**680**), mehranine (**681**), lahoricine (**682**), ervaticine, ervatinine (**683**), (20*S*)-19,20-dihydrocondylocarpine, heyneanine, stapfinine (**684**), coronaridine, ibogamine, voacangine, isovoacangine, tabernaemontanine, dregamine, 20-epiervatamine, (-)-tabersonine hydrochloride, voacristine, voacamine, descarbomethoxyvoacamine, janetine, 19-oxocoronaridine and others from the leaves, stems, flowers and bark (Delle Monache *et al*., 1972; Gomez Gonzalez and Lorincz, 1976; Gomez Gonzalez and Martinez, 1976; Atta-ur-Rahman and Daulatabadi, 1983; Atta-ur-Rahman *et al*. 1983b, 1984d,e, 1985b, 1986b,c; Atta-ur-Rahman and Muzaffar, 1985; Gomez, 1989; Gomez Gonzalez *et al*., 1981, 1989; Henriques *et al*., 1996).



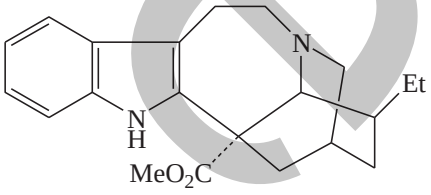
669 Japindine



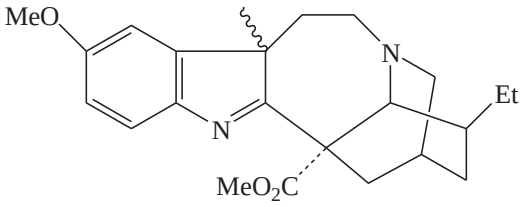
670 Funtumafrine C



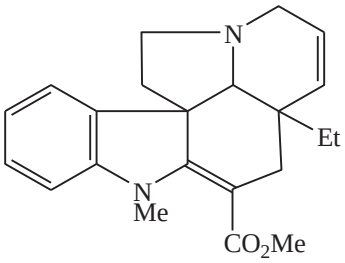
671 Chonemorphine



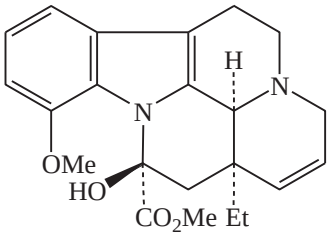
672 Coronaridine



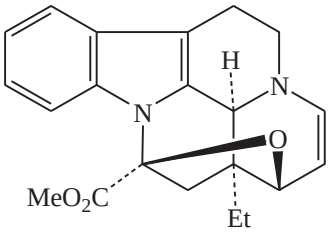
673 Hydroxyindolenine



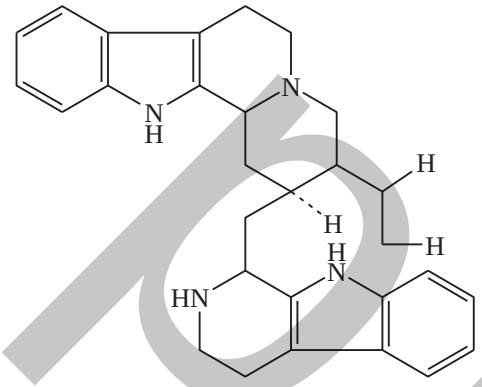
674 Tabersonine



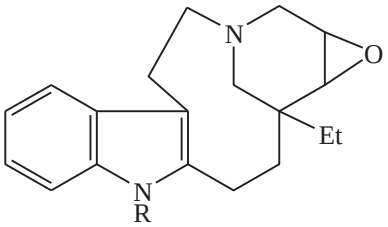
675



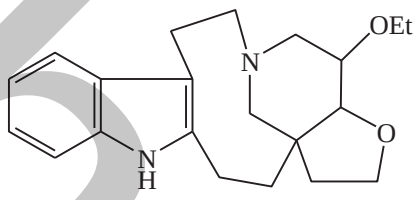
676 Criocerine



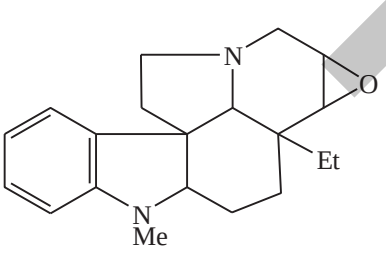
677 Ochrolifuanine



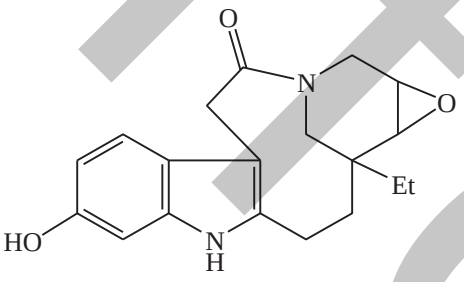
678 Hecubine R=Me
679 Voaphylline R=H



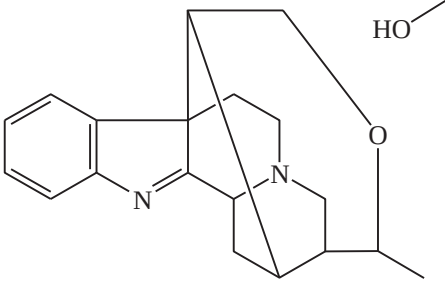
680 Hyderabadine



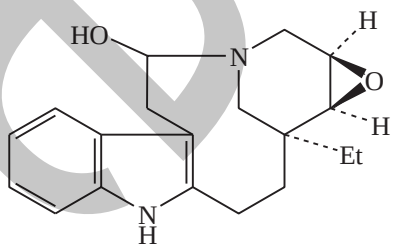
681 Mehranine



683 Ervatinine



682 Lahoricine

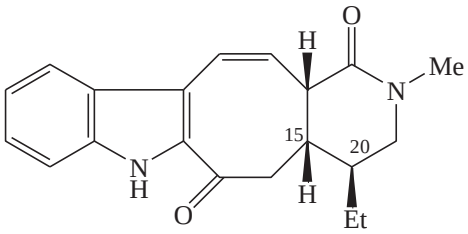


684 Stapfinine

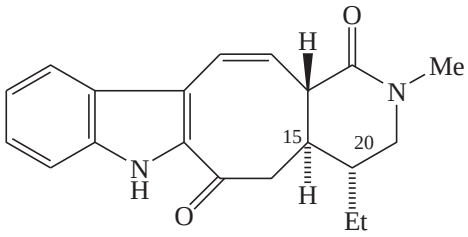
155. *Ervatamia coronaria* var. *plena*: Coronaridine, 3-oxo-coronaridine, voacangine, voacangine hydroxyindolenine, heyneanine, 3-oxo-voacangine, voacristine, and others from the whole plant (Sharma and Cordell, 1988). Total alkaloidal contents: root bark 1.28, stem bark 0.90, flowers 0.35, and leaves 0.35% (Huq *et al.*, 1967).
156. *Ervatamia daemeliana*: Conopharyngine, voacangine, iboxygaine and akuammidine (Allorge *et al.*, 1980).
157. *Ervatamia divaricata* (L.) Burk. (syn. *Tabernaemontana divaricata*): More than 50 alkaloids e.g. coronaridine, voacangine, tabernaemontanine, dregamine, 20-*epi*-

ervatamine, tabernaelegantine A, ervadivaricatine A, eridivaricatine B, harmine, apparicine, heyneanine, voacristine, 14,15-didehydro-10,11-dimethoxy-vincamine, and dehydroxyervataminol from the flowers and seeds (Jabbar and Hasan, 1980; Huang *et al*., 1997a; Joshi *et al*., 2004; Zhang *et al*., 2007).

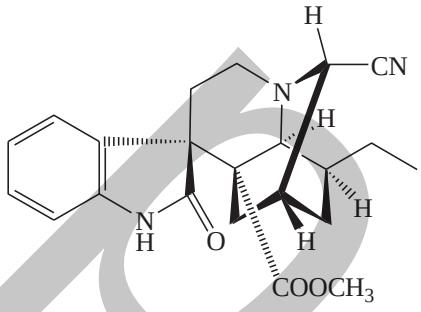
158. *Ervatamia flabelliformis*: Flabelliformides A (**685**) and B (**686**) and others from the stems (Liang *et al*., 2007b, 2008).
159. *Ervatamia hainanensis* Tsiang: Coronaridine, heyneanine, perivine, ibogamine, geissoschizol, ervahaimine A (**687**), ervahaimine B, ervahainamidine A, ervahainamidine B, ervahainanmine, bogaine, 19-heyneanine, 19-*epi*-heyneanine, 3-hydroxyl coronaridine and 3-(2-oxopropyl) coronaridine, ibogamin-3-one, ervahamine C, hainanervatasine, hainanervatacine, tabernamine, ervahainine A (a cyano-substituted oxindole alkaloid), vobasine and others from the roots, stems, leaves and twigs (Feng *et al*., 1981 1982, 1989; Huang *et al*., 2006a,b; Liang *et al*., 2007c; Tan *et al*., 2008; Zhan *et al*., 2009; Liu *et al*., 2013a; Yang *et al*., 2013).
160. *Ervatamia heyneana* (Wall.) T. Cooke: Fourteen alkaloids e.g. heyneatine (**690**), camptothecin (**688**), 9-methoxycamptothecin (**689**), coronaridine (**691**), 10-hydroxy-coronaridine (**692**), pericalline, and 10-methoxyeglandine-*N*-oxide (**693**) from the wood and stem bark (Gunasekera *et al*., 1979, 1980).
161. *Ervatamia hirta*: Thirty-three alkaloids from the leaves and root bark e.g. (*E*) affinisine, (*E*) 16-*epi*-isositsirikine, β-yohimbine, isositsirikine, 19,20-dihydroisositsirikine, antirhine, normacusine B, 16-*epi*-normacusine B, vobasine, dregamine, tabernaemontanine, norfluorocurarine, 12-hydroxynorfluorocurarine, apparicine, 3,14-dihydroellipticine, voacristine, ibogaine, iboxygaine, iboxygaine-hydroxyindolenine, iboluteine, and 19,20-dihydro-16-decarbomethoxy-voacamine (Clivio *et al*., 1991).
162. *Ervatamia lifuana*: Pandoline, epipandoline, pandine, tabernaemontanine, dregamine, conopharyngine, coronaridine, voacangine, vobasine, ervatamine and epiervatamine (Allorge *et al*., 1980; Bruneton *et al*., 1980).
163. *Ervatamia malaccensis*: Methuenine, 16-epimethuenine, *N*(1)-methoxy-methuenine, 6-oxomethuenine, 20-epiervatamine, *N*(1)-methoxy-19,20-dehydroervatamine, 19,20-dehydroervatamine and dregamine from the leaves and stem bark (Clivio *et al*., 1990a).
164. *Ervatamia microphylla*: A dimer of aspidosperma-class indoles, named III-121C from the leaves (Umezawa *et al*., 1994).
165. *Ervatamia obtusiuscula*: Coronaridine, dregamine, tabernaemontanine, vobasine, isovoacangine, pandoline and epipandoline (Bruneton *et al*., 1976b; Allorge *et al*., 1980).
166. *Ervatamia officinalis* Tsiang: Tabernanthine, jollyanine, iboluteine, conopharyngine, coronaridine, 6,16-didehydro-20-episilicine, conodurine, ervaoffines A-D, (7*S*)-3-oxo-ibogaine hydroxyindolenine, ibogaine-5,6-dione, 19-*epi*-5-oxovoacristine, 19-*S*-heyneanine, voacristine, voacristine hydroxyindolenine, tubotaiwine and others (Zhou *et al*., 1988a; Huang *et al*., 1997a; Zhang and Yue, 2005; Tang *et al*., 2014).
167. *Ervatamia orientalis*: Apparicine, dregamine, ibogaine, iboxygaine, voacristine, vobasine, tabernaemontanine, voacamine, conopharyngine, voacangine, pandoline, pandine and others (Knox and Slobbe, 1971, 1975a-c; Allorge *et al*., 1980).
168. *Ervatamia pandacqui* Pich. (*Tabernaemontana pandacqui*): Ervafoline, ervafolidine, isoervafolidine and tabernaemontanine from the leaves (Lathuilliere *et al*., 1970).
169. *Ervatamia peduncularis*: Pedunculine, peduncularidine, coronaridine, coronaridine hydroxyindolenine, heyneanine, eglandine, eglandulosine, heyneanine hydroxy-indolenine, and others from the leaves and stem bark (Zèches-Hanrot *et al*., 1995).



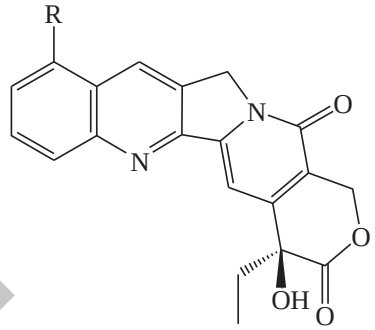
685 Flabelliformide A (15αH, 20βH')



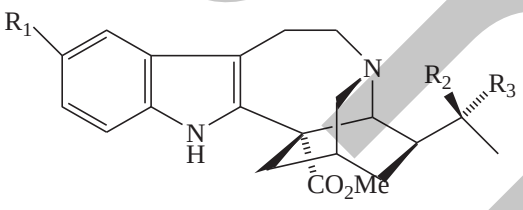
686 Flabelliformide B (15βH, 20αH)



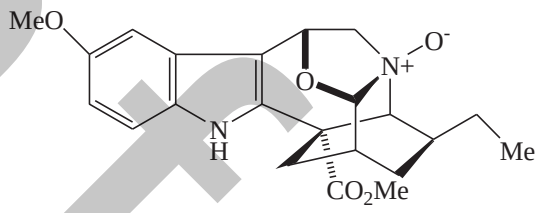
687 Ervahaimine A



688 Camptothecin R = H
689 9-Methoxycamptothecin R = OMe



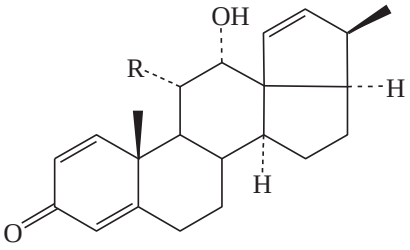
		R_1	R_2	R_3
690	**Heyneatine**	H	OH	H
691	**Coronaridine**	H	H	H
692	**10-Hydroxy coronaridine**	OH	H	H



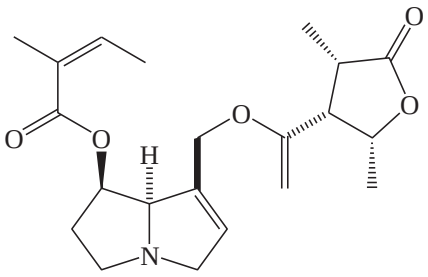
693 10-Methoxyeglandine-N-oxide

170. *Ervatamia sphaerocarpa* (Bl.) Burke (*Tabernaemontana sphaerocarpa* Bl.): Dregamine and tabernemontanine were isolated from the stem, bark and leaves (Biswas, 1973).
171. *Ervatamia yunnanensis*: Matrine, voacangine, 19-*S*-voacangarine, conodurine, coronaridine, heyneanine, 19-epiheyneanine, 3-*R*-ethoxycoronaridine, ervataine, 19-*epi*-voacristine, coronaridine hydroxyindolenine, 19-*epi*-voacristine, 19,20-*E*-vallesamine, ibogaine, ibogamine, voacangine hydroxyindolenine, (+)-minovincine, voachalotin, ervayunine, ervatamine, 20-*epi*-ervatamine tabernaemontanine, and others from the stems and roots (Liu *et al*., 1988; Yu *et al.*, 1999a,b; Liang *et al*., 2006a; Xuan *et al*., 2006; Luo *et al*., 2007; Jin *et al*., 2010).
172. *Funtumia africana* (Benth.) Stapf: Steroidal alkaloids e.g. funtuphyllamines A-C, funtumafrines B and C, holonamine, 12α-hydroxynorcona-*N*(18),1,4-trienin-3-one (**694**) and 11α,12α-dihydroxynorcona-*N*(18),1,4-trienin-3-one (**695**) (Janot *et al.*, 1960a; Wagner *et al*., 1987).
173. *Funtumia elastica* (Preuss) Stapf.: Irehdiamines A and B, conessine, isoconessimine holarrhesine, irehline, irehine, 20-*epi*-irehdiamine I, conamine, and others from the stem bark, leaves and seeds (Janot *et al*., 1963a; Oletta,1963; Truong-Ho *et al.*, 1963; Charles *et al.*, 1969; Tolela and Foche, 1979; Zirihi *et al*., 2005).

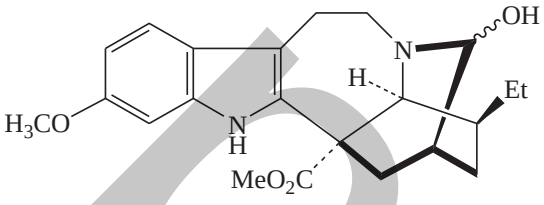
174. *Funtumia latifolia* Stapf.: Funtumine, funtumidine, funtulatine, latifoline (**696**), latifolinine and others from the leaves and bark (Janot *et al*., 1958; Janot *et al*., 1962a, 1964; Oletta,1963; Khuong-Huu *et al*., 1963, 1964; Khuong-Huu-Qui *et al*., 1965a).
175. *Gabunia eglandulosa* Stapf.: Coronaridine, eglandine, eglandulosine, isovoacangine, and 19-hydroxy isovoacangine (**697**) (Le Men *et al.*, 1974; Agwada *et al*., 1975).
176. *Geissospermum argenteum*: (+) Aspidocarpine (**698**), (-) aspidodispermine (**699**), (-)-demethyoxaspidospermine (**700**) and (+)-demethylaspido-spermine (**701**) from the leaves and trunk (Paccioni and Husson, 1978).
177. *Geissospermum laeve* (Vellozo) Baillon (syn. *Geissospermum vellosi* Allemão, nom, illeg.): Geissoschizoline, geissospermine, flavopereirine and others (Raymond-Hamet, 1933, 1954; Puiseux *et al*., 1959; Aurousseau, 1961; Almeida *et al*., 2012).
178. *Geissospermum reticulatum* A. Gentry: 10-Demethoxy-12-hydroxy-17,19-epoxy-geissovelline, *O*-demethylaspidospermine, geissospermidine, 11-methoxy-geissospermidine, flavopereirine, geissosreticulatine and others (Reina *et al.*, 2012).
179. *Geissospermum sericeum*: Three indole alkaloids, geissoschizoline, geissoschizoline N^4-oxide, 1,2-dehydro geissoschizoline, and flavopereirine from the bark (Steele *et al*., 2002).
180. *Geissospermum vellosii*: Vellosine, vellosomine, pereirine, flavopereirine, geissospermine, geissoschizoline, vellosiminol, and compound from the bark (Freund and Fauvet, 1894; Bertho *et al*., 1958; Rapoport *et al.*, 1958; Rapoport and Moore, 1962 Moore and Rapoport, 1973; Ishiyama *et al*., 2005; Mbeunkui *et al*., 2012a,b).
181. *Gonioma kamassi* E. Mey: Akuammidine, aspidofractinine, pleiocarpamine, 1,2-dehydroaspidospermidine, eburnamine, fluorocarpamine, kamassine, quebrachamine rhazidine, and others from the ground bark (Kaschnitz and Spiteller, 1965).
182. *Gonioma malagasy*: Goniomitine (**702**), goniomedines A and B, (Randriambola *et al*., 1987; Beniddir *et al.*, 2012) and others (Beniddir *et al.*, 2013).
183. *Haplophyton cimicidum*: Cimicine, cimicidine, cimiciphytine, elmicidine, haplophytine, cimilophytine (**703**), norisohaplophytine (**704**), haplocidiphytine (**705**), cimiciduphytine (**706**), haplocine, haplocidine, eburnamine, isoeburnamine, and others (Rogers *et al.*, 1952; Snyder *et al.*, 1954a,b, 1958; Rae *et al.*, 1967; Yates *et al*., 1973; Lakshmikantham *et al.*, 1978; Adesomoju *et al*., 1983a,b, 1991; Cava *et al.*, 1963a,b, 1973, 1983).
184. *Haplophyton crooksii*: Crooksiine, yohimbine, crooksidine, akuammicine, cimicine, cimicidine, akuammidine, 10-methoxy-N_1-methylperycyclivine (**707**), tubotaiwine, lanceomigine, lanceomigine *N*-oxide, haplophytine, 16-decarbomethoxy-vinervinine (**708**) and others (Mroue and Alam, 1991; Mroue *et al*., 1993, 1996).
185. *Hazunta costata*: Tabernaelegantine A and (19*R*)-19-hydroy-tabernaelegantine A (**709**) from the stems and roots (Urrea *et al*., 1981).
186. *Hazunta membranacea*: A chemotaxonomic study of *Hazunta membranacea* and *Hazunta modesta* var. *modesta* yielded twenty-two indole alkaloids (Bui *et al*., 1980).
187. *Hazunta modesta* (Bak.). Pichon (Syn. *Tabernaemontana modesta* Bak.): Ibogamine, dregamine, tabernemontanine, voacangine, coronaridine, 19-isoheyneanine, 16-decarbomethoxy-20-epiervatamine, 6-oxosilicine, tabernaelegantine A, and others (Ferrari *et al*., 1971; Vecchietti *et al*., 1978; Bui *et al*., 1980).
188. *Hazunta modesta* var. *brevituba*: Methuenine and 16-*epi*-methuenine (Bui *et al*., 1977).
189. *Hazunta modesta* var. *divaricata*: Methuenine and 16-*epi*-methuenine (Bui *et al*., 1979).
190. *Hazunta modesta* var. *modesta* subvar. *divaricata*: Hazuntiphylline (**710**) (Bui *et al*., 1986, 1991), hazuntiphillidine and anhydrohazuntiphyllidine (**711**) from the leaves.
191. *Hazunta modesta* var. *methuenii* subvar. *methuenii*: Hazuntamine (**712**), (Bui *et al*., 1994).



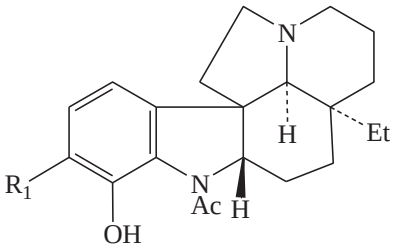
694 R=H
695 R=OH



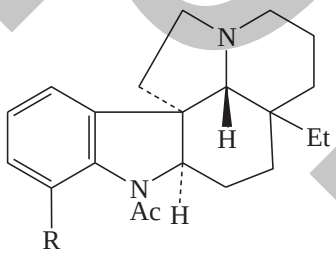
696 Latifoline



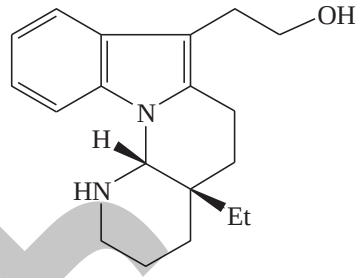
697 Isovoacangine



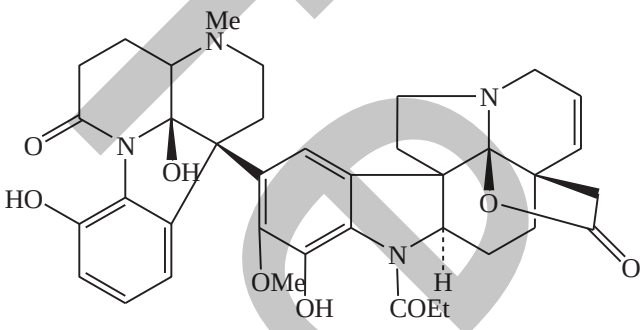
698 Aspidocarpine R_1=OMe



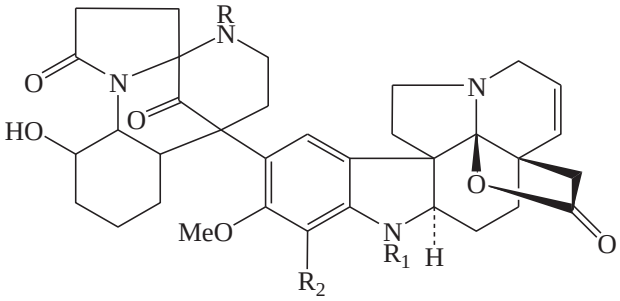
699 Aspidodispermine R=OMe
700 Demethyoxaspidospermine R=H
701 Demethylaspido-spermine R=OH



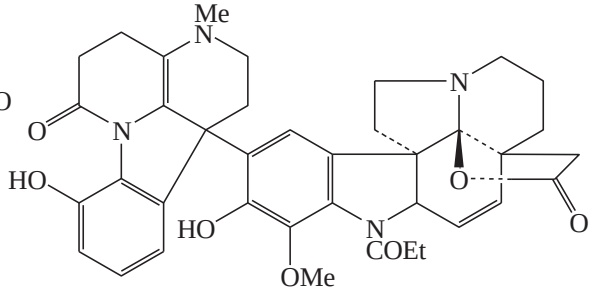
702 Goniomitine



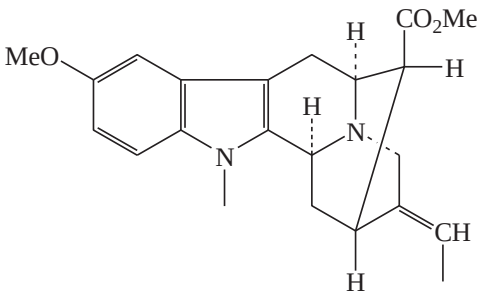
703 Cimilophytine



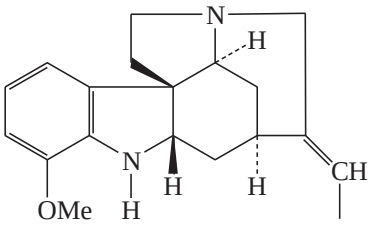
704 I-R= Me ,R_1=H, R_2 =OMe
705 II - R=H ,R_1= COEt, R_2 =OH



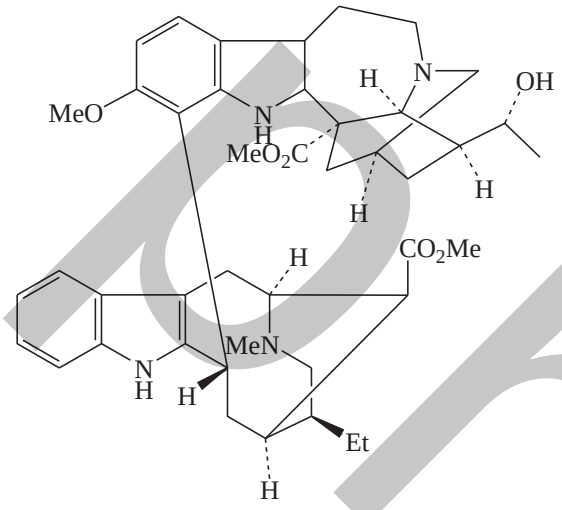
706 Cimiciduphytine



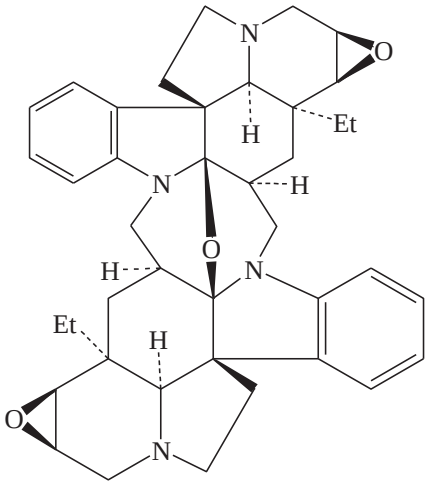
707 10-Methoxyy-*N*1 Methylpericlivine



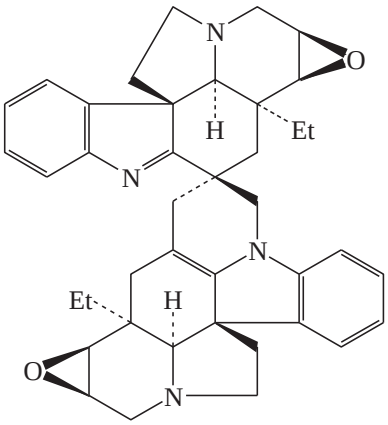
708 16-Decarbomethoxy-vinervinine



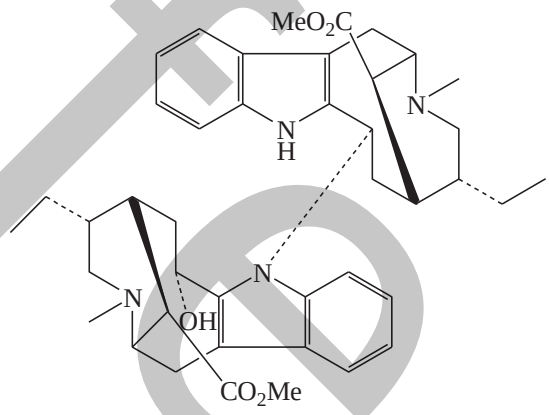
709 (19R)19-Hydroy-abernaelegantine A



710 Hazuntiphylline



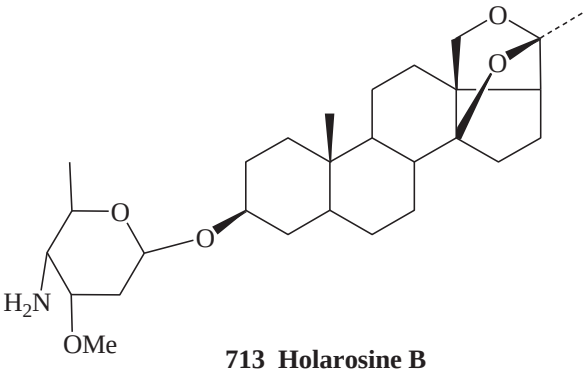
711 Anhydrohazuntiphyllidine



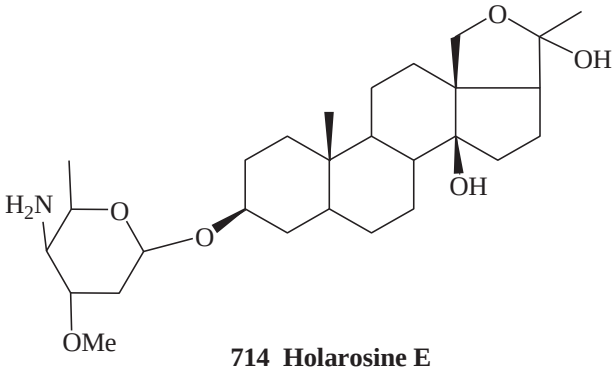
712 Hazuntamine

192. Seventeen monoindole alkaloids have been isolated and identified from *Hazunta modesta* var. *modesta* subvar. *montana* (Bui *et al*., 1980).
193. *Hazunta silicicola*: De (carbomethoxy)dihydrovobasine from the root bark (Potier *et al.*, 1972).
194. *Hazunta velutina*: Vobasine, tabernemontanine, dregamine, voacarpine, hazuntine and hazuntinine from the leaves, twigs and trunk bark (Potier *et al.*, 1968).
195. *Hedranthera barteri* Hook. f. Pichon: Vobtusine, callichiline, amatine, beninine, conoflorine, goziline, voacangine, voacanine, (-)-goziline, (-)-hedrantherine and others from the roots, stems and leaves (Agwada *et al*., 1970, 1977; Naranjo *et al*., 1972a).

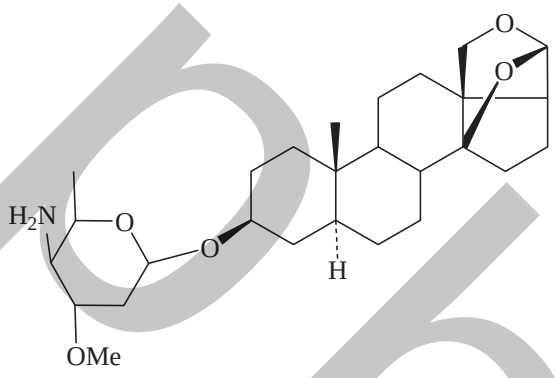
196. *Himatanthus lancifolius* (Muell. Arg.) Woodson: Uleine, its isomer and demothoxy-aspidormine from the bark (Baggio *et al*., 2005; Seidl *et al.*, 2010).
197. *Holarrhena africana* A. DG: Conessine, conessimine, holafrine, holarrhetine, holaphyllamine, holamine, holaphylline, holaphyllamine, and others from the leaves, stems and roots (Paris, 1942; Rostock and Seebeck, 1958; Oletta, 1964; Mainil, 1966).
198. *Holarrhena antidysentrica* L. (Syn. *Holarrhena pubescens* (Buch.-Ham.) Wall.): Several steroidal alkaloids e.g. concuressine, conessine, norconessine, conessidine, conessimine, dihydroconessine, epiheteroconessine, 7α-hydroxyconessine, holonamine, kurchilidine, kurchamide, kurchamine, kurcholessine, holarrhimine, holarrhenine, holarrhetine, holarrhidine, holadysenterine, kurchessine, 3α-aminooconan-5-ene, holarosines B (**713**), E (**714**) and F (**715**), holantosines A and B, holarricine (**716**), regholarrhenines A-F (**717-722**), holarrifine (**723**), holarrifine-24-ol, holamide (**724**), pubescinine (**725**), conimine and oothers from leaves, bark and seeds (Haworth, 1932; Tschesche and Wiensz, 1958; Lábler and Cerný, 1959; Labler and Sorm, 1963; Cerný *et al*., 1964; Tschesche and Ockenfels, 1964;Tschesche *et al.*, 1964b; Gjerstad and Modak, 1968; Janot *et al*., 1970 Khuong-Huu-Qui, 1971; Goutarel *et al*., 1972; Rej *et al*., 1976; Siddiqui and Siddiqui, 1982; Bhutani *et al*., 1988, 1990; Siddiqui and Shamsuddin, 1989; Begum *et al*., 1993b; Kumar and Ali 2000; Raman *et al.*, 2004 ; Kumar *et al*., 2007; Yang *et al*., 2012a). The total alkaloid content of the plant parts, from different countries had been reported (Dutta *et al*., 1950; Than *et al*., 1969; Bhutani *et al*., 1984).
199. *Holarrhena congolensis* Stapf: Holarrhenine, conessine, triacanthine, funtumine, holaphylline, holamine, dihdrohalophyllamine, bokitamine and kisantamine from the leaves (Pyman, 1919; Uffer, 1956; Dadoun and Cave, 1978).
200. *Holarrhena crassifolia* Pierre: *N*-Formyl-conkurchine and others from the leaves (Einhorn *et al*., 1972).
201. *Holarrhena curtisii* King and Gamble: Steroidal alkaloids: holacurtine, holacurtinol, holamine, 15α-hydroxyholamine, holadiolone and others from the leaves (Janot *et al*., 1968a, 1969; Cannon *et al*., 1980; Kam *et al.*, 1998a).
202. *Holarrhena febrifuga* Klotzsch: Connessine conessimine, conessidine, conkurchine, funtumine, holamine, holafebrine, holaminol, holarrhimine and others from the leaves (Siddiqui *et al*., 1945; Janot *et al*., 1962b; Dadoun *et al*., 1973a,b).
203. *Holarrhena floribunda* G. Don.: Conessine, isoconessimine, conamine, conarrhimine, conimine, conkurchine holarrhenine, holarrheline, holadienine, holaromine, holaline, (**726**), holadienine, togholamine and others from the leaves, seeds, bark, flowers and callus culture (Janot *et al.*, 1959, 1960b, 1967; Blanpin, 1960; Leboeuf *et al*., 1964, 1969; Conreur *et al*., 1970; Hoyer *et al*., 1978; Bouillard *et al*., 1987; Duez *et al*., 1987).
204. *Holarrhena mitis*: Conamine, conessine, holafebrine, holadienine, holarrhimine and others from the different parts (Bhavanadan and Wannigama, 1960; Janot *et al*., 1968b; Leboeuf *et al.*, 1972a,b; Wannigama and Cave, 1972; Foussard-Blanpin *et al*., 1973).
205. *Holarrhena pubescens* Buch. Ham (syn. *Halorrhena antidysentrica* L.): Kurchinicine, kurchinine, kurchinidine, holadiene, pubescine, pubescimine, norholadiene, conimine, conessimine, conessine, and others from the bark (Siddiqui *et al.*, 1993, 1994b, 2001; Begum *et al*., 1994; Chakraborty and Brantner, 1999; Tran *et al*., 2006).
206. *Holarrhena wulfsbergii*: Holamine, funtamine, bokitamine, triacanthine and others from the leaves (Nelle *et al*., 1970).
207. *Hunteria congolana* Pichon: Corymine, , akuammicine, vincadifformine, eburnamonine, eburnamenine, eburnamine, pleiocarpamine, umbelliamine, pleiomutinine, epinal, lanceomigine, noreripinal, norisocorymine, 17-hydroxypseudoskuammigine, 17-



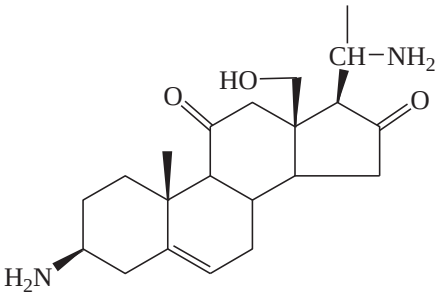
713 Holarosine B



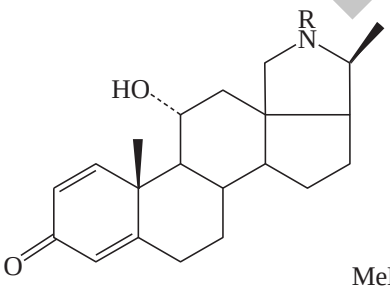
714 Holarosine E



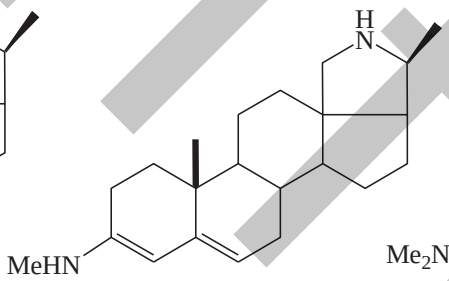
715 Holarosine F



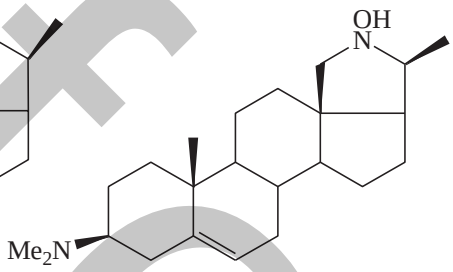
716 Holarricine



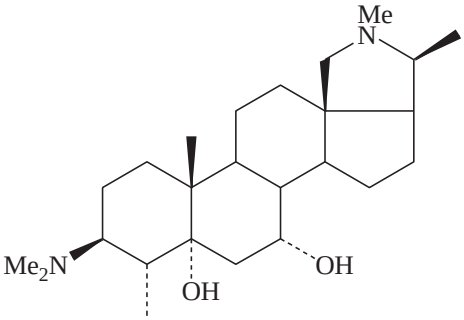
717 Regholarrhenines A R=Me
718 Regholarrhenines B R=H



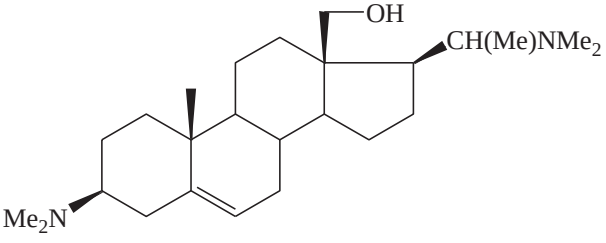
719 Regholarrhenines C



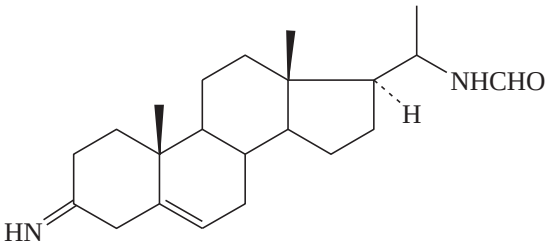
720 Regholarrhenine D



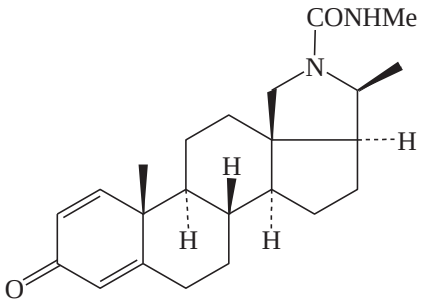
721 Regholarrhenine E



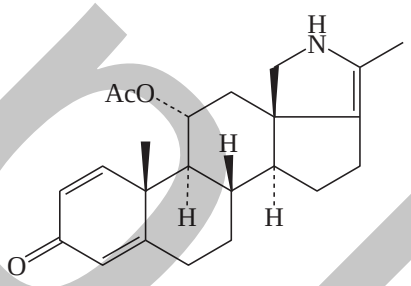
722 Regholarrhenine F



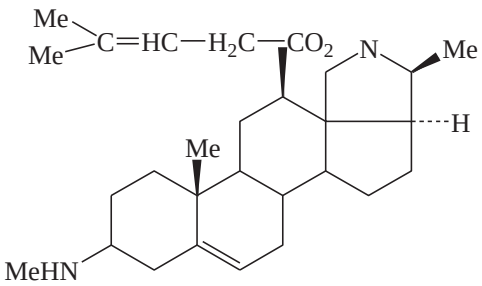
723 Holarrifine



724 Holamide



725 Pubescinine



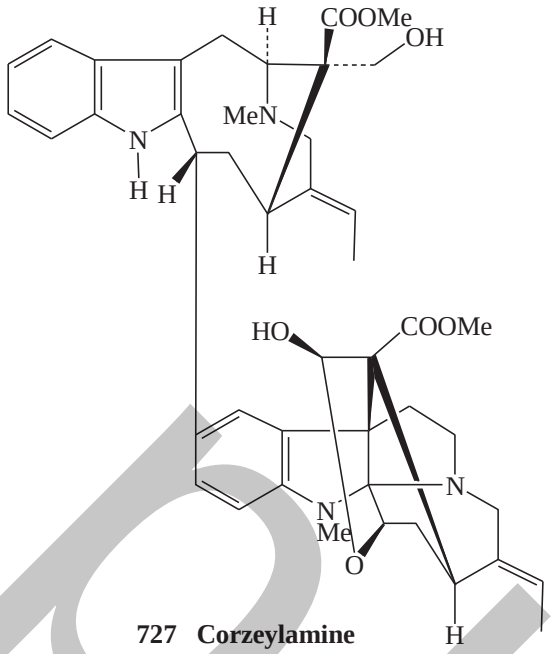
726 Holarrhesine

methoxypseudoakuammiginine and others from the leaves, root bark and seeds (Le Men-Olivier, 1978; Vercauteren *et al*., 1981b, 1982).

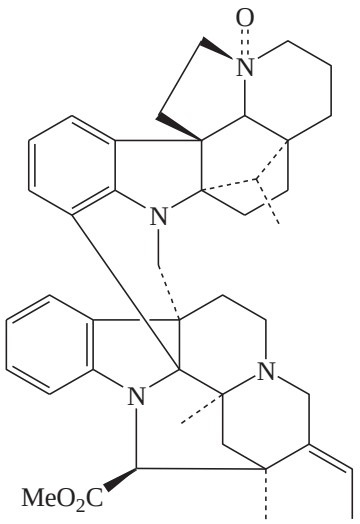
208. *Hunteria corymbosa*: Corymine and rhazine from the leaves (Kiang and Smith, 1962; Majumder, 1968).
209. *Hunteria eburnea* Pichon: Several alkaloids (including many quaternary alkaloids): antirhine β-methochloride, eburnamine, isoeburnamine, eburnamenine, eburnamonine, yohimbol methochloride, dihydrocorynanthol methochloride, akuammine, akuammicine methochloride, pleiocarpamine methochloride, hunterburnine, hunteriamine, hunterine, hunteracine, dihydroantirhine β-methochloride, corymine, eburine, eburcine, eburenine, eburnaphylline, desformocorymine, erinine, erinicine, geissoschizoline, eburnaphylline and others from the different partds (Bartlett and Taylor, 1960, 1963; Neuss and Cone, 1960; Bartlett *et al*., 1959, 1963a,b; Renner, 1963; Asher *et al*., 1965; Olivier *et al*., 1968, 1970; Burnell *et al*., 1970, 1974; Olivier, 1970; Morfaux *et al*., 1969, 1973).
210. *Hunteria elliotii*: Tetrahydroalstonine, corymine, corymine acetate, desformocorymine, aspidofractinine, eburnamenine, eburnamine, isoeburnamine, eburnamonine, kopsinine, quebrachamine, vincadifformine and others from the leaves and barks (Sondergaard and Nartey, 1976; Le Men-Olivier, 1978; Morfaux *et al.*, 1978; Vercauteren *et al*., 1980).
211. *Hunteria umbellata* (K. Schum.) Hallier: Erinicin, erinine, eripine, erinidine, corymin, chlorakuamminium (a chlorinated indole alkaloid), ikirydinium A, serpentine and others from the different parts (Kump *et al.*, 1965a; Bevan *et al.*, 1967; Morita *et al*., 1968, 1969; Adegoke and Alo, 1986; Adejuwon *et al*., 2012; Ajala *et al.*, 2011, 2012).
212. *Hunteria undulata*: Ikirydinium A (Ajala *et al*., 2011).
213. *Hunteria zeylanica* Gard.: Isocorymine, vobasine, eburnamonine, pleiocarpamine, dihydrocorynantheol, yohimbol, tuboxenine, corymine, 3-*epi*-dihydrocorymine 3-acetate, picralinal, picrinine, isositsirikine, lanceomigine, gessoschizol, gentianine, kopsinine, norpleiomutine, pleiocarpamine, tubotaiwine, pleiomutinine, bisnicalaterines B-D, 3-*O*-methylepivobasinol, 3-oxomehranine, hunterioside, strictosidinic acid, corzeylamine (**727**), hunterioside B, huncaniterine A (**728**), deformylcorzeylamine,

nicalaterine A, dihydro-antirhine, hunteriatryptamine and others from the bark, leaves, and stems (Arambewela and Khuong-Huu, 1981; Lavaud *et al*., 1982; Takayama *et al*., 1994a, 1998; Mohamad *et al*., 2007; Subhadhirasakul *et al*., 1994a,b, 1995; Awang *et al*., 2009; Nugroho *et al*., 2009, 2011; Xu *et al*., 2009b; Hirasawa *et al*., 2010a).

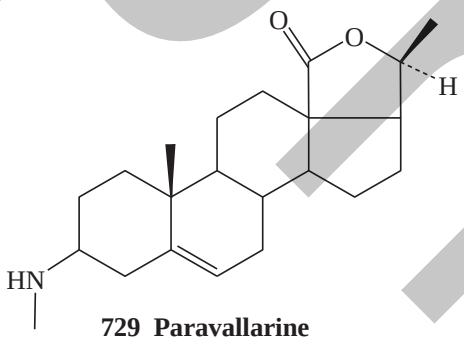
214. *Kibatalia arborea*: Holafebrine and 20-α-amino-5-pregnen-3β-ol from the stems (Janot *et al*., 1962b).
215. *Kibatalia gitingensis*: Paravallarine (**729**), *N*-methylparavallarine, 20-*epi*-paravallarine, kibataline (**730**), lanitine, lantinine and others from the leaves and stem bark (Cave *et al*., 1964, 1965, 1967; Aguilar-Santos, 1965; Bernal-Santos, 1967; Janot, 1966).
216. *Kibatalia laurifolia*: Gitingensine, paravallarine, kibalaurifoline, kibalaurifenone, 7α-hydroxyparavallarine and others from the leaves (Phi *et al*., 2011).
217. *Kopsia albiflora*: Kopsine (Bhattacharya, 1952).
218. *Kopsia arborea* Blume: Arbophylline, arboflorine, arboloscine,arboricine, arboricinine, danuphylline B, eburenine, (-)-eburnamine, prunifolines A-F, rhazinoline (**731**), 19(*S*)-methoxy-tubotaiwine (**732**), 19(*R*)-methoxytubotaiwine (**733**), kopreasin A (**734**), kopsamidine B (**735**), kopsinidine A (**736**), kopsinidine B (**737**), kopsine, (-)-kopsilongine, (-)-kopsamine, (-)-kopsiflorine, kopsiyunnanines A, B, C1, C2, C3, D, F1, F2, and F3, G, H, I, kopsamidine A, fruticosine and others from the different parts (Bisset and Chatterjee, 1962; Kam *et al*., 1993d; Toh-Seok *et al*., 1993; Sévenet *et al*., 1994; Lim and Kam, 2006a,b, 2007a,b, 2008; Lim *et al*., 2007a,c, 2008a; Wu *et al*., 2008a,b, 2009a,b, 2010; Zaima *et al*., 2008; Kogura *et al*., 2012).
219. *Kopsia dasyrachis* Ridl.: Kopsidasine, kopsidasinine, kopsirachine, danuphylline, kopsifine, decarbo-methoxykopsifine, kopsinarine, kopsoffinol, dasyrachine, rhazinicine, (+)-19(*R*)-hydroxyeburnamine (+)-isoeburnamine and many others from the leaves and stems (Homberger and Hesse, 1982, 1984; Sévenet *et al*., 1994; Kam and Subramaniam, 1998; Kam *et al*., 1998d,e,1999c,f).
220. *Kopsia deverrei* L.: (+)-Kopsinone, 12-methylkopsinone, pleiocarpamine, deacetyl-akuammiline**,** (+)-16-hydroxy-methylpleiocarpine, 14α-hydroxy-condylocarpine and others from the bark and leaves (Kan *et al*., 1995; Carreiras *et al*., 1988; Sévenet *et al*., 1994).
221. *Kopsia flavida* Blume: Flavisiamines A-D (**738**-**741**), methyl-12-methoxy-chanofruticosinate, and others from the leaves (Husain *et al*., 2001, 2003; Sekiguchi *et al*., 2008a,b).
222. *Kopsia fruticosa* (Ker) A. DC.: (-)-Fruticosine, (-)- kopsine, kopsorininerin, kopifolines A-F, mersicarpine, mersinine A (**742**), mersinine B, mersiloscine, mersilongine (a tetracyclic quinolinic alkaloid), and others from the leaves and bark (Bhattracharya *et al*., 1949; Battersby and Gregory, 1963; Guggisberg *et al*., 1963; Battersby *et al*., 1967; Sévenet *et al*., 1994; Kam *et al*., 2001b; Subramaniam *et al*., 2003; Kam and Choo, 2003, 2004d,e; Kam and Subramaniam, 2004; Kam *et al*., 2004d; Glover *et al*., 2005; Sekiguchi *et al*., 2008a).
223. *Kopsia grandifolia* Merr.: Grandilodines A-C, lapidilectine A, isolapidilectine, lapidilectam, lapidilectine B and kopsinine (Yap *et al*., 2011).
224. *Kopsia griffithii*: Pleiocarpine, 12-methoxypleiocarpine, buchtienine, 6-oxoleuconoxine, harmane, harmicine and others from the leaves and stem bark (Kam and Sim, 1998; Kam *et al*., 1999d; Lim *et al*., 2007b; Gan and Kam, 2009).
225. *Kopsia hainanensis*: (-)-Kopsinine**,** (-)-kopsininic acid, (-)-kopsinoline, kopsinilam, kopsanone, (+)-5,22-dioxokopsane, eburnamenine, (+)-eburnamine, (-)-isoeburnamine, (+)-tubotaiwine, (+)-kopsoffine, kopsihainins A-C, kopsinine, coronaridine, heyneanine, tabersonine, kopsihainanine B (**743**), Kopsihainins D-F, tubotaiwine and others from the



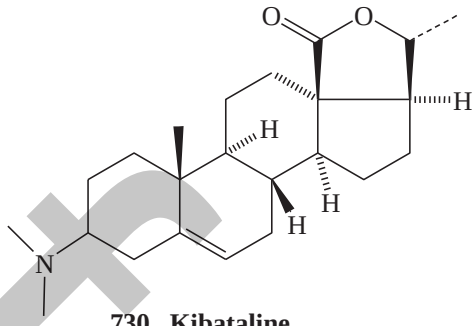
727 Corzeylamine



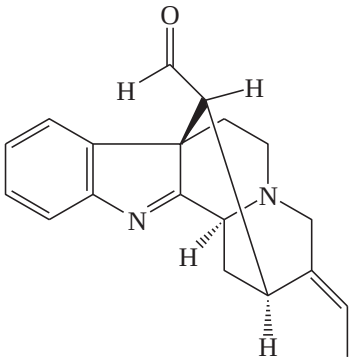
728 Huncaniterine A



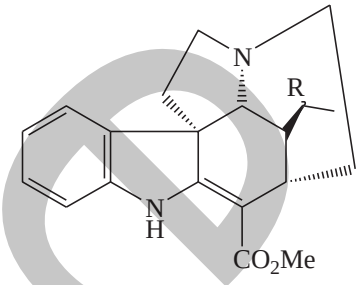
729 Paravallarine



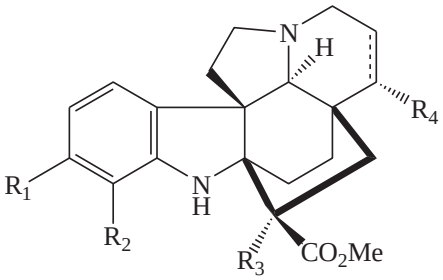
730 Kibataline



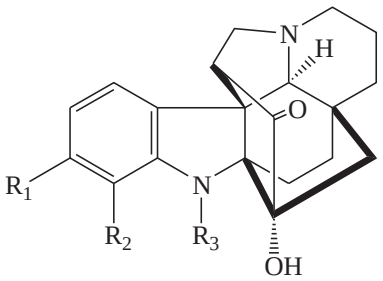
731 Rhazinoline



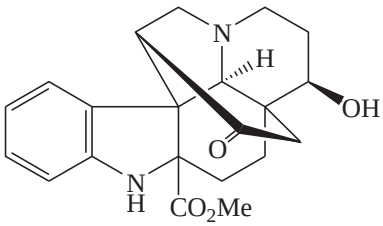
732 19(S)-methoxytubotaiwine
733 19(R)-methoxytubotaiwine



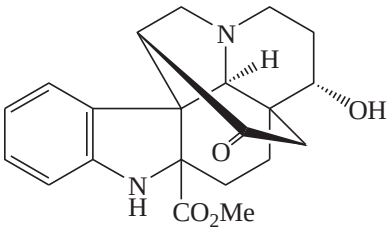
	R_1	R_2	R_3	R_4
734 Kopreasin A	OMe	OMe	H	H
735 Kopsamidine B	H	H	H	OCH_3



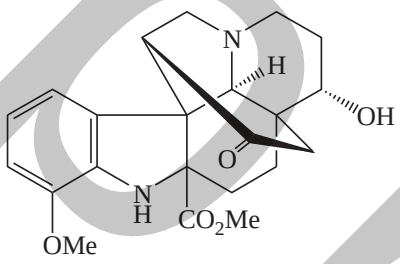
	R_1	R_2	R_3
736 Kopsinidine A	O-CH_2-O		H
737 Kopsinidine B	OMe	OMe	CO_2Me



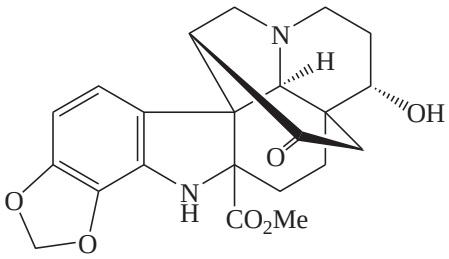
738 Flavisiamin A



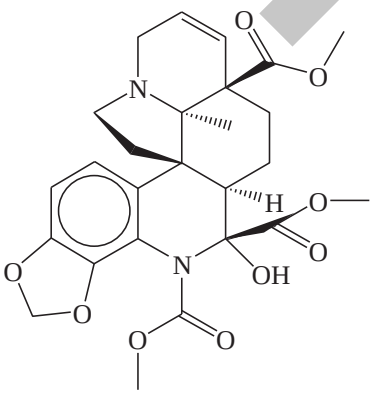
739 Flavisiamin B



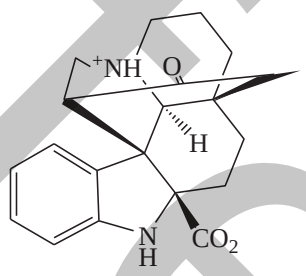
740 Flavisiamin C



741 Flavisiamin D



742 Mersinine A

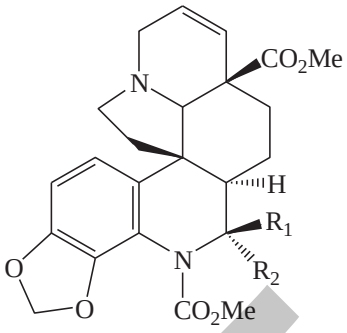


743 Kopsihainanine B

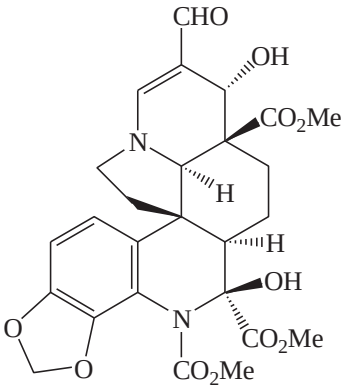
226. leave, stems, roots and twigs (Zhu *et al.*, 1986; Sévent *et al.*, 1994; Yun *et al.*, 1994; Tan *et al.*, 2011b; Chen *et al.*, 2011a, 2012, 2014 Yang *et al.*, 2012b,c).
227. *Kopsia jasminiflora*: (-)-Kopsijasminilam, (-)-kopsijasmine, (-)-jasminiflorine, fruticosine, fruticosamine, 10-demethoxy-kopsidasinine and others (Ruangrungsi *et al.*, 1987; Hamburger *et al.*, 1988; Sévenet *et al.*, 1994).
228. *Kopsia lapidilecta*: Lapidilectine A, lapidilectine B, isolapidilectine A, lapidilectam, lapidilectinol, epilapidilectinol, kopsinine and venalstonine from the bark and leaves (Awang *et al.*, 1992, 1993a; Sévenet *et al.*, 1994).
229. *Kopsia larutensis* King & Gamble: (-)-Eburnamine, (-)-eburnaminol, (-)-eburnamonine, (+)-eburnamonine, (+)-isoeburnamine, (-)-kopsanine, (+)-larutensine, larutenine and others (Awang *et al.*, 1991; Kam *et al.*, 1992a,c, 1993e; Sévenet *et al.*, 1994).

230. *Kopsia longiflora* Merr.: Kopsinine, kopsilongine, kopsamine and kopsiflorine (0.04%) from the bark (Crow and Michael, 1955).
231. *Kopsia macrophylla* Hook. f.: 8-Hydroxyskytanthine, 8-oxo-skytanthine, kopsilactone, kopsone, 5,22-dioxokopsane, 11,12-methylenedioxykopsinaline, tabernaemontanine dregamine, (-)-norpleiomutine and others (Sévenet *et al.*, 1994; Kan-Fan *et al.*, 1995).
232. *Kopsia officinalis* Tsiang: Kopsoffine, kopsinine, kopsanone, 5,18-dioxokopsan, kopsinilam, kopsamine, kopsamine *N*-oxide, pleicocarpine, eburnamine, eburnamenine, 20-oxoeburnamenine, 20-oxoeburnamine, 20-hydroxyeburnamine, perivine, (+)-vincadifformine, *N*-carbomethoxy-11-hydroxy-12-methoxykopsinaline, and others from the different parts (e.g. leaves, fruits and twigs) (Chen *et al.*, 1981b; Feng *et al.*, 1983, 1984; Zhou *et al.*, 1984, 2006; Zheng *et al.*, 1989; Li and Song, 2008, 2009).
233. *Kopsia pauciflora* Hook f.: (-)-Norpleimutine, (+)-kopsoffine, (+)-kopsoffinol, eburnamine, isoeburnamine, (-)-norpleionutine, (+)-19-oxoeburnamine, pauciflorine A and B, paucidactines A and B, paucifinine, paucifinine N-oxide, kinabalurines A-F and two cyano-substituted indole alkaloids, lahadinine A and lahadinine B (Kan-Fan *et al.*, 1985; Sévenet *et al.*, 1994; Kam *et al.*, 1996a,e,f,g; Kam and Yoganathan, 1997b; Kam *et al.*, 1997f).
234. *Kopsia pitardii* Mirr. (*Kopsia officinalis*Tsiang & Li): (-)-Kopsinine, (-)-quebrachamine, (-)-isoeburnamine, (+)-kopsoffine, (-)-isoeburnamine, kopsinine, kopsamine, eburnamine, perivine, 19-oxo-eburnamenine, eburnamenine, kopsanone, 5,22-dioxokopsane, kopsinilam, pleiocarpine, *N*-methoxycarbonyl (+)-vincadifformine, *N*-methoxycarbonyl 11-hydroxy-12-methoxykopsinaline, kopsamine *N*-oxide and others from leaves, roots, stem-bark and fruits (Sévenet *et al.*, 1994; Do *et al.*, 2007).
235. *Kopsia profunda*: Kopsinine, N_1-methoxycarbonyl-12-hydroxy-$\Delta^{16,17}$-kopsinine, N_1 – methoxy-carbonyl-12-methoxy-$\Delta^{16,17}$-kopsinine and others from the leaves and stem (Kam and Tan, 1990, 1995).
236. *Kopsia singapurensis* Ridl.: (+)-Kopsaporine, (+)-kopsingine, kopsidarine, kopsingarine, singapurensine A, singapurensine B, singapurensine C, singapurensine D, kopsiloscines A–J, 16-epikopsinine, kopsilongine-*N*-oxide, 16-epiakuammiline, aspidophylline A, vincophylline, rhazinal, rhazinilam, rhazinicine, epiakuammiline A, singaporentine, kopsifoline A, kopsininic acid, kopsimalines A-E , kopsinicine, kopsofinone, mersinine A (**744**), mersinaline (**745**) and mersirachine (**746**), mersiphyllines A (**747**) and B (**748**), kopsimaline F, singaporentine A and many others from the different parts (Awang *et al.*, 1993b; Sévenet *et al.*, 1994; Subramaniam and Kam, 2007, 2008; Subramaniam *et al.*, 2007, 2008a,b; Awang *et al.*, 2008; Low *et al.*, 2009; Ahmad *et al.*, 2012, 2013).
237. *Kopsia sleeseniana*: Kopsingine (Sévenet *et al.*, 1994).
238. *Kopsia tenuis*: Lundurines A-D, tenuisines A-C, and tenuiphylline (Kam *et al.*, 1995, 1996d, 1997e, 2004c).
239. *Kopsia teoi*: Kopsingine isoeburnamine, rhazinal, rhazinilam, lonicerine, kopsidine A, kopsidine B, kopsinginine, kopsaporine, rhazimol, kopsinol, kopsiniginol, kopsinganol, kopsidines A-D, kopsinitarines A-E, kopsonoline, mersingines A and B, nitaphylline and others from the leaves and stem bark (Kam *et al.*, 1993a,b, 1994, 1996b, 1997b,c, 1998c, 1999e; Varea *et al.*, 1993; Sévenet *et al.*, 1994; Kam and Yoganathan, 1996, 1997a).
240. *Kopsia terengganensis*: (+)-Quebrachamine, (-)-eburnamine, (+)-isoeburnamine, (-)-eburnaminol, (+)-larutensine and terengganensines A and B from the bark (Uzir *et al.*, 1997).
241. *Leuconotis eugenifolius*: Yohimbine, β-yohimbine, leuconolam, 21-*O*-methyl-leuconolam, rhazinaline N_b-oxide, leuconoxine (**749**), *E*-akuammidine and eucophylline

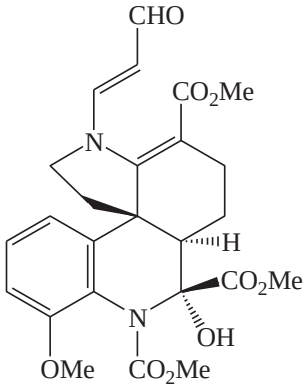
(**750**) from the leaves, stems and bark (Abe and Yamauchi, 1994b; Jaafar *et al*., 2005; Deguchi *et al*., 2010).



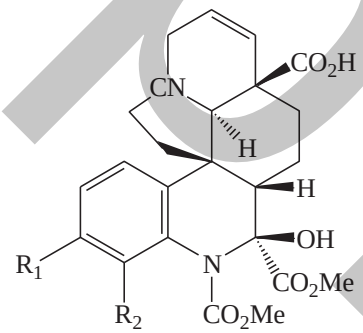
744 Mersinine A
R_1=CO_2Me, R_2=OH



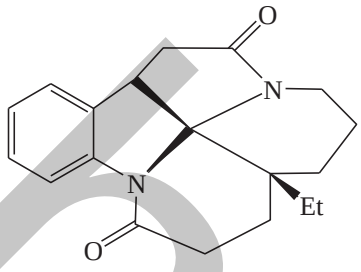
745 Mersinaline



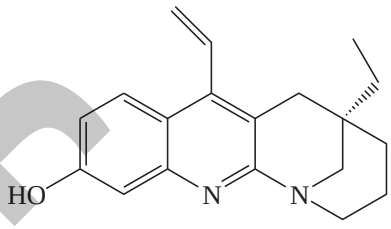
746 Mersirachine



		R_1	R_2
747	**Mersiphylline A**	$-OCH_2O-$	
748	**Mersiphylline B**	H	OMe



449 Leuconoxine



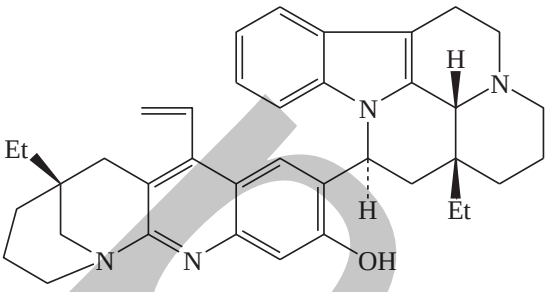
750 Eucophylline

242. *Leuconotis griffithii*: Sixty alkaloids from the stem bark e.g. *nor*-rhazinicine, 5,21-dihydrorhazinilam *N*-oxide, leuconodines A-F, rhazinilam, rhazinicine, leuconolam, leuconoxine, mersicarpine, arboloscine, *O*-methylleuconolam, *epi*-leuconolam, rhazinal, (+)-eburnamonine, (+)-eburnamenine, (+)-isoeburnamine, (-)-eburnamine, (±)-vincamine, tetrahydroalstonine, fluorocarpamine, pleiocarpamine, 16-hydroxymethyl-pleiocarpamine, (-)-isovallesiachotamine, (+)-vallesiachotamine, leucophyllidine (**751**), venoterpine, tubotaiwine, tubotaiwine *N*-oxide, leucolusine, leuconicines A-G, (−)-eburnamaline, leucoridines A-D, bisleuconothine A and others from the different parts (Goh *et al*., 1984, 1989; Gan *et al*., 2009; 2010a,b; Alfarius *et al*., 2010; Hirasawa *et al*., 2010b; Nugroho *et al*., 2010, 2012; Motegi *et al*., 2012; Gan *et al*., 2013).
243. *Lochnera lancea* (*Vinca lancea*): Ajmalicine, lanceine, tetrahydroalstonine, yohimbine and δ-yohimbine (Janot *et al*., 1954, 1956 1957).
244. *Lochnera rosea* (*Vinca rosea*): Alstonine, tetrahydroalstonine, δ-yohimbine (ajmalicine), serpentine and lochnericine from the roots (Shimizu and Uchimaru, 1958, 1959; Nair and Pillay, 1959; Pillay and Kumari, 1961).
245. *Lochnera rosea* var. *alba*: Serpentine, lochnerine and ajmalicine (also reported as vinceine and vincaine) (Mors *et al*., 1956).
246. *Macoubea guianensis* Aublet: Vincadifformine and vincadine from the seeds (Anderson *et al*., 1985; Husson *et al*., 1986).

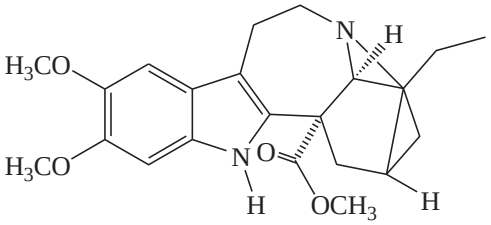
247. *Macoubea guianensis* var. *pubiflora* Monachino: (+)-Macowbeine and vincadifformine (Freise, 1936; Husson *et al*., 1986).
248. *Malouetia arborea*: Conkurchine, malarborine and malarboreine (Soti *et al*., 1967).
249. *Malouetia bequaertiana*: Malouetine, funtuphyllamines B and C, funtumafrine C, malouphylline, malouphyllamine, chonemorphine, and malouphyllinine from root bark and leaves (Janot *et al*., 1962c,d, 1963b; Khuong-Huu-Laine *et. al*., 1965).
250. *Malouetia brachyloba*: Malouetine and funtumafrine C from the leaves (Khuong-Huu *et al*., 1973).
251. *Malouetia glandulifera*: Conopharyngine (**752**) from the bark (Medina and Bracho, 1976).
252. *Malouetia heudelotii*: Five conanine derivatives from the leaves (Khuong-Huu *et al*., 1973).
253. *Malouetia nitida*: An alkaloid (very similar to malouphyline) and two others from the leaves (Castaneda de Martin, 1974).
254. *Malouetia tamaquarina*: Kurchessine, dihydrokurhcessine and tetramethyl-holarrhimine (Soti *et al*., 1967).
255. *Melodinus acutiflorus* F. Muell: Rhazicine, rhazimine, deacetylakuammiline, rhazicine *N*-oxide, and16-*epi*-rhazinaline from the leaves (Hu *et al*., 1987; Hu and Hesse, 1988).
256. *Melodinus aeneus* Baill: (+)-Vincadifformine, (-)-tabersonine, (-)-11-methoxy-tabersonine, (-)-lochnericine, (-)-lochneinine, (-)-ibogamine, venoterpine, (+)-tubotaiwine, (+) *N*-oxytubotaiwine, (+)-*epi*-16-dehydro l4,15-vincamine and (+)-*epi*-16-dehydro l4,15-vincine (Baassou *et al*., 1978; Lu *et al*., 2014).
257. *Melodinus axillaris*: Melaxillarinine from the roots (Yan and Feng, 1997).
258. *Melodinus australis* (F. Mueller) Pierre: Condylocarpine, stemmadenine, akuammidine, (-)-quebrachamine, (+)-17-methoxy-quebrachamine, (-)-rhazinilam, refractidine, pyrifoline, (-)-rhazinal, 11,12-dimethoxy-aspidofractinine, venalstonidine, venalstonine, 15β-hydroxykopsine and 19α-hydroxykopsinine from the stem bark (Linde, 1965, 1970).
259. *Melodinus balansae* Baill: Tabersonine, venalstonine, 11-hydroxy-(-)-tabersonine, venalstonidine, vindolinine, 19-epivindolinine, vindolinine N^b-oxide, 19-epivindolinine N^b-oxide, melobalineits C-19 epimer and baloxine from the leaves (Mehri *et al*., 1972a,b; Damak *et al*., 1976d).
260. *Melodinus balansae* Baiullon var. *paucivenosus* (S. Moore) Boiteau: Paucivenine, pleimoutine, reserpine N_b-oxide, 14,15-dehydrovenalostenine and 14,15α-epoxy-valostonidine (Mehri *et al*., 1978).
261. *Melodinus celastroides* H. Baill: Tabersonine, Δ^{14}-eburnamine, (+)-melonine, (+)-melonine N_b-oxide, melocelinine, meloceline, venalstonidine, *epi*-16-Δ^{14}-vincanol, venoterpine, (-) antirhine, (-)-tabersinol, leburnamine, isoeburnamine, leburnamonine and others (Rabaron and Plat, 1973; Rabaron *et al*., 1973b, 1978; Baassou *et al*., 1981, 1983, 1987; Mehri *et al*., 1991; Lu *et al*., 2014).
262. *Melodinus fusiformis* Champ. ex Benth: Kopsinine, tabersonine, 11-methoxytabersonine, 11-hydroxytabersonine, scandine, meloscandonine, venalstonine, vindolinine, tubotaiwine, deacetylpicraline, voaphylline, venalstonidine, pachysiphine, and others (He *et al*., 1992a; Cai *et al*., 2011b; Wang *et al*., 2012a,c; Zhou *et al*., 2012b).
263. *Melodinus glandulifera*: Conopharyngine (**752**) from the bark (Medina and Bracho, 1976).
264. *Melodinus guillauminii* Boiteau: 11-Hydroxytabersonine, venalstonine, venalstonidine, 14,15-seco-3-oxokopsinal, 3-oxovenalstonine, 11-methoxy-Δ^{14}-vincamenine, 3-oxo-hydroxykopsinine, 11-methoxy- Δ^{14}-vincanol, kopsinine, 15-α-hydroxykopsinine, 11-

methoxytabersonine, pleiocarpamine, 19-β-hydroxyvenalstonine and guillauminiine from the stem bark and aerial parts (Zeches *et al.*, 1984).

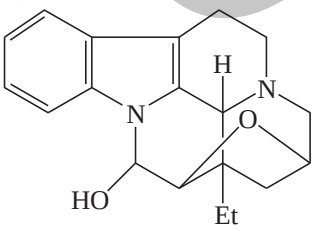
265. *Melodinus henry*i Craib.: 11-Methoxy-tabersonine, lochnerinine, Δ^{14}-vincamine, tenuicasine, 16-*epi*-Δ^{14}-vincamine, Δ^{14}-eburnamine, 14.17-epoxyeburnamine (**753**), henrycinols A (**754**) and B (**755**), melohenines A (**756**) and B (**757**), melodinines A-G (**758**-**764**), melodinoxanine and others from the different parts (Li *et al*., 1989a, 1992; Zhang *et al*., 2003; Feng *et al*., 2009b, 2010a; Zhou *et al*., 2010; Kitajima *et al*., 2012).



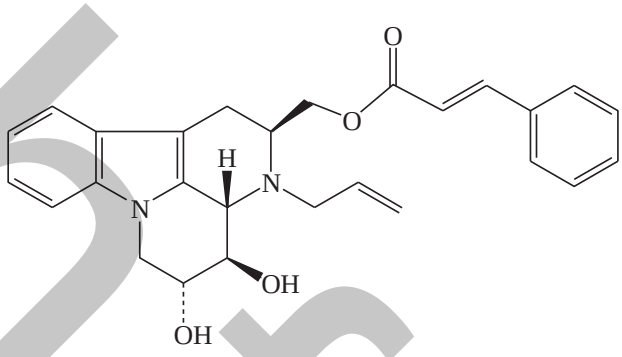
751 Leucophyllidine



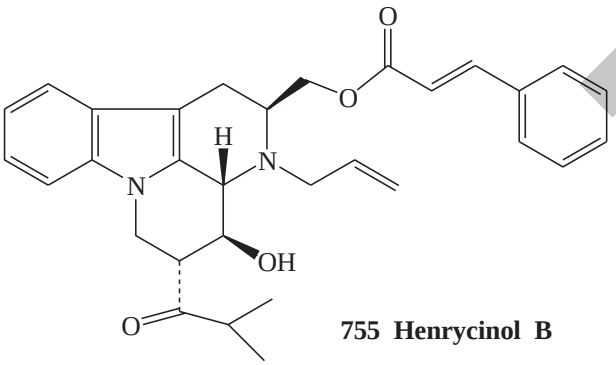
752 Conopharyngine



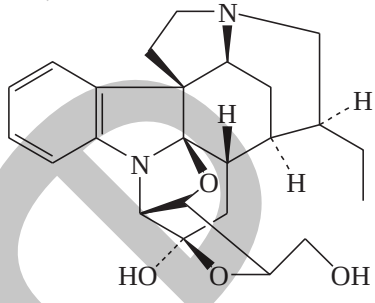
753 14,17-Epoxyeburnamine



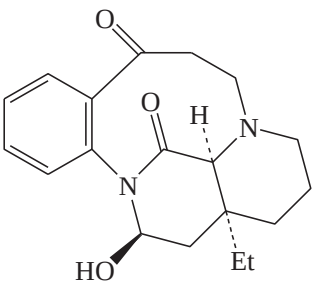
754 HenrycinolO A



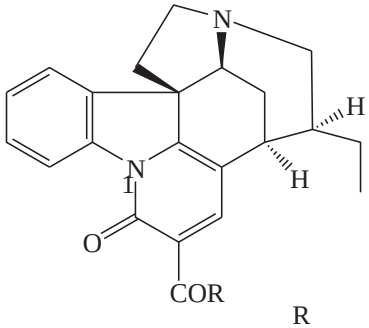
755 Henrycinol B



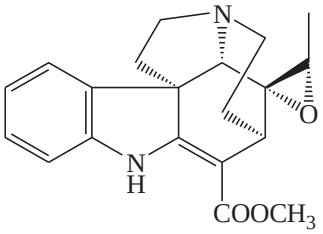
756 Melohenine A



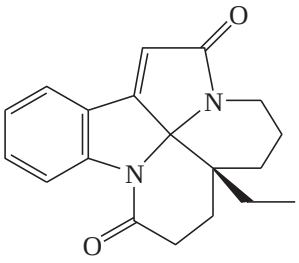
757 Melohenine B



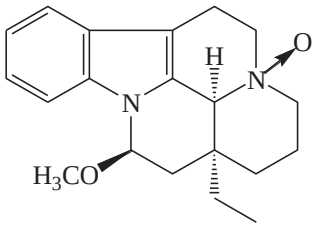
		R
758	**Melodinine A**	NH_2
759	**Melodinine B**	OCH_3 ,$\Delta^{20,21}$
760	**Melodinine C**	OH



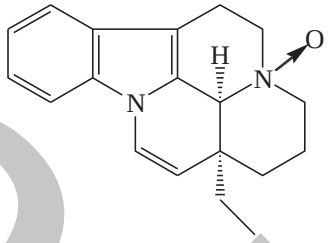
761 Melodinine D



762 Melodinine E



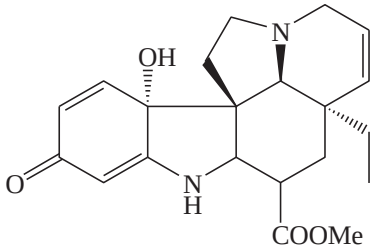
763 Melodinine F



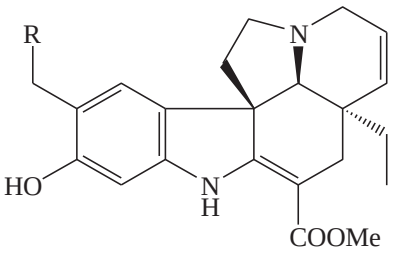
764 Melodinine G

266. *Melodinus insulae-pinorum* Boiteau: (+)-Venalstonine, venalstonidine, 19β-hydroxy-venalstonidine, 19β-hydroxykopsinine, 15α-hydroxykopsinine, Δ^{14}-vincanol, 16-*epi*-Δ^{14}-vincanol, isositsirkine and insulopinine from the aerial parts and stem bark (Batchily *et al*., 1985a).
267. *Melodinus khasianus*: Scandine, 10-hydroxyscandine, meloscine and meloscandonine from the stem-bark (Li *et al*., 1994a).
268. *Melodinus magnificus*: Scandine, tabersonine, 11-hydroxytabersonine and 19*S*-vindolinine (Wang *et al*., 2012b).
269. *Melodinus morsei* Tsiang: Kopsinine, 15-hydroxykopsinine, vindolinine, epivindolinine, vindolinine *N*(b)-oxide, vincadifformine, vincoline, quebrachamine, melomorsine, 1,2-dehydroaspermidine, rhazidine, aspidospermidine, geissochizol, melofusine I, melomorsine I and others (He *et al.*, 1992b, 1993, 1994a,b; Cai *et al*., 2011b).
270. *Melodinus oblongus* Pierre: Picralinal, picrinine, akuammicine, akuammicine *N*-oxide, condylocarpine, tubotaiwine, β-epoxytaberonine, 11-hydroxytabersonine, venalstonine, tetrahydroalstonine, rhazicine, picraline, desacetylpicraline, scandine, meloscandonine, 16-hydroxyvindolinine, 16-hydroxy-19-*epi*-vindolinine, Δ^{14}-vincanol, 16-*epi*-Δ^{14}-vincanol, akuammiline, and others from the leaves and stem bark (Liên *et al.*, 2002a,b).
271. *Melodinus phylliraeoides* Labill: (-)-Venalstonine, (-)-venalstonidine, (+)-geissoschizine, vindolinine, 19-epivindolinine, (+)-vindolinine *N*-oxide, (+)-19-*epi*-vindolinine *N*-oxide and (-)-isositsirikine from the leaf petioles (Mehri *et al.*, 1984).
272. *Melodinus polyadenus* Baill. Boit: (-)-Tabersonine, (+)-vincadifformine, (-)-11-methoxy tabersonine, (-)-venalstonidine, (-)-venalstonine, (+)-20-*R*-pseudovincadifformine, (+)-20-*R*-pandoline, (+)-20-*S*-pandoline and (+)-Δ^{14}-vincine (Rabaron *et al*., 1981).
273. *Melodinus reticulatus*: (-)Tabersonine, (-)-11-methoxytabersonine venalstonidine, kopsinine, venalstonine and its 3-oxoderivative, 19-hydroxyvenalstonine, 19-hydroxy-venalstonidine and 3-oxovenalstonidine from fruits, stems and leaves (Mehri *et al*., 1983).
274. *Melodinus scandens* J. R. Forst. & G. Forst: Tabersonine, scandine, epimelmoscine, epimeloscine-9-oxide, vincadifformine, lochnericine, akuammidine, venalstonine, venalstonidine, epimeloscine, scandine, meloscandonine, meloscine, scadomelonine, scandomeline, and others from the seeds and aerial parts (Bernauer *et al*., 1969; Mehri *et al.*, 1971, 1995; Daudon *et al.*, 1976; Chazelet *et al*., 1986; Mehri and Plat, 1992).

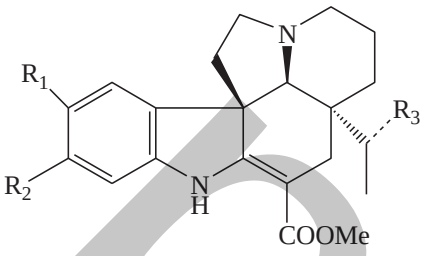
275. *Melodinus suaveolens* (Hance) Champ. ex Benth: Suaveolenine, hazuntine, 11-methoxyvineadifformine, cathovalinine, vincoline, 19*R*-hydroxy-tabersonine, 11,19*R*-dihydroxy-tabersonine, tabersonine, melodinines J, M-U (**765-773**), melosuavines A-H (**e.g 774-778**), tenuicausine, 11-hydroxytabersonine (**779**), 11-methoxy-tabersonine (**780**), tabersonine (**781**), 19-sonine (**782**), lochnericine (**783**), 3α-acetonyltabersonine (**784**), 3- tubotaiwine and others (Jian *et al.*, 1991; Liu *et al.*, 2012a, 2013b; Zhang *et al.*, 2013e).
276. *Melodinus tenuicaudatus* Tsiang et P. T. Li: Scandine, Δ^{14}-eburnamine, vindolinine, *epi*-vindolinine *N*(b)-oxide, hazuntine, compactinervine, Δ^{14}-vincine, normacusine B, 10-hydroxyscandine, melotenine A, melodinines H-L, (Zhou *et al.*, 1988b; Feng *et al.*, 2010b,c).
277. *Melodinus yunnanensis* Tsiang & P. T. Li: Meloscandonine, meloyunines A-C, scandine, 14,15-dehydromelohenine B, Δ^{14}-vincamenine, meloyine I, 19*S*-methoxytubotaiwine N_4-oxide and many others (Cai *et al*., 2011c, 2012; Wang *et al.*, 2011d, 2013b).
278. *Microplumeria anomala*: Anomaline, demethoxyanomaline and12-*O*-methylanomaline (Reis Luz *et al*., 1983).
279. *Muntafara sessilifolia* (Baker) Pichon (or *Tabernaemontana sessilifolia*): (-)-Coronaridine, (-)-eglandine, (-)-tabernaemontanine, (-)-appharicine, (-)-eglandulosine, (-)-3,6-oxido *iso*-voacangine (**785**), (-)-6-hydroxy 3-oxo *iso*-voacangine (**786**), tabernaelegantinals A, B and E and others (Panas *et al*., 1975; Girardot *et al*., 2012a,b).
280. *Neisosperma glomerata*: About 30 alkaloids from the leaves and bark e.g. ochropposinine, isoreserpliline, tetraphylline, 11-methoxy-α-yohimvine (**787**), 11-methyoxy-17-*epi*-α-yohimbine (**788**), 10,11-dimethoxy-17-*epi*-α-yohimbine (**789**), and others (Seguin and Koch, 1982; Seguin *et al.*, 1984).
281. *Neisosperma kilneri* (F. V. Mueller): Angustine, cathafoline, 1-carbamoyl-β-carboline, 1-carbamoyl-7-methoxy-β-carboline, reserpiline, isoreserpiline, ochrolifuanine A, and others from the leaves and stem bark (Batchily *et al*., 1985b).
282. *Neisosperma oppositifolia* (*Ochrosia oppositifolia*): Oppositinines A (**790**) and B (**791**), isoreserpiline, epirauvanine, ochropposinine, bleekerine, vobasine, and others from the bark (Amarasekera and Arambewela, 1986; Gunatilaka *et al*., 1989; Ahmad *et al*., 2010).
283. *Ochrosia acuminata* Vahl.: Ellipticine, 9-methoxyellipticine, polyneuridine-*N*-oxide, 17-hydroxy-10-methoxy-yohimbane, quebrachidine, voachalotine, reserpiline, isoreserpiline and strictosamide from the stems and roots (Lin *et al*., 1985a; Salim *et al*., 2004b).
284. *Ochrosia alyxioides*: 10-Methoxycorynantheol (**792**), 10-methoxyantirhine (**973**), 10-hydroxyantirhine (**794**) and others from the leaves and bark (Boughandjioua *et al*., 1989).
285. *Ochrosia balansae* Vahl.: Aricine, reserpiline, ellipticine, 9-methoxyellipticene, 1,2-dihydroxy-9-methoxy-ellipticene, 1,2,3,4-tetrahydro-9-methoxy-ellipticene and others from the leaves and bark (Bruneton and Cavé, 1972a,c).
286. *Ochrosia borbonica* J. F. Gmel. (Yellow wood): 9-Methoxyellipticine, 10-hydroxy-isovallesiachotamine, ochroborines A and B, akuammidine 17-*O*-β-D-glucoside, ellipticine, 10-methoxyellipticine 15α-hydroxy-appharicine and others from the bark, leaves and twigs (Poisson and Miet, 1967; Zhang *et al*., 2013b).
287. *Ochrosia confusa*: Ellipticine, rauvoxine, carapanaubine, ochrolifuanine, dihydro-ochrolifuanine and 10-methoxy-dihydrocorynantheol (Bruneton and Cavé, 1972b).
288. *Ochrosia elliptica* Labill.: Ellipticine, methoxyellipticine, elliptinine, epchrosine isoreserpilline from the leaves barks and cell culture (Goodwin *et al.*, 1959; Kouadio *et al.*, 1985; Pawelka *et al*., 1986; Kuroda *et al*., 1999).



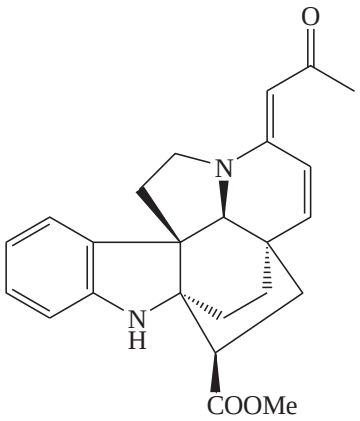
765 Melodinine M



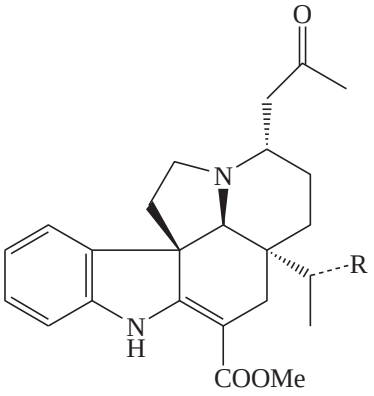
766 Melodinine N R=H
767 Melodinine O R=OMe



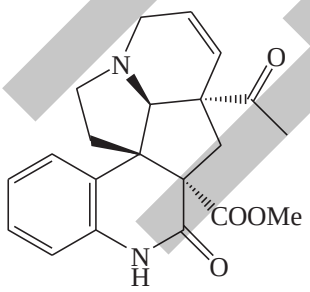
		R_1	R_2	R_3	
768	**Melodinine P**	OH	H	H	$\Delta^{14,15}$
779	**11-Hydroxytabersonine**	H	OH	H	$\Delta^{14,15}$
780	**11-Methoxytabersonine**	H	OMe	H	$\Delta^{14,15}$
781	**Tabersonine**	H	H	H	$\Delta^{14,15}$
782	**11-Methoxy-19-(R)-hydroxytaber-sonine**	H	OMe	OH	$\Delta^{14,15}$
783	**Lochnericine**	H	H	H	14,15 αepoxy



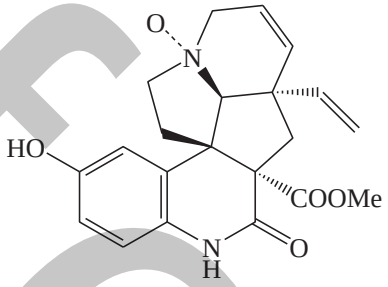
769 Melodinine Q



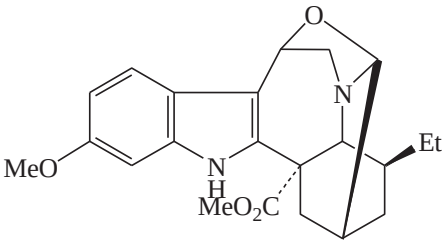
770 Melodinine R R=OH, $\Delta^{14,15}$
771 Melodinine S R=H, 14,15 epoxy
784 3α-Acetonyltabersonine R=H, $\Delta^{14,15}$



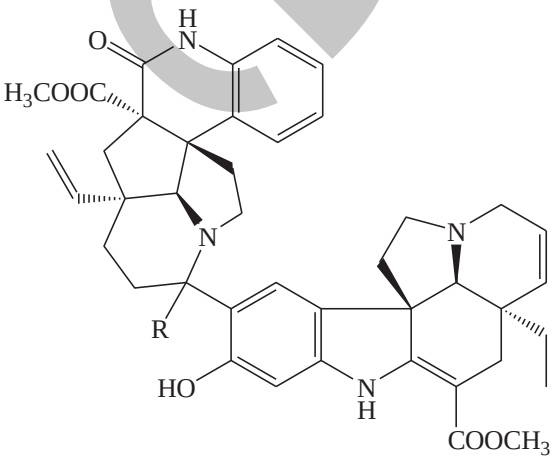
772 Melodinine T



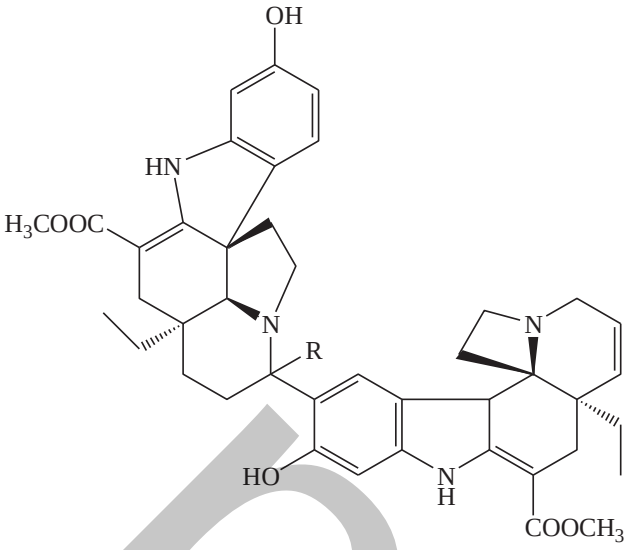
773 Melodinine U



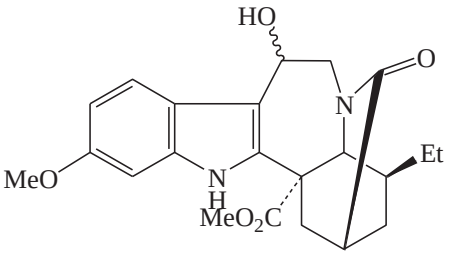
785



774 Melosuavine A R=α-H
775 Melosuavine B R=β-H



776 Melosuavine D R=β-H, Δ14',15' αepoxy
777 Melosuavine E R=α-H, Δ14',15'
778 Melosuavine F R=β-H, Δ14',15'



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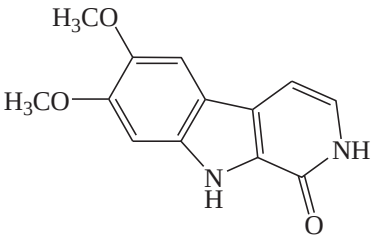
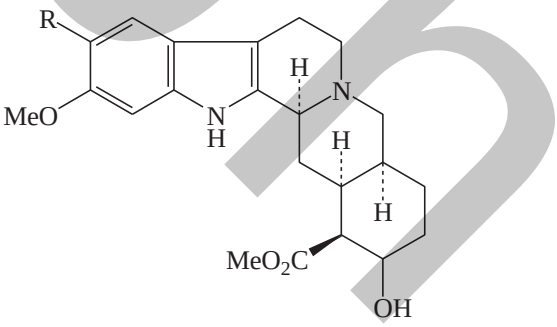
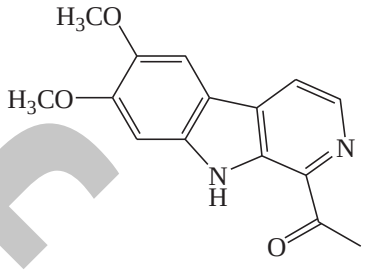


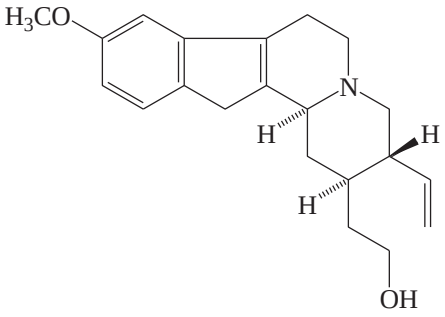
790 Oppositinine A



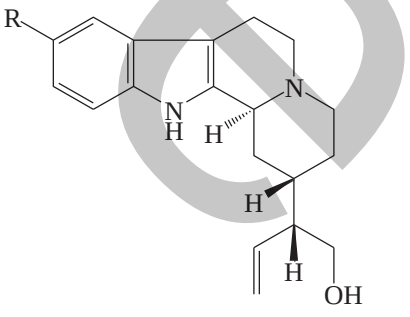
787 11-Methoxy-a-yohimbine R=H, 17α
788 11-Methoxy-17-epi-a-yohimbine R=H, 17β
789 10,11-Dimethoxy-17-epi-a-yohimbine R=OMe, 17β



791 Oppositinine B



792 10-Methoxycorynantheol

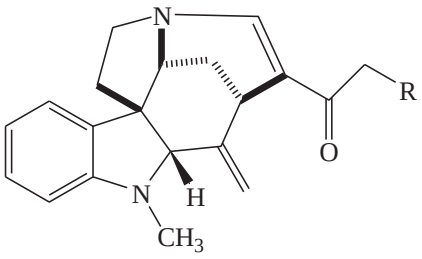


793 10-Methoxycorynantheol R=OMe
794 10-Hydroxyantirhine R=OH

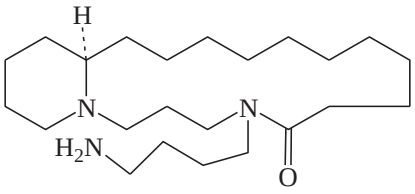
289. *Ochrosia lifuana* Guill.: Ochrolifuanines A and B, dehydro-3-ochrolifuanine, and others from the leaves (Peube-Locou *et al.*, 1971, 1972a, 1973).
290. *Ochrosia maculata* Jacq. (*Ochrosia borbonica* Gmel.): Reserpine and 9-methoxy-ellipticine (Sovoboda *et al.*, 1968).
291. *Ochrosia miana* H. Bn. ex Guill. (*Neisosperma miana* (Baillon ex-White) Boiteau): Descarbomethoxy-dihydrogambirtannine, ochrolifuanines A and B ochromianine,

ochromianoxine and hydroxyochrolifuanine from the leaves and bark (Peube-Locou *et al.*, 1973; Preaux *et al*., 1974a,b).

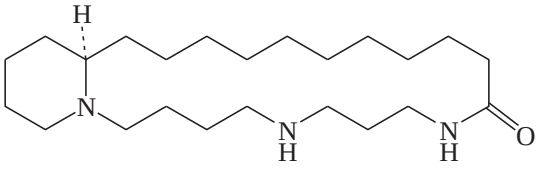
292. *Ochrosia moorei*: Ellipticine, 10-methoxyellipticine, apparicine, 10,11-dimethoxy-18,19-dihydro-16*S*,20*R*-sitsirikine, 3*S*,7*S*-ochropposinine oxindole, desoxycordifoline, ochrosamines A (**795**) and B (**796**) and others (Ahond *et al*., 1981; Carroll *et al*., 2008).
293. *Ochrosia nakaiana* (Koidz.) Koidz. ex H. Hara: Vobasine, harman, reserpiline, akuammidine, venoterpine, ochrolifuanines A and B, hydroxyo-chrolifuanine, ochromianine, ochromianoxine decarbomethoxy-dihydrogambirtannine and others from the leaves and bark (Preaux *et al*., 1974a,b; Sakai *et al.*, 1974; Peube-Locou *et al.*, 1973).
294. *Ochrosia oppositifolia*: Ochropposine, ochropposinine, reserpiline, isoreserpiline, reserpinine, isoreserpinine, ochrolifuanine, 10-hydroxyapparicine and others (Akhter *et al*., 1978; Peube-Locou *et al.*, 1972b,c; Nasab, 2012).
295. *Ochrosia poweri* Bailey: Reserpine, isoreserpiline, elliptamine (reserpiline), powerine, poweridine, poweramine, powerchrine, ochropine and ochropamine (Doy and Moore, 1962; Douglas *et al*., 1964; Johns *et al*., 1975).
296. *Ochrosia sandwicensis* A. Gray: Two quaternary alkaloids *viz*. hunterburnine α-methochloride and ochrosandwine (Jordan and Scheuer, 1965).
297. *Ochrosia silvatica* Dän.: Apparicine, ellipticine and isoreserpiline from the trunk bark (Cosson and Schmid, 1970).
298. *Ochrosia vieillardii* Guil.: Ellipticine, reserpiline, isorerpiline, dimethoxypicraphylline, ochropposinine, 1,2-dihydroellipticine, 1,2,3,4-tetrahydroellipticine and others from the leaves and bark (Kan-Fan *et al*., 1970; Bruneton *et al.*, 1972).
299. *Oncinotis inandensis* Wood et Evans: Inandenine A and inandenine B from the leaves (Veith *et al.*, 1970).
300. *Oncinotis nitida* Benth.: Spermidine alkaloids: oncinotine (**797**), neooncinotine (**798**) and isooncinotine (**799**) from the stem bark (Badawi *et al.*, 1968; Guggisberg *et al*., 1974).
301. *Oncinotis tenuiloba* Stapf: Inandenin-13-one, inandenin-12-one, N^4-benzoylspermidine and three polyamine alkaloids, tenuilobine, oncinotin-11-one and oncinotin-12-one (Doll *et al*., 1994, 1995, 1996a,b).
302. *Pagiantha cerifera* Mkgf.: (-)-Voacangine, (-)-ibogaine, apparicine, pagisulfine (a sulphur containing alkaloid), pagicerine (**800**), ceridimine (**801**) and others (Harmouche *et al*., 1976; Ros *et al*., 1978; Bert *et al*., 1985, 1986, 1989; Baudouin *et al*., 1986).
303. *Pagiantha macrocarpa*: Coronaridine, voacangine, voaphylline and 7-hydroxy-1-dehydrovoacangine from the seeds (Miet and Poisson, 1977).
304. *Pandaca boiteaui*: Capuvosidine, dehydrocapuvosidine, dihydrocapuvosidine, ervatamine, ervitsine and methuenine (Andriantsiferana *et al*., 1977, 1979; Husson *et al*., 1978).
305. *Pandaca caducifolia*: Ervafolidine (**802**), salicine, 16-*epi*-salicine (**803**), (+)-ψ-tabersonine, (+)-(20*R*) ψ-vincadifformine, (+)-pandoline, (+)-pandine and others from the different parts (Le Men *et al*., 1974b; Zeches *et al*., 1975, 1982; Clivio *et al*., 1995b).
306. *Pandaca calcarea*: (-)-Dregamine, pandoline and (-)-apparicine (Hoizey *et al*., 1974; Le Men *et al.*, 1974c).
307. *Pandaca debrayi*: (-)-Dregamine and (-)-apparicine (Hoizey *et al*., 1974).
308. *Pandaca euspala*: (-)-Ibogaine, (-)-19-*epi*-voacangarine, (-)-apparicine, (-)-vobasine, (+)19,20-dihydro-condylocarpine, (+)(20*R*)dihydrocleavamine, (-)-(20*S*)-dihydro-cleavamine, (+)(20 *S*)Δ^1-ψ-aspidospermidine and others (Quirin *et al*., 1975).



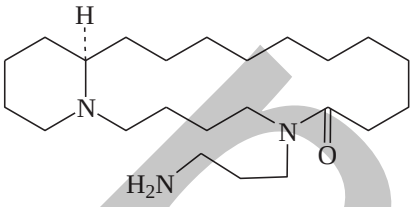
795 Ochrosamine A R=OH
796 Ochrosamine B R=H



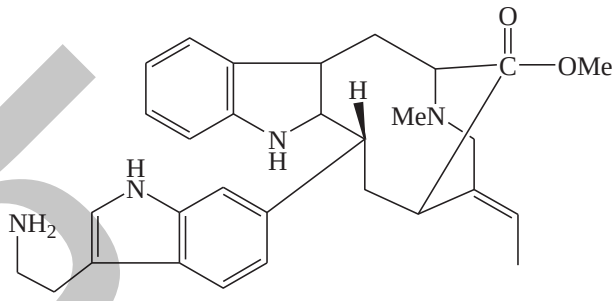
797 Oncinotine



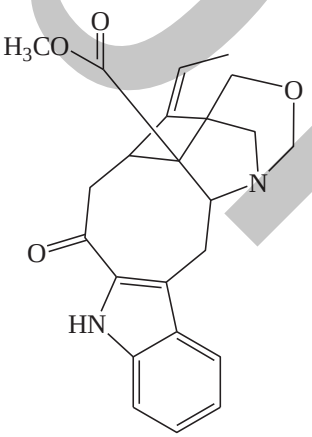
799 Isooncinotine



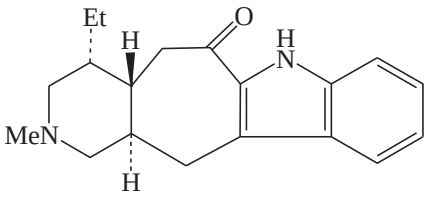
798 Neooncinotine



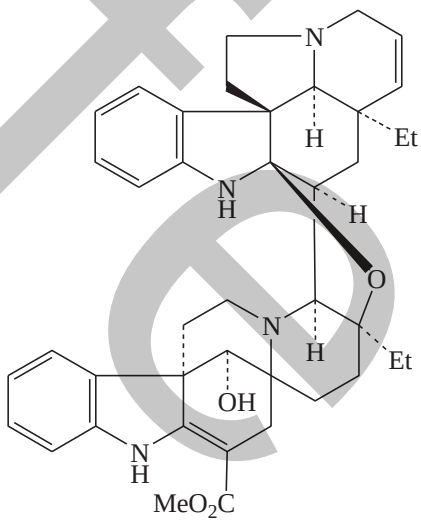
801 Ceridimine



800 Pagicerine



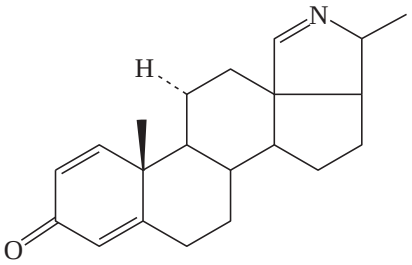
803 16-*epi*-silicine



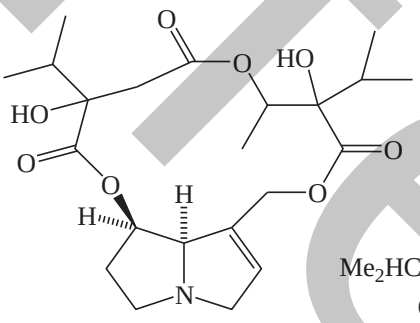
802 Ervafolidine

309. *Pandaca mauritiana*: Vobasine, dregamine and tubotaiwine (Picot *et al*., 1974).
310. *Pandaca minutiflora*: (-)-Vobasine, (-)-coronaridine, (+)-vincadifformine, (+)-stemmadenine, (+)-condylocarpine, (+)-5,6,5',6'tetrahydropresecamine and (+)-tubotaiwine (Petitfrere *et al*., 1975).
311. *Pandaca mocquerysii* var. *pendula*: (-)-Coronaridine, voacangine, voacangarine, (-)-19-*epi*-voacangarine, (-)-heyneanine and (-)19-*epi*-heyneanine (De Bellefon *et al*.. 1975).

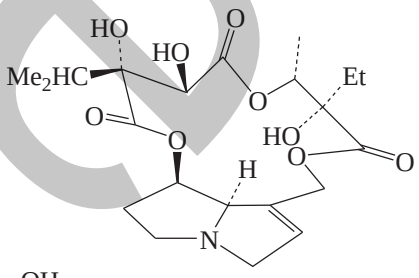
312. *Pandaca ochrascens*: Appariciné, akuammicine, akuammidine, ibogaine, iboluteine, and others from the leaves and root bark (Panas *et al.*, 1974).
313. *Pandaca retusa* (Lmk) Mgf: Coronaridine, heyneanine, (-)-tabersonine, (-)-pachysiphine, voaphylline, voacangine, oxo-3-voacangine and voacristine from the leaves, seeds and trunk bark (Picot *et al*., 1973; Le Men-Olivier *et al.*, 1974).
314. *Pandaca speciosa*: (-)-Ibogaine, iboluteine, (-)-iboxygaine, (-)-voacangine, (-)-voacangarine, and (-)-decarbomethoxyvoacamine from the roots, leaves and stems (Lévy *et al.*, 1975).
315. *Pandacastrum saccharatum* Pichon: Pandicine from the leaves (Kan-Fan *et al.*, 1981).
316. *Paravallaris maingaya*: Maingayine (**804)**, paravallarine, paravallaridine and their *N*-methyl derivatives from the bark and leaves (Davis *et al*., 1970; Janot, 1966).
317. *Paravallaris macrophylla* Pitard: 20-*epi*-Kibataline from the leaves (Ngoc *et al*., 1984).
318. *Paravallaris microphylla* Pitard: 7α-hydroxy, 7β-hydroxy, and 11α-hydroxy-paravallarine, paravallarine, paravallaridine, and their *N*-methyl derivatives from the leaves, stems and roots (Le Men and Bellon, 1962; Le Men, 1963 Janot, 1966; Husson *et al.*, 1966, 1969, 1971; Emmerich and Aurousseau, 1970).
319. *Parsonia eucalyptophylla* F. Muel.: Pyrrolizidine alkaloids: intermedine and/or indicine and its acetyl derivative and lycopsamine from the aerial parts (Edgar and Culvenor, 1975).
320. *Parsonia heterophylla* A. Cunn.: Heterophylline and parsonsine (Eggers and Gainsford, 1979; Edgar *et al*., 1980).
321. *Parsonsia* species: Parsonine (**805**), parsonsianine (**806**), parsonsianidine (**807**), 12-*seco*-14-deoxy-parsonsianine-13-methylester, 14-deoxyparsonsianine (**808**), 14-deoxy-parsonsianidine and from the leaves of *Parsonsia laevigata*, *Parsonsia eucalyptophlla* and *Parsonsia straminea* (Abe and Yamauchi, 1987c; Abe *et al.*, 1990, 1991a,b).
322. *Parsonia spiralis* Wall.: Spiracine, spiraline and spiranine from the leaves (Edgar *et al*., 1980).



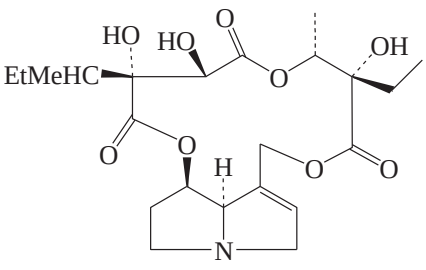
804 Maingayine



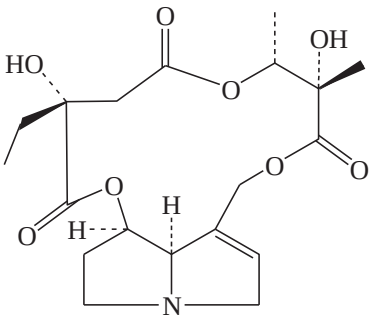
805 Parsonine



806 Parsonsianine



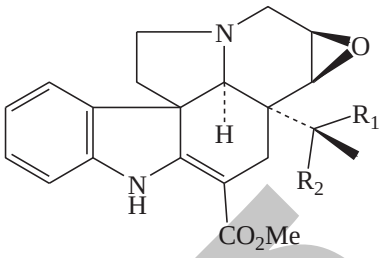
807 Parsonsianidine



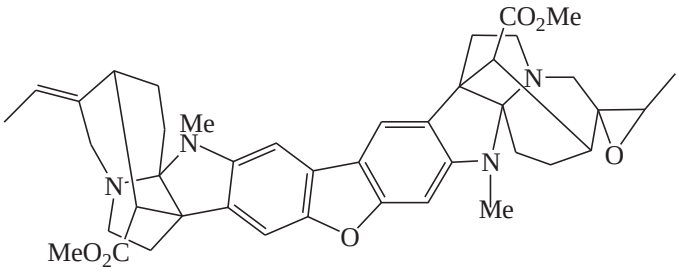
808 14-Dexoyparsonsianine

323. *Parsonia straminea* (R. Br.) F. Muel.: Intermedine and/or indicine and its acetyl derivative and lycopsamine ( ) from the aerial parts (Edgar and Culvenor, 1975).
324. *Peschiera affinis* (Muell. Arg.) Miers: Coronaridine, epiheyneanine, affinine, affinisine, vobasine, olivacine, voacangine, voacristine, iboxygaine, 19-hydroxyibogamine, 19-epivoacristine, affinisine, 6*N*-hydroxy-olivacine and 2*N*-oxide-olivacine from the bark, roots and stems (Weisbach *et al.*, 1963; Wolter Filho *et al*., 1985; Lemos *et al*., 1996; Santos *et al.*, 2009a, 2012).
325. *Peschiera australis* (Muell. Arg.) Miers var. *australis*: Coronaridine, tabersonine, olivacine, coronaridine-hydroxyindolenine, catharinensine, decarbomethoxyvoacamine and tabernamine from the root bark, leaves and seeds (Rates *et al.*, 1988, 1993).
326. *Peschiera buchtieni* (syn. *Tabernaemontana buchtieni* Mgf.): Thirty-four alkaloids from the stem bark and leaves e.g. apodine, *N*-methyl-pericyclivine, 18,19(*R*)-dihydroxy-coronaridine, buchtienine, demethylceridimine, coronaridine, voaphylline, heyneanine, eglandine, eglandulosine, normacusine B, janetine, 3,14-dihydroolivacine, 3'(*R/S*)-hydroxy-*N*-demethyl-tabernamine, ceridimine, *N*-demethyltabernamine, vallesamine, voacristine, olivacine and others (Azoug *et al*., 1995).
327. *Peschiera campestris*: Coronaridine, heyneanine, voacangine, voacangine hydroxyl-indolenine, vobasine, voacamine, voachalotine 12-methoxy-N_b-methyl-voachalotine, isovoacangine, isovoacristine, and from the leaf, bark and root (Gower *et al*., 1986).
328. *Peschiera catharinensis*: Catharinensine, coronaridine, isovoacangine, heyneanine, 16-epiaffinine, decarbomethoxyvoacamine and conodurine (Araujo *et al*., 1984).
329. *Peschiera echinata*: Voacangine, vobasine, voacangine 7-hydroxy-indolenine, voacristine, voacamidine, olivacine, voacamine, voacamidine, coronaridine, 3-oxo-voacangine and others from the different parts (Ghorbel *et al*., 1981; Abaul *et al*., 1984).
330. *Peschiera fuchsiaefolia*: Voacamine, decarbomethoxyvoacamine, dimethyl-voacamine, voacamidine, voacangine, perivine, 16-epiaffinine, voacangine hydroxyindolenine, voachalotine, affinisine, fuchsiaefoline and others (Braga *et al*., 1984; Braga and Reis, 1987; Lepine *et al*., 2002).
331. *Peschiera laeta* (Mart. ex A. DC.) Miers (syn. *Tabernaemontana laeta* Mart.): Affinine, akuammidine, conodurine, coronaridine, conoduramine, geissoschizol, tombozine, voacamine and vobasine mainly from leaves, twigs and bark (Jahodář *et al*., 1974; Votický *et al*., 1977; You *et al*., 1994).
332. *Peschiera lundii* (D.C.) Miers: Voacangine, coronaridine, voacristine, voacristine pseudoindoxyl, 20-epivoacristine, iboxygaine, iboxygaine hydroxyindolenine, ibogaine, olivacine and vobasine (Hwang *et al*., 1969).
333. *Peschiera vanheurkii* (Muell. Arg.) L. Allorge (syn. *Tabernaemontana van heurkii* Muell. Arg.): Affinisine, vobasine, ibogamine, coronaridine, voacangine, voacangarine, voacamine, vobasine, vobasinol, 16'-decarbomethoxyvoacamine, affinisine, normacusine B, *N*(a)-methylpericyclivine, perivine, 16-epiaffinine, coronaridine hydroxyl-indolenine, apodine, hedrantherine, conodurine, gabunine, conoduramine, accedinisine, voacamidine and others from the different parts (Muñoz *et al*., 1994; Tournon *et al*., 1994).
334. *Petchia ceylanica*: Ajmalicine, lochnericine, peceylamine, peceyline, pelankine, (19*R*)-epimisiline (**809**), (19*S*)-epimisiline (**810**), dimethyl-peceyline (**811**), ceylanine (**812**) and petchine (**813**) (Atta-ur-Rahman *et al*., 1987h, 1988b,c, 1989a; Cave *et al*., 1987).
335. *Picralima klaineana* Pierre:: Akuammine, akuammenine, akuammidine, akuammiline, akuammicine, pseudoakuammicine, akuammigine and pseudoakuammigine from the seeds (Henry and Sharp, 1927; Henry, 1932).
336. *Picralima nitida* Stapf.: Akuammigine, akummicine, picraline, picracine, akuammine, pseudoakuammine, akuammidine, akuammiline, ψ-akuammigine, picraphylline,

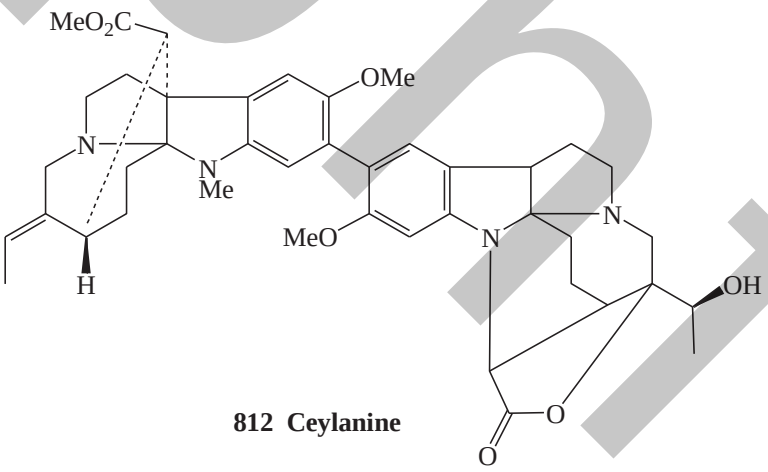
picratidine (**814**) and picranitine (Robinson and Thomas, 1954a,b, 1955; Olivier *et al*., 1962, 1963, 1964; Ledouble *et al*., 1964; Moeller *et al*., 1972; Ansa-Asamoah *et al*., 1990; Menzies, 1998; Tane *et al*., 2002). Pericalline and pericine from the cell suspension culture (Arens *et al*., 1982).



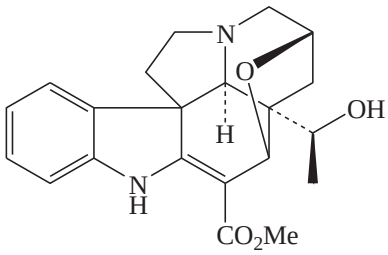
809 (19R) Epimisiline R_1=H,R_2=OH
810 (19S) Epimisiline R_1=OH,R_2 =H



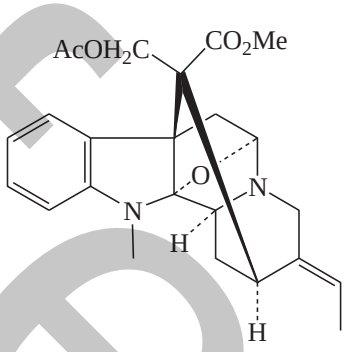
811 Dimethyl-peceyline



812 Ceylanine



813 Petchine



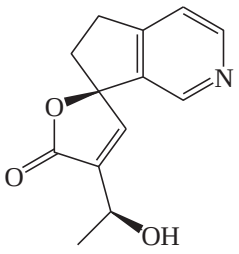
814 Picratidine

337. *Pleiocarpa mutica* Benth.: Kopsinine, kopsinoline, eburnamenine, pleiomutine, pleiomutinine, pleiocarpinidine, flavocarpine, isotuboflavine, norisotuboflavine, several quaternary alkaloids (e.g. hunterburnine and hunterburninine) and many others (Kump and Schmid, 1961; Battersby and LeCount, 1962; Plourde, 1962; Achenbach and Biemann, 1965a,c; Khan *et al*., 1965b; Taylor, 1965; Thomas *et al*., 1966a,b).
338. *Pleiocarpa pycnantha* (K. Schum) Stapf: Pleiocarpoline, pleiocarpolinine, kopsinoline, (-)-eburnamine and (+)-pycnanthinine (Kump *et al*., 1965b; Gorman and Schmid, 1967).
339. *Pleiocarpa pycnantha* var. *pycnantha*: (+)-Pycnanthine, (+)-pleiocarpamine, (+)-quebrachamine and (+)-macusine B (Gorman *et al*., 1969).
340. *Pleiocarpa pycnantha* (K. Schum) Stapf var. *tubicina* (Stapf) Pichon: Kopsinine, tubifoline, tubotaiwine, 19,20-dihydroakuammicine, tuboxenine, pleiocarpine and tubifolidine (Kump *et al*., 1964b; Patel and Rowson, 1964b).

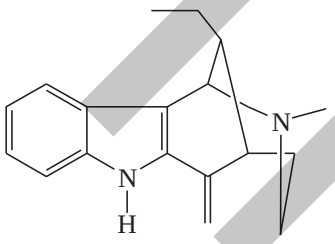
341. *Pleiocarpa talbotii* Wernham: Pleiocarpinilam, kopsinilam, talbotine, talpinine, talcarpine, 16-*epi*-affinine, normacusine B, tetradehydrotalbotine, didehydrotalbotine and deformyltalbotinic acid methyl ester from the leaves and stem bark (Kump and Schmid, 1962; Naranjo *et al.*, 1972b; Pinar *et al.*, 1973).
342. *Pleiocarpa tubicina* Stapf: Tuboflavine, tubifolidine, kopsinine, (+)-quebrachamine, (-)-1,2-dehydroaspidospermidine, tubifoline, tubotaiwine, tuboxenine, 19,20-dihydro-akuammicine, caffeine and others from the leaves and roots (Kump and Schmid, 1962; Kump *et al*., 1963, 1964a,b; Bycroft *et al.*, 1964; Taylor, 1965; Khan *et al*., 1967a).
343. *Plumeria acutifolia* Rubra: Grandine A, grandine B, grandine C, phoebegrandine B, laurelliptine and plumerianine (**815**) (Almahy and Elegami, 2007; Hassan *et al*., 2008).
344. *Plumeria lancifolia* Müll-Arg.: (+)-Uleine (**816**) and (+)- demethoxyaspidospermine (**817**) from the bark (França *et al*., 2000).
345. *Plumeria rubra*: Plumerinine from the stem (Kazmi *et al*., 1989).
346. *Plumeria rubra* L. *cv. acutifolia*: Plumericidine (**818**) from the flowers (Ye *et al*., 2009).
347. *Plumiera sericifolia* C. Wright: Vincubine from the stems (Cuellar and O'Farrill Tejera, 1976b).
348. *Pterotaberna inconspicua* Stapf.: Voacangine, voacangine 3-carbonitrile, voacristine, vobasine, methuenine, apparicine, tubotaiwine, methuenine, 16-*epi*-methuenine, 6-oxomethuenine, 16-*epi*-methuenine *N*-oxide and others from the leaves, seeds and root-bark (Morfaux *et al.*, 1982; Bakana *et al*., 1984; Massiot *et al*., 1988).
349. *Rauwolfia amsoniaefolia* A. DC.: Reserpine and rescinnamine (Bernal *et al*., 1960).
350. *Rauvolfia bahiensis* (=*Rauwolfia bahiensis*) A. DC.: Demethoxypurpeline, 12-methoxy-vellosimine, picrinine, vinorine, raucaffrinoline, normacusine B, norseredamine, seredamine, purpeline and others from the bark and leaf (Kato *et al*., 2002).
350. *Rauwolfia beddomei*: δ-Yohimbine and sarpagine from the roots (Bose *et al*., 1956; Talapatra and Chatterjee, 1957).
351. *Rauwolfia biauriculata*: Lochnerine, lochvinerine, vomilenine, perakine, ajmaline, corynanthine, reserpiline and others from the different parts (Abaul *et al*., 1986).
352. *Rauwolfia boliviana*: Ajmaline, reserpiline, isoreserpiline and reserpine from the root bark (Jacobucci and Deulofeu, 1958).
353. *Rauvolfia caffra* Sond.: Ajmalicine, ajmaline, rescinnamine, reserpiline, reserpine, serpentine, rauwolfine, raucaffrinoline, raucaffrine, raucaffricine, perakine, peraksine, aricine, renoxidine, sarpagine, diacetylajmaline, vomilenine, normacusine B, α-yohimbine, geissoschizol, pleiocarpamine and others mainly from the bark and roots (Koepfli, 1932; Khan *et al.*, 1965a, 1982; Khan and Siddiqui, 1972; Habib and Court, 1973, 1974; Madati *et al.*, 1977; Nasser and Court, 1983a, 1984; Khan, 1986).
354. *Rauwolfia cambodiana* Pierre ex. Pitard: Ajmaline, aricine, isoreserpiline, pelirine, reserpiline and reserpine (Kidd, 1957, 1958; Boonchuay and Court, 1976a). The plant, growing in Vietnam contained 2% alkaloids (Pham Thanh Ky *et al.*, 1983). *Rauwolfia cambodiana*, *Rauwolfia serpentina*, *Rauwolfia verticillata* and *Rauwolfia vomitoria* are reported as suitable commercial sources of hypotensive alkaloids (Nguyen Kim Can and Nikolaeva, 1991).
355. *Rauwolfia canescens* L.: Ajmaline, ajmalicine, aricine, canescine, raunescine, isoraunescine, α-yohimbine, β-yohimbine, reserpine, isoreserpine, isoreserpinine, reserpiline, raupine, reserpinine, lankanescine (**819**), sarpagine, corynanthine, deserpidine, serpine, serpentine, isquinoline, harman and others mainly from the roots (Mookerjee, 1946; Chatterjee, 1951a; Haack *et al.*, 1954; Harrisson *et al*., 1955; Hofmann,1955; Hosansky and Smith, 1955; Keck, 1955; Neuss *et al*., 1955; Schlittler *et al*., 1955; Stoll and Hofmann, 1955a,b; Stoll *et al*., 1955; Klohs *et al*., 1955b-1957;

Bhattacharji *et al*., 1956; Ulshafer *et al*., 1956; Rothman and Toekes, 1957; Ghosh, 1958a,b; Belikov, 1969; Arambewela and Madawela, 2001).

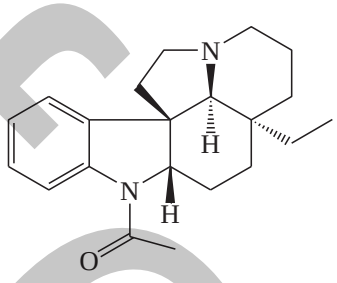
356. *Rauwolfia capuroni* Mgf: 11-Methoxy-yohimbine and 11-methoxy-pseudo-yohimbine (Miet *et al*., 1977).
357. *Rauwfolia confertiflora* M. Pichon: Rauflorine, raufloridine, raufloricine and others from the root bark (Danieli *et al*., 1971, 1972; Bombardelli *et al*., 1973).
358. *Rauwolfia cubana* A. DC.: Tetrahydroalstonine, aricine, isoreserpiline, reserpine, lochnerine, sarpagine, sandwicine, vellosomine and others from stem bark, leaves and roots (Lastra *et al*., 1982; Gomez Gonzalez *et al*., 1989; Martìnez *et al*., 1989a,b, 1992a).
359. *Rauwolfia cumminsii* Stapf.: Reserpine, serpentine, yohimbine, corynantheol, endolobine, sarpagan, norpurpeline, normitoridine, norserdamine, seredamine, and others mainly from the roots (Court *et al*., 1967a; Iwu and Court, 1977a,b, 1978a,b,c).
360. *Rauwolfia decurva* Hook: Reserpiline, isoreserpiline, reserpine, sarpagine and others (Atal, 1959).
361. *Rauwolfia densiflora* (Wall) Benth. ex Hook. f: Reserpine, rescinnamine, isoreserpinine, reserpiline, reserpinine, sarpagine, ajmaline and densiflorine (Chatterjee and Talapatra, 1955a,b; Bhattacharji *et al*., 1962; Iqbal *et al*., 2013).
362. *Rauwolfia discolor*: Reserpiline, isoreserpiline, tetraphyllinine, tetraphylline, tabernaemontanine and quebrachidine (Combes *et al*., 1966).
363. *Rauwolfia fruticosa* Burck: Ajmaline, serpentine and yohimbine from the roots (Chaudhury and Chatterjee, 1959a).
364. *Rauvolfia grandiflora* Mart. ex A. DC.: Darcyribeirine (**820**), isoreserpiline, isoreserpine and others from the root bark (Cancelieri *et al*., 2002, 2003).



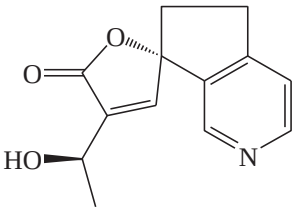
815 Plumerianine



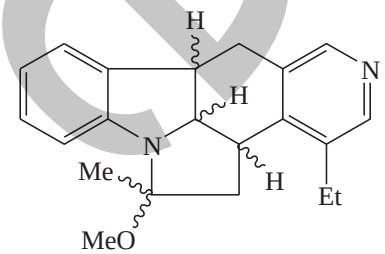
816 (+) Uleine



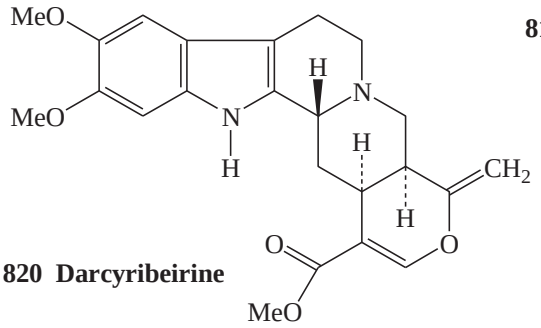
817 (+) Demethoxy-aspidospermine



818 Plumericidine



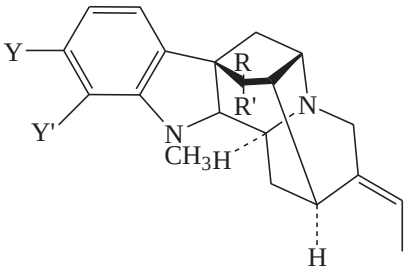
819 Lankanescine



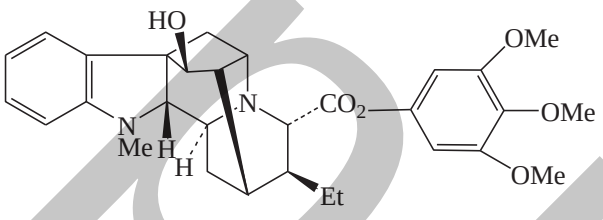
820 Darcyribeirine

365. *Rauwolfia heterophylla* Roem. and Schult.: Reserpine, narcotine, serpentine, ajmaline, ajmalicine, yohimbine and others mainly from the roots (Paris and Daza, 1941; Djerassi *et al.*, 1953, 1954; Janot *et al*., 1954b; Hochstein *et al*., 1955; Ishidate *et al*., 1955).
366. *Rauwolfia hirsuta*: Reserpine, sarpagine, rauwolscine and alstonine from the roots (Mezey and Uribe, 1954a,b; Vergara, 1955).
367. *Rauwolfia indecora*: Ajmaline, reserpine and sarpagine from the roots (Ishidate *et al*., 1955).
368. *Rauwolfia inebrians* H. Schum.: Reserpine from the root and stem barks (Paris and Dillemann, 1956).
369. *Rauwolfia javanica*: δ-Yohimbine and serpentinine from the stem bark (Talapatra, 1962).
370. *Rauwolfia linearifolia* Britt.: 3-*epi*-Yohimbine and others (Martinez Perez *et al*.,1991; Martìnez *et al*., 1994).
371. *Rauwolfia lingustrina* Roem et Schult.: Aricine, tetrahydroalstonine, reserpiline, isreserpiline, reserpinine, isreserpinine, raugstine, α-yohimbine and ajmaline mainly from stem bark (Müller, 1957; Martinez Perez *et al*., 1987; Martìnez *et al.*, 1992b).
372. *Rauwolfia littoralis*: Ajmaline alstonine, reserpine, serpentine and serpentinine from the root bark (Nguyen Kim Can, 1990, 1991).
373. *Rauwolfia macrophylla* Stapf: Ajmalicine, ajmaline, rescinnamine, reserpine, serpentine, normacusine B, suaveoline, yohimbine, heteroyohimbine, and others from the root and stem barks (Timmens and Court, 1974a; Amer and Court, 1980a, 1981a).
374. *Rauwolfia mannii*: Reserpine from the roots (Monseur, 1957) and vincamajine from the leaves (Patel *et al*., 1965).
375. *Rauwolfia media*: Cabucine, reserpiline, mauiensine and 12-hydroxy-mauiensine from the bark (Kan *et al*., 1986).
376. *Rauwolfia micrantha*: Ajmalicine, reserpine, reserpiline, srapagine, δ-yohimbine, serpentine, raunamine and neosarpagine mainly from the roots (Rao and Rao, 1956; Talaptra and Chatterjee, 1957; Pillay *et al.*, 1960).
377. *Rauwolfia mombasiana* Stapf: Ajmalicine, ajmaline, normacusine B, norpurpeline, yohimbine, endolobine, serpentine, dihydroindole, reserine, rescinnamine and others from the leaves, stem and root barks (Court, 1964a, 1966; Iwu and Court, 1978d- 1980).
378. *Rauwolfia natalensis*: Ajmaline and reserpine from the aerial bark (Schüler and Warren, 1956).
379. *Rauwolfia nitida* Jacq.: Raunitidine, 11-methoxy-δ-yohimbine, rauniticine and ajmalicine from the leaves (Salkin *et al*., 1961; Martinez Perez *et al*., 1987). Thirty-three indole alkaloids from the root bark, comprising reserpine, serpentinine, pseudoreserpine, reserpiline sarpagan, dihydro-indole, indolenine, yohimbine and others (Amer and Court, 1981b; Smith *et al.*, 1964a,b).
380. *Rauwolfia obscura* K. Schum.: Alstonine, reserpine, ajmaline, norajmaline, obscurine, obscuridine, tetraphyllicine, α-yohimbine, rescinnamine, vomalidine, rauvomitine, choline and others from leaves, stems and roots (Schlittler *et al*., 1952; Roland, 1959; Timmins and Court, 1974b, 1975, 1976a,b).
381. *Rauwolfia oreogiton* Mgf.: Ajmalicine, ajmaline, rescinnamine, reserpiline, reserpine, α-yohimbine, another yohimbine isomer, renoxydine from the root bark (Timmins and Court, 1974c). Twenty-one indole alkaloids from the leaves e.g. heteroyohimbine, akuammiline, akuammicine, picraline, picrinine, and sarpagan types (Akinloye and Court, 1980). Dihydroindole, heteroyohimbine, oxindole, yohimbine and others from the roots (Akinloye and Court, 1981a).

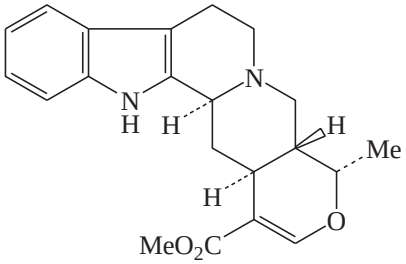
382. *Rauwolfia perakensis*: Reserpine, perakenine, ajmaline, isoreserpiline, sarpagine, pelirine and perakine from the roots (Chatterjee and Talapatra, 1955a,b; Kiang and Wan, 1960). Aricine, perakine, neoreserpiline, rauwolscine, sarpagine, tombozine and others from the leaves and stems (Kaiang *et al*., 1964).
383. *Rauwolfia psychotrioides*: Harman, ethyl harman, and rauvoxinine (Cordova B. and Pena, 1979).
384. *Rauwolfia reflexa* Teijsm. and Binn.: Purpeline (**821**), reflexine (**822**) and rauflexine (**823**) and others (Chatterjee *et al*., 1976a, 1978b, 1982, 1998).
385. *Rauwolfia rosea* K. Schum.: Reserpine, reserpiline, ajmaline, serpentine and others (Court *et al*., 1967b).
386. *Rauwolfia salicifolia*: Raucubaine, (-)-ajmalicine, (+)-ajmalidine, (-)-reserpiline, (-)-isoreserpiline, (-)-isocarapanaubine, (+)-vellosamine, (+)-yohimbine and others (Kutney *et al*., 1980; Pauptit and Trotter, 1981; Sierra and Novotný, 1981; Sierra *et al*., 1982).
387. *Rauwolfia schueli*: Ajmaline (3.1%), aracine, reserpiline, isoreserpiline and reserpine from the root bark (Iacobucci and Deulofeu, 1957 1958; Martino *et al*., 1978).
388. *Rauwolfia sellowii* Muell. Arg.: Aricin, ajmalicine, reserpine, ajmaline, ajmalidine, serpentine, tetrahydroalstonine, tetrahydrophyllicine, reserpiline, sarpagine, lochnerine, harman and β-yohimbine from the root bark (Seba *et al*., 1954; Hochstein, 1955; Pakrashi *et al*., 1955; Belem-Pinheiro *et al*., 1988). Sellowiine, perakine, raucaffrinoline, vomilenine, 19α,20α-epoxy-akuammicine, picrinine and 12-demethoxytabernulosine from the leaves (Batista *et al*., 1996).
389. *Rauwolfia semperflorens* Schlechter: Semperflorin (Schlittler and Furlenmeier, 1953).
390. *Rauwolfia semperflorens* var. *viridis* Boiteau: Sandwicine, vinorine, raucaffrinoline, reserpinine, isoreserpiline and an isomer of ajmaline from the trunk bark and leaves (Libot *et al*., 1987).
391. *Rauwolfia serpentina* Benth. (Indian Snake root): It is the important member of the genus. About 50 alkaloids have been so far isolated from the roots e.g. ajmalicine (**824**), ajmaline (raugalline), ajmalinimine, ajmalinine (**825**), ajmalicidine (**826**), raunatine, chandrine, corynanthine, deserpidine, isoajmaline, isorauhimbine, methyl reserpate, neoajmaline, papaverine, parakenine, rauhimbine, raupine, rauwolfinine, rescinnamine, reserpiline, reserpine (**827**) (3%), reserpinine, sandwicolidine (**828**), sarpagine, seredine, serpentine (**829**), serpentinine, serpine, tetraphyllicine, thebaine, vomilenine, yohimbine, γ-yohimbine, δ-yohimbine, sandwicoline (**830**), recinnaminol (**831**), yohimbinine (**832**), indobinine (**833**), rescinnamidine (**834**), indobine (**835**), 3-*epi*-α-yohimbine, 12-hydroxyajmaline, 3-hydroxysarpagine, yohimbinic acid, isorauhimbinic acid and thebaine (Greshoff, 1890; Siddiqui and Siddiqui, 1931; Bodendorf and Eder, 1953; Stoll and Hofmann, 1953; Hofmann, 1954a,b; Neuss *et al*., 1954; Rakshit, 1954; Schlitter *et al*., 1954; Bose, 1954, 1955, 1956; Klohs *et al*., 1954a-c, 1955a; Chatterjee and Talapatra, 1955a,b; Phillips and Chadha, 1955; Siddiqui and Alauddin, 1958; Kolesnikov *et al*., 1959, 1961; Taylor *et al*., 1963; Chaudhuri, 1970; Haider, 1986; Siddiqui *et al*., 1985a,b; 1986a, 1987a-g; Khaleque *et al*., 1987; Ruyter *et al*., 1988; Falkenhagen *et al*., 1993; Wachsmuth and Matusch, 2002; Itoh *et al*., 2005; Lounasmaa and Sainio, 2007). The production of ajmaline, serpentine and other alkaloids by tissue culture was reported (Vollosovich and Tsarenko, 1968; Uddin *et al*., 1978; Shimolina and Minina, 1981; Sheludko *et al*., 2002).
392. *Rauwolfia sprucei* Muell. Arg.: Lochnerine, 18-hydroxylochnerine, perakine and compactinervine. lochnerine, 18-hydroxylochnerine, spegatrine, 3-epi-α-yohimbine and others from the leaves and stems (Madinaveitia *et al*., 1995a; Valencia A. *et al*., 1996).



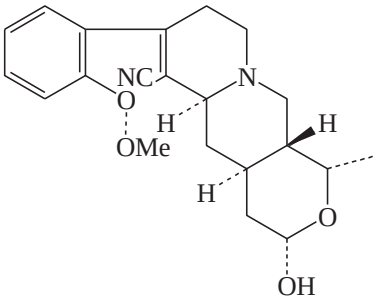
821 Purpeline Y=H, Y'=OCH_3, R, R'=O
822 Reflexine Y=H, Y'=OCH_3, R=H, R'=OH
823 Rauflexine Y=OCH_3, Y'=H, R, R'=O



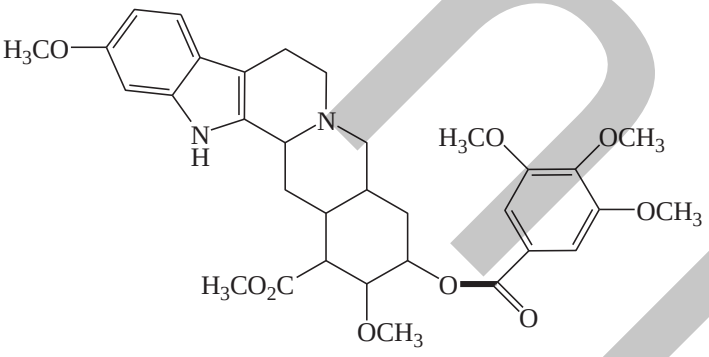
825 Ajmalinine



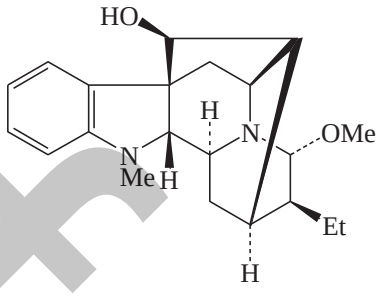
824 Ajmalicine



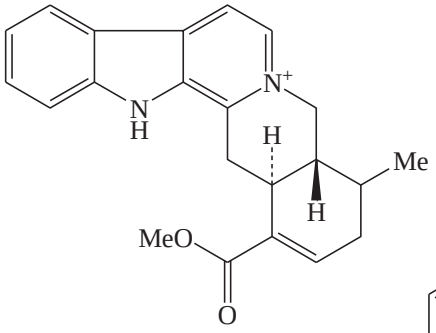
826 Ajmalicidine



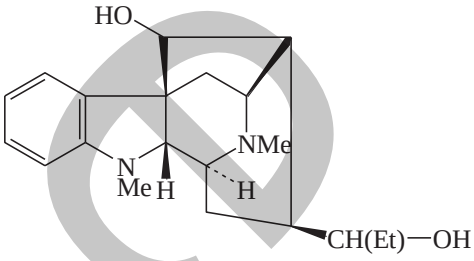
827 Reserpine



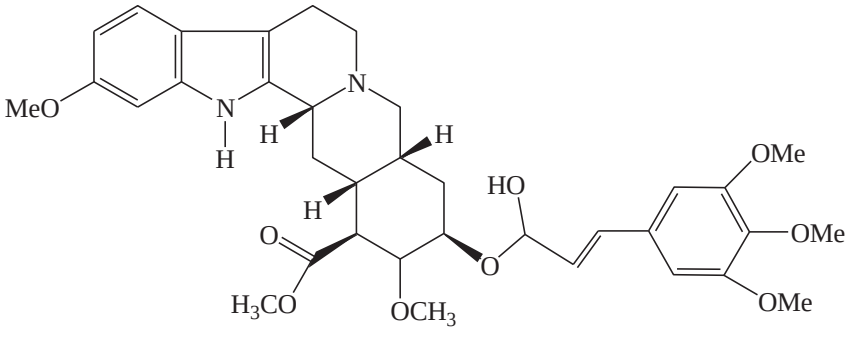
828 Sandwicolidine



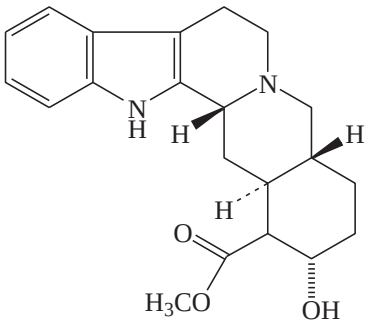
829 Serpentine



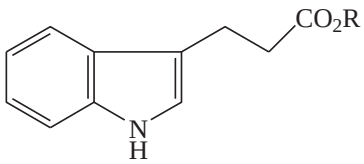
830 Sandwicoline



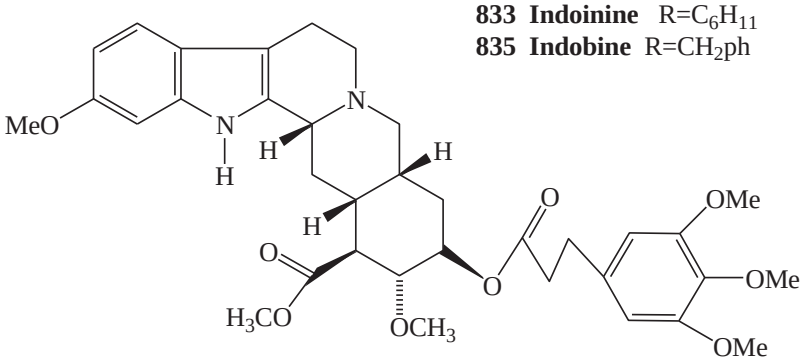
831 Rescinnaminol



832 Yohambinine

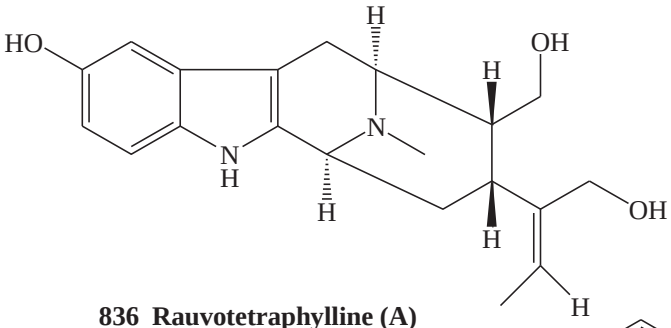


833 Indoinine R=C_6H_{11}
835 Indobine R=CH_2ph

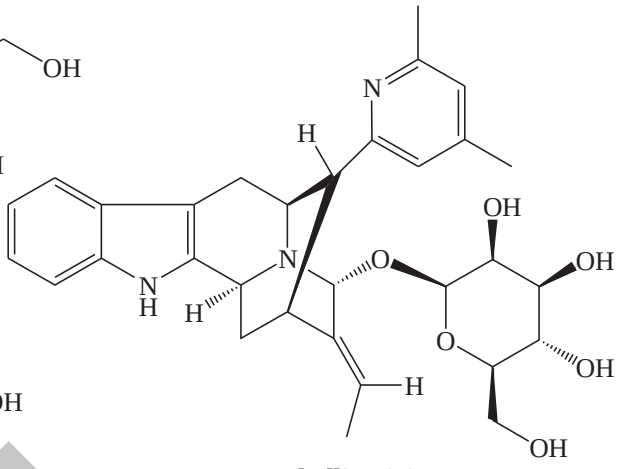


834 Rescinnamidine

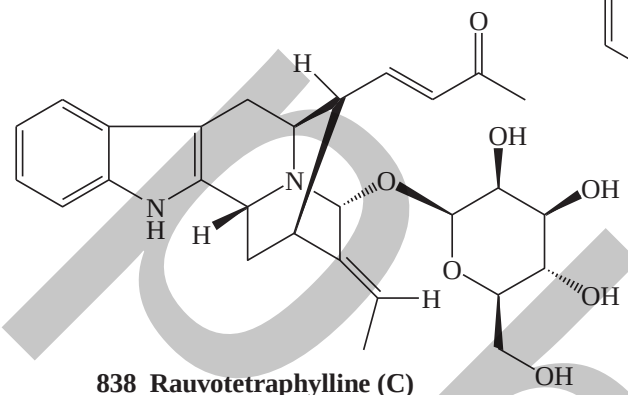
393. *Rauwolfia suaveolens*: Suaveoline, ajmaline, tetraphyllicine, normacusine B, lochnerine, polyneuridine, norajmaline, a hydroxyyohimbine and a methoxyheteroyohimbine (Majumdar *et al.*, 1972, 1973a).
394. *Rauwolfia sumatrana* Jack.: Ajmaline, yohimbine, aricine, serpentine, reserpine, sarpagine, harman, tetraphyllicine, flexicorine, lanceomigine, perakine, β-carboline, peraksine, cabufiline, compactinervine, serpentinine and others (Chaudhury and Chatterjee, 1959a,b; Hanaoka *et al*., 1970; Arbain *et al*., 1991; Subhadhirasakul *et al*., 1994c; Takayama *et al*., 1994b).
395. *Rauwolfia ternifolia*: Reserpine and others from ther roots (Cardoso and Venancio, 1956)
396. *Rauwolfia tetraphylla* L.: Reserpine, ajmaline, serpentine, serpentinine, ψ-yohimbine, aricine, reserpiline, isoreserpiline, reserpinine, α-yohimbine, rauvotetraphyllines A-E (**836**-**840**), alstonine (**841**), nortetraphyllicine, peraksine, sarpagine, raucaffricine, dihydroperaksine and others from the roots and leaves (Djerassi and Fishman, 1955; Djerassi *et al*., 1957; Lastra *et al*., 1982; Martinez Perez *et al*., 1982a,b, 1987; Martìnez *et al.*, 1989b; Gao *et al*., 2012; Gupta *et al.*, 2012a,b; Maurya *et al*., 2013). The production of reserpine in callus culture was reported (Anitha and Kumari, 2006, 2013).
397. *Rauwolfia verticillata* (Lour.) Baill: Reserpine, serpentine, ajmaline, actinidine, vellosamine, peraksine, δ-yohimbine, sandwicine, raunescine, rauverines A-G and others from the bark, roots, leaves and wood (Arthur, 1956; Chiang *et al*., 1963; Arthur and Loo, 1966; Arthur *et al*., 1967, 1968; Hong *et al*., 2012; Zhang *et al*., 2013f).
398. *Rauwolfia verticellata* (Lour) Baill. var. *hainanensis* Tsiang: Quaternary alkaloids e.g. macrospegatrine (**842**) (Lin *et al.*, 1986, 1987).
399. *Rauwolfia verticellata* (Lour) Baill. f. *rubrocarpa* H. D. Zhang Mss.: Ajmalicine, reserpine, tetraphyllicine, ajmaline, antirhine, normacusine B, spegatrine and verticillatine (Yu and Lin, 1982; Lin *et al*., 1985b).
400. *Rauwolfia viridis* Roem and Schultz (Bitter bush): (+)-Ajmaline, (-)-rauviridine, (+)-querbachidine, (+)-sarpagine, (+)-serpentine, (-)-vobasine, α-yohimbine, ajmalidine, rauviridine, epirauviridine, harman and others from the different parts (Martinez Perez and Eckacka Ockomby, 1983; Martinez Perez *et al*., 1983, 1988a,b, 1989b; Navajas Polo *et al*., 1983; Martìnez *et al.*, 1996).



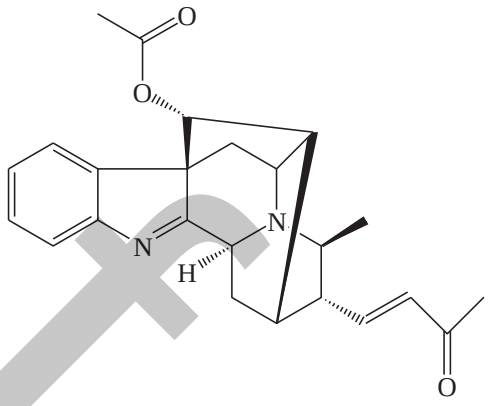
836 Rauvotetraphylline (A)



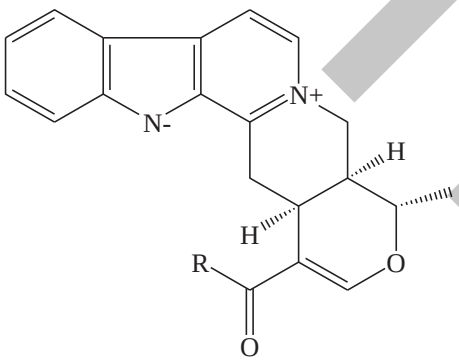
837 Rauvotetraphylline (B)



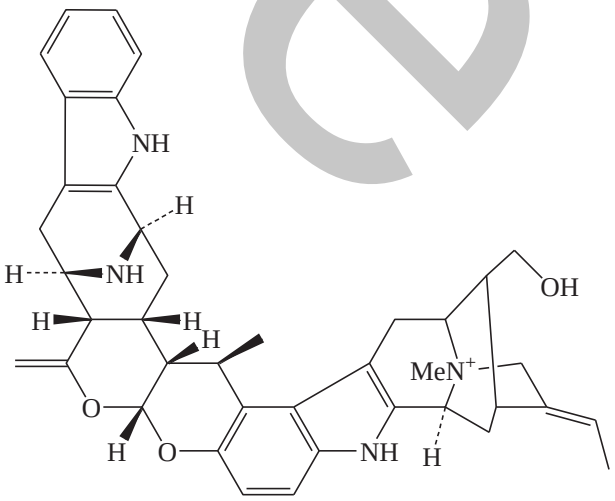
838 Rauvotetraphylline (C)



839 Rauvotetraphylline (D)

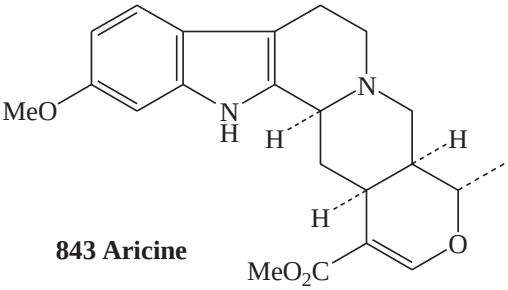


840 Rauvotetraphylline (E) R=OH
841 Alstonine R=OCH_3

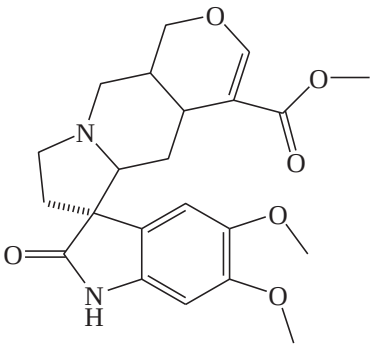


842 Macrospegatrine

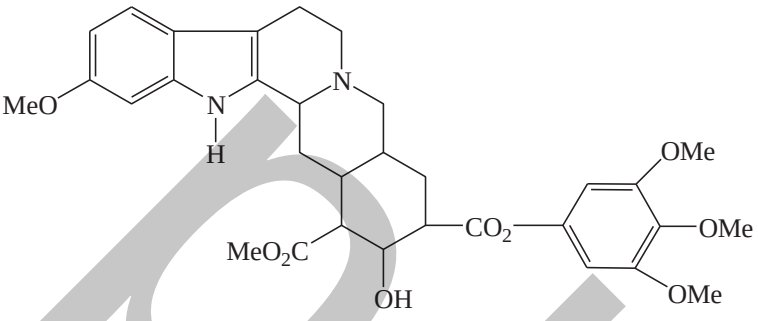
401. *Rauwolfia volkensii*: Reserpine, reserpiline, ajmaline, serpentine, reserpiline, tetraphyllicine, isoreserpiline, α-yohimbine, yohimbine, peraksine and others from the different parts (Court, 1964b, 1968; Akinloye and Court, 1979, 1980a, 1981b).
402. *Rauwolfia vomitoria* Afz.: At least 72 alkaloids classified into 19 types occur in the plant e.g. reserpine, aricine (**843**), isoreserpiline, reserpiline, rauvomitine, raumitorine, yohimbine, carapanaubine (**844**), 10-deoxysarpagine, neonorreserpine (**845**), ajmalinol (**846**), ajmalidine, serpenticine (**847**), rescinnamine, yohimbine, seredine, vomalidine, geissochizol, isocarapanaubine, vomifoline, sandwicine, isosandwicine, vomifoline, vomilenine, sarpagine normacusine B, purpeline, tetraphyllicine, *N*-methylajmaline, perakine, tetraphylline, reserpic acid, mitoridine, harman, mauiensine, and others from the leaves, fruits, stem bark and roots (Dubois, 1955; Kidd, 1955; Haack *et al.*, 1955a,b, 1956; Poisson *et al.*, 1955; Poisson and Goutarel, 1956; Hofmann and Frey, 1957; Goutarel *et al*., 1954, 1961; Monseur, 1957; Siddiqui and Manzur-i-Khuda, 1961; Popelak*et al*., 1961; Finch *et al*., 1963; Patel *et al*., 1964; Poisson *et al.*, 1964; Pousset and Poisson, 1964; Tsarenko and Shraiber, 1965; Bombardelli *et al*., 1967; Muquet *et al*., 1968; Russo *et al*., 1971; Iwu and Court, 1977c; Pousset *et al*., 1977; Sabri and Court, 1978; Chatterjee and Bandyopadhyoy, 1979; Malik and Siddiqui, 1979, 1983; Siddiqui and Malik, 1979; Amer and Court, 1980b; Iwu, 1980; Voelter, 1980; Iwu and Court, 1982; Haider, 1986; Lovati *et al*., 1996; Petati *et al*., 1996; Li *et al*., 2007).
403. *Rauwolfia yunnanensis* Tsiang: Ajmalicine, 19 *epi*-ajmalicine, ajmaline, reserpine, serpentine, tetraphyllicine, vellosimine and others from the roots (Wei, 1965; Chen and Bai, 1979; Feng and Fu, 1981; Hu *et al*., 2006). Rauvoloids A–E (**848- 852**), raucaffrinoline (**853**) and perakine (**854**) from the leaves (Geng and Liu, 2013).
404. *Rejoua aurantiaca*: Voacangine, voaluteine, vobtusine and iboluteine from the bark, fruits and leaves (Guise *et al*., 1965).
405. *Schizozygia coffaeoides* (Boj.) Baill.: Isoschizogaline (**855**), schizozygine, α-schizozygol, schizophilline, schizogaline, schizogamine, caffaeoschizine and others from the leaves, roots and twigs (Renner and Kernweisz, 1963; Renner, 1964; Hajicek *et al*., 1998; Kariba *et al*., 2002; Atilaw *et al*., 2014).
406. *Skytanthus acutus* Meyen: Skytanthine, β-skytanthine *N*-oxide, hydroxyskytanthines I and II and others from the different parts (Djerassi *et al.*, 1962b; Casinovi *et al*., 1963; Adolphen *et al*., 1967; Streeter P. *et al*., 1969; Appel and Streeter P., 1970a,b).
407. *Stemmadenia alfari* (Donn. Smith) Woodson: Coronaridine and tabersonine from the seeds (Cicció-Alberti, 1977).
408. *Stemmadenia donnell-smithii* (Rose) Woodson: Coronaridine, (+)-quebrachamine, tabernanthine, tabersonine, stemmadenine, isovoacangine, voacamine, and others from the different parts (Watts *et al.*, 1958; Collera *et al*., 1962; Cicció-Alberti, 1977).
409. *Stemmadenia galeottiana*(A. Rich.) Miers: Ibogamine from the wood dust (Watts *et al.*, 1958; Soriano-Garcia *et al.*, 1988) and coronaridine from the fruit rind (Dominguez *et al.*, 1976).
410. *Stemmadenia glabra* Benth.: Coronaridine, ibogamine, tubotaiwine, voacangine and voacristine from the different parts (Cicció-Alberti *et al*., 1979, 1982; Herrera-Ramírez *et al*., 1982).
411. *Stemmadenia grandiflora*: Coronaridine, heyneanine, voacangine, 3-hydroxyvoacangine, voacangarine, 3-hydroxyvoacangarine, 3-oxovincadifformine and others from the leaves, stems and seeds (Henriques *et al*., 1982; Tessier *et al*., 1984; Torrengera *et al*., 1988).
412. *Stemmadenia minima* A. Gentry: Coronaridine, 13-hydroxycoronaridine, voacangine, heyneanine, voacristine, 16-*epi*-pinarine and others from the different parts (Achenbach *et al*., 1991; Gupta *et al*., 1991).



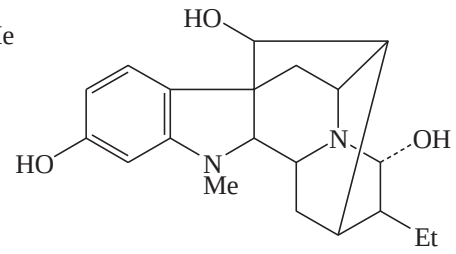
843 Aricine



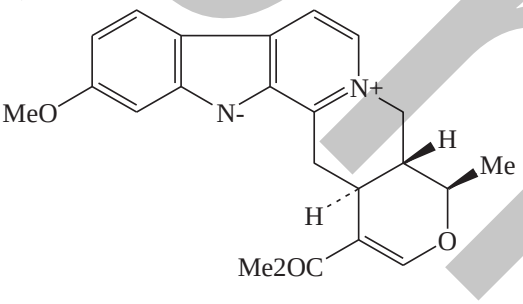
844 Carapanaubine



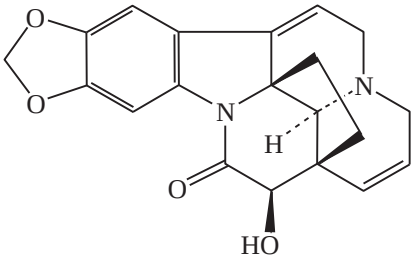
845 Neonorreserpine



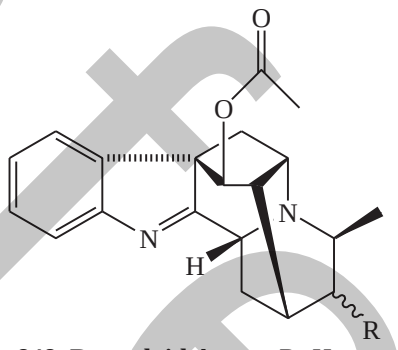
846 Ajmalinol



847 Serpenticine



855 7,8-Dehydro-19β-hydroxyschizozygine

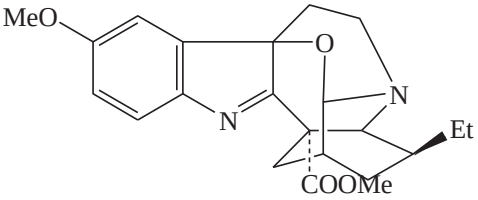


848 Rauvoloid A R=H
849 Rauvoloid B R=αC
850 Rauvoloid C R=βC
851 Rauvoloid D R=α–(1E)3oxo-butenyl
852 Rauvoloid E R=α-CH(OH)$_2$
853 Raucaffrinoline R=α-CH(OH)$_2$
854 Rerakine R=β-CH(OH)$_2$

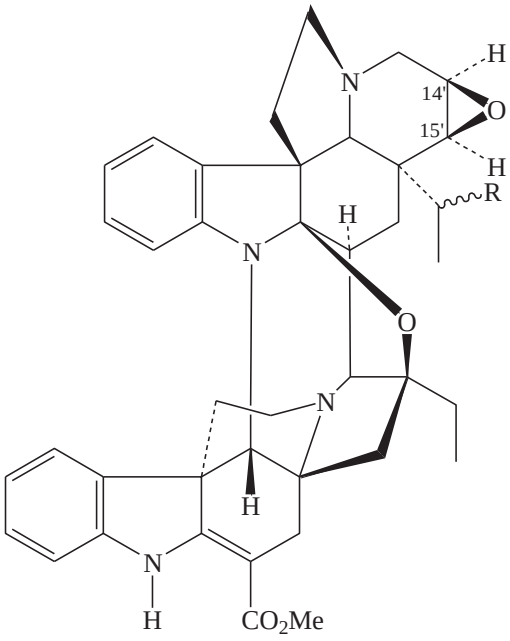
413. *Stemmadenia obovata*: Obovatine, coronaridine, voacangine, (19*S*)-heyneanine, voacristine, ajmalicine, ajmalicinine, obovamine (**856**) and others from the different parts (Collera *et al*., 1962; Valencia *et al*., 1995; Madinaveitia *et al*., 1995b, 1996).
414. *Stemmadenia obovata* (Hk. &Arn.) Schum var. *mollis* (Benth.) Woodson: Coronaridine and tabersonine from the seeds of (Cicció-Alberti, 1977).
415. *Stemmadenia tomentosa* var. *palmeri*: Coronaridine, tabersonine and stemmadenine from the seeds and fruit (Collera *et al*., 1962). Cell suspension cultures of the plant synthesized the eight major indole alkaloids: (-)-tabersonine, (-)-minovincinine, (+)-

conoflorine (voaphylline), condylocarpine, (+)-tubotaiwine (dihydrocondylocarpine), (-)-norfluorocurarine (vincanine), (-)-vinervine, and (-)-coronaridine (Stöckigt *et al*., 1982).

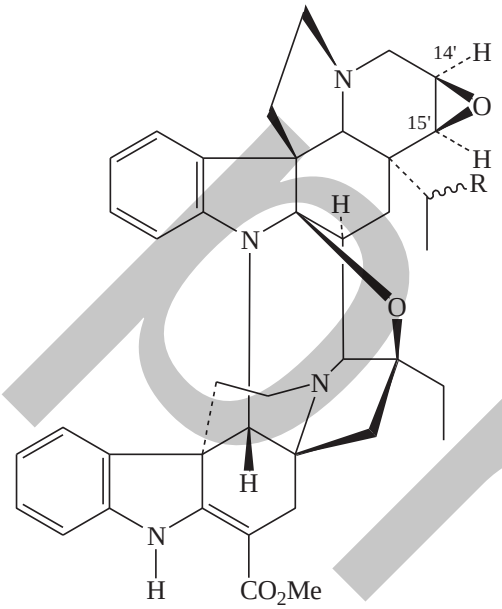
416. *Stenosolen heterophyllus* (Vahl) Mgf: About 25 alkaloids from the plant e.g. ervafoline (**857**), 19'-hydroxyervafoline (**858**) ervafolene (**859**) and 19'-hydroxy-ervafolene (**860**), voacangine hydroxyindolenine (**861**), voacangine (**862**), conoflorine (**863**), pandoline (**864**), pandine (**865**), ervafolidine, voaphylline, tabernamine, vobasine, vallesamine, pericalline, affinisine, ibogamine, ibogaine, and coronaridine (Henriques *et al*.,1978-1980, 1982; Kan *et al*., 1984).
417. *Strempeliopsis strempelioides* K. Schum.: Aspidospermine, vincadifformine, fannine (**866**), (+)-pleiocarpamine, (+)-eburnamonine, (+)-haplocidine, (+)-strempeliopidine, strempeliopine and others from the different parts (Laguna and Iglesias, 1978; Laguna *et al*., 1980a,b, 1982, 1984).
418. *Strophanthus hispidus* DC.: Trigonelline and choline (Agyare *et al*., 2013b).
419. *Tabernaemontana accedens*: Accedine (**867**), *N*-demethyl-16-*epi*-accedine, $N_{(a)}$-methyl-epiaffinine (**868**), accedinine, accedinisine, voacamine, voacamine $N_{(b)}$-oxide, voacamidine and *N*-demethylvoacamine (Achenbach and Schaller, 1975, 1976a,b).
420. *Tabernaemontana albiflora*: Albifloranine, coronaridine, pendoline, 20-epipandoline, 20-epiibophyllidine, (+)-(20*R*)-18,19-dihydroxy-ψ-vincadifformine, ibophyllidine, and deethylibophyllidine from the stem bark (Kan *et al*., 1980, 1981a,b).
421. *Tabernaemontana amblyocarpa* Urb: Coronaridine, ibogamine, voacangine, isovoacangine, voacristine, isovoacristine, akuammidine, (-)-iboxygaine, vallesamine, tubotaiwine, tabersonine, (-)-heyneanine and others from the different parts (Perez and Sierra, 1980, 1983, 1985; Fajardo *et al*., 1984; Perez, 1984; Perez *et al*., 1995).
422. *Tabernaemontana amygdalifolia*: *O*-Demethylpalosine, homocylindrocarpidine 17-demethoxycylindrocarpidine, and 10-oxo-cylindrocarpidin from the roots (Achenbach, 1966a, 1967a,b).
423. *Tabernaemontana angulata* Mart. ex Müll. Arg.: Coronaridine and voacangine (de Assis *et al*., 2009).
424. *Tabernaemontana apoda* Wr. ex Sauv. (*Peschiera apoda* Markgraf): Coronaridine, voacangine, isovoacangine, ibogamine, voacamine, voacristine, olivacine, apodinine (**869**) and others (Sierra and Iglesias, 1975; Perez and Iglesias, 1976, 1979; Iglesias, 1977, 1979; Laguna and Iglesias, 1977a,b; Sierra *et al*., 1977; Perez *et al*., 1979).
425. *Tabernaemontana arborea* Rose (Wild orange jessamine): Tabersonine, voacangine, isovoacangine, voacamine, epivoacorine, 19-epivoacristine, vobasine and others (Kingston, 1978; Chaverri *et al*., 1980b; Ciccio *et al*., 1985; Cabezas and Ciccio, 1986).
426. *Tabernaemontana armeniaca* Areces: Apodine (**870**) and deoxyapodine (Iglesias and Diatta, 1975a,b).
427. *Tabernaemontana australis* (Müll. Arg.) Miers: Coronaridine, voacangine, voacangine hydroxyindolenine, rupicoline, ibogamine, ibogaine, ibogaline, desethylvoacangine, voachalotine and affinisine from the stalk (Gorman *et al*., 1960; Andrade *et al*., 2005).
428. *Tabernaemontana bovina*: (-)-Mehranine, 3-oxomehranine, hecubine, ibogaine, ibogaline, pedunculine, isovoacristine, tabernaebovine (**871**), tabernaemontavine and 14α,15β-dihydroxy-*N*-methylaspidospermine from the leaves and stems (Lien *et al*., 1998a,b; Ripperger *et al*., 1999).
429. *Tabernaemontana brachyantha*: Normacusine B, anhydrovobasinediol, voacorine and an isomer of voacrine from the trunk bark (Patel *et al*., 1973).
430. *Tabernaemontana calcarea*: Voacangine, voacristine, isovoacangine, coronaridine, 11-hydroxycoronaridine, heyneanine, ibogamine, 10-methoxyibogamine, isovoacristine, 19-*epi*-voacristin and others (Prakash Chaturvedula *et al*., 2003b, 2005).



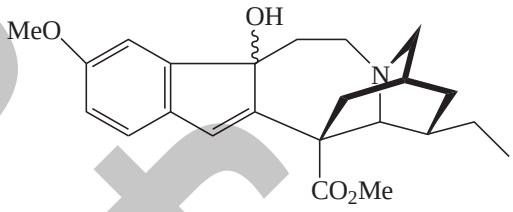
856 Obovamine



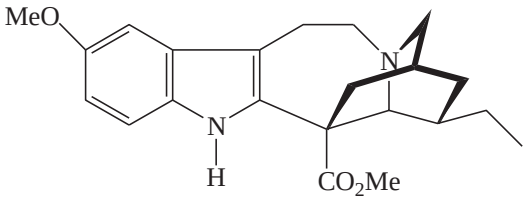
857 Ervafoline R=H
858 19'-Hydroxyervafoline R=OH



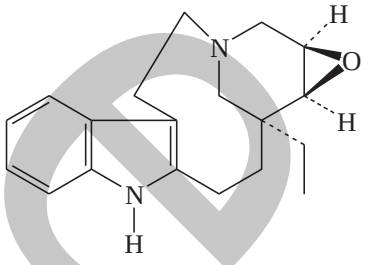
859 Ervafolene R=H; $\Delta^{14', 15'}$
860 19'-Hydroxyervafolene R=OH; $\Delta^{14', 15'}$



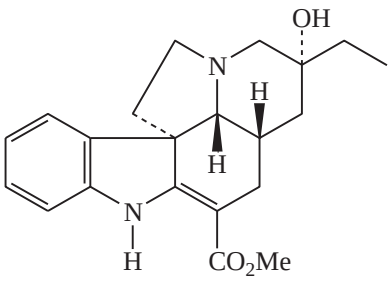
861 Voacangine hydroxyindolenine



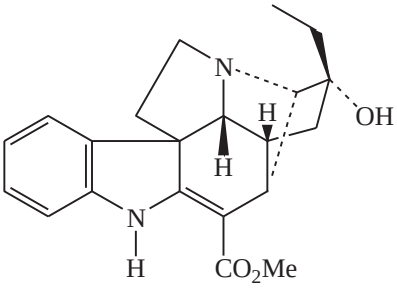
862 Voacangine



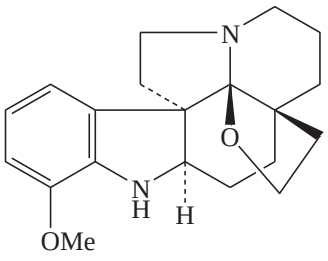
863 Conoflorine



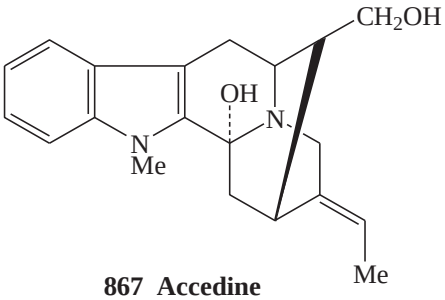
864 Pandoline



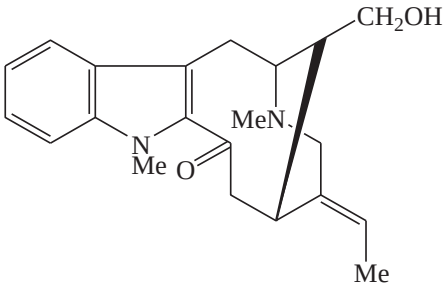
865 Pandine



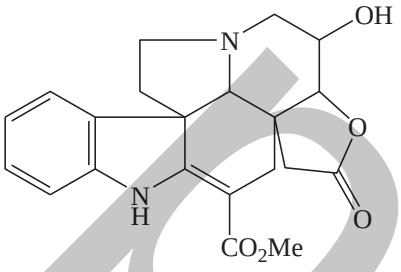
866 Fanine



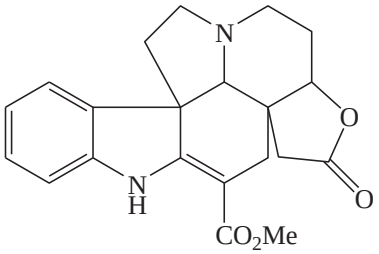
867 Accedine



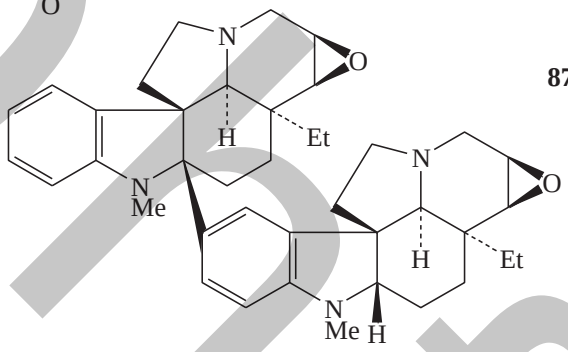
868 N(a)-methylepiaffinine



869 Apodinine



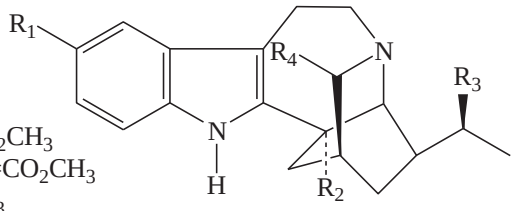
870 Apodine



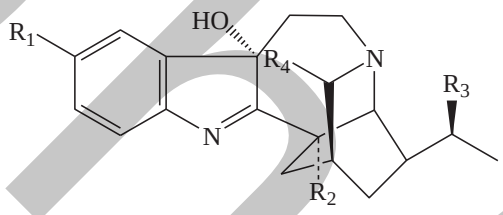
871 Tabernaebovine

431. *Tabernaemontana catharinensis* A. DC. (syn. *Peschiera catherinesis* A. DC. Miers) (Milkweed): Coronaridine (**872**), ibogamine (**873**), heyneanine (**874**), voachalotine (**882**), voacristine (**875**), voacristine hydroxyindolenine (**876**), 3-oxo-coronaridine (**877**), 3-hydroxycoronaridine hydroxyindolenine (**878**), 16-*epi*-affinine, voacangine (**879**), voacangine hydroxyindolenine (**880**), vobasine (**881**) and others from different parts (Pereira *et al*., 1999, 2006b, 2008; Nicola *et al*., 2013)
432. *Tabernaemontana chippii*: Forty-five alkaloids, comprising monogagain, vobparicine, 3-hydroxy derivatives of dimeric voacamine and others belonging to the corynanthean, ibogan, or bisindole classes from the root bark (Van Beek *et al*., 1984a, 1985a,b). Conoflorin from the leaves (Robinson *et al*., 1967).
433. *Tabernaemontana citrifolia* L (*Tabernaemontana alba* Mill) (White milkweed).: (-)-Coronaridine, (-)-ibogamine, ibogaine, (-)-voacangine, (-)-iboxygaine, (-)-voacristine, (-)-19-oxovoacangine, (-)-apparicine, (-)-19-oxovoacristine, (-)-tabersonine, (-)-lochnericine, (+)-vallesamine, akuammidine and others from different parts (Iglesias and Rodriguez, 1979; Kutney and Perez, 1982; Abaul *et al*., 1989 Rastogi *et al*., 1998).
434. *Tabernaemontana coronaria* R.Br. (syn. *Ervatamia coronaria*): Dregamine, coronarine, tabernaemontanine, vobasine, voacangine and isovoacristine from the different parts (Ratnagiriswaran and Venkatachalam, 1939; Warri and Ahmed, 1949; Karawya and Aboutabl, 1979; Rao and Singri, 1979).
435. *Tabernaemontana corymbosa*: Several alkaloids have been isolated from the different plant parts; most of these alkaloids are indoles of different types. However, alkaloids of the quinoline types and others were also isolated. The following are some of these

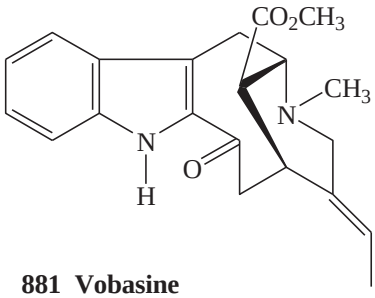
alkaloids: conolutinine (**883**), conodiparines A-F, conodutarines A and B, conodirinines A (**884**) and B, coronaridine, 5-oxo-19,20-dehydroervatamine (**885**), dippinines A, B (**886**), C and D (**887**), ervahanine A, heyneanine, ibogaine, ibogamine, jerantinines A-G (**888- 894**), jerantiphyllines A and B, vobasonidine (**895**), vobatricine (**896**), 19(*S*)-hydroxy-ibogamine (**897**), tabercarpamines A-J, tronoharine (**998**), tronocarpine (**899**), voastrictine (**900**), conoliferine (**901**), isoconoliferine (**902**), conomicidines A (**903**) and B (**904**), isoconomicidines A (**905**) and B (**906**) (Kam and Loh, 1993; Kam and Sim, 1999a,b, 2001, 2002a-c, 2003a,b; Trinh *et al*., 2001a,b; Kam *et al*., 1998b, 1999b, 2000, 2001a, 2003a; Lim *et al*., 2008b, 2009a-c; Lim and Kam 2009a,b; Ma *et al*., 2014a,b).



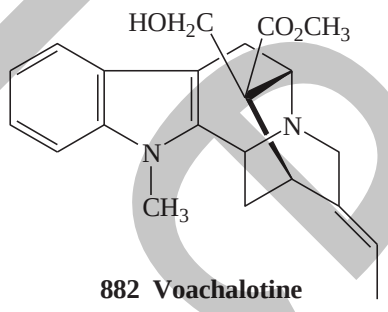
872 Coronaridine $R_1=R_3=R_4=H$, $R_2=CO_2CH_3$
873 Ibogamine $R_1=R_2=R_3=R_4=H$
874 Heyneanine $R_1=H$, $R_3=OH$, $R_4=H$, $R_2=CO_2CH_3$
875 Voacristine $R_1=OCH_3$, $R_3=OH$, $R_4=H$, $R_2=CO_2CH_3$
877 3-oxo-Coronaridine $R_1=R_3=H$, $R_4=O$, $R_2=CO_2CH_3$
879 Voacangine $R_1=OCH_3$, $R_3=R_4=H$, $R_2=COOCH_3$



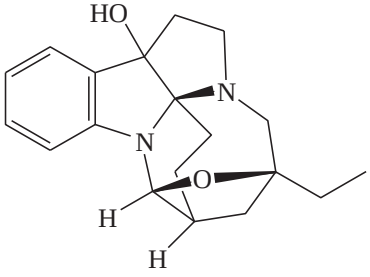
876 Voacristine hydroxyindolenine $R_1=OCH_3$, $R_4=H$, $R_3=OH$, $R_2=CO_2CH_3$
878 3-Hydroxycoronaridine hydroxyindolnine $R_1=R_3=H$, $R_4=OH$, $R_2=CO_2CH_3$
880 Voacangine hydroxyindolenine $R_1=OCH_3$, $R_3=R_4=H$, $R_2=CO_2CH_3$



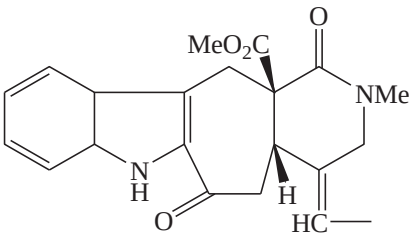
881 Vobasine



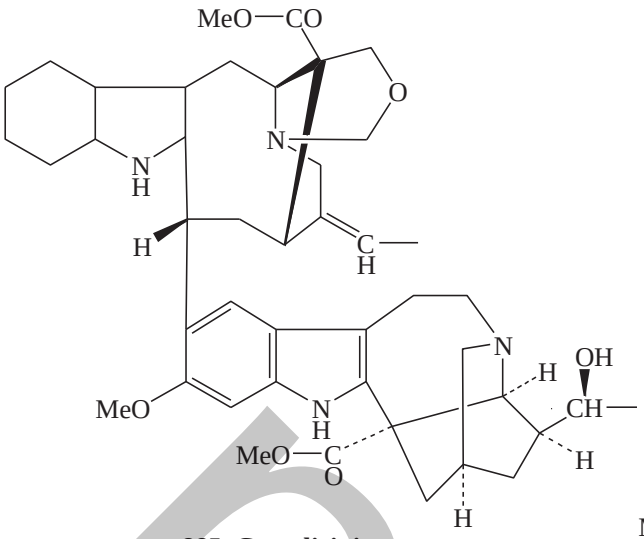
882 Voachalotine



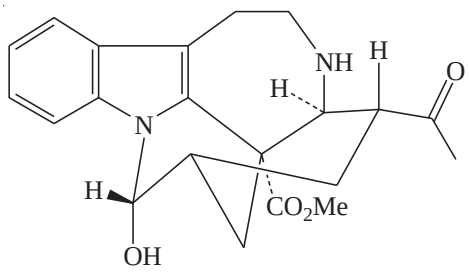
883 Conolutinine



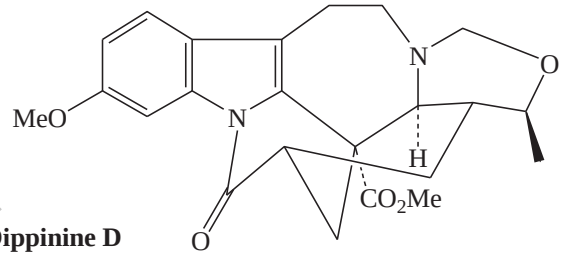
884 19,20- dehydroervatemine



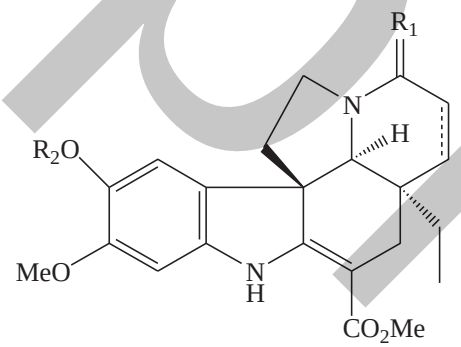
885 Conodirinines



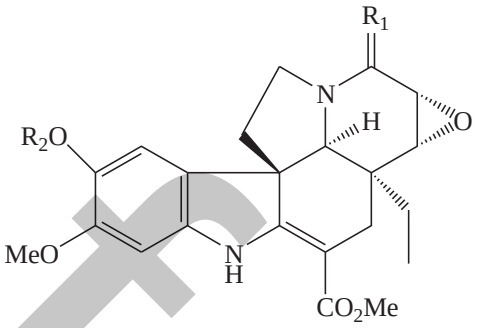
886 Dippinine B



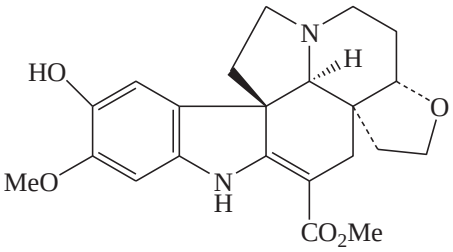
887 Dippinine D



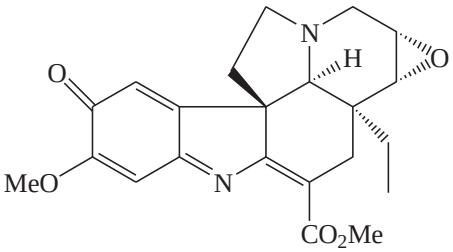
888 Jerantinine A R_1=H_2, R_2=H, $\Delta^{14,15}$
889 Jerantinine C R_1=O, R_2=H, $\Delta^{14,15}$
890 Jerantinine E R_1=H_2, R_2=H



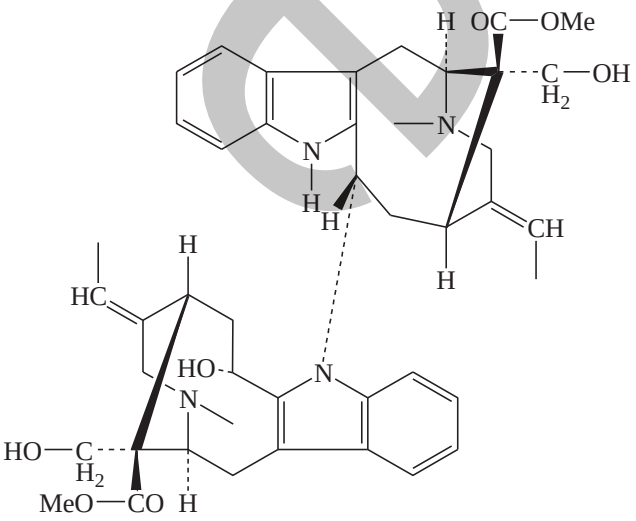
891 Jerantinine B R_1=H_2, R_2=H
892 Jerantinine D R_1=O, R_2=H



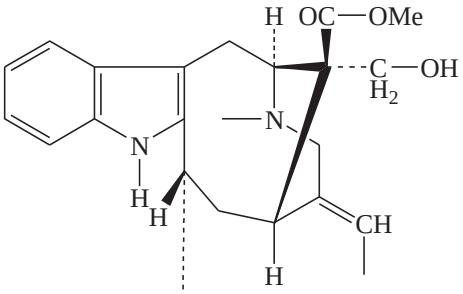
893 Jerantinine F

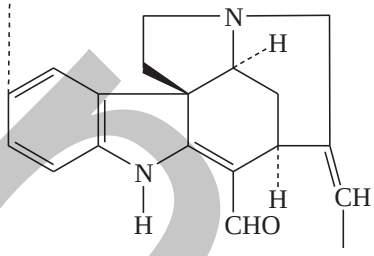


894 Jerantinine G

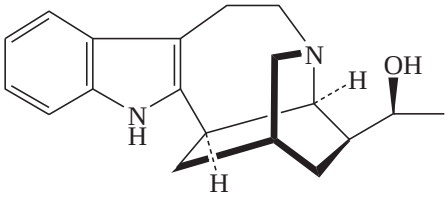


895 Vobasonidine

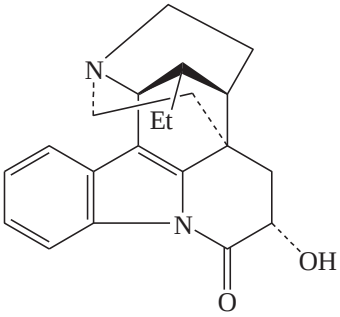




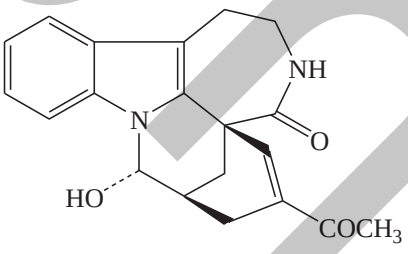
896 Vobatricine



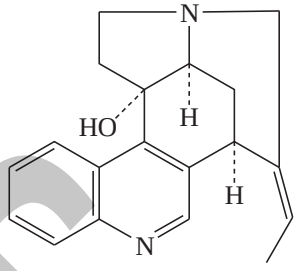
897 19(S)-hydroxy-Ibogamine



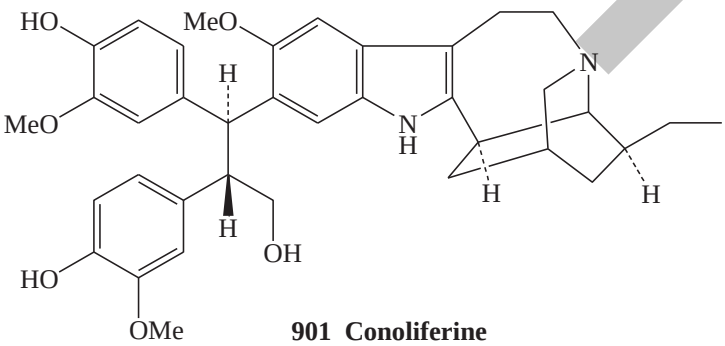
898 Tronoharine



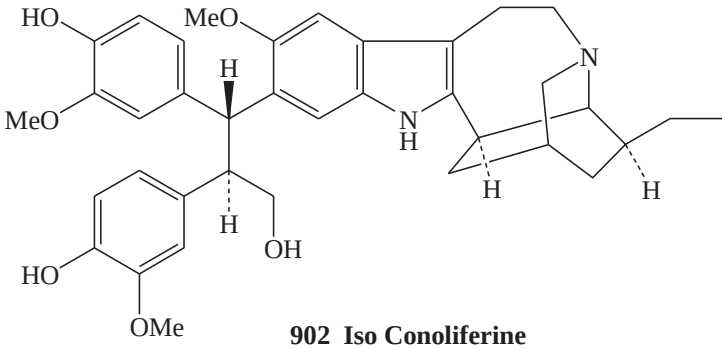
899 Tronocarpine



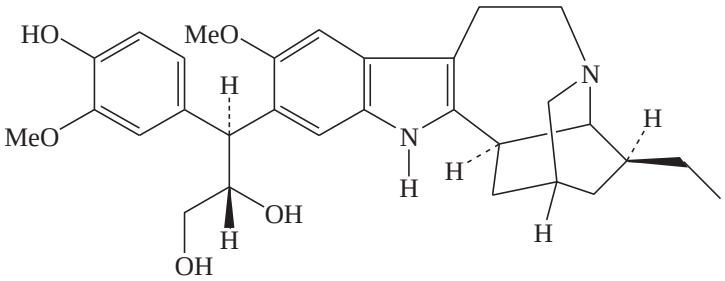
900 Voastrietine



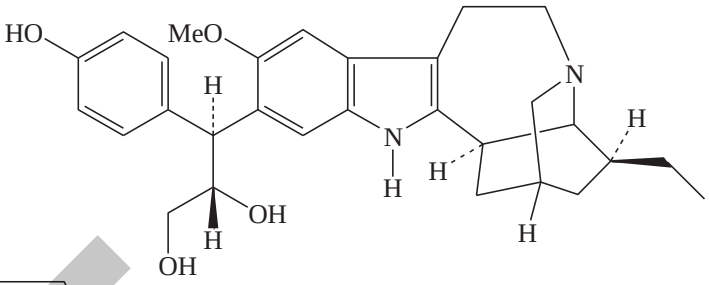
901 Conoliferine



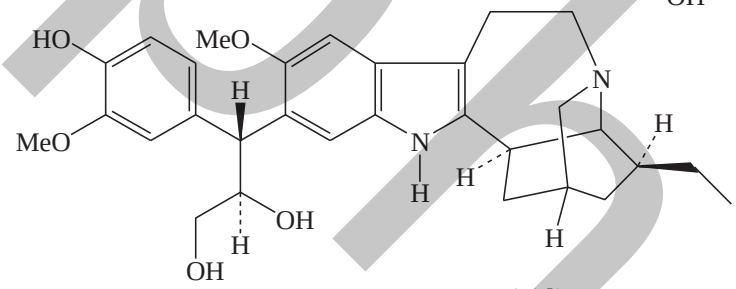
902 Iso Conoliferine



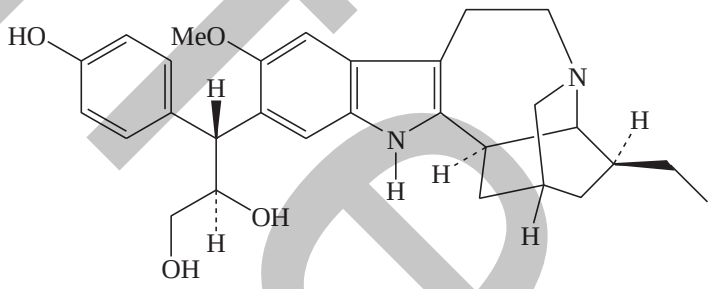
903 Conomicidine A



904 Conomicidine B



905 Isoconomicidine A

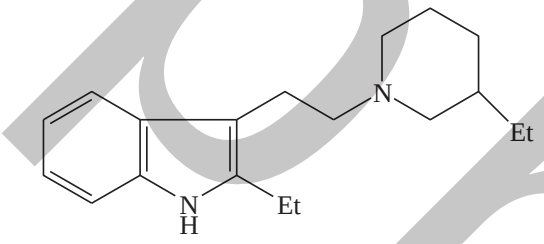


906 Isoconomicidine B

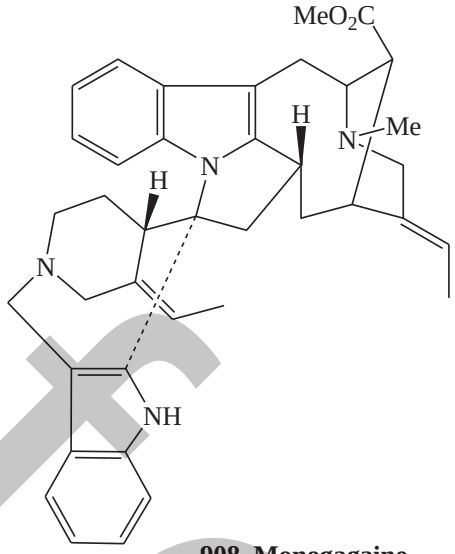
436. *Tabernaemontana crassa* Benth.: Crassanine, conopharyngine, ibogaine and palmatine (Cava *et al.*, 1968b; Van Beek *et al*., 1985c; Kuete, 2010).
437. *Tabernaemontana cumminsii*: (-)-Apparicine, jollyanine (conopharyngine hydroxyl-indolenine) and 2-ethyl-3-[2-(3-ethylpiperidino)ethyl] indole (**907**) from the leaves (Crooks *et al.*, 1968; Crooks and Robinson, 1970a,b).
438. *Tabernaemontana cymosa* Jacquin (*Tabernaemontana psychotrifolia*): Seventeen indole alkaloids from the seeds e.g. coronaridine, tabersonine, voacangine, condylocarpine, heyneanine, 3-oxotabersonine, 3-oxovoacangine, tabersonine-*N*-oxide, stemmadenine, stemmadenine-*N*-oxide, isositsirikine, 9-(β-D-glucopyranosyloxy)-tetrahydroalstonine, and voacristine, (Achenbach *et al.*, 1997).
439. *Tabernaemontana dichotoma* (Roxb.) Blatter: Coronaridine, alstonisine, (-)-alstonerine, cathafoline, dichomine, hydroxyindolenine, ibogamine, (-)-apparicine, isomethuenine, lochnerine, monogagaine (**908**), perivine, stemmadenine, 12-methoxyvoaphylline,

tabernamine, voacamine, voaphylline, vobasine, vallesamine, voacangine, voaphylline, vobasine and others from the different parts (Kupchan *et al*., 1963; Perera *et al*., 1983a-c, 1984a,b, 1985a; Van Beek *et al*., 1985b; Zaima *et al*., 2013).

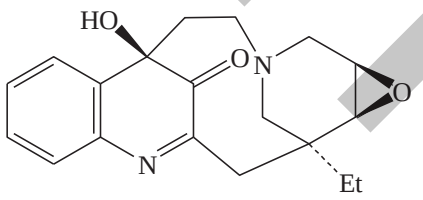
440. *Tabernaemontana divaricata* (L.) R. Br. ex. Roem & Schult. (syns. *Ervatamia divaricata*, *Ervatamia microphylla*, *Tabernaemontana coronaria*): About 70 alkaloids were extracted from the plant e.g. appericine, catharanthine, conodurine, conodusarine, conofoline, conolidine, conolobine A, conolobine B, conophyllidine, conophylline, conophyllinine, coronaridine, dregamine, ervaticine, ibogamine, isovoacangine, isovoacristine, lahoricine, *O*-acetylvallesamine, pachysiphine, pericyclivine, perivine, stemmadenine, taberhanine, tabernaelegantine A, tabernaemontanine, tabernaricatines A-G, tubotaiwine, vallesamine, voacamine, voacangine, voacristine, voacristine hydroxyindolenine, voafinidine, voafinine (**909**), voaharine, voalenine, voaphylline and others (Van Beek *et al*., 1984b; Arambewela and Ranatunge, 1991; Pratchayasakul *et al*., 2008; Low *et al*., 2010; Bao *et al*., 2013; Chaiyana *et al*., 2013).



907 2-ethyl-3-[2-(3-ethylpiperidino)ethyl] Indole



908 Monogagaine

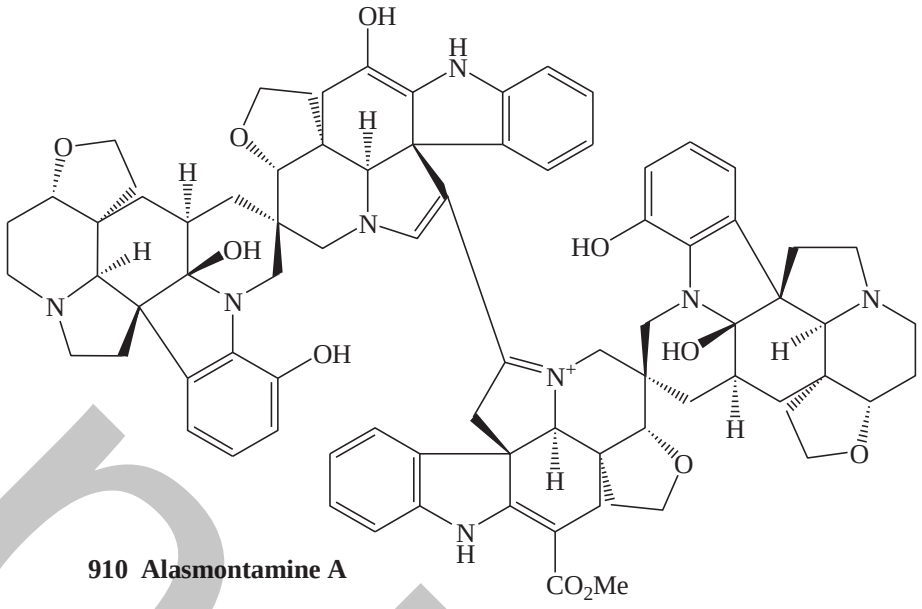


909 Voafinine

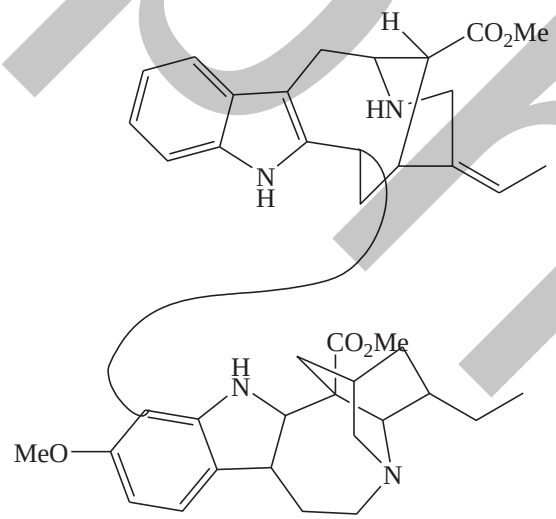
441. *Tabernaemontana eglandulosa*: From the leaves and twigs, 22 alkaloids were isolated, including coronaridine, dichomine, voaphylline, tubotaiwine, ibogamine and others from the leaves, twigs and stem bark (Van Beek *et al*., 1982b, 1984c; Perera *et al*., 1983b).
442. *Tabernaemontana elegans* Stapf.: Alasmontamine A (**910**), apparicine, conoduramine, dregamine, dregaminol, tabernaelegantines A-D, tabernines A-C, tabernaemontaninol, tabernemontanine, tabernaelegantinines A, and B, tabernaelgantinidine, tubotaiwine, voacangine, vobasine, vobasinol and others from the different parts (Gabetta *et al*., 1975; Bombardelli *et al*., 1976a; Danieli *et al*., 1978, 1980a ; van der Heijden*et al*., 1986a; Hirasawa *et al*., 2009c; Mansoor *et al*., 2009a, 2013; Pallant *et al*., 2012). Several alkaloids have been isolated from a callus culture of the plant e.g. 3-oxo-isovoacangine, isovoacangine, isositsirikine, geissoschizol, tabernaemontanine, vobasine, vobasinol, apparicine, tubotaiwine, 3-*R*/*S*-hydroxy-conodurine and monogagaine (van der Heijden *et al*., 1986b; Lucumi *et al*., 2002).
443. *Tabernaemontana flavicans*: Ipophyllidine and ibophyllidine N_b-oxide, from the stems (Achenbach and Raffelsberger, 1980b).
444. *Tabernaemontana fuchsiaefolia* A. DC.: Affinisine, catharanthine, conopharyngine, coronaridine, ibogaline, ibogamine, tabernanthine, voacangine, voacamidine, voacangine

hydroxyindolenine, voachalotine, and others from the different parts (Achenbach, 1966b; Fernandez *et al.*, 1967; Braga *et al.*, 1980; Zocoler *et al*., 2005).

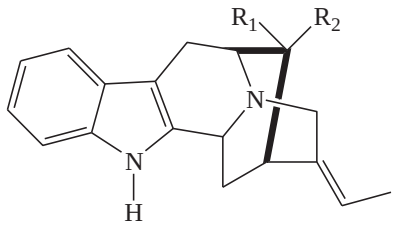
445. *Tabernaemontana glandulosa*: Conophylline, difforlemenine, difforlemenitine, 10,12-dimethoxynareline, tabernulosine, 12-demethoxytabernulosine, vincadiffine and others (Achenbach and Raffelsberger, 1980d; Achenbach *et al*., 1982a, 1994).
446. *Tabernaemontana heterphylla*: Affinisine, coronaridine, epiheyneanine, olivacine, vobasine and voacangine from the roots (Filho *et al*., 1983).
447. *Tabernaemontana heyneana* Wall. (syn. *Ervatamia heyneana*): Heyneanine, coronaridine, ibogamine, hydroxyibogamine, voacangine, tabernoxidine, tabersonine, voacristine, voacristine hydroxyindolenine, isovoacristine and other from the different parts (Govindachari *et al*., 1965b, 1966; Kupchan *et al*., 1966; Ramiah and Mohandas, 1966; Saradamma *et al*., 1971; Meyer *et al.*, 1973; Rao and Singri, 1979; Joshi *et al*., 1984; Srivastava *et al*., 2001; Grover *et al.*, 2002).
448. *Tabernaemontana holstii*: Conoduramine, conodurine, coronaridine, 19-oxoconodurine, 19-oxocoronaridine, 19-(2-oxopropyl)conodurine, gabunine, pericyclivine, perivine, tubotaiwine-*N*-oxide and vobasine from the roots (Kingston *et al*., 1977a,b).
449. *Tabernaemontana hystrix* Steud : Affinine, affinisine, N_b-methylaffinisine, coronaridine, coronaridine hydroxyindolenine, 3-oxocoronaridine, olivacine, 3-oxo-coronaridine hydroxyindolenine, hystrixnine, ibogamine, ibogamine-7,8-dione, vobasine and others from the root bark (Monnerat *et al*., 2005; de Souza *et al*.., 2010).
450. *Tabernaemontana johnstonii* (Stapf) Pichon (syn. *Tabernaemontana stapfiana*): Conodurine, conoduramine, 19,20-epoxyconoduramine, gabunamine, gabunine, isovacangine, ibogamine, pericyclivine and perivine from the stem bark (Kingston *et al.*, 1976, 1978).
451. *Tabernaemontana hilariana*:: Catharanthine, coronaridine, coronaridine pseudoindoxyl, 3-hydroxycoronaridine, 3-oxocoronaridine, ibogamine, tabernanthine, tetraphyllicine, voacangine, voacangine hydroxyindolenine, voacangine pseudoindoxyl, isovoacangine and others from the root bark, fruits and seeds (Cardoso *et al*., 1997, 1998; Cardoso and Vilegas, 1999).
452. *Tabernaemontana laeta* Mart. (syn. *Peschiera laeta* (Mart.) Mieres): Conodurine (**911**), coronaridine (**912**), heyneanine (**913**), tabernamine (**914**), voacamine (**915**), voacangine (**916**) and N_b-methylvoachalotine (**917**), ibogamine (**918**), olivacine (**919**), voacangine hydroxyindolenine (**920**), pericyclivine (**921**), normacusine B (**922**), affinisine (**923**), vobasine (**924**), dehydrovoachalotine (**925**), conopharyngine (**926**), voachalotine (**927**) and voachalotine oxindole (**928**) from the root bark and stalks (Medeiros *et al.*, 1999, 2001; Vieira *et al*., 2008).
453. *Tabernaemontana laurifolia*: Isovoacristine (Cava *et al*., 1965).
454. *Tabernaemontana longipes* Donn. Smith: Coronaridine, tabersonine and voacangine from the leaves and seeds (Cicció-Alberti, 1979; Cicció-Alberti and Hoet, 1981).
455. *Tabernaemontana macrocarpa* Jack: Coronaridine, 3oxo-coronaridine, 19*R*-heyneanine, coronaridine pseudoindoxyl, voacangine pseudoindoxyl, voacangine hydroxyindolenine and others ndoxyl from the roots (Husain *et al*., 1997).
456. *Tabernaemontana markgrafiana* (syn. *Bonafousia longituba*): Twenty-four indole alkaloids from the bark including 19(*E)*-akuammidine, chippiine, coronaridine, 3-oxocoronaridine, eglandine, ibogaine, ibogamine, vallesamine, *O*-acetylvallesamine, voacangine, (-)-3*R*-methoxyvoacangine, and19*S*-voacristine (Nielsen *et al*., 1994).
457. *Tabernaemontana mucronata*: Tabernamontanine from the bark (Santos *et al*., 1965).



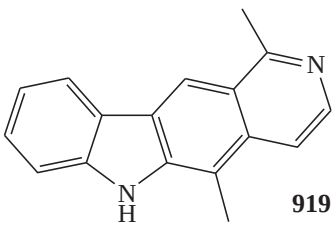
910 Alasmontamine A



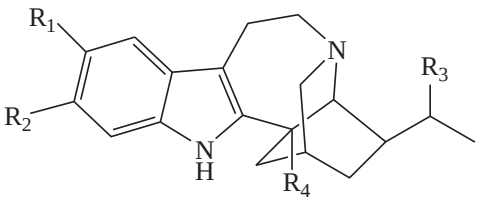
911 Conodurine



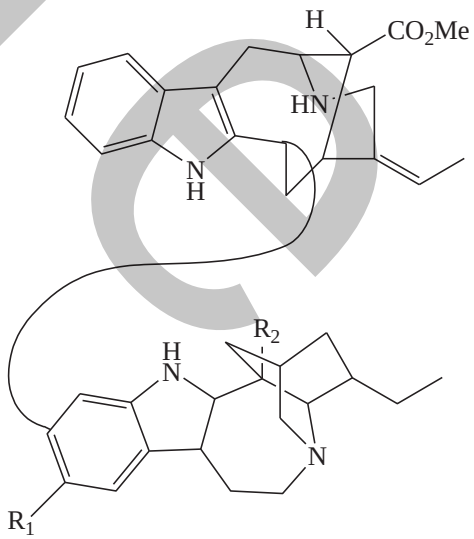
917 N_b-Methyl voachalotine R_1=CH_2OH, R_2=CH_2OH
922 Normacusine B R_1=CH_2OH, R_2=H



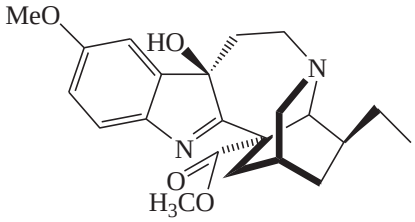
919 Olivacine



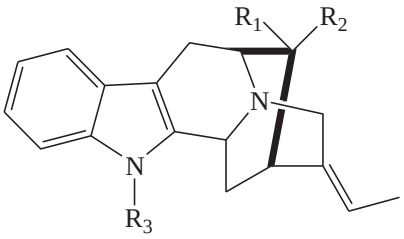
		R_1	R_2	R_3	R_4
912	**Coronaridine**	H	H	H	CO_2Me
913	**Heyneanine**	H	H	OH	CO_2Me
916	**Voacangine**	OMe	H	H	CO_2Me
918	**Ibogamine B**	H	H	H	H
926	**Conopharyngine**	OMe	OMe	H	CO_2Me



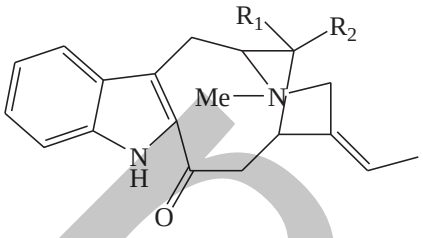
		R_1	R_2
914	**Tabernamine**	H	H
915	**Voacamine**	OMe	CO2Me



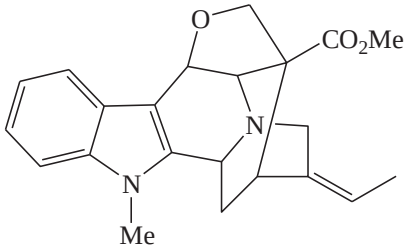
920 Voacangine hydroxyindolenine



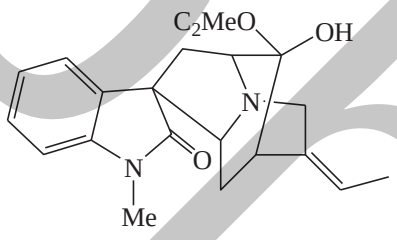
		R_1	R_2	R_3
921	**Peryclyclivine**	CO_2Me	H	H
923	**Affinisine**	H	CH_2OH	Me
927	**Voachalotine**	CH_2OH	CO_2Me	Me



924 Vobasine R_1=CO_2Me, R_2=H



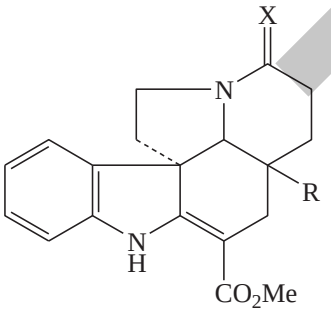
925 Dehydrovoachalotine



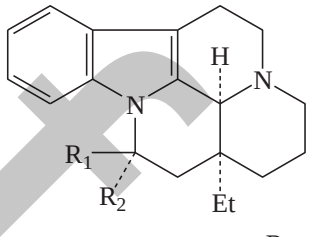
928 Voachalotine oxindole

458. *Tabernaemontana olivacea*: Akuammidine, condylocarpine N_b-oxide, coronaridine, coronaridine hydroxyindolenine, coronaridine pseudoindoxyl, heyneanine, ibogaine, ibogamine, voacangine, voacangine hydroxyl-indolenine, voacangine pseudoindoxyl and voacristine from the stems (Achenbach and Raffelsberger, 1980a).
459. *Tabernaemontana oppositifolia*: Coronaridine, ibogamine, voacamine and voacangine from the roots (Gorman *et al.*, 1960).
460. *Tabernaemontana pachysiphon*: Apparicine, affinine, bobasine, conoduramine, conodurine, conopharyngine, coronaridine, 3-oxocoronaridine, gabunine, tubotaiwine, isositsirikine, normacusine B, isovoacangine, pachysiphine, pericyclivine, perivine, tubotaiwine, ibogaline, voacamine, voacangine, isovoacangine, lochnericine and others from the different parts (Patel and Poisson, 1966; Van Beek *et al*., 1984b,d; Höft *et al*., 1998; Ingkaninan *et al*., 1999).
461. *Tabernaemontana pachysiphon* var. *cumminsi*: Conopharyngine, 20-hydroxy-conopharyngine, conopharyngine pseudoindoxyl and others from the leaves of (Crooks and Robinson, 1973).
462. *Tabernaemontana pandacaqui* Poir. (Banana bush): Akuammicine, coronaridine, ervafoline, (-)-ibogamine, iboxygaine, isovoacangine, pericyclivine, tabernaemontanine, tabernanthine, vallesamine and others from the different parts (Angular-Santos, 1963, 1964; Aguilar-Santos *et al.*, 1964; Van Beek *et al*., 1984d; Okuyama *et al*., 1992 Abe *et al.*, 1993). Alkaloid production in cell tissue cultures was reported (Sierra *et al*., 1991).
463. *Tabernaemontana pauciflora* Bluyme (syn. *Ervatamia blumeana* Mark gr.): Coronaridine, 3-(2-oxopropyl)coronaridine and others (Okuyama *et al*., 1992).

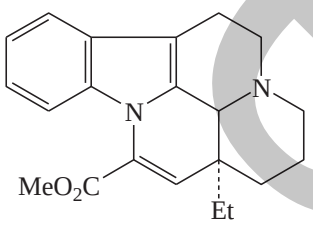
464. *Tabernaemontana penduliflora* K. Schum.: Coronaridine, 10-hydroxy-coronaridine, conopharyngine, voacangine and others from the different parts (Van Beek *et al*., 1984d; Ambujam and Parimoo, 1985; Masuda *et al*., 2000).
465. *Tabernaemontana psorocarpa*: Coronaridine, 16-*epi*-isositsirkine, tetrahydroalstonine, vallesiachotmaine, isovallesiachotamine, voacangine and others from the stem bark, twigs and leaves (Achenbach *et al*., 1982b; Van Beek *et al*., 1983).
466. *Tabernaemontana psychotrifolia*: Affinine, angustine, ibogaine, olivacine, voacamine, pleiocarpamine, (+)-tubotaiwine, coronaridine, voacamidine, and others from the different parts (Benoin *et al*., 1968; Burnell and Medina, 1971; Van Beek *et al*., 1984d).
467. *Tabernaemontana quadrangularis*: Coronaridine, 3-oxocoronaridine, coronaridine hydroxyindolenine, ibogaine, (-)-ibogamine, (19*R*)-19-hydroxyibogamine, voacangine, 3-oxovoacangine and others from the roots (Achenbach and Raffelsberger, 1980c).
468. *Tabernaemontana recurya* Rox.: Tabernemontanine from the root bark (Khan and Nur-E-Kamal, 1985).
469. *Tabernaemontana retusa*: Coronaridine, coronaridine hydroxyindolenine, (-)-heyneanine, (+)-ibogamine, (-)-ibogamine, pachysiphine, tabersonine, voacristine, voaphylline, and others from the different parts (Van Beek *et al*., 1984d).
470. *Tabernaemontana ridelii*: Minovincine (**929**), (+)-8-oxominovincine (**930**), (±)-vincadifformine (**931**) and (+)-vincadifformine (Cava *et al*., 1968a).
471. *Tabernaemontana rigida*: (±)-Vincamine, (+)-vincamine (**932**), (+)-apovincamine (**933**), (±)-14-epivincamine (**934**), (-)-epivincamine (Cava *et al*., 1968a).



	X	R
929 (+)-Minovincine	H_2	Ac
930 (+)-8-Oxominovincine	O	Ac
931 (+)-Vincadifformine	H_2	Et



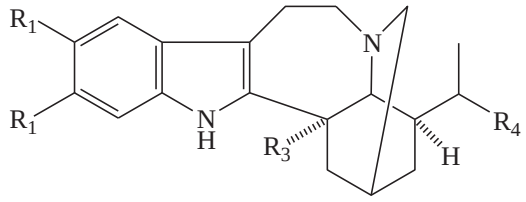
	R_1	R_2
932 (+)-Vincamine	OH	COOMe
934 (-)-14-Epivincamine	COOMe	OH



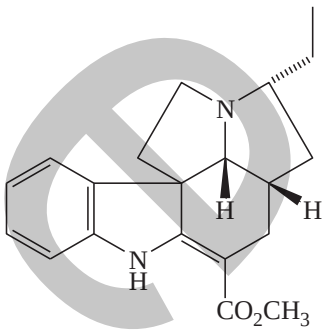
933 (+)-apovincamine

472. *Tabernaemontana rupicola*: Rupicoline (voacangine pseudoindoxyl) and montanine (voacristine pseudoindoxyl) (Niemann and Kessel, 1966).
473. *Tabernaemontana salzmanni* A. DC.: Coronaridine, (19*S*)-heyneanine, voachalotine, olivacine, voacangine, isovoacangine, isovoacristine, (3*S*)-hydroxiisovoacangine, and 3-oxo-coronaridine from the root barks and leaves (Figueiredo *et al*., 2010).
474. *Tabernaemontana sananho* Ruiz & Pav.: Coronaridine, 19-hydroxycoronaridine, 20-hydroxycoronaridine, ibogamine and voacangine from the bark (Delle Monache *et al*., 1977).

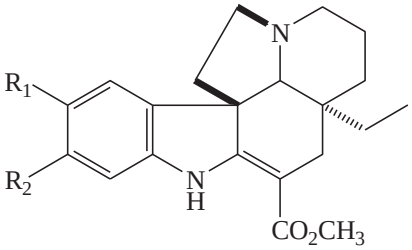
475. *Tabernaemontana siphilitica*: Appariciné, bonafousine, isobonafousine, coronaridine, geissoschizine, pleiocarpamine, tetrastachynine, tetrahydroalstonine, (+)-tubotaiwine, vincadifformine, voacangine and others from the leaves (Van Beek *et al*., 1984d).
476. *Tabernaemontana sphaerocarpa*: Dregamine, biscarpamontamines A and B and tabernemontanine from the stem and leaves (Chatterjee *et al*., 1968; Zaima *et al*., 2009).
477. *Tabernaemontana stapfiana*: Pericyclivine, perivine, conodurine, conoduramine, 19',20'-epoxyconoduramine, gabunamine, gabunine, (-)-ibogamine, isovoacangine, (+)-tubotaiwine, tubotaiwine N_4-oxide, and tabernamine from the stem and root barks (Van Beek *et al*., 1984d).
478. *Tabernaemontana stellata*: Coronaridine from the root bark (Van Beek *et al*., 1984d).
479. *Tabernaemontana subglobosa* Merr.: Conodurine, 19'(*R*)-hydroxycondurine, conoduramine, 19'(*R*)-hydroxy-conduramine, coronaridine, dregamine, heyneanine, tabernaelegantine A, tabernaelegantine B, tabernaemontanine, tabernamine and isovoacangine from the leaves and roots (Takayama *et al*., 1994c).
480. *Tabernaemontana undulata*: Coronaridine, 18-hydroxycoronaridine, 19*R*-heyneanine, 18-hydroxyvoacangine, 19*R*-voacristine, 19-epiheyneanine, quebrachidine, voacangine and voaphylline from the seeds, stem and root barks (Cave *et al*., 1972; Bruneton *et al*., 1979; Van Beek *et al*., 1984d; Van Beek and Verpoorte, 1985).
481. *Tabernaemontana ventricosa*: Akuammicine, akuammicine *N*-oxide appariciné, conopharyngine, 10-hydroxycoronaridine, 16-*epi*-isositsirikine, hydroxyheyneanine, norfluorocurarine, rauwolfine and 10-tubotaiwine (Raymond-Hamet, 1935; Van Beek *et al*., 1984d; Schripsema *et al*., 1986).
482. *Tabernaemontana wallichiana*: Coronaridine, voacangine, isovoacangine, and voacristine from the leaves and stem bark (Talapatra *et al*., 1976).
483. *Tabernanthe elliptica* (*Daturicarpa elliptica*): Coronaridine (**935**), ibogaine (**936**), iboxygaine (**937**), voacangine (**938**), ibogaline (**939**), ibophyllidine (**940**), tabersonine (**941**), vincadifformine (**942**), pandoline (**943**) and *epi*-pandoline (**944**) from the different parts (Bruneton *et al*., 1976; Delaude *et al*., 1984; Bisset, 1989).



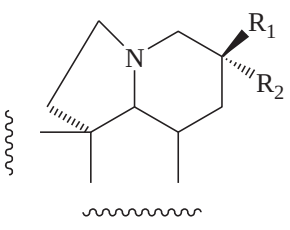
935 Coronaridine $R_1=R_2=R_4$, $R_3=COOCH_3$
936 Ibogaine $R_1=OCH_3$, $R_2=R_3=R_4=H$
937 Iboxygaine $R_1=OCH_3$, $R_2=R_3=H$, $R_4=OH$
938 Coronaridine $R_1=OCH_3$, $R_2=R_4=H$, $R_3=COOCH_3$
939 Coronaridine $R_1=R_2=OCH_3$, $R_3=R_4=H$



940 Ibophyllidine



941 Tabersonine $R_1=R_2=H$, $\Delta^{14,(15)}$
942 Vincadifformine $R_1=R_2=H$

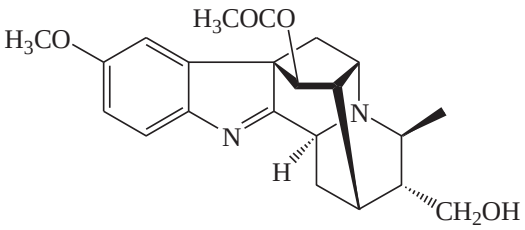


943 Pandoline $R_1=C_2H_5$, $R_2=OH$
944 epi-Pandoline $R_1=OH$, $R_2=C_2H_5$

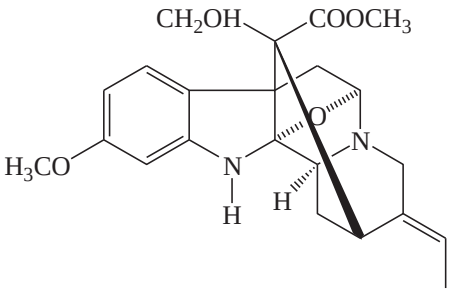
484. *Tabernanthe iboga* Baillon: Coronaridine, ibogaine, ibogamine, ibogaline, iboluteine, iboquine, ibochine, demethoxyiboluteine, iboxygaine, iboxyphylline, tabernanthine, voacangine, voacristine, gebonine, kisantine, kimvuline and oters from the leaves, roots and seeds (Delourme-Houdé, 1946; Burchardt *et al*., 1952; Goutarel and Janot, 1953; Taylor, 1957; Dickel *et al*., 1958; Bartlett *et al*., 1958; Neuss, 1959; Goutarel *et al*., 1958, 1974; Percheron, 1959; Khuong-Huu *et al*., 1976; Jenks, 2002). Several alkaloids were isolated from the cell suspension culture (Pawelka and Stöckigt, 1983; Bisset, 1989; Kontrimavičiūt *et al*., 2007).
485. *Tabernanthe pubescens*: From the fruits, leaves, trunk-barks and root-barks, sixteen alkaloids were isolated e.g. coronaridine, ibogaine, ibogaline, ibogamine, 3,6-oxidoibogaine, voacangine, voacristine and voaphylline (Mulamba *et al*., 1981).
486. *Tabernanthe subsessilis* Stapf: Ibophyllidine and iboxyphylline from the leaves (Khuong-Huu *et al*., 1976).
487. *Tonduzia longifolia*: Ajmaline, deserpidine, reserpine, rescinnamine from the roots (St. Andre *et al*., 1956) and vincamajine from the trunk bark (Goodwin and Horning, 1956).
488. *Tonduzia pittieri* (*Alstonia pittieri*): Akuammine, cabucraline, cabufiline, cathafoline, picrinine and others from the leaves and stem bark (Morfaux *et al*., 1990, 1992).
489. *Trachelospermum jasminoides*: Coronaridine, voacangine, apparicine, conoflorine, 19-*epi*-voacangarine, ibogaine, tabernaemontanine, vobasine and voacangine-7-hydroxyindolenine from the leaves and stems (Atta-ur-Rahman *et al*., 1987a, 1988d).
490. *Vallesia antillana* Wood: (+)-Apparicine, aspidospermine, demethylaspidospermine, vallesine, (-)-vincadifformine and others from the leaves, branches and roots (Cuellar Cuellar and Lorenzo, 1977; Cuellar Cuellar and Padron Palomares, 1978a,b).
491. *Vallesia dichotoma* Ruiz et Pav: Twenty-eight indole and dihydroindole alkaloids from the bark and leaves e.g. (+)-akuammidine, (-)-appricine, aspidospermine, dichotamine, dichotine, (-)-*N*-methyl-quebrachamine, vincadifformine, *N*-acetylaspidoalbidine, pleiocarpamine, reserpine, stemmadenine, (-)-vallesamidine and (-)-vallesine (Deulofeu *et al*., 1940, 1941; Holker *et al*., 1959; Brown *et al*., 1963, 1968; Walser and Djerassi, 1964, 1965; Djerassi *et al*., 1966; Ling and Djerassi, 1970; Ling *et al*., 1970).
492. *Vallesia glabra* (Cav.) Link.: Apparicine, vallesine, aspidospermatine, aspidospermine, condylocarpine, haplocidine, 18-oxohaplocidine, 11-methoxydichotine, (-)-rhazinilam, tubotaiwine and vincadifformine from leaves and stems (Deulofeu *et al*., 1939 1940; Hartmann and Schlittler, 1939; Schlittler and Rottenberg, 1948; Zèches *et al*., 1995).
493. *Vinca difformis* (Pourr.) M. Pichon: Akuammidine, difforine, difforlemenine, normacusine B, sarpagine, vellosimine, vincadiffine, vincamajine, vincadifformine and vincamidine (Gosset *et al*., 1962; Janot *et al*., 1965; Solans *et al*., 1987; Garnier and Mahuteau, 1985, 1986).
494. *Vinca elegantissima* Hort.: Elegantine, elegantissine, isoelegantissine, reserpine, vincarpine and dihydrovincarpine from the whole plant (Bhattacharyya and Pakrashi, 1972; Ali *et al*., 1976a,b).
495. *Vinca erecta* Rgl. et Schmalh: Akuammicine, akuammidine, akuammine, apovincamine, copsinilame, eburnamine, (-)-eburnamonine, epoxykopsinine, ercinamine, ercinaminine, ericine, ericinine, ervamicine, ervamine, ervanamine, ervine, ervinceine, ervincidine, ervincine, ervincinine, ervinidinine, kopsinine nitrate, kopsanone, kopsinilam, kopsinilamine, minovincinine, quebrachamine, reserpinine, tombozine, venalstonine, vincanicine, vincine, vincamine, vincanidine, vincanine, vincaricine, vincaridine, vincarine, vincarinine, vineridine, vinerine, vinerinine, vinervine, vinervinine and others (Koretskaya *et al*., 1963; Kuchenkova *et al*., 1965, 1967; Yuldashev and Yunusov, 1965; Aripov *et al*., 1966, 1967; Kasymov *et al*., 1965, 1966, 1967; Rakhimov *et al*., 1967a,b,

1969a-c, 1970a,b, 1971; Abdurakhimova *et al.*, 1968a,b; Malikov *et al*., 1970; Il'yasova *et al*., 1970, 1971; Malikov and Yunusov, 1967, 1971a,b; Khalmirzaev *et al*., 1973a-c, 1974, 1975, 1977, 1980; Osmanov *et al*., 1973; Sharipov *et al*., 1974, 1976; Yagudaev *et al*., 1983).

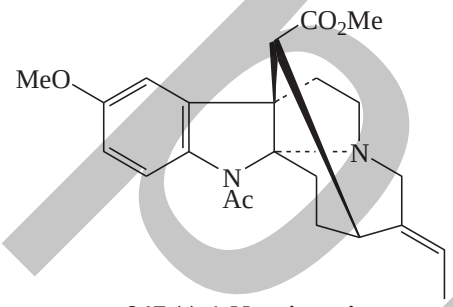
496. *Vinca herbacea* Waldst. et Kit (*Vinca libanotica* Zucc.) (periwinkle): Akuamicine, akuammine, burnamine, caboxine A, elegantine, 10-methoxyraucaffrinoline (**945**), 11-methoxyburnamine (**946**), carapanaubine, ervine, herbaceine, herbadine, herbaine, herbaline, herbarinine, herbavine, isoherbavine, hervine, kopsinine, lochnerine, isomajdin, majdine, isomajdine, norfluorocurarine, picrinine, reserpine, reserpinine, iso-reserpinine, serpentine, tabersonine, vincaherbine, vincaherbinine, vincamajine and vincamine, vincanine (norfluorocurarine), vincarine and others from the different parts (Babaev, 1967; Pyuskyulev *et al*., 1967a,b; Ognyanov, 1966; Ognyanov *et al*., 1966, 1967, 1968; Babaev, 1967; Clauder *et al*., 1969; Zabololtnaya *et al.*, 1969; Bocharova, 1970; Dzhakeli and Mudzhiri, 1970; Aliv *et al.*, 1971; Asatinani *et al*., 1971; Vachnadze *et al*., 1971 1972a,b, 2010; Dzhakeli, 1978a,b; Chkhikvadze *et al*., 1980; Babaev and Aliev, 1981; Chkhikvadze, 1985, 1986; Chkhikvadze and Vachnadze, 1986; Ebrahimzadeh *et al*., 1995; Boğa *et al*., 2011).
497. *Vinca libanotica* Zucc.*:* Herbadine, herbamine and vincamajine (Aynilian and Farnsworth, 1974; Aynilian *et al.*, 1974, 1975).
498. *Vinca major*: Ajmalicine, ajmaline, akuammicine, akuammine, catharantine, ervine, isomajdine, lochvinerine, majdine, majoridine, majorinine, majvinine, perivincine, pseudo-akuammigine, reserpine, reserpinine, serpentine, vinblastine, vincadifformine, vincamajine, vincamajoreine, vincamedine, vincamine, vincarine, vincawajine, vincristine, vindoline and others (Farnsworth *et al*., 1960; Trojanek and Hodkova, 1962; Janot *et al*., 1965; Gorunovic and Lukic, 1969; Potier *et al*., 1965; Zsadon *et al*., 1972; Banerji and Chakrabarty, 1974, 1977;Vachnadze *et al*., 1976; Il'yashenko *et al*., 1977; Balsevich *et al*., 1982; Hu and Wang, 1982; Zhukovich and Vachnadze, 1984; Zhukovich, 1987; Atta-ur-Rahman *et al*., 1995a; Ebrahimzadeh *et al*., 1995).
499. *Vinca major* subsp. *major* L.: 11-Hydroxypolyneuridine (Bahadori *et al*., 2012).
500. *Vinca minor* L. (Small periwinkle): Akuammicine, apovincamine, eburnamine, ervine, isoeburnamine, eburnamenine, (-)-eburnamontine, epipleiocarpamine N^4-oxide, majdine, methoxyvincamine, picrinine, tombozine, methoxyminovincine, minovincine, minovincinine, (-) norvincorine (**947**), N^1-methyl-2β,16β-dihydroakuammicine-N^4-methochloride, reserpine, reserpinine, vallesiachotamine, vicine, vincesine, (-)-vincadifformine, vincamajine, vincamidine, vincamine, epivincamine, isomajdine, isovincamine, vincaminine, vincanine, vincaminorine, vincarubine (**948)**, vincasine, vincatine, vincinine, vineridine, vinerine, vinoxine, vintsine, 4-methylraucubaininium chloride and others from blossoms, leaves, stems, roots (Trojanek *et al*., 1959, 1962; Lyapunova and Borisyuk, 1961; Plat *et al*., 1962b; Chekan, 1964; Lyapunova, 1964, Neczypor, 1965 Doepke and Meisel, 1966, 1968a,b; Mokry *et al*., 1967; Doepke *et al*., 1968, 1969; Grossmann *et al*., 1973; Votický *et al.*, 1974, 1979; Robakidze *et al*., 1978, 1980; Trojanek *et al*., 1980; Proksa *et al*. 1986, 1987, 1989; Proksa and Grossmann, 1991; Tulyaganov and Nigmatullaev, 2000; Bahadori *et al*., 2012).
501. *Vinca pubescens* (periwinkle): Majoridine and reserpinine (Chkhikvadze *et al*., 1971).
502. *Vinca pusilla*: Rauwolscine (α-yohimbine, corynanthidine), vindoline, demethoxyvindoline and vincapusine (Chatterjee *et al*., 1971; Mitra *et al*., 1981).
503. *Vinca sardosa* (Stearn) Pignatti: Conoflorine, venalstonine *N*(1)-methyl-14,15-didehydrotuboxenine, $N_{(1)}$-methyl-14,15-didehydro-12-methoxyaspidofractinine,



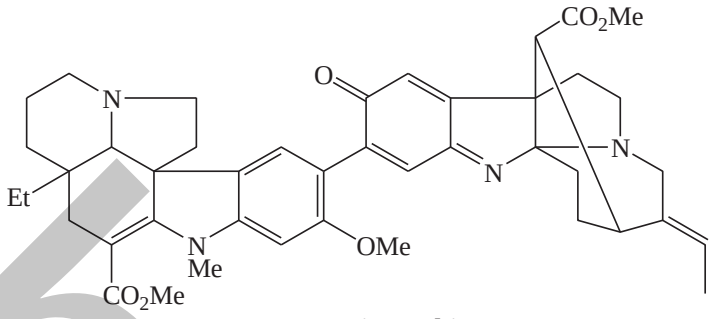
945 10-Methoxyraucaffrinoline



946 11-Methoxyburnamine



947 (-)-1-Norvincorine



948 Vincarubine

$N_{(1)}$-methyl-14,15-didehydro-12-hydroxyaspidofractinine and others from the different parts (Crippa *et al.*, 1990; Nicoletti *et al.*, 1998).

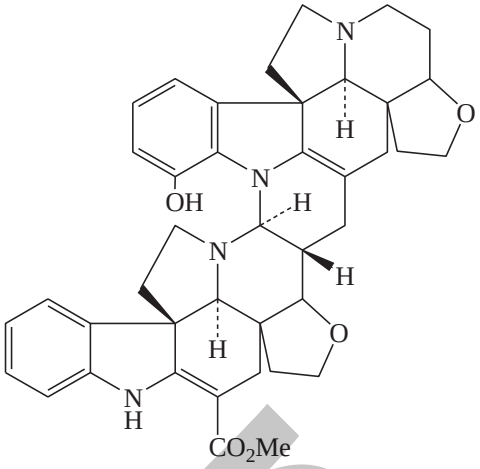
504. *Voacanga africana* Stapf.: Beninine, conoflorine, coronaridine, folicangine, ibogaine, iboluteine, iboxygaine, perakine, reserpine, tabernanthine, tabersonine, Δ^{14}-vincanol, voacamidine, Δ^{14}-vincamone, voacafricine, voacafrine, voacaline,voacamine, voacamine *N*-oxide, voacangalactone, voacangine, voacanginine, voacorine, voacandimine A (**949**), voacryptine, voafolidine, isovoafoline, voaphylline, vobasine, vobtusine, β-yohimbine, and others from leaves, stem bark, roots and seeds (Janot and Goutarel, 1955a; La Barre and Gillo, 1955; Goutarel and Janot, 1956; Goutarel *et al.*, 1956; Quevauviller and Blanpin, 1957; Rao, 1958; Stauffacher, 1958; Stauffacher and Seebeck, 1958; Pecherson, 1959; Renner, 1957, 1959; Renner and Prins, 1959; Quevauviller *et al.*, 1965; Gorman *et al.*, 1966;Kunesch *et al.*, 1967a,b, 1968a,b; 1970, 1977, 1981; Puisieux *et al.*, 1967; Poisson, 1969; Thomas and Biemann, 1968a,b; Diavara *et al.*, 1984; Pegnyemb *et al.*, 1999; Jenks, 2002; Koroch *et al.*, 2009; Kitajima *et al.*, 2011, 2013; Harada *et al.*, 2012; Mei *et al.*, 2012; Dan *et al.*, 2013). Cell suspension cultures produced lochnericine, (-)-minovincinine, (-)-tabersonine, voafrine and voafrine B (Stöckigt *et al.*, 1982, 1983).

505. *Voacanga bracteata*: Epivoacangarine, epivoacorine and vobtusine from the bark (Poisson *et al.*, 1965; Puisieux *et al.*, 1965).

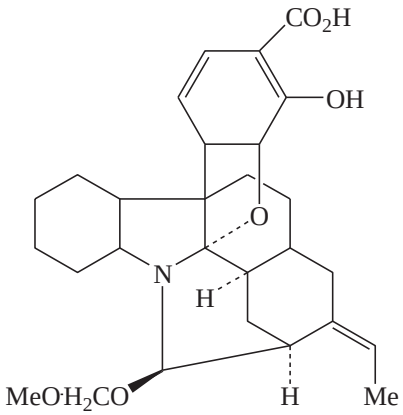
506. *Voacanga chalotiana*: Akuammidine, amatine, beninine, cuanzine, quimbeline, 3ξ-hydroxyvobtusine, polyneuridine, tetrahydroalstonine, Δ^{14}-vincamine, voacarpine, voachalotine, voacoline, voamonine, vobtusamine, vobtusine and others from the root bark (Pecher *et al.*, 1960; Denayer Tournay *et al.*, 1965; Lhoest *et al.*, 1965; Braekman *et al.*, 1969b; Tirions *et al.*, 1968; Gabetta *et al.*, 1974; Bombardelli *et al.*, 1974b,c, 1975, 1976b; Bombardelli and Gabetta, 1977; Danieli *et al.*, 1980b, 1983).

507. *Voacanga dregei*: Dragamine, voacangine and vobtusine from the different parts (Schüler*et al.*, 1958; Neuss and Cone, 1959).

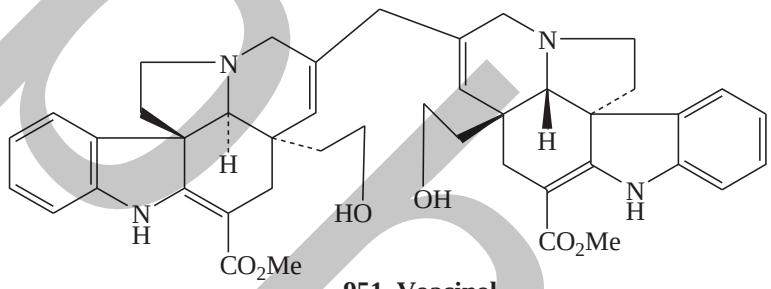
508. *Voacanga foetida* (Bl.) Rolfe: Lombine, voacamine voacangine and vobtusine from the bark (Santos and Aguilar-Santos., 1964; Hadi and Bremner, 2006).
509. *Voacanga globosa*: Globospiramine, tabernaemontanine voacamine, voacangine and vobtusine from the different parts (Quirin *et al*., 1964; Santos and Aguilar-Santos, 1964; Santos *et al.*, 1964; Geoffrey, 2010; Lleander *et al*., 1972).
510. *Voacanga grandifolia* (Miq) Rolfe: Rhazine, voacalgines (**950**), B-E, voacamine, voacangine, voacinol (**951**), vobtusine, deoxyvobtusine, desacetylvindoline and others from the leaves, fruits and bark (Biswas, 1970; Majumbar and Dinda, 1974; Majumder *et al*., 1973b, 1974b), (Govindachari *et al*., 1987; Hirasawa *et al*., 2013).
511. *Voacanga megacarpa*: Voacamine and vobtusine (Renner *et al*., 1963; Magno *et al.*, 1964).
512. *Voacanga obtusa*: Voacangine was isolated from the roots and trunk bark (Janot and Goutarel, 1955a,b).
513. *Voacanga papuana*: Voacangine, vobustine and voacamine from bark, root bark and leaves (Guise *et al*., 1965).
514. *Voacanga schweinfurthii*: Voacamine, voacangine, voacorine, vobtusine and others from the leaves and stem bark (Fish *et al*., 1960; Fish and Newcombe, 1964; Newcombe and Patel, 1969).
515. *Voacanga schweinfurthii* var. *puberula*: Coronaridine, ibogain, perivine, voacamidine, voacamine, voacangine, 3,6-oxidovoacangine, vobasine and vobasinol from the seeds, root bark and stem bark (Richard *et al*., 1983).
516. *Voacanga thouarsii*: Ibogaine, voacangine, voacristine, vobtusine, vobtusine lactone, subsessiline and others from the leaves (Rolland *et al*., 1973, 1975; Kunesch *et al*., 1977). Tabersonine and others were formed by tissue cultures (Fenchal *et al*., 1983).
517. *Voacanga thouarsii* var. *obtusa*: Voacangine (**952**), ibogaine (**953**), voacamine (**954**), vobtusine (**955**), voacristine (**956**), iboluteine (**957**), vobasine (**958**), 18-decarbomethoxyvoacamine (**959**) and voaluteine (**960**), from the bark (Goldblatt *et al*., 1970).
518. *Winchia calophylla*: Alstoguestine, calophylline A (**961**), cantleyine, *N*(4)-demethyl-12-methoxyalastogustine (**962**) echitamidine, echitamine, picrinine, 17-*O*-acetylechitamine, evodiamine, rhazimanine, rutaecarpine, stemmadenine, tubotaiwine, vallesamine, venotropine and others from the leaves, stem bark and roots (Chen *et al*., 1988; Ming *et al*., 1988; Li *et al*., 1993; Zhu *et al*., 2005; Gan *et al*., 2006; Li *et al*., 2012b).
519. *Wrightia antidysentrica* R. Br. (= *Holarrhena antidysentrica* (Roxb) Wall): Wrightine (conessine, neriine) from the seeds and bark (Jeger and Prelog, 1960).
520. *Wrightia coccinea* Sims.: Qualitative study of the alkaloids of the different parts (leaf, stem and bark) of the plant growing in Egypt, revealed the presence of 6 spots; 2 of which were identical with conessine and kurchicine (Zaki *et al*., 1983).
521. *Wrightia javanica*: Two pregnane alkaloids, wrightiamines A (**963**) and B (**964**) (Kawamoto *et al*., 2003).
522. *Wrightia tinctoria* (Roxb.) R. Br.: Tryptanthrin (**965**) from the leaves (Sethi, 1969; George *et al*., 1996).
523. *Wrightia tomentosa* Roem. and Sch.: Conkurchine, conessine, conessidine, holarrhine and kurchine (Jayaswal, 1977).



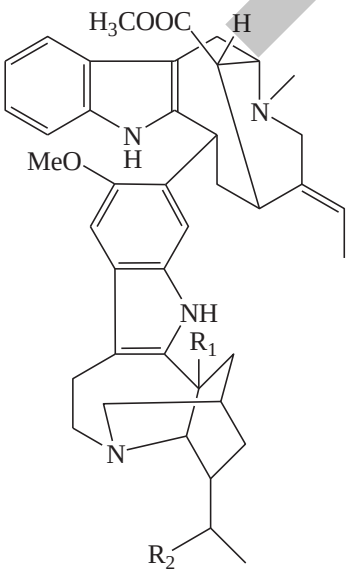
949 Voacandimine A



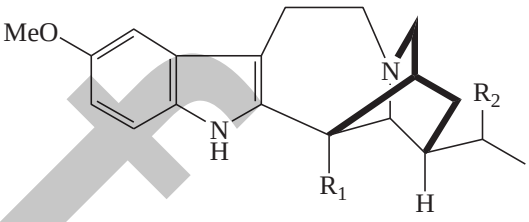
950 Voacalgine A



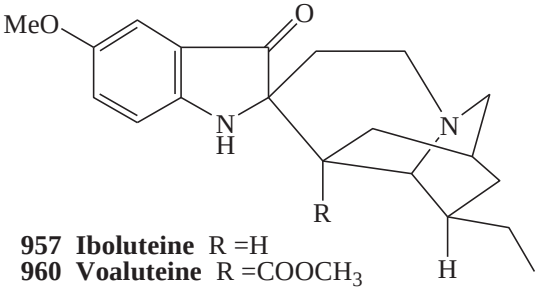
951 Voacinol



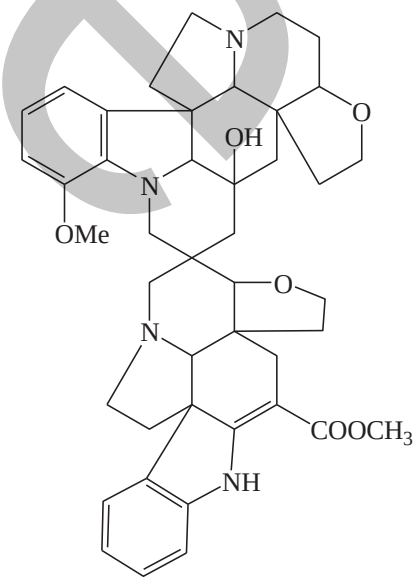
954 Voacamine R =$COOCH_3$, R_2=H
959 18-Decarbomethoxyvoacamine R =$COOCH_3$,R_2=OH



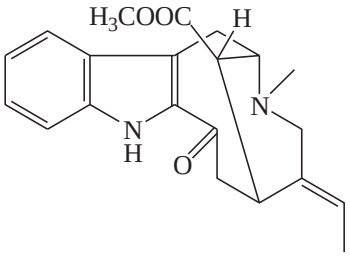
952 Voacangine R_1 =$COOCH_3$, R_2 =H
953 Ibogaine R_1 =H, R_2 =H
956 Voacristeine R_1 =$COOCH_3$, R_2 =OH



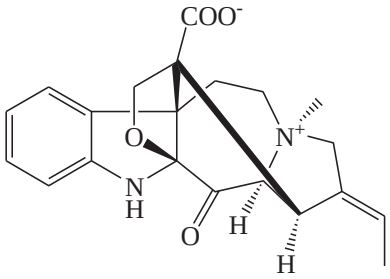
957 Iboluteine R =H
960 Voaluteine R =$COOCH_3$



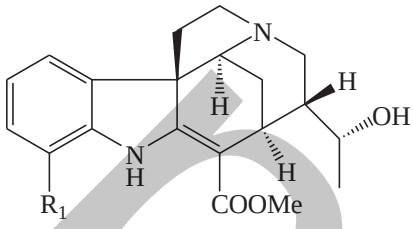
955 Vobtusine



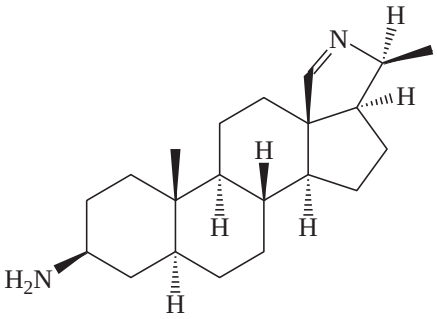
958 Vobasine



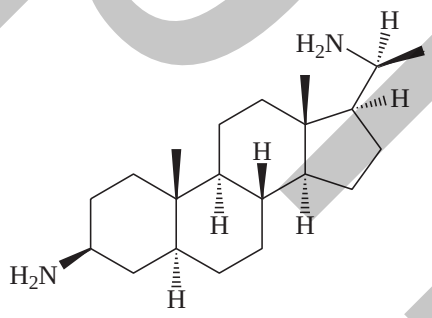
961 Calophylline A



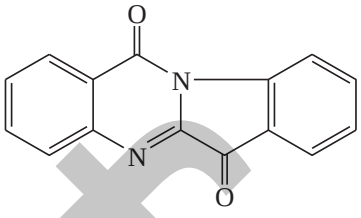
962 N(4)-demethyl-12-methoxyalstogustine



963 Wrightiamine A



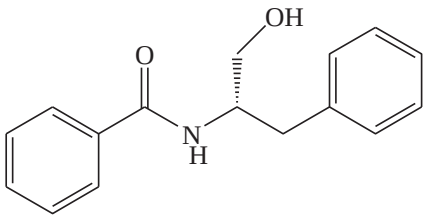
964 Wrightiamine B



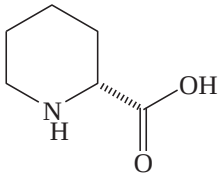
965 Tryptanthrin

Other Nitrogenous Compounds

1. *Catharanthus lanceus*: 3,4-Dimethoxyphenylacetamide (Segelman *et al*., 1970).
2. *Catharanthus pusillus*: *N*-Benzonyl-L-phenylalaninol (**966**) [Benzamide, *N*-[(1*S*)-1-(hydroxymethyl)-2-phenylethyl-] (Battersby and Kapil, 1965).
3. *Cerbera manghas*: Benzamide from the leaves of (Zhang *et al.*, 2010c).
4. *Holarrhena pubescens*: Pubamide (3,18-dioxo-11α-hydrocona-1,4-diene) (Siddiqui *et al*., 2001), norkurchamide (3,20-dioxo-11α-hydroxycona1,4-diene) and pubatriol (3-oxo-11α,19,22-trihydroxycona-1,4-diene) (Siddiqui *et al*., 2003a) from the bark.
5. *Rauwolfia yunnanensis*: A macrocyclic diamide, cylodiacaprylamide from the roots (Geng and Liu, 2008).
6. *Strophanthus scandens*: Pipecolinic acid (**967**), 4-hydroxypipecolinic acid and others from the leaves and latex (Schenk and Schuette, 1961, 1953).
7. *Vinca rosea*: Cytokinin N^6-(Δ^2-isopentenyl)adenosine from the crown gall tumour tissue (Chen *et al*., 1976) .



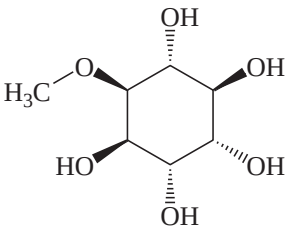
966 N-Benzoyl-L-phenylalaninol



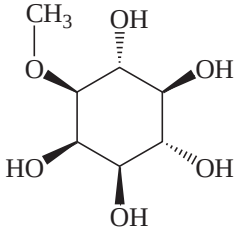
967 Pipecolinic acid

Cyclitols

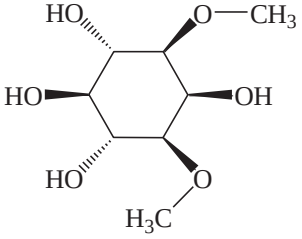
Cyclitols (cycloalkanes containing one hydroxyl group on each of three or more ring atoms, cyclic polyols) have been isolated from several species of the family. Quebrachitol (**968**), L-bornesitol (**969**) and dambonitol (**970**) were isolated from some species of the Apocynaceae (Plouvier, 1961, 1973). The yields of dambonitol from the stems and leaves of six *Trachelospermum* varied from 0.05 to 0.44 % (Nishibe *et al*., 1973g; 2001a). The cyclitols of several Apocynaceae leaves were investigated from the viewpoint of chemotaxonomy. (+)-Bornesitol or dambonitol were isolated from saubfamily Plumerioideae leaves except for (-)-quebrachitol from *Aspidosperma quebracho-blanco*. The difference in cyclitols was observed between genera *Catharanthus* ((+)-bornesitol) and *Vinca* (dambonitol), which gave a significant comment to the classification of *Catharanthus roseus*. (-)-Bonesitol or dambonitol were isolated from subfamily Apocynoideae leaves except for (-)-quebrachitol from *Trachelospermum difforme*. The difference of cyclitols was observed between *Trachelospermum difforme* grown in North America ((-)-quebrachitol) and *Trachelospermum* species grown in Asia (dambonitol), which gave a significant suggestion to the classification of *Trachelospermum difforme*. Dambonitol was detected in *Trachelospermum asiaticum*, *Trachelospermum foetidum*, *Trachelospermum gracilipes*, *Trachelospermum jasminoides*, *Trachelospermum jasminoides* var. *pubescens* and *Trachelospermum liukiuense* (Nishibe *et al.*, 1973g). (-)-Quebrachitol was identified in *Aspidosperma quebracho-blanco* and *Trachelospermum difforme*. (+)-Bornesitol was detected in several species e.g. *Amsonia elliptica* (Nishibe *et al*., 1973f), *Apocynum androsoemifolium*, *Apocynum cannabinum* (Nishibe *et al.*, 1973g), *Apocynum venetum* var. *basikurmon* (Sakushima *et al*., 1978), *Catharanthus lanceus*, *Catharanthus roseus* (*Vinca rosea*) (Nishibe *et al*., 1973f), *Cerbera manghas* , (Nishibe *et al.*, 1973g), *Ochrosia nakaiana*, *Plumeria acutifolia* (Nishibe *et al*., 1971d), *Poacynum hendersonii*, *Poacynum pictum*, *Rauwolfia serpentine* (Nishibe *et al.*, 1973g) and *Thevetia neriifolia* (Nishibe *et al.*, 1973c). Also, dambonitol was detected in *Anodendron affine* (Shima *et al*., 1971b, 1972), *Chonemorpha griffithii* (Bai *et al*., 2013), *Nerium indicum* (Nishibe *et al*., 1971c), *Strophanthus gratus*, *Vinca herbacea*, *Vinca major*, *Vinca minor* (Nishibe *et al.*, 1973g). The following are examples of other species which contain cyclitols. Moreover, methyl-*myo*-inositol the acetyl derivative of methoxy-*myo*-inositiol and inositol di-methyl ether were isolated from *Himatanthu sarticulata* (De Sa Barreto *et al*., 1998), *Mucoa duckei* (De Assis Galotta *et al*., 2012) and *Trachelospermum asiaticum* var. *intermedium* (Miyazaki *et al*., 1958) respectively.



968 Quebrachitol



969 D-(-)-bornesitol

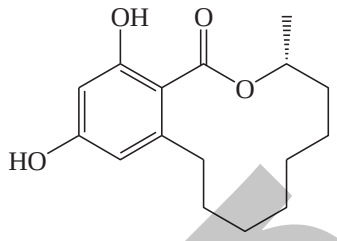


970 Dambonitol

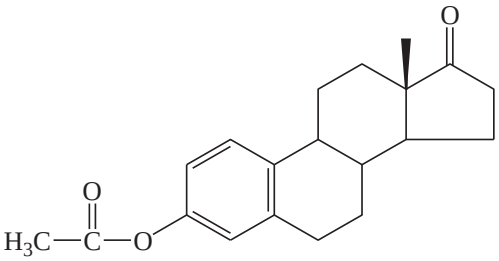
Other Constituents

1. *Allamanda cathartica* L.: 2-Furancarboxaldehyde-5-(hydroxymethyl) from the leaf and stem (Prabhadevi *et al.*, 2012).
2. *Allamanda* species: (2*R*)-2,5,7,8-Tetramethyl-2-[(4*R*,8*R*)-(4,8,12-trimethyl-tridecyl)]-6-chromanol was identified from *Allamanda neriifolia*, *Allamanda schottii* and *Allamanda violacea* (Chaveerach *et al.*, 2014). (3*S*,8*S*, 9*S*, 10*R*,13*R*,14*S*,17*R*)-17-[(2*R*,5*S*)-5-Ethyl-6-methylheptan-2-yl]-10,13-dimethyl-2,3,4,7,8,9,11,12,14,15,16,17-dodecahydro-1*H*-cyclo-penta[a]phenanthren-3-ol was identified from both *Allamanda neriifolia* and *Allamanda schottii* (Chaveerach *et al.*, 2014). Five major carotenoids, β-carotene, neoxanthin, lutein, violaxanthin and zeaxanthin were found in the flowers (Tinoi *et al.*, 2006). α-Tocopherol, a form of vitamin E is one of the predominant components of three out of four species *viz.Allamanda violacea*, *Allamandas chottii*, and *Allamanda neriifolia* at 26.33%, 15.41%, and 9.16%, respectively (Chaveerach *et al.*, 2014).
3. *Alstonia boonei* De Wild: Two sulphur compounds *viz.* thiobenzoic acid and 1,2-oxathiane from the leaves (Okwu and Ighodaro, 2010).
4. *Alstonia venenata* R. Br.: 2-Butanone, 2-propen-1-ol, 2,4-dihydroxy-2,5-dimethyl-3(2*H*)-, 2,4-dihydroxy-2,5-dimethyl-3(2*H*)-furan-3-one, tetrahydropyran *Z*-10-dodecenoate, *Z*-2-dodecenol, 4-dodecanol, 1-cyclohexylnonene, thymine and vitamin E from the leaves (Sutha *et al.*, 2012).
5. *Apocynum venetum*: Adhyperforin [4-hydroxy-6-methyl-1,3,7-tris(3-methylbut-2-en-1-yl)-5-(2-methylbutanoyl)-6-(4-methylpent-3-en-1-yl)bicycle [3.3.1]non-3-ene-2,9-dione] from the leaves (Zhang *et al.*, 2010b).
6. *Beaumontia grandiflora* Wall.: Benzyl β-D-gluocopyranoside from the leaves and branches (Kanchanapoom *et al*., 2002).
7. *Catharanthus roseus*: Two long chain aliphatic glucosides, 3,7,11,19,23,27-hexamethyl-15-(hydroxymethyl)octacosa-5,8,20-triene-10β,18α-diol-10β-D-glucopyranoside 15-acetate and*n*-heptacosan-13α-ol 13β-D-glucopyranoside, along with *n*-pentadecyl octadec-9-enoate and *n*-hentetracont-36-en-5β-ol, from the hairy root cultures (Chung *et al*., 2007b, 2008b).
8. *Cerbera manghas*: Des-*O*-methyllasiodiplodin (a macrolide (*R*)-de-*O*-methyl-lasiodiplodin (**971**) (Zhou *et al.*, 2013a), blumenol A [(4S)-4-Hydroxy-4-[(1E,3*R*)-3-hydroxy-1-buten-1-yl]-3,5,5-trimethyl-2-cyclohexen-1-one] (Zhang *et al*., 2006b), loliolide (6*S*,*7αR*)-6-hydroxy-4,4,7α-trimethyl-6,7-dihydro-5*H*-1-benzofuran-2-one) (Zhang *et al*., 2010c) and *Z*-Ligustilide, a phthalide, (3*Z*)-3-butylidene-4,5-dihydro-2-benzofuran-1(3*H*)-one) (Wang *et al*., 2007).
9. *Ecdysanthera rosea*: An apocarotenoid, 2,4,7-trimethyl-2,4,6,8-tetraene-dialdehyde (Zhu *et al*., 2010).
10. *Holarrhena antidysenterica*: Two resinols, lettoresinol-A, $C_{28}H_{60}O_5$, m. 227-8° and lettoresinol-B (I), $C_{32}H_{54}(OH)_2$, m-136-7°, from the latex (Chowdhury and Peacock, 1935).
11. *Holarrhena pubescens*: Puboestrene (**972**) (3-acetoxy-17-oxo-1,3,5(10)-estratiene) (Siddiqui *et al*., 2001).
12. *Hunteria zeylanica*: (2*E*,6*S*)-8-(α-L-Arabinopyranosyl-(1→6)-β-D-gluco-pyranosyloxy)-2,6-dimethyloct-2-eno-1, 2''-lactone was isolated from the leaves (Xie *et al*., 2013).
13. *Ichnocarpus frutescens*: Butyl oleate, *n*-octyltetracontane, tetratriacontadiene, *n*-nonadecanyl benzoate, and benzocosanylarachidate from the stems (Aggarwal *et al*., 2010).
14. *Landolphia owariensis* O. Beauv.: (5R)-5 -[(1S)- 1,2- dihydroxyethyl]- 3,4-di-hydroxyfuran-2(5*H*)-one from the seed pulp (Okonkwo and Osadebe, 2013).

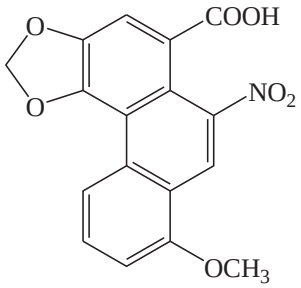
15. *Melodinus fusiformis*: (6*Z*,8*E*,17*E*)-Icosa-6,8,17-trien-10-ol and 1,3-diolein (glyceryl-dioleate) from the leaves (Wang *et al*., 2012a).
16. *Nerium oleander*: Two aristolochic acid derivatives (**e.g. 973**), two aristolactam derivatives (**974, 975**) and methylparaben (**976**) from the leaves (Almahy and Khalid, 2006).



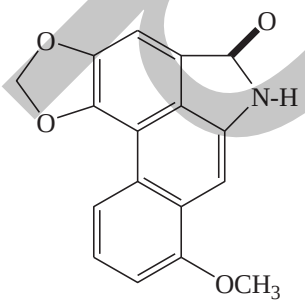
971 (*R*)-de-O-methyl-lasiopodin



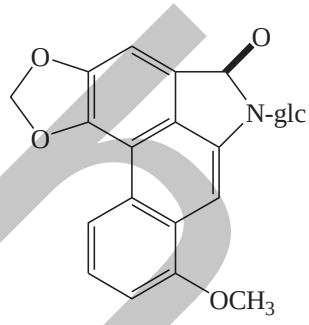
972 Puboestrene



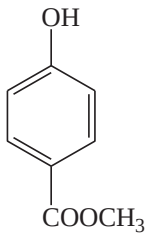
973 Aristolochic acid



974 Aristolactam

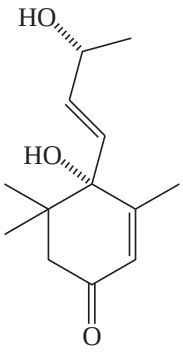


975 Aristolactam-N-β-D-glucoside



976 Methylparaben

17. *Plumeria rubra*: 2,3-Dihydroxypropyl octacosanoate from the stem bark (Kuigoua *et al*., 2010).
18. *Poacynum hendersonii*: Benzyl alcohol β-D-glucopyranoside and benzyl alcohol β-D-xylopyranosyl-(1→6)-β-D-glucopyranoside and roseoside from the flowers (Morikawa *et al*., 2012).
19. *Rauwolfia vomitoria*: Vomifoliol (**977**) [blumenol A, (6*S*,9*R*)-6-hydroxy-3-oxo-α-ionol] from the leaves (Pousset and Poisson, 1969).



977 Vomifoliol

20. *Rauwolfia yunnanensis*: Loliolide from the roots (Geng and Liu, 2008).
21. *Stemmadenia* species: Physalienpalmitic acid ester (β,β-carotene-3β,3'β-dioldipalmitate) was isolated from the ripe fruit (Ciccio and Castro, 1984).

22. *Tabernaemontana divaricata*: Tetratriacontanol and bis (2,3-dihydroxy-propyl) octacosanedioate, from the roots and stems (Liang *et al*, 2007a).
23. *Thevetia peruviana*: β-Carotene, neoxanthin, lutein, violaxanthin, zeaxanthin and β-cryptoxanthin (Tinoi *et al*., 2006).
24. *Trachelospermum asiaticum* var. *intermedium*: Hydroxymethylfurfural from the stems (Nishibe *et al*., 1973h).

In addition, several species of the family Apocynaceae have been reported to produce rubber e.g. *Landolphia gentilii*, *Landolphia heudelotii*, *Landolphia klainei*, *Landolphia thollonii*, *Landolphia owariensis* (Kirsche and Viaud, 1982). The latex from *Landolphia owariensis*, *Landolphia owariensis* var. *owariensis*, *Landolphia dulcis* and *Landolphia dulcis* var. *barteri* gave *cis*-1,4-polyisoprene rubber in 24.20, 23.35, 16.08, and 17.44% yield, respectively (Nwadinigwe, 1981). *Plumeria acutifolia*, *Plumeria mexicana* and *Plumeria rubra* are reported as rubber-yielding plants in Mexico (Olsson-Seffer, 1911). The sap of *Pluneria rubra*, indigenous to Mexico contains 25.5% caoutchouc of excellent quality (Anon, 1913). The young branches yield about 4% of their wt. of a rubber of good quality (Cayla, 1913).