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TABERNAEMONTANA L. (APOCYNACEAE): A REVIEW OF ITS TAXONOMY, PHYTOCHEMISTRY, ETHNOBOTANY AND PHARMACOLOGY*

T.A. VAN BEEK[a], R. VERPOORTE[a], A. BAERHEIM SVENDSEN[a], A.J.M. LEEUWENBERG[b,†] and N.G. BISSET[c]

[a]*Department of Pharmacognosy, Subfaculty of Pharmacy, State University of Leiden, P.O. Box 9502, Leiden,* [b]*Laboratory for Plant Taxonomy and Plant Geography, Agricultural University, Wageningen (The Netherlands) and* [c]*Pharmacognosy Research Laboratories, Department of Pharmacy, Chelsea College, University of London, Manresa Road, London SW3 6LX (U.K.)*

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Summary

The taxonomy, phytochemistry, ethnobotany, and pharmacology of the genus *Tabernaemontana* L. (Apocynaceae) is reviewed. The genus is currently being revised taxonomically; most of the segregate genera are being reunited with it and the number of species that will ultimately be recognized will probably be about 100. All the names encountered in the chemical and ethnobotanical literature have been evaluated as far as possible, and a list is presented of the recognized species and their synonyms.

The biogenesis and classification of the indole alkaloids found in *Tabernaemontana* species is set out and some problems in the determination of their stereochemistry are discussed. To facilitate access to the information, three lists have been compiled: the alkaloids in alphabetical order; the alkaloids in order of increasing molecular weight; and the alkaloids grouped according to their biogenetic classification, together with the species and plant part(s) in which they are known to occur. Biogenetic and chemotaxonomic aspects are briefly considered. A table of the non-alkaloidal constituents is also included.

*Part 8 in the series "Pharmacognostical studies of *Tabernaemontana* species." For Part 7, see Ref. 444.

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The ethnobotany of individual *Tabernaemontana* species is outlined and an overall assessment made. Likewise, information on the pharmacology of crude extracts and individual alkaloids from *Tabernaemontana* species has been assembled and appraised.

1. Introduction

The genus *Tabernaemontana* was named after J. Th. Müller, a German physician and botanist who was born in Bergzabern and died in Heidelberg in the Pfalz in 1590; he latinized his birthplace as Tabernaemontanus. It is a large genus, belonging to the Apocynaceae and comprising about 100 species distributed throughout the tropical, as well as some subtropical, parts of the world. Everywhere, its species are used in traditional medicine and for other purposes. The medicinal forms and uses are varied and range from decoctions for washing wounds to steam-baths for curing syphilis. Two examples of the numerous non-medicinal applications are the use of root extracts as ingredients in arrow poisons and latex as birdlime. In the chemical screening of *Tabernaemontana* species usually alkaloids are found and only occasionally other important secondary plant metabolites. Most of the phytochemical work has therefore been concerned with the alkaloids. Although in the latter part of the 19th century it was realized that many of the uses were connected with the alkaloid content of the plants, it is only during the last 25 years that the structures of the often complex indole alkaloids have been elucidated. During this period, about 150 phytochemical papers dealing with members of the genus *Tabernaemontana* have appeared and more than 200 different alkaloids have been isolated and identified.

Major problems with this genus concern the assessment of its taxonomic status and that of the species assigned to it and its relationships with neighboring genera. In a number of instances, research groups have worked on the same plant without realizing it, because the names used in the identification of the material have subsequently been recognized as belonging to the same species, e.g. *T. crassa* with 5 synonyms and *T. coffeoides* with many synonyms and numerous infra-specific taxa.

The phytochemical findings should be able to give information about the biosynthetic routes involved in the production of indole alkaloids as well as the chemotaxonomy of the genus. They can also be of help in finding new medicinally interesting compounds or in establishing a rationale for the local use of a plant or extract against particular ailments or diseases. In contrast with the enormous amount of phytochemical work, relatively little pharmacological research has been carried out on the alkaloids that have been isolated. This is due not to the absence of pharmacologically interesting compounds, for camptothecine, vincamine, coronaridine, ibogaine and olivacine are among the alkaloids present in the genus, but mostly to the often small amounts of pure compound isolated or to the lack of pharmacological expertise and equipment necessary for screening the pure substances or crude extracts. Better co-operation between phytochemists and pharmacologists could well lead to new and useful findings. The ethnobotanical literature gives many examples of similar uses of different species from different parts of the world; and although some of the reported uses may be of questionable validity, it is hard to believe that others are without any foundation at all.

The authors hope that the present review will facilitate solution of the problems encountered in the taxonomy of the species which have been studied chemically and in the scattered and sometimes rather old literature concerning the isolation and structure-elucidation of the alkaloids. It is also hoped that the ethnobotanical data will provide new clues and stimulate further research, because many species still remain to be investigated and undoubtedly new chemically or pharmacologically interesting compounds remain to be discovered.

2. Notes on the taxonomy of *Tabernaemontana* L.

The plant family Apocynaceae has long been a major center of interest to phytochemists, pharmacists and others. However, the nomenclature encountered in the literature, especially that relating to the genus *Tabernaemontana*, has been a recurring source of difficulty. One of the authors (A.J.M.L.) is currently preparing a monograph of the genus and of most of the other genera placed in the Tabernaemontaneae (= Tabernaemontanoideae); and in the course of this work it has been possible to check the identity of some of the voucher herbarium specimens cited in the chemical literature.

Tabernaemontana L. belongs to the tribe Tabernaemontaneae of the subfamily Plumerioideae of the family Apocynaceae. Some authors consider the Tabernaemontaneae to be a subfamily, but this view is not followed here since the differences between the Tabernaemontaneae and the other tribes of the Plumerioideae are no greater than the differences between the other tribes themselves, e.g. Carisseae, Chilocarpeae, Ambelanieae, Plumerieae and Rauvolfieae. This conclusion is based on a comparative study involving most of the genera of the Plumerioideae and many of those belonging to the Apocynoideae (= Echitoideae).

Available phytochemical data tend to support this classification. Many genera of the Plumerioideae, including those of the Tabernaemontaneae, contain indole alkaloids, while genera of the Apocynoideae often have steroidal glycosides. There are, nevertheless, certain exceptions, e.g. *Holarrhena* R.Br., which is usually placed in the Plumerioideae, contains steroidal instead of indole alkaloids (see references cited in Bisset, 1981). So far, no such exceptions have been found among the genera allocated to the Tabernaemontaneae.

The following sections list the names and synonyms of the tribe, the genus and certain of the species. Where appropriate, notes are added, but in the case of the species only where there has been confusion in the nomenclature and/or delimitation.

2.1. *The Tribe*

Tabernaemontaneae G.Don 1837: 87 (partly, excl. *Cameraria*, *Vahea* (= *Landolphia*), *Plumeria*, *Vinca* and *Catharanthus*); Pichon 1949: 238; 1950: 147; Boiteau & Sastre 1975: 247; Boiteau & Allorge 1981a: 9.

Type genus: *Tabernaemontana* L.

Homotypic synonyms: Tabernaemontaninae (as subtribe) K. Schum. 1895a: 145 (partly, excl. *Geissospermum*). Tabernaemontanoideae (as subfamily) Stapf 1902: 26; Pichon 1949: 212; Boiteau & Sastre 1975: 247 (partly, as regards *Tabernaemontana* and *Voacanga*); Boiteau & Allorge 1981a: 9.

Heterotypic synonyms: Voacangeae Boiteau et Sastre 1975: 246. Type genus: *Voacanga* Thou.

Ervatamioideae (as subfamily) Tsiang et Li. 1977: 98. Type genus: *Ervatamia* Stapf (= *Tabernaemontana* L.). Homotypic synonyms: Ervatamieae (as tribe) Tsiang et Li 1977: 98. Ervatamiinae (as subtribe) Boiteau in Boiteau et Allorge 1981a: 9.

Small trees, often shrub-like, repeatedly dichotomously branched, with 1—2 pedunculate inflorescences in the forks. Leaves opposite, petiolate or less often sessile, those of a pair being equal or subequal, thin and herbaceous (e.g. in *Callichilia*, *Crioceras*, and several species of *Stemmadenia*, *Tabernaemontana* and *Voacanga*) or thick and coriaceous (e.g. in several species of *Tabernaemontana* and *Voacanga*). Corolla lobes overlapping to the left (except in *Callichilia subsessilis* (Benth.) Stapf and *Schizozygia* Baill.). Anthers mostly narrowly triangular, partly sterile. Fruit consisting of two carpels, free or partly to completely fused, dehiscent or not, with a mostly fleshy, often thick wall. Seeds more or less obliquely ellipsoid, with a deep groove on one side, usually with an aril.

About 10 genera throughout the tropics.

2.2. *The genus*

Tabernaemontana L. 1753: 210.

Lectotype species: *T. citrifolia* L. (designated by Britton & Wilson 1914: 89). Homotypic synonym: Section Taberna A.DC.

Heterotypic synonyms: *Pandaca* Noronha ex Du Petit Thouars 1806: x10. Type species: *P. retusa* (Lam.) Mgf. (= *T. retusa* (Lam.) Pichon). Homotypic synonym: *Conopharyngia* G. Don 1837: 98 (*C. retusa* (Lam.) G. Don).

Rejoua Gaud. 1826: 451. Type species: *R. aurantiaca* (Gaud.) Gaud. (= *T. aurantiaca* Gaud.).

Bonafousia A.DC. 1844: 359. Type species: *B. undulata* (Vahl) A.DC. (= *T. undulata* Vahl).

Peschiera A.DC. 1844: 360. Lectotype species: *P. hystrix* (Steud.) A.DC. (= *T. hystrix* Steud., designated by Markgraf 1938: 171).

Taberna Miers 1878: 61, not of A.DC. Lectotype species: *T. discolor* (Sw.) Miers (= *Tabernaemontana discolor* Sw., designated by Leeuwenberg 1976: 390).

Anacampta Miers 1878: 64. Lectotype species: *A. congesta* Miers (= *A. coriacea* (Link ex Roem. et Schult.) Mgf. = *T. coriacea* Link ex Roem. et Schult., designated by Markgraf 1938: 162).

Phrissocarpus Miers 1878: 71. Type species: *P. rigidus* Miers (= *T. rigida* (Miers) Leeuwenberg).

Codonemma Miers 1878: 72. Type species: *C. calycina* Miers (= *T. muelleriana* Mart. ex Muell.Arg.).

Merizadenia Miers 1878: 78. Lectotype species: *M. sananho* (Ruiz et Pav.) Miers (= *T. sananho* Ruiz et Pav., designated by Markgraf 1938: 166).

Anartia Miers 1878: 79. Lectotype species: *A. flavicans* (Roem. et Schult.) Miers (= *T. flavicans* Roem. et Schult., designated by Markgraf 1938: 165).

Ochronerium Baill. 1889a: 199; 1889b: 774. Type species: *O. humblotii* Baill. (= *T. humblotii* (Baill.) Pichon).

Tabunia K. Schum. 1896: 224. Lectotype species: *G. crispiflora* (K. Schum.) Stapf (= *T. crispiflora* K.Schum., designated by Bullock 1962: 395 = *T. eglandulosa* Stapf).

Ervatamia (A.DC.) Stapf 1902: 126. Type species: *E. coronaria* (Jacq.) Stapf (= *T. divaricata* (L.) R.Br. ex Roem. et Schult.).

Pagiantha Mgf. 1935: 549. Type species: *P. dichotoma* (Roxb.) Mgf. (= *T. dichotoma* Roxb.).

Oistanthera Mgf. 1935: 550. Type species: *O. telfairiana* (Wall.) Mgf. (= *T. telfairiana* Wall. = *T. mauritiana* Poir.).

Pestudipes Mgf. 1935: 550. Type species: *T. recurva* (Roxb.) Mgf. (= *Tabernaemontana recurva* Roxb.).

Stenosolen Mgf. 1937: 455. Type species: *S. heterophyllus* (Vahl) Mgf. (= *T. heterophylla* Vahl).

Taberna Mgf. 1938: 166, not of A.DC. or of Miers. Type species: *T. albiflora* (Miq.) Mgf. (= *Tabernaemontana albiflora* (Miq.) Pulle).

Hazunta Pichon 1948a: 207. Type species: *H. modesta* (Bak.) Pichon (= *T. modesta* Bak. = *T. coffeoides* Boj. ex A.DC.).

Muntafara Pichon 1948a: 209. Type species: *M. sessiliflora* (Bak.) Pichon (= *T. sessiliflora* Bak.).

Pandacastrum Pichon 1948a: 209. Type species: *P. saccharatum* Pichon.

Capuronetta Mgf. 1972a: 61; 1976: 177, *syn.nov.* Type species: *C. elegans* Mgf. (= *T. capuronii* Leeuwenberg, not *T. elegans* Stapf).

Sarcopharyngia (Stapf) Boiteau and Allorge 1976: 272. Type species: *S. ventricosa* (Hochst. ex A.DC.) Boiteau (= *T. ventricosa* Hochst. ex A.DC.).

Camerunia (Pichon) Boiteau and Allorge 1976: 274. Type species: *C. penduliflora* (K. Schum.) Boiteau (= *T. penduliflora* K.Schum.).

Leptopharyngia (Stapf) Boiteau and Allorge 1976: 276. Type species: *L. elegans* (Stapf) Boiteau (= *T. elegans* Stapf).

Protogabunia Boiteau and Allorge 1976: 276. Type species: *P. letestui* (Pellegr.) Boiteau (= *T. letestui* (Pellegr.) Pichon).

As pointed out above, there is much confusion in the botanical literature regarding the delimitation of the genus *Tabernaemontana* and it is for this reason that the present revision is being undertaken. So far, it has been possible to study living plants, mostly with both flowers and fruits, of at least 25 species: 6 Asian, 7 American and the rest continental African.

Examination of living and herbarium material of these plants and of herbarium material of most of the other species included in the genus leads to the conclusion that *Tabernaemontana* has at least 27 synonyms, listed above. The genus is thus accepted here sensu lato, and the basis for this broad delimitation will be discussed in the forthcoming monograph. To complete the revision of this large genus will take several years. The following notes represent a preliminary evaluation of the species which have so far been investigated chemically. Every effort has been made to find the earliest names for the various species in order to minimize name changes at a later stage.

As is common in taxonomic publications, references are cited by author, date and page number after the plant name; they are listed alphabetically in § 2.6.

2.3. *The species*

Tabernaemontana amygdalifolia Jacq. 1760: 14; 1763: 39, *t* 181, 15.

Type: Cult. Hort. Bot. Schoenbrunn, Vienna, *Jacquin* s.n. (W: lectotype).

Heterotypic synonym: *T. nereifolia* Vahl 1807: 21, *syn.nov.* Type: Puerto Rico: sin.loc., *von Rohr* 76 (C-VAHL: holotype; BM: isotype).

The species is clearly characterized by the rather small flowers and the almost completely exserted anthers. The leaf, flower and fruit characters indicate that it is closely allied to *T. citrifolia*, the type species of the genus, to *T. divaricata*, the type species of the synonym *Ervatamia*, and to *T. coffeoides*, the type species of the synonym *Hazunta*.

The plant occurs in Central America, the Caribbean, Colombia and Venezuela.

Tabernaemontana attenuata (Miers) Urb. 1915: 471.

Basionym: *Bonafousia attenuata* Miers 1878: 51.

Type: French Guiana: Karouany, *Sagot* 993 (BM: lectotype; K, P, W: isotypes).

This species is closely allied to *T. disticha* (q.v.). It is a much branched treelet occurring in the understory of forests in northern South America. The present author has collected it in French Guiana, the country of origin of the specimen *C. Moretti* 474 (CAY, P, WAG). This latter collection has been cited by Ladhar et al. (1981: 463) under the name *Anartia* cf. *meyeri* (G.Don) Miers, but it belongs here. As Don's description of *T. meyeri* is very incomplete and it has not been possible to trace the type specimen of the name, the identity of this taxon remains uncertain. It may thus be that *T. meyeri* G.Don is an earlier name for *T. attenuata*. Further investigation should clarify the point one way or the other.

Tabernaemontana calcarea Pichon 1948b: 241.

Type: Madagascar: Tsingy de Bemaraha, Res. Nat. IX, *Léandri* 558 (P: holotype).

Homotypic synonym: *Pandaca calcarea* (Pichon) Mgf. 1970: 32; 1976: 196.

Heterotypic synonym: *P. caducifolia* Mgf. 1970: 31; 1976: 200, *syn.nov.* Type: Madagascar: Saharaina River basin, Sahafary Forest, *Capuron* SF 20127 (P: holotype).

The leaves of both type specimens and of the other material cited by Markgraf and examined by the writer are exactly alike. The flowers of the material cited under *P. calcarea* are larger than indicated in the description, while the corolla tube may be twisted — a feature considered to be characteristic of *P. caducifolia*. The taxa are therefore united.

Tabernaemontana callosa Pichon 1948b: 247.

Type: Madagascar: Soanierana-Ambohoabe, *Lam & Meeuse* 5668 (P: holotype; G, K, L, WAG: isotypes).

Re-examination of the vegetative specimen *Boiteau 2121* (P), cited as a paratype of *Pandaca boiteaui* by Markgraf (1972b; 1976), shows that the specimen belongs here.

Tabernaemontana capuronii Leeuwenberg 1938: 335.

Basionym: *Capuronetta elegans* Mgf. 1972a: 61; 1976: 177, pl. 26, not *T. elegans* Stapf.

In accordance with the generic limits indicated in the previous section, this species, recently described in a new monotypic genus, belongs in *Tabernaemontana*. Its flowers resemble strikingly, those of *T. citrifolia* and *T. coffeoides*, while the leaves resemble those of *T. callosa* and *T. dichotoma*. The fruits are still unknown.

Tabernaemontana coffeoides Boj. ex A.DC. 1844: 370; Baker 1877: 224 (as *coffeaefolia*).

Type: Comores, Anjouan: sin.loc., *Richard* 268 (G-DC: holotype, not seen, microfiche in WAG; P: isotype, seen).

Homotypic synonyms: *Conopharyngia coffeoides* (Boj. ex A.DC.) Summerhayes 1928: 392. *Hazunta coffeoides* (Boj. ex A.DC.) Pichon 1948a: 208; Markgraf 1976: 162.

Heterotypic synonyms: *T. membranacea* A.DC. 1844: 370, *syn.nov.* Type: Madagascar: Ile Nossibé, *Richard* 369 (G-DC: holotype, not seen, micro-

fiche in WAG; P: isotype, seen). Homotypic synonyms: *Hazunta membranacea* (A.DC.) Pichon 1948a: 208; Markgraf 1976: 168. *Ervatamia membranacea* (A.DC.) Mgf. 1950: 29.

T. modesta Bak. 1882: 219, *syn.nov.* Type: Madagascar: Forests of West Betsileo, *Baron* 150 (K: holotype). Homotypic synonyms: *Ervatamia modesta* (Bak.) Stapf 1913: 78. *Hazunta modesta* (Bak.) Pichon 1948a: 207; Markgraf 1976: 171.

Ervatamia methuenii Stapf et M.L. Green 1913: 78. Type: Madagascar: near Beloha, *Methuen* s.n. (K: holotype). Homotypic synonym: *Hazunta modesta* var. *methuenii* (Stapf et M.L. Green) Pichon 1948a: 208; Markgraf 1976: 175, *syn.nov.*

Hazunta modesta var. *divaricata* Pichon 1948a: 208. Type: Madagascar: Bay of Diégo-Suarez, *Boivin* 2457 (P: holotype). Homotypic synonym: *H. modesta* var. *modesta* subvar. *divaricata* (Pichon) Mgf. 1970: 28, *syn.nov.*

H. angustifolia Pichon 1948a: 208. Type: Madagascar: Beloha sur Tsiribihina, *Grevé* 30 (P: holotype; BM, C, G, K, S: isotypes).

H. silicola Pichon 1948a: 208; Markgraf 1976: 166, *syn.nov.* Type: Madagascar: Analamera, Diégo-Suarez, *Humbert* 19094 (P: holotype).

H. velutina Pichon 1948a: 208. Madagascar: Mandrare, *Humbert* 13014 (P: holotype). Homotypic synonym: *H.modesta var. methuenii* subvar. *velutina* (Pichon) Mgf. 1970: 29; 1976: 176, *syn.nov.*

H. graciliflora Pichon 1948a: 209; Markgraf 1976: 170, *syn.nov.* Type: near Ankaladina, Boina, Lower Betsiboka River bank, *Perrier de la Bâthie* 1410 (P: holotype).

H. costata Mgf. 1970: 27; 1976: 163, *syn.nov.* Type: Madagascar: Majunga, *Perrier de la Bâthie* 17654 (P: holotype).

H. modesta var. *modesta* subvar. *brevituba* Mgf. 1970: 29; 1976: 173, *syn.nov.* Type: Madagascar: Majunga, *Humbert* 2356 (P: holotype).

H. modesta var. *modesta* subvar. *montana* Mgf. 1970: 29; 1976: 174, *syn.nov.* Type: Madagascar: Analandraisoa Forest, south-west of Tsiroano-Mandidy, *Léandri* 1848 (P: holotype).

H. membranacea f. *pilifera* Mgf. 1972b: 222; 1976: 170. *syn.nov.* Type: Madagascar: Anbalabongo, *Boiteau* 2025 (P: holotype).

T. coffeoides exhibits variation in many leaf, inflorescence, and flower characters; features of its fruits, on the other hand, are fairly constant. The considerable degree of variation is reflected in the large number of synonyms. Comparative studies of more than 100 specimens show that none of the taxa here reduced to synonymy could be maintained. The elaborate notes provided by Markgraf (1976) to distinguish the various taxa are unsatisfactory, as several of the specimens cited do not fit the descriptions of the taxa to which they are allocated.

This species occurs in Madagascar, the Seychelles and the Comores.

Tabernaemontana crassa Benth. 1849: 447; Huber 1963: 66.

Type: Liberia: Grand Bassa, *Vogel* 21 (K, holotype).

Homotypic synonyms: *Conopharyngia crassa* (Benth.) Stapf 1902: 144. *Sarcopharyngia crassa* (Benth.) Boiteau and Allorge 1981b: 233.

Heterotypic synonyms: *T. durissima* Stapf 1894: 24. Type: Gabon: Sibange Farm, Libreville, *Soyaux* 172 (K, holotype). Homotypic synonym: *Conopharyngia durissima* (Stapf) Stapf 1902: 143.

T. smithii Stapf 1898: 305, *syn.nov.* Type: Zaïre: Lower Zaïre River, *Smith* s.n. (BM: lectotype; C, P: isotypes). Homotypic synonym: *Conopharyngia smithii* (Stapf) Stapf 1902: 142.

T. thonneri Th. Dur. et De Wild. ex Stapf 1898: 306, *syn.nov.* Type: Zaïre: Lower Zaïre, Bogolo, near Businga, *Thonner* 109 (BR: holotype). Homotypic synonym: *Conopharyngia thonneri* (Th. Dur. et De Wild. ex Stapf) Stapf 1902: 143.

T. jollyana Pierre ex Stapf 1902: 144. Type: Ivory Coast: Dabou, *Jolly* 168 (K: holotype; BR, P: isotypes).

Gabunia gentilii De Wild. 1903: 68, *syn.nov.* Type: Zaïre: Kasai, Lubue, *L. Gentil* 15 Feb. 1902 (BR: lectotype). Homotypic synonyms: *Conopharyngia gentilii* (De Wild.) De Wild. 1907: 539. *Sarcopharyngia gentilii* (De Wild.) Boiteau and Allorge 1981b: 233.

G. odoratissima Stapf 1906: 526, *syn.nov.* Type: Uganda: Western Ankole, *Dawe* 352 (K: holotype).

Conopharyngia smithii var. *brevituba* De Wild. 1907: 541, *syn.nov.* Type: Zaïre: Mushenge, *Lescrauwaet* 392 (BR: holotype).

C. thonneri var. *demeusei* De Wild. 1907: 541, *syn.nov.* Type: Zaïre: Stanley Falls, *Demeuse* 440 (BR: holotype).

C. thonneri var. *lescrauwaetii* De Wild. 1907: 542, *syn.nov.* Type: Zaïre: Mununga, *Lescrauwaet* 265 (BR: lectotype).

Gabunia dorotheae Wernham 1914: 25. Type: Nigeria: Cross River State, Eket District, *Talbot* 3387 (BM: holotype).

T. crassa occurs widely in tropical Africa, from Sierra Leone to Uganda in the north and to Angola and Tanzania in the south. It is a bush or small tree which grows particularly in sparse forest or in secondary vegetation from the coast up to 2000 m altitude. The flowers open shortly before dusk, giving off a pleasant, sweet-smelling odour and they fall at the beginning of the next day. The part of the corolla above where the stamens are inserted varies greatly in length, so that the overall length of the corolla tube ranges from 34 to 100 mm. From the many collections, including spirit collections, made by the writer in different West and Central African countries it is evident that the flowers of trees growing on the coast are shorter than those growing further inland. In coastal forest they were approx. 34—45 mm and further away approx. 60—100 mm long; this last measurement was taken from the collection *Letouzey* 5135 (P), km 75 Yokadouma-Moloundou road, Cameroun, a distance of about 500 km from the coast. The corolla tube increases greatly in length just before the flowers open, and since the plants flower at night the flowers of many herbarium specimens have fallen off or have been dried in a withered condition. The considerable variation in

the length of the corolla tube, which in different type collections is to be seen only in buds in various stages of development, has been the reason why this species has so many synonyms.

T. crassa is similar to *T. contorta* in most characters. However, the two species differ particularly in the shape of the flowers, although in both the corolla tube is twisted at the base. The two species can be distinguished as follows:

Sepals 7—13 mm long; corolla tube 3.3—6 times as long as the calyx and above the insertion of the stamens 10—13 mm wide; inside the corolla tube from the point of insertion of the stamens to the mouth densely pilose; pubescent at the base of the lobes; stamens inserted 16—22 mm from the corolla base. Cameroun ..... *T. contorta*

Sepals 2.5—5—8 mm long; corolla tube 8—20 times as long as the calyx and above the insertion of the stamens (3—) 4—6 mm wide; inside the corolla tube and from the point of insertion of the stamens to the mouth glabrous, or first glabrous and in the throat pubescent; stamens inserted at (5—) 8—14 (—17) mm from the base of the corolla, Continental tropical Africa ..... *T. crassa*

Tabernaemontana debrayi (Mgf.) Leeuwenberg 1938: 336.

Basionym: *Pandaca debrayi* Mgf. 1970: 30; 1976: 188, pl. 29, 1—5.

Type: Madagascar: Sambava, *Debray* 458 (P: holotype).

Since *Pandaca* is not maintained here as a distinct genus and since this species is considered to be different from those already described in *Tabernaemontana*, the new combination indicated is required.

The leaves and flowers resemble very much those of *T. crispa* Roxb. *T. debrayi* is endemic in Madagascar, while *T. crispa* is known from India, Burma and the Andaman Islands.

Tabernaemontana disticha A.DC. 1844: 362.

Type: French Guiana: Cayenne, *Martin* 49 (G-DC: holotype, not seen, microfiche in WAG; FI-W: isotype, seen).

Homotypic synonyms: *Taberna disticha* (A.DC.) Miers 1878: 64. *Anacampta disticha* (A.DC.) Mgf. 1938: 162.

Heterotypic synonym: *Tabernaemontana oblongifolia* A.DC. 1844: 368 (partly, as regards the lectotype), *syn.nov.* Type: Brazil: Bahia, *Blanchet* 2358 (G-DC: lectotype, not seen, microfiche in WAG; BP, FI-W, P, W: isotypes, seen).

T. disticha occurs, together with the closely allied *T. attenuata*, in the understory of the forests of northern South America. The species have been confused both in the herbarium and in the literature. They are distinguished mainly by the shape and size of the leaves: those of *T. attenuata* are abruptly long-acuminate and smaller than the shortly-acuminate leaves of *T. disticha*. As observed in the field by the writer, *T. disticha* is smaller and less branched than *T. attenuata*.

As already noted by Urban (1915), the only paratype of *T. oblongifolia* (French Guiana: Cayenne, *Martin s.n.* (G-DC, not seen, microfiche in WAG)), belongs to *T. attenuata*.

The names *T. disticha* and *T. oblongifolia* were both published in the same paper, but because the latter name has been used for different plants in certain publications, the first one, *T. disticha*, is less confusing and is chosen here.

Tabernaemontana divaricata (L.) R.Br. ex Roem. et Schult. 1819; 424; Merrill 1934: 141.

Basionym: *Nerium divaricatum* L. 1753: 209 (partly, excl. synonyms).

Type: Cult. in Sri Lanka, *herb. Hermann* 1: 7 (BM: lectotype).

Homotypic synonym: *Ervatamia divaricata* (L.) Burkill 1925: 320.

Heterotypic synonyms: *T. alternifolia* L. 1753: 211. Type: *Van Rheede tot Drakestein* 1678: 1, *t.* 46.

Nerium coronarium Jacq. 1787 (?): 5, pl. 52; 1787: 138. Type: Cult. Hort. Bot. Schoenbrunn, Vienna, *Jacquin* s.n. (W: holotype). Homotypic synonyms: *T. coronaria* (Jacq.) Willd. 1809: 275. *Ervatamia coronaria* (Jacq.) Stapf 1902: 127.

T. siamensis Warb. ex Pitard 1933: 1158. Type: Thailand: Bangkok, *Zimmermann* 65 (P: holotype; L, M, W: isotypes). Homotypic synonym: *Ervatamia siamensis* (Warb. ex Pitard) Kerr 1939: 447.

This species — the type species of the generic synonym *Ervatamia* — is widely distributed in tropical countries as a garden plant, usually with sweet-scented double flowers. It is indigenous in India.

Linnaeus's description in the *Flora Zeylanica* (1747) and the first phrase in the *Species Plantarum* (1753) refer to *Tabernaemontana*, while the vernacular name in the *Flora Zeylanica* and the other phrases in the *Species Plantarum* refer to *Wrightia antidysenterica* (L.) R.Br. Stapf (1902) and Boiteau (1981), neither of whom accepted the epithet *divaricata*, probably erroneously considered the lectotype of *Wrightia antidysenterica*, which is also in the Hermann herbarium, as the basis for the name *Nerium divaricatum*.

Tabernaemontana eglandulosa Stapf 1894: 24; Huber 1963: 66.

Type: Nigeria: Lower Niger, Eppah, *Barter* 3306 (K: lectotype; P: isotype, designated by Boiteau and Allorge (1981b).

Homotypic synonym: *Gabunia eglandulosa* (Stapf) Stapf 1902: 138; Boiteau and Allorge 1981b: 220.

Heterotypic synonyms: *T. crispiflora* K. Schum. 1895a: 148, *syn. nov.* Type: Gabon: Sibange Farm, Libreville, *Soyaux* 183 (B: holotype, not seen, destroyed; K: lectotype; P, W, Z: other isotypes, seen, paratype of *T. eglandulosa*). Homotypic synonym: *Gabunia crispiflora* (K. Schum.) Stapf 1902: 139; Boiteau & Allorge 1981b: 230, pl. 3.

T. brachypoda K. Schum. 1896: 223. Type: Cameroun: Lolodorf, *Staudt*

8 (P: lectotype; G, K, S: isotypes, designated by Boiteau & Allorge 1981b). Homotypic synonym: *Gabunia brachypoda* (K. Schum.) Stapf 1902: 137; Boiteau & Allorge 1981b: 226.

Gabunia latifolia Stapf 1902: 137. Type: Gabon: Mt. John, Kongui River, Corisco Bay, *Mann* 1794 (K: holotype; P: isotype, paratype of *T. glandulosa*). Homotypic synonym: *T. latifolia* (Stapf) Pichon 1948b: 253.

G. longiflora Stapf 1902: 138. Type: Fernando Po, *Mann* 239 (K: holotype; P: isotype, paratype of *T. eglandulosa*). Homotypic synonym: *T. chartacea* Pichon 1948b: 253 (not *T. longiflora* Benth.).

G. eglandulosa var. *macrocalyx* Stapf 1902: 139. Type: Nigeria: Cross River State, Old Calabar River, *Mann* 2253 (K: holotype; P: isotype, paratype of *T. eglandulosa*). Homotypic synonym: *G. macrocalyx* (Stapf) Boiteau in Boiteau & Allorge 1981b: 224, pl. 5.

G. macrocarpa Boiteau in Boiteau & Allorge 1981b: 224, pl. 4, *syn. nov.* Type: Zaïre: Yangambi, *Donis* 3043 (BR, holotype).

The species is a small liane widely distributed in Central Africa and occurring in the forest usually as more or less solitary individual plants. They flower at night and as a result there are few good flowers to be seen in the available herbarium material. The fruits are smooth; in the unripe condition they have narrow wings which in the herbarium sometimes appear broader and when ripe the wings disappear or are often reduced to scarcely visible ridges. Much the same can be seen with the fruits of *T. penduliflora* and *T. sananho*.

The slender corolla tube varies in length, but much less than is the case with *T. crassa*, and the corolla lobes are obtuse or rounded (in the herbarium often seemingly acute) and to a greater or lesser extent undulate.

The recent revision of Boiteau and Allorge (1981b) is of the *Tabernaemontana* species assigned to the genus *Gabunia* — a genus which is not recognized here. In it, in addition to *T. eglandulosa*, they distinguish among others *T. brachypoda*, *G. macrocalyx* and *T. crispiflora*. The first two have already been reduced to synonymy by Huber (1963), while in the present author's view the third one must also be included here.

Careful comparison of this revision with specimens cited in it, as well as a number of other specimens, shows that the descriptions given only partially fit the cited specimens. For example, the sepals of the type of *G. macrocalyx* are 5—7 mm long, not 10 mm as indicated in the key, and they are just as large as those of *T. crispiflora*. The corolla tube of the type specimen of *T. crispiflora* varies in length from 2.5 to 3.5 cm, thus more than the 2.5—3 cm given in the description of the species; that of *T. brachypoda* is not 5 mm long, as indicated in the key, but at least 3.5 cm. Boiteau and Allorge analysed a bud of this last species and assumed that the style remains short. In fact, it grows along with the corolla tube until just before the flower opens.

A mature fruit of *T. eglandulosa* is illustrated in the above-mentioned paper by Boiteau and Allorge (p. 229, pl. 7.5—8) as representing that of *Gabunia hallei* Boiteau. In spite of this latter species being based on a mature, it is here proposed to give it the name *Tabernaemontana hallei* (Boiteau) Leeuwenberg, *comb. nov.*, since the type at least was correctly recognized as belonging to a new species. The West African specimens cited are of *T. glandulosa*, while *N. Hallé* 3341 (P), the one illustrated, is of *T. eglandulosa* as it has no colleters in the calyx. In the meantime, a few other collections, not seen by the above authors, have been recognized as belonging to *T. hallei*, e.g. *J. & A. Raynal* 10445 (P), Ebemwok, 55 km west of Ebelowa, Cameroun. This collection has narrow pod-like instead of almost spherical fruits, but it has the colleters characteristic of *T. hallei*. Sometimes, the carpels are partly connate, e.g. as in *Compère* 1768 (BR: paratype of *T. macrocarpa*), Thysville Territory, Gombe Matadi, Zaïre.

Tabernaemontana eusepaloides (Mgf.) Leeuwenberg, *comb. nov.*
Basionym: *Pandaca eusepaloides* Mgf. 1970: 30; 1976: 185, pl. 28.
Type: Madagascar: Vohémar, *Capuron* SF 27286 (P: holotype).
A new combination for this species is required for the reason already indicated under *T. debrayi* (q.v.). The plant is endemic in Madagascar.

Tabernaemontana humblotii (Baill.) Pichon 1948b: 244.
Basionym: *Ochronerium humblotii* Baill. 1889a: 199; 1889b: 774.
Type: Madagascar: sin. loc., *Humblot* 435 (P: holotype).
Homotypic synonym: *Pandaca humblotii* (Baill.) Mgf. 1970: 32; 1976: 190, pl. 30, 7—12.
Heterotypic synonyms: *T. ochrascens* Pichon 1948b: 245, *syn. nov.* Type: Madagascar: Ste. Marie, *Boivin* Nov. 1850 (P: holotype). Homotypic synonym: *Pandaca ochrascens* (Pichon) Mgf. 1970: 32; 1976: 194, pl. 32, 1—3.
Pandaca speciosa Mgf. 1970: 30; 1976: 192, pl. 31, 1, *syn. nov.* Type: Madagascar: Tsingafiafy, north of Fort Dauphin, *Capuron* SF 28684 (P: holotype).
This species, which is represented in herbaria by only a few collections, appears to be variable. Further synonyms may have to be added to those cited above. It is not yet certain whether the plant parts figured in pl. 31, 2—6 in the *Flore de Madagascar et des Comores* belong here and the appearance of the fruits is therefore uncertain.

Tabernaemontana mocquerysii Aug. DC. 1901: 579.
Type: Madagascar: Nosy Mangabé, Antongil Bay, *Mocquerys* 436 (G: lectotype; Z: isotype).
Homotypic synonym: *Pandaca mocquerysii* (Aug. DC.) Mgf. 1970: 33; 1976: 212.
Heterotypic synonym: *Pandaca boiteaui* Mgf. 1972b: 218; 1976: 214 (partly, excl. *Boiteau* 2121, which belongs to *T. callosa*), *syn. nov.* Type: Madagascar: Manombo, *Boiteau* 2118 (P: holotype).
The number of secondary veins present in the leaves of this species may

vary more than was supposed by Markgraf. As there is no other character to distinguish *Pandaca boiteaui*, the name must be reduced to a synonym.

This species is endemic in Madagascar.

Tabernaemontana orientalis R.Br. 1810: 468.

Type: Australia: sin. loc., *Robert Brown* 2858 (BM: holotype; K: isotype).

Homotypic synonym: *Ervatamia orientalis* (R.Br) Domin 1913: 97

Heterotypic synonyms: *T. pubescens* R.Br. 1810: 468, *syn. nov.* Type: Australia: North Coast, Good's Island, Prince of Wales Islands, *Robert Brown* 2859 (BM: holotype; K: isotype). Homotypic synonym: *Ervatamia pubescens* (R.Br.) Domin 1913: 96.

T. pubescens var. *ebracteata* R.Br. 1810: 468, *syn. nov.* Type: Australia: Prince of Wales Islands, *Robert Brown* 2860 (BM: holotype).

T. floribunda Bl. 1826: 1028, *syn. nov.* Type: Indonesia: Java, sin. loc., *Blume* (L 925:250—252, lectotype). Homotypic synonym: *E floribunda* (Bl.) Pichon 1949: 220.

T. punctulata Warb. 1891: 405. Type not seen. Name reduced to a synonym of *E. pubescens* by Markgraf 1927b: 199. *E. punctulata* (Warb.) Mgf. 1927a: 285.

T. diclinis Laut. et K. Schum. 1901: 503. Type: New Guinea: Stephansort, *Lewandowsky* 11 (B: holotype, not seen, destroyed). Reduced to synonymy by Markgraf 1927b: 200. Topotype: *Nyman* 85 (UPS: identified as *T. diclinis* by K. Schumann).

Ervatamia daemeliana Domin 1913: 97, *syn. nov.* Type: Australia: Queensland, Cape York, *Daemel* s.n. (BM: isotype).

E. montensis S. Moore 1923: 32. Type: New Guinea: Sogere, *Forbes* 478 (BM: lectotype). Name reduced to a synonym of *E. pubescens* by Markgraf 1927b: 199.

E. punctulata var. *barbatocalyx* Mgf. 1927a: 286. Type: Indonesia: West Irian, Merauke, *Koch* Aug. 1904 (L: lectotype). Homotypic synonym: *E. pubescens* var. *barbatocalyx* (Mgf.) Mgf. 1927b: 199.

E. obtusiuscula Mgf. 1935: 547, 551. Type: Western Samoa, Safune, *Vaupel* 265 (M: holotype; HBG, K: isotypes).

E. lifuana Allorge et al., 1980: 521, pl. 4, French description only; 1981a: 240, pl. 42, *syn. nov.* Type: Loyauté Islands: Lifou, *Sevenet* 461 (P: holotype).

T. orientalis is a widely distributed species and is known from Indonesia, New Guinea, northern Australia, and the Pacific region. Many fine specimens have been collected and from a study of more than 100 of these it has become evident that the species has been described several times — again as recently as 1980 from New Caledonia. During a visit to the Paris herbarium the writer received from Mme Allorge living material of several plants which had been cultivated in the phytotron at Gif-sur-Yvette and which she considered to belong to different although closely related species. They are referred to in her paper (Allorge et al., 1980) under the names *Ervatamia orientalis*, *E. obtusiuscula*, *E. daemeliana* and *E. lifuana*. Comparison of this material, preserved in alcohol, with the illustrations accompanying the paper cited and with similarly preserved material of *E. orientalis* from Bogor, as well as with herbarium collections, shows that the taxa cannot be maintained. The descriptions of the taxa given in the above paper, in each case defined on the basis of a single specimen, are not in complete agreement with the material. The following paragraphs set out in more detail the reasons for concluding that the above names must be treated as synonyms of *T. orientalis*.

The leaves of the type of *E. obtusiuscula* are rounded and more or less asymmetric at the base, as is the case with those of *T. orientalis* and *E. lifuana*.

The "5 saillies" of *E. lifuana*, clearly seen in the living material received in Paris, are also observed in other specimens, including the type specimen of *E. obtusiuscula*.

The calyx of the type of *E. obtusiuscula* is only 3 mm long and does not reach 5 mm. In none of the specimens of *T. orientalis* as understood here, when the bud is almost ready to open, do the sepals reach the swelling of the corolla where the anthers are inserted. The corolla tube varies in length from 10 to 20 mm and the corolla lobes from 7 to 22 mm.

The outside of the calyx is pubescent in the types of *T. pubescens* and *E. daemeliana*, among others, and is sparsely pubescent in the type of *E. pubescens* var. *barbatocalyx*. It is glabrous in most of the other specimens examined. There is little correlation between the size of the calyx and that of the corolla tube and between the size of the corolla tube and that of the corolla lobes.

The number of flowers in the inflorescence varies greatly, from about 10 to several 10s. The arrangement of the colleters in the calyx is remarkably constant: they are always in a single row at the bottom of the inner surface of the sepals. There is little variation in the insertion of the anthers and they are usually slightly more than one length below the mouth of the corolla. The fruits are usually narrowly ovate and have longitudinal ridges; they differ little in shape and size.

Further investigation will almost certainly show that *T. orientalis* has more synonyms, but much additional material will have to be studied. When only one specimen of a species is examined, it is not possible to determine which characters are constant and which are variable.

T. orientalis is closely related to *T. divaricata*. The two show little difference in the leaves and fruit but more distinctly in the flowers. From the investigation so far, the following characters appear to be reliable:

Colleters not in a single row, scattered over the lower half of the inner surface of the sepals; stamens inserted at the middle of the corolla tube or slightly above ..... *T. divaricata*

Colleters in a single row at the base of the sepals; stamens inserted high up in the corolla tube; apices of the anthers about 1—2 mm below the mouth of the corolla tube ..... *T. orientalis*

Tabernaemontana pachysiphon Stapf 1894: 22; Huber 1963: 66.

Type: Nigeria: Lower Niger River, Anembra State, Onitsha, *Barter* 1320 (K: holotype).

Homotypic synonym: *Conopharyngia pachysiphon* (Stapf) Stapf 1902: 146.

Heterotypic synonyms: *T. angolensis* Stapf 1894: 23, *syn. nov.* Type: Angola: Pungo Andongo, *Welwitsch* 5989 (BM: holotype, G, K, LISU, P: isotypes). Homotypic synonym: *Conopharyngia angolensis* (Stapf) Stapf 1902: 146.

T. holstii K. Schum. 1895b: 317, *syn. nov.* Type: Tanzania: Tanga Province, Lushoto District, Derema, *Holst* 2247 (K: lectotype). Homotypic synonym: *Conopharyngia holstii* (K. Schum.) Stapf 1902: 146.

Voacanga dichotoma K. Schum. 1895b: 317, *syn. nov.* Type: Tanzania: Northern province, Moshi District, Marangu, *Volk* 2076 (HBG: lectotype).

Conopharyngia cumminsii Stapf 1902: 145. Type: Ghana: Ashanti, Assin-Yan-Kumassi, *Cummins* 114 (K: holotype). Homotypic synonym: *T. pachysiphon* var. *cumminsii* (Stapf) H. Huber 1963: 66, *syn. nov.*

Comparative studies of more than 100 specimens show that none of the taxa here reduced to synonymy can be maintained. The variation of the length of the corolla tube is not discontinuous, as was supposed by Huber (1963), and therefore the var. *cumminsii* cannot be kept as a separate entity.

The author has made interesting field studies and collections in Ghana, Nigeria and Kenya, which gave the opportunity to collect both flowers and fruits in spirit and to study fresh and well-preserved material of both the vulnerable clavuncula and the very thick-walled large fruits.

T. pachysiphon is closely allied to *T. contorta* in all characters: habit, bark, leaves, flowers, fruits and seeds. The indumentum in the corolla is the same, and not different as thought by Huber. However, the two species differ from each other as follows:

Sepals 4—7 mm long, inside with (1—)3 rows of colleters; corolla tube twisted at the base by up to 1/4 turn, 18—35 (—42) mm long; anthers 9—13 mm long and inserted at 8—14 mm from the bottom of the corolla tube. Throughout most of Continental tropical Africa . . . . . *T. pachysiphon*

Sepals 7—13 mm long, inside with (3—)5 rows of colleters; corolla tube twisted at the base by about 1 turn, 40—65 mm long, showing 3 almost parallel lines of the twisted angles crossing more or less diagonally from one side of the tube to the other; anthers 15—18 mm long and inserted at 16—22 mm from the bottom of the corolla tube. Cameroun . . . *T. contorta*

Tabernaemontana rigida (Miers) Leeuwenberg 1938, 339.

Basionym: *Phrissocarpus rigidus* Miers 1878: 72, based on *T. macrophylla* Muell. Arg. 1860: 75, not of Poir.

Type: Brazil: Amazonas, Barra do Rio Negro, *Spruce* 1470 (BM: holotype; BR, GOET, K, W: isotypes).

Homotypic synonym: *Anacampta rigida* (Miers) Mgf. 1938: 162.

A new combination is proposed for this species, since, as already indicated by Mueller, it evidently belongs to *Tabernaemontana* and its original name in the genus is a homonym.

Tabernaemontana sananho Ruiz et Pav. 1799: 22, *t.* 144.

Type Peru: S. Antonio de Playa, *Ruiz & Pavón* s.n. (MA: holotype).

Homotypic synonyms: *Merizadenia sananho* (Ruiz et Pav.) Miers 1878: 78. *Bonafousia sananho* (Ruiz et Pav.) Mgf. 1938: 166.

Heterotypic synonym: *Tabernaemontana poeppigii* Muell. Arg. 1859—1860: 405. Type: Peru: Tocache, *Poeppig* 1923 (W: holotype). Homotypic synonym: *Taberna poeppigii* (Muell. Arg.) Miers 1878: 63.

Misapplied names: *Tabernaemontana speciosa* auct. non Poir. *Bonafousia speciosa* (auct. non Poir.) Boiteau 1975: 247, pl. on p. 250, excl. the specimens cited.

This species is widely distributed in South America. Its branchlets are elliptic in section, as is clear from the figure by Ruiz & Pavón and from field observations. The carpels are subglobose and bear two narrow ridges.

Boiteau did not see the type of *T. speciosa* (here considered to be a synonym of *T. siphilitica*), and erroneously identified the specimens cited in his paper as such — they belong in fact to *T. sananho*. The specimen in the Lamarck herbarium, which Boiteau supposed to be a duplicate of the type of *T. speciosa*, belongs here.

Tabernaemontana siphilitica (L.f.) Leeuwenberg 1938, 339.

Basionym: *Echites siphilitica* L.f. 1781: 167.

Type: Surinam: sin. loc., *Dalberg* s.n. (LINN 302.3: holotype; S, S-LINN, UPS-THUNB 6156: isotypes).

Heterotypic synonyms: *T. speciosa* Poir. 1817: 275, *syn. nov.* Type: French Guiana: Cayenne, *Martin* s.n. in *herb. Desfontaines* s.n. (FI-W: holotype). Homotypic synonym: *Bonafousia speciosa* (Poir.) Boiteau 1975: 247 (partly, excl. the specimens cited, which belong to *T. sananho*).

T. tetrastachya H.B.K. 1819: 177, *syn. nov.* Type: Colombia: sin. loc., *Bonpland* 1469 (P-BO: holotype). Homotypic synonyms: *Malouetia tetrastachya* (H.B.K.) Miers 1878: 92. *Bonafousia tetrastachya* (H.B.K.) Mgf. 1937: 454.

T. longifolia Benth. 1841: 243. Type: Guyana (Georgetown): sin. loc., *Schomburgk* 292 (K: lectotype; FI-W, L, W: isotypes).

T. guianensis Miq. 1844: 754. Type: Surinam: near Paramaribo, *Kappler* 1627 (U: holotype; S, W: isotypes).

T. cuyabensis Malme 1927: 11, *syn. nov.* Type: Brazil: Mato Grosso. Cuyabá, *Malme* II 1871 (S: holotype; UPS: isotype).

Bonafousia juruana Mgf. 1938: 181, *syn. nov.* Type: Brazil: Amazonas. Marary, Juruá, *Ule* 5178 (L: isotype). Homotypic synonym: *T. juruana* K. Schum, ex Ule 1907: 136, name only; (Mgf.) Macbride 1959: 405.

T. siphilitica was encountered in the above-listed historical herbaria

under the name *Echites siphilitica*. Woodson (1936: 250) in his treatment of *Echites* and related genera was not able on the basis of the original, brief description to determine the species to which Linnaeus fil. referred. Later, when he saw one of the duplicates of the Dalberg collection, he identified it as *T. tetrastachya* without realizing that it was the type of an older name for the same species.

T. siphilitica is widely distributed in South America.

Tabernaemontana stapfiana Britten 1894: 25.

Type: Malawi: Mt. Mlanje, *Whyte* 87 (BM: holotype).

Homotypic synonyms: *Conopharyngia stapfiana* (Britten) Stapf 1902: 147. *Sarcopharyngia stapfiana* (Britten) Boiteau 1981b: 233, partly, exclusive of synonym *Gabunia odoratissima* Stapf (= *T. crassa* Benth.).

Heterotypic synonyms: *C. johnstonii* Stapf 1902: 147. Type: Uganda: Nandi Plateau, *Johnston* s.n. (K: holotype). Homotypic synonym: *T. johnstonii* (Stapf) Pichon 1948b: 251, *syn. nov.*

C. bequaerti De Wild. 1922: 397. Type: Zaïre: Ruwenzori, Lamia River valley, *Bequaert* 4315 (BR: holotype).

After comparative studies (which will be discussed in the forthcoming revision) of the type specimens cited above and about 100 other specimens it is clear that they all belong to a single species, distributed in montane forests from Zaïre and Kenya south to Zimbabwe. It is a tree 5—25(—35) m high with large white sweet-scented flowers and very big subglobose carpels.

2.4. *Excluded species*

In addition to the species which are listed in the next section as not belonging to the genus *Tabernaemontana*, the following names must also be mentioned:

T. macrophylla Poir, 1817: 276. Type: French Guiana: *Martin* s.n. in *herb. Desfontaines* s.n. (FI-W: holotype). Homotypic synonym: *Merizadenia amplifolia* Miers 1878: 79 = *Macoubea guianensis* Aubl. Type: French Guiana, *Aublet* s.n. (BM: holotype).

This synonymy was previously noted by Boiteau (1975: 246), who, however, did not actually see the type specimens.

T. populifolia Poir. 1817: 276. Type: Cult. Hort. Bot. Paris, *herb. Desfontaines* s.n. (FI-W: holotype). Homotypic synonym: *Thyrsanthus populifolia* (Poir.) Miers 1878: 99 = *Logania vaginalis* (Labill.) F.v.Muell. (Loganiaceae). Type: Australia: sin. loc., *herb. Labillardière* s.n. (FI-W: holotype).

Both type specimens are well preserved and resemble each other closely in all essential details, so that the identity of *T. populifolia* is easily verified. Woodson (1935: 234) did not see the type of *T. populifolia* and supposed erroneously that it belonged to *Trachelospermum difforme* (Walt.) A. Gray.

2.5 *List of recognized Tabernaemontana species and their synonyms encountered in the chemical and ethnobotanical literature*

Anacampta angulata (Mart. ex Muell. Arg.) Miers: see *T. angulata*
Anacampta disticha (A.DC.) Mgf. : see *T. disticha*
Anacampta macrocalyx (Muell. Arg.) Mgf. : see *T. macrocalyx*
Anartia flavicans (Willd. ex Roem. et Schult.) Miers : see *T. flavicans*
Anartia meyeri (G. Don) Miers : see *T. attenuata*
Bonafousia longituba Mgf. : see *T. markgrafiana*
Bonafousia speciosa (Poir.) Boiteau : see *T. siphilitica*
Bonafousia tetrastachya (H.B.K.) Mgf. : see *T. siphilitica*
Bonafousia undulata (Vahl) A.DC. : see *T. undulata*
Capuronetta elegans Mgf. : see *T. capuronii*
Conopharyngia angolensis (Stapf) Stapf : see *T. pachysiphon*
Conopharyngia brachyantha (Stapf) Stapf : see *T. brachyantha*
Conopharyngia chippii Stapf : see *T. chippii*
Conopharyngia crassa (Benth.) Stapf : see *T. crassa*
Conopharyngia cumminsii Stapf : see *T. pachysiphon*
Conopharyngia durissima (Stapf) Stapf : see *T. crassa*
Conopharyngia elegans (Stapf) Stapf : see *T. elegans*
Conopharyngia gentilii De Wild. : see *T. crassa*
Conopharyngia holstii (K. Schum.) Stapf : see *T. pachysiphon*
Conopharyngia johnstonii Stapf : see *T. stapfiana*
Conopharyngia longiflora (Benth.) Stapf : see *T. longiflora*
Conopharyngia odoratissima Stapf : see *T. crassa*
Conopharyngia pachysiphon (Stapf) Stapf : see *T. pachysiphon*
Conopharyngia penduliflora (K. Schum.) Stapf : see *T. penduliflora*
Conopharyngia retusa (Lam) G. Don : see *T. retusa*
Conopharyngia stenosiphon (Stapf) Stapf : see *T. stenosiphon*
Conopharyngia thonneri (Th.Dur. et De Wild. ex Stapf) Stapf : see *T. crassa*
Conopharyngia thouarsii auct. non : *Voacanga thouarsii* Roem. et Schult.
Conopharyngia usambarensis (K. Schum. ex Engl.) Stapf : see *T. ventricosa*
Conopharyngia ventricosa (Hochst. ex A.DC.) Stapf : see *T. ventricosa*
Ervatamia angustisepala Domin : *T. orientalis?*
Ervatamia aurantiaca auct. non : see *T. aurantiaca*
Ervatamia blumeana Mgf. : see *T. pauciflora*
Ervatamia bufalina (Lour.) Pichon : see *T. bufalina*
Ervatamia coronaria (Jacq.) Stapf : see *T. divaricata*
Ervatamia corymbosa (Roxb. ex Wall.) King et Gamble : see *T. corymbosa*
Ervatamia cylindrocarpa King et Gamble : see *T. cylindrocarpa*
Ervatamia daemeliana Domin. : see *T. orientalis*
Ervatamia dichotoma (Roxb. ex Wall.) Burkill : see *T. dichotoma*
Ervatamia divaricata (L.) Burkill : see *T. divaricata*

Ervatamia eriophora Mgf. : *T. orientalis?*
Ervatamia floribunda (Bl.) Pichon : see *T. orientalis*
Ervatamia harmandiana (Pierre ex Pitard) Kerr : see *T. harmandiana*
Ervatamia heyneana (Wall.) Cooke : see *T. heyneana*
Ervatamia hirta (Hook.f.) King et Gamble : see *T. hirta*
Ervatamia kwangsiensis Tsiang : *T. bufalina?*
Ervatamia lifuana Boiteau : see *T. orientalis*
Ervatamia luensis (Pierre ex Pitard) Kerr : see *T. luensis*
Ervatamia macrocarpa (Jack) Merr. : see *T. macrocarpa*
Ervatamia malaccensis (Hook.f.) King et Gamble : see *T. malaccensis*
Ervatamia microphylla (Pitard) Kerr : see *T. microphylla*
Ervatamia montensis S. Moore : see *T. Orientalis*
Ervatamia obtusiuscula Mgf. : see *T. orientalis*
Ervatamia officinalis Tsiang : *T. orientalis?*
Ervatamia orientalis (R.Br.) Domin : see *T. orientalis*
Ervatamia pandacaqui (Poir.) Pichon : see *T. pandacaqui*
Ervatamia peduncularis (Wall.) King et Gamble : see *T. peduncularis*
Ervatamia polysperma (Merr.) Pichon : see *T. polysperma*
Ervatamia pubescens (R.Br.) Domin : see *T. orientalis*
Ervatamia sralensis (Pierre ex Pitard) Kerr : see *T. sralensis*
Gabunia brachypoda (K. Schum.) Stapf : see *T. eglandulosa*
Gabunia crispiflora (K. Schum.) Stapf : see *T. eglandulosa*
Gabunia dorotheae Werh. : see *T. crassa*
Gabunia eglandulosa (Stapf) Stapf : see *T. eglandulosa*
Gabunia gentilii De Wild. : see *T. crassa*
Gabunia glandulosa Stapf : see *T. glandulosa*
Gabunia hallei Boiteau : see *T. hallei*
Gabunia latifolia Stapf : see *T. eglandulosa*
Gabunia macrocarpa Boiteau : see *T. eglandulosa*
Gabunia odoratissima Stapf : see *T. crassa*
Hazunta coffeoides (Boj. ex A.DC.) Pichon : see *T. coffeoides*
Hazunta costata Mgf. : see *T. coffeoides*
Hazunta membranacea (A.DC.) Pichon : see *T. coffeoides*
Hazunta membranacea forma pilifera (A.DC.) Pichon : see *T. coffeoides*
Hazunta modesta (Bak.) Pichon : see *T. coffeoides*
Hazunta modesta var. *methuenii* subvar. *methuenii* Mgf. : see *T. coffeoides*
Hazunta modesta var. *methuenii* subvar. *velutina* (Pichon) Mgf. : see *T. coffeoides*
Hazunta modesta var. *modesta* subvar. *brevituba* Mgf. : see *T. coffeoides*
Hazunta modesta var. *modesta* subvar. *divaricata* Mgf. : see *T. coffeoides*
Hazunta modesta var. *modesta* subvar. *modesta* Mgf. : see *T. coffeoides*
Hazunta modesta var. *modesta* subvar. *montana* Mgf. : see *T. coffeoides*
Hazunta silicola Pichon : see *T. coffeoides*
Muntafara sessilifolia (Bak.) Pichon : see *T. sessilifolia*

Pagiantha cerifera (Panch. et Séb.) Mgf. : see *T. cerifera*
Pagiantha dichotoma (Roxb. ex Wall.) Mgf. : see *T. dichotoma*
Pagiantha macrocarpa (Jack) Mgf. : see *T. macrocarpa*
Pagiantha sphaerocarpa (Bl.) Mgf. : see *T. sphaerocarpa*
Pandaca boiteaui Mgf. : see *T. mocquerysii*, except for herbarium specimen *Boiteau* 2121 which is *T. callosa*
Pandaca caducifolia Mgf. : see *T. calcarea*
Pandaca calcarea (Pichon) Mgf. : see *T. calcarea*
Pandaca callosa (Pichon) Mgf. : see *T. callosa*
Pandaca debrayi Mgf. : see *T. debrayi*
Pandaca eusepala (Aug.DC.) Mgf. : see *T. eusepala*
Pandaca eusepaloides Mgf. : see *T. eusepaloides*
Pandaca mauritiana (Poir.) Mgf. et Boiteau : see *T. mauritiana*
Pandaca minutiflora (Pichon) Mgf. : see *T. minutiflora*
Pandaca mocquerysii (Aug.DC.) Mgf. : see *T. mocquerysii*
Pandaca ochrascens (Pichon) Mgf. : see *T. humblotii*
Pandaca retusa (Lam.) Mgf. : see *T. retusa*
Pandaca speciosa Mgf. : see *T.. humblotii*
Peschiera affinis (Muell.Arg.) Miers : see *T. affinis*
Peschiera hystrix A.DC. : see *T. hystrix*
Peschiera laeta (Mart.) Miers : see *T. laeta*
Peschiera lundii (A.DC.) Miers : see *T. lundii*
Peschiera psychotriifolia (H.B.K.) Miers : see *T. psychotriifolia*
Rejoua anguinea auct. non : see *T. novo-guineensis*
Rejoua aurantiaca (Gaud.) Gaud. : see *T. aurantiaca*
Rejoua novo-guineensis (Scheff.) Mgf. : see *T. novo-guineensis*
Stenosolen heterophyllus (Vahl) Mgf. : see *T. heterophylla*
Tabernaemontana acapulcensis Miers
Tabernaemontana accedens Muell.Arg.
Tabernaemontana affinis Muell.Arg.
Tabernaemontana alba Mill. : *T. alba* if collected on the mainland of South America, but *T. citrifolia* (q.v.) if collected in the Antilles or Cuba
Tabernaemontana albiflora (Miq.) Pulle
Tabernaemontana alternifolia L. : see *T. divaricata*
Tabernaemontana amblyocarpa Urb.
Tabernaemontana amygdalifolia Jacq.
Tabernaemontana angolensis Stapf : see *T. pachysiphon*
Tabernaemontana anguinea Hemsl. : see *T. novo-guineensis*
Tabernaemontana angulata Mart. ex Muell. Arg.
Tabernaemontana angustifolia Ait. : *Amsonia angustifolia* Mich.
Tabernaemontana apoda Wr. ex Sauv.
Tabernaemontana arborea J.N. Rose ex J.D. Smith
Tabernaemontana arcuata Ruiz et Pav.
Tabernaemontana armeniaca Areces ex R. Iglesias et L. Diatta : see *T. apoda*

Tabernaemontana attenuata (Miers) Urb.
Tabernaemontana aubletii Pulle : *Macoubea guinensis* Aubl.
Tabernaemontana aurantiaca Gaud.
Tabernaemontana australis Muell. Arg.
Tabernaemontana borbonica Lam. ex Cordemoy : *Ochrosia borbonica* J.F. Gmel.?

Tabernaemontana bovina Lour.
Tabernaemontana brachyantha Stapf
Tabernaemontana brachypoda K. Schum. : see *T. eglandulosa*
Tabernaemontana bracteolaris Mart. ex Muell. Arg.
Tabernaemontana bufalina Lour.
Tabernaemontana calcarea Pichon
Tabernaemontana callosa Pichon
Tabernaemontana capsicoides Merr.
Tabernaemontana capuronii Leeuwenberg
Tabernaemontana catharinensis A. DC.
Tabernaemontana cerifera Panch. et Séb.
Tabernaemontana chartacea Pichon : see *T. eglandulosa*
Tabernaemontana chippii (Stapf) Pichon
Tabernaemontana citrifolia L. : *T. citrifolia* if collected in the Antilles or Cuba, but *T. alba* (q.v.) if collected in Central America
Tabernaemontana coffeaefolia Bojer : see *T. coffeoides*
Tabernaemontana coffeoides Boj. ex A. DC.
Tabernaemontana contorta Stapf
Tabernaemontana coronaria (Jacq.) Willd. : see *T. divaricata*
Tabernaemontana corymbosa Roxb. ex Wall.
Tabernaemontana crassa Benth.
Tabernaemontana crassifolia Pichon
Tabernaemontana crispa Roxb. ex Wall.
Tabernaemontana crispiflora K. Schum. : see *T. eglandulosa*
Tabernaemontana cumingiana A. DC.
Tabernaemontana cumminsii auct. non : see *T. pachysiphon*
Tabernaemontana cylindracea Wall. Cat. : *Rauvolfia serpentina* (L.) Benth. ex Kurz

Tabernaemontana cylindrocarpa (King et Gamble) Merr.
Tabernaemontana cymosa Jacq.
Tabernaemontana dammar oetan auct. non : *T.* sp.
Tabernaemontana debrayi (Mgf.) Leeuwenberg
Tabernaemontana dichotoma Roxb. ex Wall.
Tabernaemontana dinhensis Pitard
Tabernaemontana disticha A. DC.
Tabernaemontana divaricata (L.) R.Br. ex Roem. et Schult.
Tabernaemontana donnell-smithii Rose : *Stemmadenia donnell-smithii* (J.N. Rose ex Donn. Sm.) Woods

Tabernaemontana echinata Vell. *non* Aubl. : see *T. hystrix*

Tabernaemontana eglandulosa Stapf
Tabernaemontana elastica Spreng. : *Urceola elastica* Roxb.
Tabernaemontana elegans Stapf
Tabernaemontana entarctica Scheff. : see *T. pentasticta*
Tabernaemontana eusepala Aug. DC.
Tabernaemontana eusepaloides (Mgf.) Leeuwenberg
Tabernaemontana flavicans Willd. ex Roem. et Schult.
Tabernaemontana floribunda Bl. : see *T. orientalis*
Tabernaemontana fuchsiifolia A. DC.
Tabernaemontana glandulosa (Stapf) Pichon
Tabernaemontana globosa Blanco : *Voacanga globosa* (Blanco) Merr.
Tabernaemontana grandiflora Jacq. : *Stemmadenia grandiflora* (Jacq.) Miers
Tabernaemontana haematosticta auct. non : *T.* sp.?
Tabernaemontana harmandiana Pierre ex Pitard
Tabernaemontana heterophylla Vahl
Tabernaemontana heyneana Wall.
Tabernaemontana hilariana Muell. Arg.
Tabernaemontana hirta Hook. f.
Tabernaemontana holstii K. Schum. : see *T. pachysiphon*
Tabernaemontana humblotii (Baill.) Pichon
Tabernaemontana hystrix Steud.
Tabernaemontana javanica Miq. : see *T. sphaerocarpa*
Tabernaemontana johnstonii (Stapf) Pichon : see *T. stapfiana*
Tabernaemontana jollyana Pierre ex Stapf : see *T. crassa*
Tabernaemontana killipii Woods.
Tabernaemontana laeta Mart.
Tabernaemontana laevis Vell. : *Geissospermum laeve* (Vell.) Miers
Tabernaemontana latifolia (Stapf) Pichon : see *T. eglandulosa*
Tabernaemontana laurifolia Blanco *non* L. : see *T. pandacaqui*
Tabernaemontana longiflora Benth.
Tabernaemontana longifolia Benth. : see *T. siphilitica*
Tabernaemontana longipes Donn. Sm.
Tabernaemontana luensis Pierre ex Pitard
Tabernaemontana lundii A.DC.
Tabernaemontana macrocalyx Muell. Arg.
Tabernaemontana macrocarpa Jack
Tabernaemontana macrophylla Poir. : *Macoubea guianensis* Poir.
Tabernaemontana macrophylla Muell. Arg. : see *T. rigida*
Tabernaemontana malaccensis Hook. f.
Tabernaemontana markgrafiana Macbr.
Tabernaemontana martensii Peyr. : see *T. alba*
Tabernaemontana mauritiana Poir.
Tabernaemontana membranacea A. DC. : see *T. coffeoides*
Tabernaemontana microphylla Pitard
Tabernaemontana minutiflora Pichon

abernaemontana mocquerysii Aug. DC.
abernaemontana modesta Bak. : see *T. coffeoides*
abernaemontana mucronata Merr.
abernaemontana muricata Link. ex Roem. et Schult.
abernaemontana nereifolia Vahl : see *T. amygdalifolia*
abernaemontana noronhiana Boj. ex A. DC. : see *T. retusa*
abernaemontana novo-guineensis Scheff.
abernaemontana oblongifolia A. DC. : see *T. disticha*
abernaemontana ochrascens Pichon : see *T. humblotii*
abernaemontana olivacea Muell. Arg.
abernaemontana oppositifolia (Spreng.) Urb. : see *T. citrifolia*
Tabernaemontana orientalis R. Br.
Tabernaemontana ovalis Miq.
Tabernaemontana pachysiphon Stapf
Tabernaemontana pacifica Seem.
Tabernaemontana paisavelensis Loes.
Tabernaemontana pandacaqui Poir.
Tabernaemontana parviflora Heyne ex Wall. : *Hunteria zeylanica* (Retz.) Gardn. ex Thw.

Tabernaemontana pedunculatis Wall.
Tabernaemontana penduliflora K. Schum.
Tabernaemontana pentasticta Scheff.
Tabernaemontana persicariifolia Jacq.
Tabernaemontana poeppigii Muell. Arg. : see *T. sananho*
Tabernaemontana polysperma Merr.
Tabernaemontana psorocarpa (Pierre ex Stapf) Pichon
Tabernaemontana psychotriifolia H.B.K.
Tabernaemontana pubescens R. Br. : see *T. orientalis*
Tabernaemontana quadrangularis auct. non : *Rhigospira quadrangularis* (Muell. Arg.) Miers (?)

Tabernaemontana retusa (Lam.) Pichon
Tabernaemontana riedelii Muell. Arg.
Tabernaemontana rigida (Miers) Leeuwenberg
Tabernaemontana rimulosa Woods
Tabernaemontana rubro-striolata Mart. ex Muell. Arg.
Tabernaemontana rupicola Benth.
Tabernaemontana salicifolia Wall. : *Hunteria zeylanica* (Retz.) Gardn. ex Thw.
Tabernaemontana salzmannii A. DC.
Tabernaemontana sananho Ruiz et Pav.
Tabernaemontana semperflorens Perr. : see *T. pandacaqui* (according to Quisumbing, 1950)

Tabernaemontana sessilifolia Bak.
Tabernaemontana siphilitica (L.f.) Leeuwenberg
Tabernaemontana sphaerocarpa Bl.
Tabernaemontana squamosa Smith ex Spreng.
Tabernaemontana sralensis Pierre ex Pitard.
Tabernaemontana stapfiana Britten
Tabernaemontana stellata Pichon
Tabernaemontana stenosiphon Stapf
Tabernaemontana subglobosa Merr.
Tabernaemontana telfairiana Wall. : see *T. mauritiana*
Tabernaemontana tetrastachya H.B.K. : see *T. siphilitica*
Tabernaemontana thonneri Th. Dur. et De Wild. ex Stapf : see *T. crassa*
Tabernaemontana undulata Vahl
Tabernaemontana usambarensis K. Schum. : see *T. ventricosa*
Tabernaemontana utilis Arn. : *Lacmellea utilis* (Arn.) Mgf.
Tabernaemontana ventricosa Hochst. ex A. DC.
Tabernaemontana wallichiana Steud.

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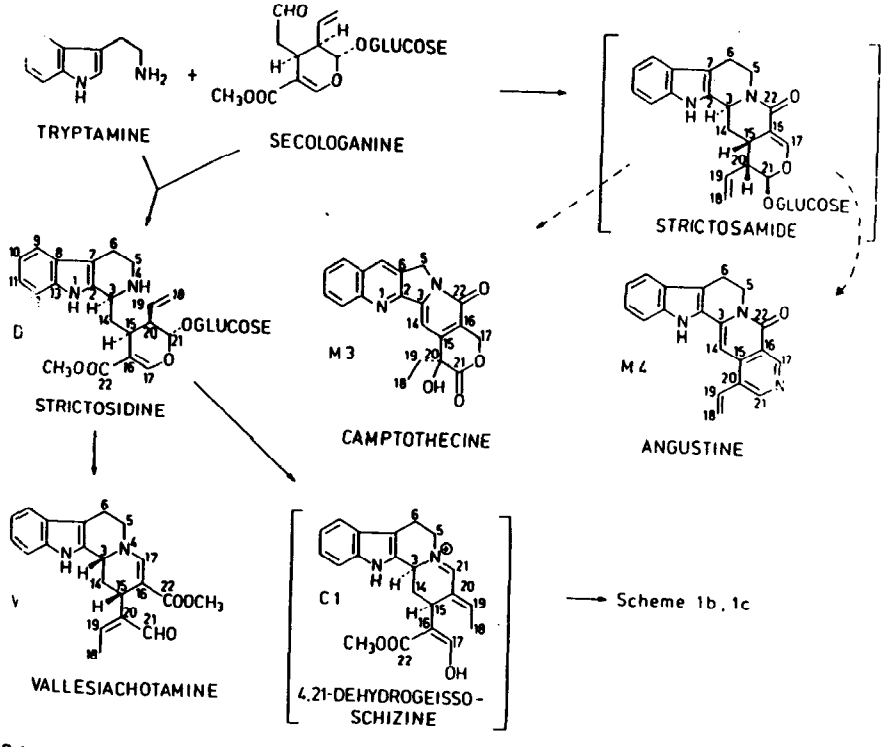
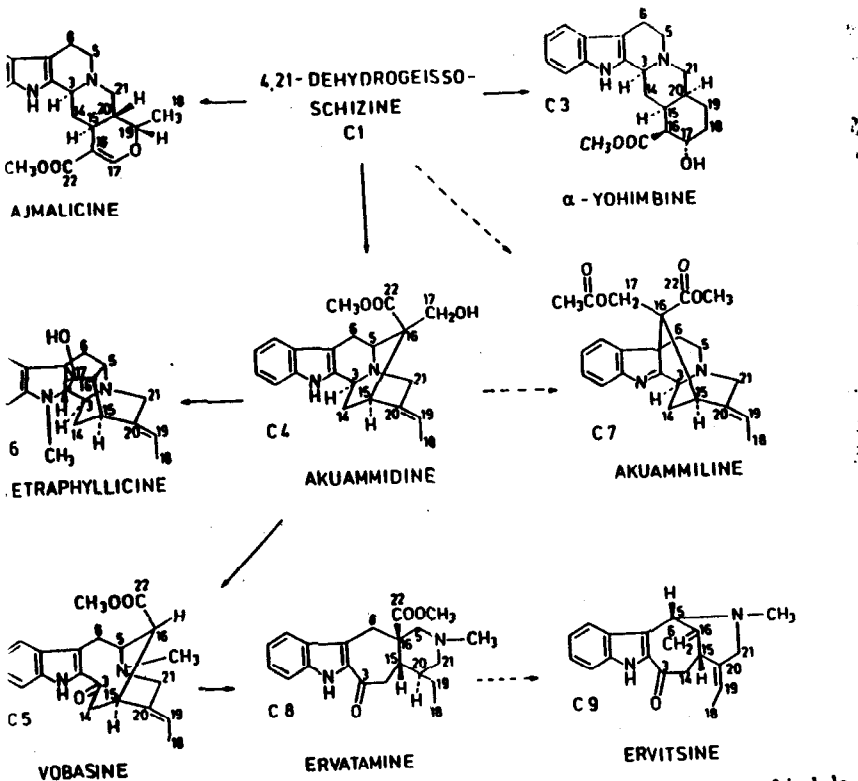
. Biogenesis and classification of the indole alkaloids occurring in the genus *Tabernaemontana*

3.1. Biogenesis

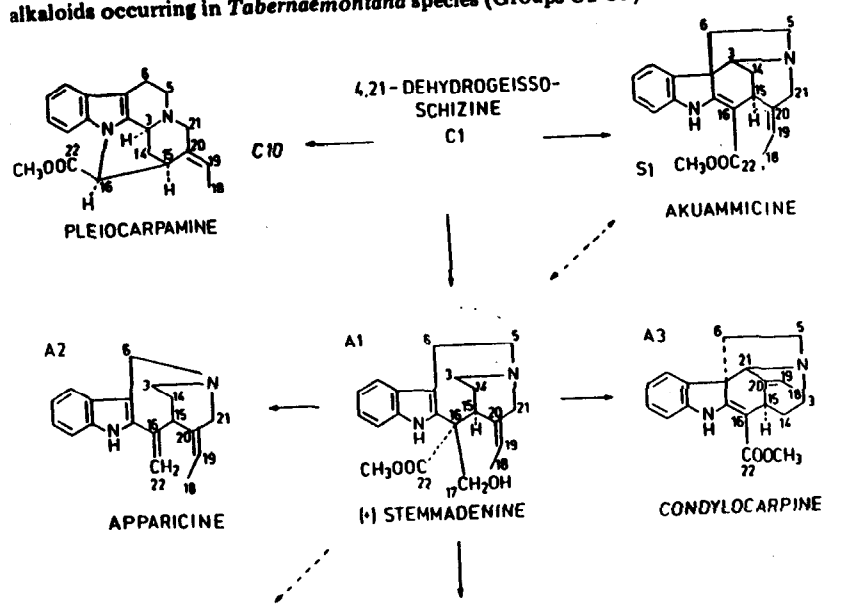
Schemes 1 a–d set out plausible biogenetic pathways leading to the different groups of alkaloids so far found in *Tabernaemontana* species, the carbon skeleton for each group being illustrated by an appropriate example. Presumed intermediates which have not so far been isolated from members of the genus are enclosed in square brackets. Interrelationships for which there is insufficient evidence are shown as dashed lines. Although no results of biogenetic research on *Tabernaemontana* species have so far been published, it seems unlikely that the biosynthesis of the indole alkaloids in these plants will differ from the general picture presented in the schemes. Literature references are given in Table 2, where more detailed information on the biogenesis of the individual subgroups can be found.

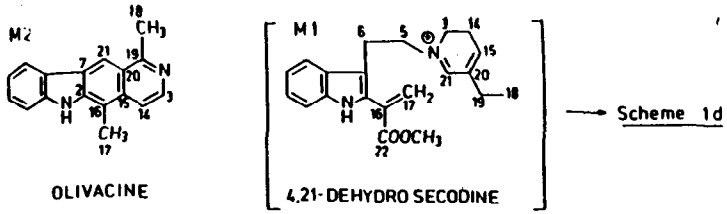


Scheme 1a. Plausible biogenetic interrelationships between various groups of indole alkaloids occurring in *Tabernaemontana* species (Groups D, V, M3 and M4).

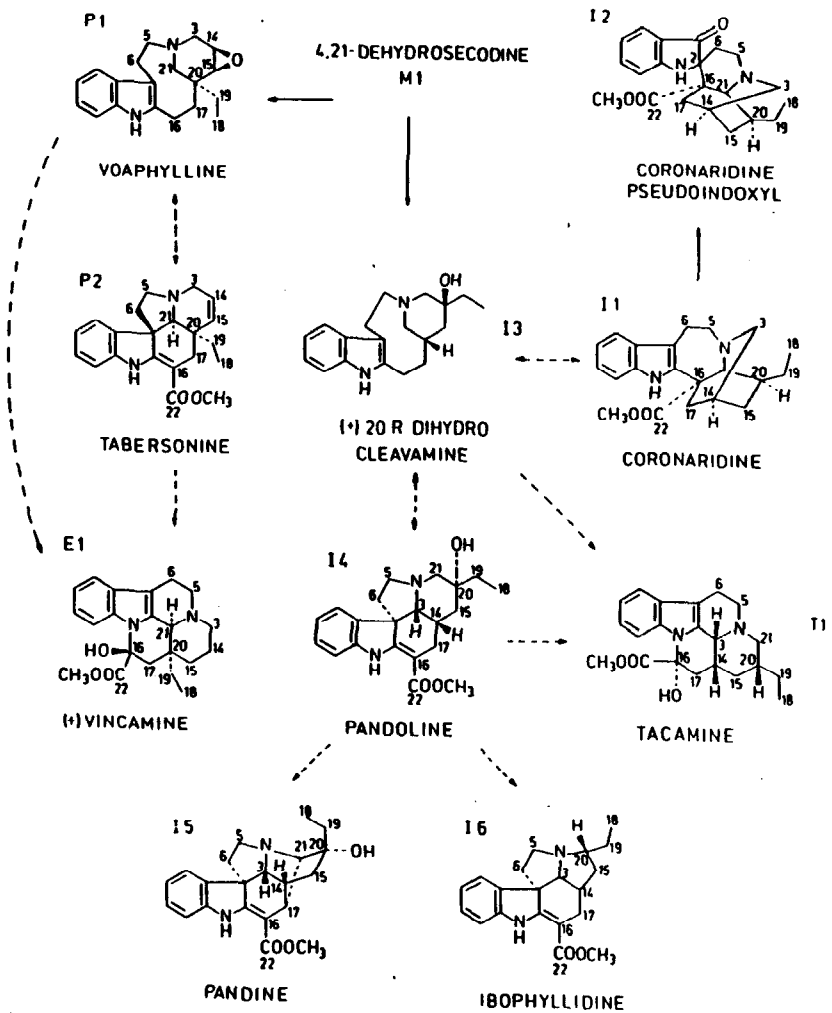


Scheme 1b. Plausible biogenetic interrelationships between various groups of indole alkaloids occurring in *Tabernaemontana* species (Groups C1-C9).





Scheme 1c. Plausible biogenetic interrelationships between various groups of indole alkaloids occurring in *Tabernaemontana* species (Groups S, C10, M1, M2 and A).



Scheme 1d. Plausible biogenetic interrelationships between various groups of indole alkaloids occurring in *Tabernaemontana* species (Groups I, P, E and T).

2. Classification

The biogenetic schemes 1 a–d also serve as a basis for the classification of the alkaloids occurring in *Tabernaemontana*. As set out in Table 1, it is similar to the one proposed by Kisakürek and Hesse [405], but with minor changes. These authors divided the indole alkaloids into eight classes, according to the structural characteristics of their skeletons: (1) vincosan (D type); (2) corynanthean (C type); (3) vallesiachotaman (V type); (4) strychnan (S type); (5) aspidospermatan (A type); (6) plumeran (P type); (7) eburnan (E type); (8) ibogan (I type). Dimeric alkaloids were counted twice (each monomeric part once), while unusual alkaloids like camptothecine and ellipticine were ignored.

In the present paper the alkaloids are arranged in 11 main groups: the 8 just listed, together with: (9) the new tacaman group (T type); (10) other indole and non-indole alkaloids (M type); (11) bis-indole alkaloids (B type) (see Table 1). While the necessity for a class of miscellaneous alkaloids, to accommodate those whose biogenesis is still obscure, speaks for itself, the incorporation of the bis-indole alkaloids in a separate class is less obvious. This latter class is subdivided to show the various combinations of monomers, a procedure which is more informative since the chemotaxonomic significance of the occurrence of the various types of bis-indole bases is not then lost. Of the 11 main classes set out in Table 1, no member of the vincosan type and only a few representatives of the strychnan, eburnan, vallesiachotaman and tacaman types have so far been isolated from *Tabernaemontana* species.

TABLE 1

CLASSIFICATION OF THE INDOLE ALKALOIDS OCCURRING IN *TABERNAEMONTANA* SPECIES

Class (abbreviation)		Structural characteristics[a]
1. Vincosan	(D)	C(2)-C(3)-C(14) unit, no N(4)-C(17) or N(4)-C(21) bond
2. Corynanthean	(C)	C(2)-C(3)-C(14) unit, N(4)-C(21) bond
3. Vallesiachotaman	(V)	C(2)-C(3)-C(14) unit, N(4)-C(17) bond
4. Strychnan	(S)	C(2)-C(16)-C(15) unit, C(3)-C(7) bond
5. Aspidospermatan	(A)	C(2)-C(16)-C(15) unit, no C(3)-C(7) bond
6. Plumeran	(P)	C(2)-C(16)-C(17)-C(20) unit
7. Eburnan	(E)	N(1)-C(16)-C(17)-C(20) unit
8. Ibogan	(I)	C(2)-C(16)-C(17)-C(14) unit[b]
9. Tacaman	(T)	N(1)-C(16)-C(17)-C(14) unit
10. Miscellaneous	(M)	—
11. Bis-indole	(B)	Two indole alkaloids attached to each other

[a] Throughout this paper the generally accepted "biogenetic" numbering system proposed by Le Men and Taylor [176] is used.

[b] The alkaloid crassanine forms an exception with its C(16)-C(17)-C(14) unit.

These classes are therefore not subdivided here. As shown in Table 2, the other classes are subdivided into two or more groups, the subdivision being designed especially for the alkaloids occurring in *Tabernaemontana* species and established on the basis of the variations in carbon skeleton within the main class. A higher subdivision number usually corresponds with a biogenetically more evolved structure, although this does not always mean a chemically more complex one, cf. for example, the groups I1 and I6.

TABLE 2

SUBDIVISION OF THE MAIN CLASSES OF INDOLE ALKALOIDS

Subdivision	References
Vincosan (D)	271, 410
Corynanthean (C)	
C1: Geissoschizine group	271, 410
C2: Ajmalicine group	271, 410
C3: Yohimbine group	271
C4: Akuammidine group	271
C5: Vobasine group	271
C6: Ajmaline group	271
C7: Akuammiline group	271
C8: Ervatamine group	271, 327
C9: Ervitsine group	327
C10: Pleiocarpamine group	271
Vallesiachotaman (V)	
V1: Vallesiachotamine group	410
Strychnan (S)	
S1: Akuammicine group	271, 386
Aspidospermatan (A)	
A1: Stemmadenine group	271, 318
A2: Apparicine group	319, 401
A3: Condylocarpine group	271, 386
Plumeran (P)	
P1: Voaphylline group	271
P2: Tabersonine group	271, 318
Eburnan (E)	
E1: Vincamine group	271, 318
Ibogan (I)	
I1: Coronaridine group	271, 318
I2: Pseudoindoxyl / Oxindole group	243
I3: Cleavamine group	
I4: Pandoline group	271, 303, 318

TABLE 2 (continued)

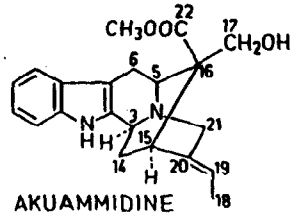
Subdivision	References
I5: Pandine group	303
I6: Ibophyllidine group	403, 425
Tacaman (T)	
T1: Tacamine group	357, 434
Miscellaneous (M)	
M1: Secodine[a] group	271, 318, 319
M2: Ellipticine group	319, 398
M3: Camptothecine group	399
M4: Angustine group	386
M5: Non-indole group	
Bis-indole (B)	
B1: C-C group	
B2: C-I group	
B3: P-P group	
B4: P-I group	
B5: I-I group	
B6: I-M group	
B7: M-M group	
B8: P-M group	

[a] Alkaloids of this group are arranged separately because they are intermediate between the A, P and I classes.

3.3. Stereochemistry

After elucidation of the basic structure of an indole alkaloid, the stereochemistry still has to be determined. In this section, some of the stereochemical problems concerning the most common groups of indole alkaloids occurring in *Tabernaemontana* species, i.e. the corynanthe and iboga types, are pointed out and the methods are indicated by which the configuration of particular carbon atoms may be determined.

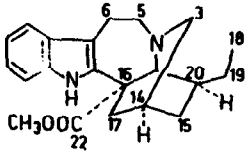
Corynanthe (C) type (especially groups C4 and C5): Alkaloids of groups C4 and C5, the akuammidine and vobasine groups, respectively, have the following asymmetric centers: C-3, C-5, C-15, C-16 and C-19. In the 19, 20-dihydroderivatives this last center is at C-20 instead.



AKUAMMIDINE

Biogenetic considerations indicate that C-15 is the same in all indole alkaloids containing an unrearranged monoterpenoid unit, i.e. that H-15 always has the same (α) configuration [405]. In alkaloids of groups C4 and C5, in order to allow formation of the C(5)-C(16)-C(15) bridge H-3 also always has to have the α-configuration. In bases of the C1 (geissoschizine), C2 (ajmalicine) and C3 (yohimbine) groups, H-3 can have either the α- or β-configuration, distinguishable by the presence or absence of Bohlmann bands in the IR spectrum [109,208], by the ORD/CD curves [208,238], and by the ^{1}H- [208,406] and ^{13}C- [324] NMR spectra. In bases of the C4 and C5 groups the stereochemistry at C-16 can be deduced from the ^{1}H-NMR spectrum [148], through the shift in the signal for the $COOCH_3$ function, and in alkaloids belonging to the C5 group also from the ^{13}C-NMR spectrum [307]. If there is a CH_2OH group present in an alkaloid of group C4, the 16-epimers can be differentiated by means of the mass spectrum, i.e. polyneuridine, which is 16-*epi*-akuammidine, has an intense $M^{+\cdot} - 18$ ($M^{+\cdot} - H_2O$) peak while akuammidine does not [141,273]. The configuration at C-19 can be deduced from the ^{1}H- [166] and ^{13}C- [345] NMR spectra; in the former case, NOE experiments may be applied [267]. For 19,20-dihydro compounds, such as dregamine and tabernaemontanine, the stereochemistry at C-20 can be established by chemical reactions [295], including conversion to the stereochemically known ervatamine [260], and from the ^{1}H- [308] and ^{13}C- [307,308] NMR spectra.

Iboga (I) type: Alkaloids of group I1 possess the following asymmetric centers: C-14, C-16, C-20 and C-21, and also C-19 when, as in heyneanine, a 19-hydroxyl function is present.



CORONARIDINE

The relative stereochemistry at C-14, C-16 and C-21 is always the same because of the existence of the C(14)-C(3)-N(4) bridge. Only the absolute configuration can change. Determination of the absolute configuration of the iboga alkaloids was a problem for many years and was finally solved by CD studies [247]. Most of the iboga type alkaloids belong to the coronaridine series and only a few to the enantiomeric catharanthine series. Regrettably, even in some recent publications incorrect structures have been shown. This has resulted in confusion, for, especially when an iboga alkaloid is part of a bis-indole alkaloid, changes in the physical properties and spectral data are not just limited to the $[\alpha]_D$ and ORD and CD data, as in the case of the monomeric iboga alkaloids (diastereoisomers as opposed to enantiomers).

For the correct identification of an iboga alkaloid ORD and CD are to be preferred over $[\alpha]_D$ data, the sign of which can change because of changes in solvent, temperature, etc. The C-20 stereochemistry can be determined from a study of the ^{13}C-NMR spectrum [325], while that at C-19 can be derived from the ^{1}H- [304] and ^{13}C- [325] NMR spectra.

4. Alkaloidal constituents of the genus *Tabernaemontana*

4.1. *Alphabetical list of the alkaloids*

Table 3 lists the alkaloids so far isolated from *Tabernaemontana* species in alphabetical order, together with some of their synonyms. Over the years the nomenclature of some groups of indole alkaloids has become very complex and unsystematic. Often, alkaloids with the same basic skeleton have been given quite unrelated names, as the following examples show: akuammidine and polyneuridine in group C4; dregamine, tabernaemontanine and vobasine in group C5; coronaridine, heyneanine and voacangine in group I1. For reasons of clarity it would we preferable to have one name for the basic structure and to use the usual prefixes such as methoxy, dihydro, *epi*, etc. in naming the derivatives, but revision of the nomenclature is outside the scope of this article and the alkaloids are arranged under their usual names.

TABLE 3

ALPHABETICAL LIST OF THE ALKALOIDS KNOWN TO OCCUR IN *TABERNAEMONTANA* SPECIES

Alkaloid name	Class, group and individual no.
Accedine	C5-1
Accedine, N_1-demethyl-16-*epi*-	C5-2
Accedinine	B1-1
Accedinisine	B1-2
Affinine	C5-3
Affinine, N_1-methyl-16-*epi*-	C5-4
Affinisine	C4-1
Akuammicine	S1-1
Akuammidine	C4-1
Akuammiline	C7-1
Albifloranine, see: Coronaridine, 18-hydroxy-	
Alstonine, tetrahydro-	C2-4
Angustine	M4-1
Apodine	P2-1
Apodine, desoxo-	P2-2
Apodinine	P2-3
Apparicine	A2-1

TABLE 3 (*continued*)

Alkaloid name	Class, group and individual no.
Aspidospermine, (+)-demethyl-	P2-4
Bonafousine	B6-1
Camptothecine	M3-1
Camptothecine, 9-methoxy-	M3-2
Capuronidine	I4-4
Capuronidine, 14,15-anhydro-	I4-5
Capuronidine, 14,15-anhydro-1,2-dihydro-	I4-6
Capuronine	I3-1
(20*R*)-Capuvosidine	B2-1
(20*R*)-Capuvosidine, 1,2-dihydro-	B2-2
(20*S*)-Capuvosidine, 1,2-dihydro	B2-37
Capuvosine	B2-3
Capuvosine, dehydroxy-	B2-4
Capuvosine, N_4,-demethyl-	B2-5
(+)-(20*R*)-Cleavamine, 15,20-dihydro-	I3-2
(−)-(20*S*)-Cleavamine, 15,20-dihydro-	I3-3
(+)-Condylocarpine	A3-1
(20 Condylocarpine, 19,20-dihydro-, see: (+)-Tubotaiwine	
Condylocarpine N_4-oxide	A3-2
Conoduramine	B2-7
Conoduramine, 19',20'-epoxy-	B2-8
Conodurine	B2-9
Conodurine, 3-oxo-	B2-10
Conodurine, 3-(2'-oxopropyl)-	B2-11
Conoflorine, see: Voaphylline	
Conopharyngine	I1-1
Conopharyngine, 19-hydroxy-	I1-2
Conopharyngine hydroxyindolenine	I1-4
Conopharyngine, 3-oxo-	I1-3
Conopharyngine pseudoindoxyl	I2-1
Coronaridine	I1-5
Coronaridine, 3-ethoxy-	I1-6
Coronaridine, 3-hydroxy-	I1-7
Coronaridine, 10-hydroxy-	I1-8
Coronaridine, 11-hydroxy-	I1-48
Coronaridine, 18-hydroxy-	I1-9
Coronaridine, (3*S*)-3-(β-hydroxyethyl)-	I1-52
Coronaridine hydroxyindolenine	I1-17
Coronaridine hydroxyindolenine, 3-oxo-	I1-18
Coronaridine, 5-hydroxy-6-oxo-	I1-10
Coronaridine, 6-hydroxy-3-oxo-	I1-14
Coronaridine, (6*R*)-3,6-oxido-	I1-16
Coronaridine, 3-oxo-	I1-11
Coronaridine, 5-oxo-	I1-12
Coronaridine, 6-oxo-	I1-13
Coronaridine, 3-(2'-oxopropyl)-	I1-15
Coronaridine pseudoindoxyl	I2-2
12,12'-bis(Coronaridinyl, 11-hydroxy-)	B5-1

TABLE 3 (*continued*)

Alkaloid name	Class, group and individual no.
Crassanine	I2-8
Cylindrocarpidine	P2-5
Cylindrocarpidine, 12-demethoxy-	P2-6
Cylindrocarpidine, homo-	P2-7
Cylindrocarpidine, 5-oxo-	P2-8
Dregamine	C5-5
Eglandine, see: Coronaridine, (6*R*)-3,6-oxido-	
Eglandine, 10-methoxy-, see: Voacangine, (6*R*)-3,6-oxido-	
Eglandulosine, see: Coronaridine, 6-hydroxy-3-oxo-	
Ellipticine, 3,14-dihydro-	M2-1
Ervafolene	B4-1
Ervafolene, 19′-hydroxy-	B4-2
Ervafolidine	B4-7
Ervafolidine, (19′*R*)-19′-hydroxy-	B4-9
Ervafolidine, 3-*epi*-	B4-8
Ervafolidine, (19′*S*)-19′-hydroxy-3-*epi*-	B4-10
Ervafoline	B4-3
Ervafoline, 19′-hydroxy-	B4-4
Ervahanine A	B2-33
Ervahanine B	B2-34
Ervahanine C	B2-35
Ervatamine	C8-1
Ervatamine, 19,20-dehydro-	C8-2
Ervatamine, 20-*epi*-	C8-3
Ervitsine	C9-1
Gabunamine	B2-12
Gabunine	B2-13
Geissoschizine	C1-1
Geissoschizol	C1-2
Geissoschizol, 10-hydroxy-	C1-4
Hazuntine	P2-9
Hazuntinine	P2-10
Hecubine, see: Voaphylline, N_1-methyl	
(+)-Heyneanine	I1-19
(−)-Heyneanine	I1-20
(−)-Heyneanine, 19-*epi*-	I1-21
Heyneanine, 10-hydroxy-	I1-49
Heyneanine, 11-hydroxy-	I1-50
(−)-Heyneanine, 3-oxo-	I1-22
Heyneatine, see: Voacangine, (19*S*)-3,19-oxido-	
Ibogaine	I1-23
Ibogaine hydroxyindolenine	I1-24
Ibogaine pseudoindoxyl	I2-3
Ibogaline	I1-25
(+)-Ibogamine	I1-26
(−)-Ibogamine	I1-27
Ibogamine, (19*R*)-19-hydroxy-	I1-28
Ibogamine pseudoindoxyl	I2-4

TABLE 3 (*continued*)

Alkaloid name	Class, group and individual no.
Ibogamine pseudoindoxyl, (19*R*)-19-hydroxy-	I2-5
Iboluteine, see: Ibogaine pseudoindoxyl	
Ibophyllidine	I6-1
Ibophyllidine, desethyl-	I6-2
Ibophyllidine, 20-*epi*-	I6-3
Ibophyllidine, 19-hydroxy-	I6-4
Ibophyllidine, 18-hydroxy-20-*epi*-	I6-5
Ibophyllidine, (19*R*)-19-hydroxy-20-*epi*-	I6-6
Ibophyllidine, (19*S*)-19-hydroxy-20-*epi*-	I6-7
Ibophyllidine N_4-oxide	I6-8
Iboxygaine	I1-29
Iboxygaine, 19-*epi*-	I1-30
Iboxygaine hydroxyindolenine	I1-31
Iboxygaline, 19-*epi*-	I1-32
Isobonafousine	B6-2
Isocapuvosine, dehydroxy-	B2-6
Isomethuenine	C8-5
Isoreserpiline	C2-2
Isositsirikine, 16-*epi*-	C1-3
Isovallesiachotamine	V1-2
Isovoacangine	I1-36
Isovoacangine, 3-hydroxy-	I1-35
Isovoacangine, 6-hydroxy-3-oxo-	I1-38
Isovoacangine, (6*R*)-3,6-oxido-	I1-40
Isovoacristine	I1-45
Janetine, see: Olivacine, 3,14;4,19-tetrahydro-	
Jollyanine, see: Conopharyngine hydroxyindolenine	
Lochnericine	P2-11
Lochneridine, 20-*epi*-	S1-2
Methuenine	C8-4
Methuenine, 6-oxo-	C8-6
(+)-Minovincine	P2-12
(+)-Minovincine, 3-oxo-	P2-13
Modestanine, see: Apodine, desoxo-	
Montanine, see Voacristine pseudoindoxyl	
Normacusine B	C4-3
Olivacine	M2-2
Olivacine, 3,14;4,19-tetrahydro-	M2-3
Pachysiphine	P2-14
Palosine, *O*-demethyl-	P2-15
Pandicine	B8-1
Pandine	I5-1
Pandoline	I4-7
Pandoline, 20-*epi*-	I4-8
(+)-Pandoline, 19-hydroxy-20-*epi*-	I4-9
Pericalline, see: Appariceine	
Pericyclivine	C4-4
Perivine	C5-6

TABLE 3 (*continued*)

Alkaloid name	Class, group and individual no.
Pleiocarpamine	C10-1
Pleiocarpamine, 16-*epi*-	C10-2
Polyneuridine	C4-5
Polyneuridine, *O*-acetyl-	C4-6
Pregn-5-ene, 20α-amino-3β-yl β-D-glucoside	M5-1
(+)-Presecamine, 15,20; 15′,20′-tetrahydro-	B7-1
(+)-(20*R*)-Pseudo-aspidospermidine	I4-1
(−)-(20*S*)-Pseudo-aspidospermidine	I4-2
(+)-(20*S*)-Pseudo-aspidospermidine, 1,2-dehydro-	I4-3
Pseudo-tabersonine	I4-10
(+)-(20*R*)-Pseudo-vincadifformine	I4-11
(+)-(20*R*)-Pseudo-vincadifformine, 18,19-dihydroxy-	I4-12
Quebrachidine	C6-1
Reserpiline	C2-1
Rupicoline, see: Voacangine pseudoindoxyl	
Secodine, decarbomethoxy-15,20; 16,17-tetrahydro-	M1-1
Serpentine	C2-3
Silicine	C8-7
Silicine, 20-*epi*-	C8-8
Silicine, 6-oxo-	C8-9
Silicine, 6-oxo-16-*epi*-	C8-10
(+)-Stemmadenine	A1-1
Tabernaelegantine A	B2-14
Tabernaelegantine A, (19*R*)-19-hydroxy-	B2-36
Tabernaelegantine B	B2-15
Tabernaelegantine C	B2-16
Tabernaelegantine D	B2-17
Tabernaelegantinine A	B2-18
Tabernaelegantinine B	B2-19
Tabernaelegantinine C	B2-20
Tabernaelegantinine D	B2-21
Tabernamine	B2-22
Tabernamine, 19′,20′-dihydro-	B2-32
Tabernaemontana cumminsii alkaloid, see: Secodine, decarbomethoxy-15,20; 16,17-tetrahydro-	
Tabernanthine	I1-33
Tabernaemontanine	C5-7
Tabernulosine	C7-2
Tabernulosine, 12-demethoxy-	C7-3
Tabernoschizine, see: Apparicine	
Taberpsychine, see: Vobasindiol, anhydro-	
Tabersonine	P2-16
Tabersonine, 10-hydroxy-11-methoxy-	P2-17
Tabersonine, 3-oxo-	P2-18
Tacamine	T1-1
Tetraphyllicine	C6-2
Tetraphyllicine monomethoxybenzoate	C6-3
Tetraphyllicine dimethoxybenzoate	C6-4

TABLE 3 (*continued*)

Alkaloid name	Class, group and individual no.
Tetraphyllicine trimethoxybenzoate	C6-5
Tetrastachyne	B4-5
Tetrastachynine	B4-6
Tombozine, see: Normacusine B	
(−)-Tubotaiwine	A3-3
Tubotaiwine N_4-oxide	A3-4
Vallesamine	A2-2
Vallesamine, *O*-acetyl-	A2-3
Vallesiachotamine	V1-1
Vincadiffine	C5-12
(+)-Vincadifformine	P2-19
(−)-Vincadifformine	P2-20
Vincadifformine, 14,15-dihydroxy-	P2-21
Vincadifformine, 12-hydroxy-	P2-22
(+)-Vincamine	E1-1
(−)-Vincamine	E1-2
(−)-Vincamine, apo-	E1-3
(+)-Vincamine, 14,15-dehydro-16-*epi*-	E1-8
(+)-Vincamine, 14,15-dehydro-12-methoxy-	E1-9
(+)-Vincamine, 16-*epi*-	E1-4
(−)-Vincamine, 16-*epi*-	E1-5
(+)-Vincamine, 21-*epi*-	E1-6
(−)-Vincamine, 21-*epi*-	E1-7
Vincanidine	S1-3
Voacamidine	B2-23
Voacamine	B2-24
Voacamine, 16-decarbomethoxy-	B2-25
Voacamine, 16-decarbomethoxy-19′,20′-dihydro-	B2-26
Voacamine, 16-decarbomethoxy-19′,20′-dihydro-20′-*epi*-	B2-27
Voacamine, N_4′-demethyl-	B2-28
Voacamine N_4′-oxide	B2-29
Voacangarine, see: Voacristine	
Voacangine	I1-34
Voacangine hydroxyindolenine	I1-41
Voacangine, (6*R*)-3,6-oxido-	I1-51
Voacangine, (6*R*)-3,6-oxido-, N_4-oxide	I1-42
Voacangine, (19*S*)-3,19-oxido-	I1-39
Voacangine, 3-oxo-	I1-37
Voacangine, 19-oxo-	I1-47
Voacangine pseudoindoxyl	I2-6
Voacarpine	C5-8
Voachalotine	C4-7
Voacorine	B2-30
Voacorine, 19-*epi*-	B2-31
Voacristine	I1-43
Voacristine, 19-*epi*-	I1-44
Voacristine hydroxyindolenine	I1-46
Voacristine pseudoindoxyl	I2-7

TABLE 3 (*continued*)

Alkaloid name	Class, group and individual no.
Voacryptine, see: Voacangine, 19-oxo-	
Voaluteine, see: Voacangine pseudoindoxyl	
Voaphylline	P1-1
Voaphylline, 12-methoxy-	P1-3
Voaphylline, N_1-methyl-	P1-2
Vobasindiol, anhydro-	C5-9
Vobasine	C5-10
Vobasinic acid, 16-*epi*-	C5-11
Vobtusine	B3-1
Yohimbine	C3-1

4.2. *Alkaloids in order of increasing molecular weight*

In Table 4 the alkaloids are listed in order of increasing molecular weight. When an alkaloid is isolated from a *Tabernaemontana* species this will facilitate a rapid initial orientation from the mass spectrum by indicating on the basis of the molecular-ion peak whether an alkaloid of the observed molecular weight has been isolated before and on the basis of the fragmentation pattern the group to which the alkaloid could belong.

TABLE 4

LIST OF ALKALOIDS OCCURRING IN *TABERNAEMONTANA* SPECIES ARRANGED IN ORDER OF INCREASING MOLECULAR WEIGHT

Molecular weight	Molecular formula and alkaloid name	Class, group and individual no.
246.1157	$C_{17}H_{14}N_2$	
	Olivacine	M2-2
248.1313	$C_{17}H_{16}N_2$	
	3,14-Dihydro-ellipticine	M2-1
250.1470	$C_{17}H_{18}N_2$	
	3,14;4,19-Tetrahydro-olivacine	M2-2
264.1626	$C_{18}H_{20}N_2$	
	Apparicine	A2-1
278.1783	$C_{19}H_{22}N_2$	
	14,15-Anhydrocapuronidine	I4-5
280.1939	$C_{19}H_{24}N_2$	
	14,15-Anhydro-1,2-dihydrocapuronidine	I4-6
	(+)-(20*S*)-1,2-Dehydro-pseudoaspidospermidine	I4-3
	(+)-Ibogamine	I1-26
	(−)-Ibogamine	I1-27
282.2096	$C_{19}H_{26}N_2$	
	(+)-(20*R*)-15,20-Dihydrocleavamine	I3-2

TABLE 4 (*continued*)

Molecular weight	Molecular formula and alkaloid name	Class, group and individual no.
	(−)-(20*S*)-15,20-Dihydrocleavamine	I3-3
	(+)-(20*R*)-Pseudoaspidospermidine	I4-1
	(−)-(20*S*)-Pseudoaspidospermidine	I4-2
294.2252	$C_{19}H_{30}N_2$	
	Decarbomethoxy-15,20; 16,17-tetrahydrosecodine	M1-1
292.1576	$C_{19}H_{20}N_2O$	
	Ervitsine	C9-1
294.1732	$C_{19}H_{22}N_2O$	
	Isomethuenine	C8-5
	Methuenine	C8-4
	Normacusine B	C4-3
296.1525	$C_{18}H_{20}N_2O_2$	
	Desethyl-ibophyllidine	I6-2
296.1889	$C_{19}H_{24}N_2O$	
	Capuronidine	I4-4
	20-*epi*-Silicine	C8-8
	Geissoschizol	C1-2
	(19*R*)-19-Hydroxy-ibogamine	I1-28
	Ibogamine pseudoindoxyl	I2-4
	Silicine	C8-7
	Voaphylline	P1-1
298.2045	$C_{19}H_{26}N_2O$	
	Capuronine	I3-1
308.1525	$C_{19}H_{20}N_2O_2$	
	6-Oxomethuenine	C8-6
	Vincanidine	S1-3
308.1889	$C_{20}H_{24}N_2O$	
	Affinisine	C4-1
	Anhydrovobasindiol	C5-9
	Tetraphyllicine	C6-2
310.1681	$C_{19}H_{22}N_2O_2$	
	N_1-Demethyl-16-*epi*-accedine	C5-2
	6-Oxo-16-*epi*-silicine	C8-10
	6-Oxosilicine	C8-9
310.2045	$C_{20}H_{26}N_2O$	
	Ibogaine	I1-23
	N_1-Methylvoaphylline	P1-2
	Tabernanthine	I1-33
312.1838	$C_{19}H_{24}N_2O_2$	
	10-Hydroxygeissoschizol	C1-4
	(19*R*)-19-Hydroxy-ibogamine pseudoindoxyl	I2-5
313.1215	$C_{20}H_{15}N_3O$	
	Angustine	M4-1
322.1681	$C_{20}H_{22}N_2O_2$	
	Akuammicine	S1-1
	(+)-Condylocarpine	A3-1
	16-*epi*-Pleiocarpamine	C10-2

TABLE 4 (*continued*)

Molecular weight	Molecular formula and alkaloid name	Class, group and individual no.
	Pericyclivine	C4-4
	Pleiocarpamine	C10-1
324.1838	$C_{19}H_{24}N_2O_3$	
	Accedine	C5-1
	Affinine	C5-3
	20-*epi*-Ibophyllidine	I6-3
	Ibophyllidine	I6-1
	(+)-Tubotaiwine	A3-3
326.1994	$C_{19}H_{26}N_2O_3$	
	19-*epi*-Iboxygaine	I1-30
	Ibogaine hydroxyindolenine	I1-24
	Ibogaine pseudoindoxyl	I2-3
	Iboxygaine	I1-29
	12-Methoxyvoaphylline	P1-3
336.1838	$C_{21}H_{24}N_2O_2$	
	(+)-Apovincamine	E1-3
	(+)-Pseudotabersonine	I4-10
	Tabersonine	P2-16
338.1630	$C_{19}H_{22}N_2O_3$	
	Condylocarpine N_4-oxide	A3-2
	16-*epi*-Vobasinic acid	C5-11
	Perivine	C5-6
338.1994	$C_{21}H_{26}N_2O_2$	
	Coronaridine	I1-5
	N_1-Methyl-16-*epi*-affinine	C5-4
	(+)-(20*R*)-Pseudovincadifformine	I4-11
	(+)-Vincadifformine	P2-19
	(−)-Vincadifformine	P2-20
340.1787	$C_{19}H_{24}N_2O_3$	
	20-*epi*-Lochneridine	S1-2
	18-Hydroxy-20-*epi*-ibophyllidine	I6-5
	(19*R*)-19-Hydroxy-20-*epi*-ibophyllidine	I6-6
	(19*S*)-19-Hydroxy-20-*epi*-ibophyllidine	I6-7
	19-Hydroxy-ibophyllidine	I6-4
	Ibophyllidine N_4-oxide	I6-8
	Tubotaiwine N_4-oxide	A3-4
	Vallesamine	A2-2
340.2151	$C_{21}H_{28}N_2O_2$	
	(+)-Demethylaspidospermine	P2-14
	Ibogaline	I1-25
342.1943	$C_{19}H_{26}N_2O_3$	
	Iboxygaine hydroxyindolenine	I1-31
348.1110	$C_{19}H_{14}N_2O_4$	
	Camptothecine	M3-1
348.1474	$C_{21}H_{20}N_2O_3$	
	Serpentine	C2-3
350.1630	$C_{21}H_{22}N_2O_3$	

TABLE 4 (*continued*)

Molecular weight	Molecular formula and alkaloid name	Class, group an individual no.
	Isovallesiachotamine	V1-2
	3-Oxotabersonine	P2-18
	Vallesiachotamine	V1-1
352.1787	$C_{21}H_{24}N_2O_2$	
	Akuammidine	C4-1
	(+)-14,15-Dehydro-16-*epi*-vincamine	E1-8
	19,20-Dehydro-ervatamine	C8-2
	Desoxo-apodine	P2-2
	Geissoschizine	C1-1
	Lochnericine	P2-11
	(+)-Minovincine	P2-12
	(6*R*)-3,6-Oxidocoronaridine	I1-16
	3-Oxocoronaridine	I1-11
	5-Oxocoronaridine	I1-12
	6-Oxocoronaridine	I1-13
	Pachysiphine	P2-14
	Pandine	I5-1
	Polyneuridine	C4-5
	Quebrachidine	C6-1
	Tetrahydro-alstonine	C2-4
	Vobasine	C5-10
354.1943	$C_{21}H_{26}N_2O_2$	
	Coronaridine hydroxyindolenine	I1-17
	Coronaridine pseudoindoxyl	I2-2
	Dregamine	C5-5
	(−)-19-*epi*-Heyneanine	I1-21
	20-*epi*-Ervatamine	C8-3
	16-*epi*-Isositsirikine	C1-3
	20-*epi*-Pandoline	I4-8
	(+)-16-*epi*-Vincamine	E1-4
	(−)-16-*epi*-Vincamine	E1-5
	(+)-21-*epi*-Vincamine	E1-6
	(−)-21-*epi*-Vincamine	E1-7
	Ervatamine	C8-1
	(+)-Heyneanine	I1-19
	(−)-Heyneanine	I1-20
	3-Hydroxycoronaridine	I1-7
	10-Hydroxycoronaridine	I1-8
	11-Hydroxycoronaridine	J1-48
	18-Hydroxycoronaridine	I1-9
	12-Hydroxyvincadifformine	P2-22
	Pandoline	I4-7
	(+)-Stemmadenine	A1-1
	Tabernaemontanine	C5-7
	Tacamine	T1-1
	(+)-Vincamine	E1-1
	(−)-Vincamine	E1-2

TABLE 4 (*continued*)

Molecular weight	Molecular formula and alkaloid name	Class, group and individual no.
	Yohimbine	C3-1
354.2307	$C_{21}H_{30}N_2O_2$ *O*-Demethylpalosine	P2-15
356.2100	$C_{21}H_{28}N_2O_3$ 19-*epi*-Iboxygaline	I1-32
366.1579	$C_{21}H_{22}N_2O_4$ Apodine	P2-1
	(+)-3-Oxominovincine	P2-13
366.1943	$C_{21}H_{26}N_2O_3$ Voachalotine	C4-7
368.1736	$C_{21}H_{24}N_2O_4$ 12-Demethoxytabernulosine	C7-3
	5-Hydroxy-6-oxocoronaridine	I1-10
	6-Hydroxy-3-oxocoronaridine	I1-14
	3-Oxocoronaridine hydroxyindolenine	I1-18
	(−)-3-Oxoheyneanine	I1-22
	Voacarpine	C5-8
368.2100	$C_{22}H_{28}N_2O_3$ 12-Demethoxycylindrocarpidine	P2-6
	Isovoacangine	I1-36
	Voacangine	I1-34
370.1892	$C_{21}H_{26}N_2O_4$ (+)-(20*R*)-18,19-Dihydroxy-pseudovincadifformine	I4-12
	14,15-Dihydroxyvincadifformine	P2-21
	(+)-19-Hydroxy-20-*epi*-pandoline	I4-9
	10-Hydroxyheyneanine	I1-49
	11-Hydroxyheyneanine	I1-50
378.1216	$C_{21}H_{18}N_2O_5$ 9-Methoxycamptothecine	M3-2
382.1528	$C_{21}H_{22}N_2O_5$ Apodinine	P2-3
382.1892	$C_{22}H_{26}N_2O_4$ *O*-Acetylvallesamine	A2-2
	14,15-Dehydro-12-methoxyvincamine	E1-9
	Hazuntine	P2-9
	10-Hydroxy-11-methoxytabersonine	P2-16
	Lochnericine	P2-11
	(6*R*)-3,6-Oxido-isovoacangine	I1-40
	(6*R*)-3,6-Oxidovoacangine	I1-51
	(19*S*)-3,19-Oxidovoacangine	I1-39
	3-Oxovoacangine	I1-37
	19-Oxovoacangine	I1-47
	Vincadiffine	C5-12
382.2256	$C_{23}H_{30}N_2O_3$ 3-Ethoxycoronaridine	I1-6
	(3*S*)-3-(β-Hydroxyethyl)-coronaridine	I1-52
384.2049	$C_{23}H_{28}N_2O_4$	

TABLE 4 (*continued*)

Molecular Weight	Molecular formula and alkaloid name	Class, group and individual no.
	19-*epi*-Voacristine	I1-44
	3-Hydroxy-isovoacangine	I1-35
	Isovoacristine	I1-45
	Voacangine hydroxyindolenine	I1-41
	Voacangine pseudoindoxyl	I2-6
	Voacristine	I1-43
394.1892	$C_{23}H_{26}N_2O_4$ *O*-Acetylpolyneuridine	C4-5
	Akuammiline	C7-1
394.2256	$C_{24}H_{30}N_2O_3$ 3-(2′-Oxopropyl)-coronaridine	I1-15
398.1842	$C_{23}H_{26}N_2O_5$ 6-Hydroxy-3-oxo-isovoacangine	I1-38
	(6*R*)-3,6-Oxidovoacangine N_4-oxide	I1-42
	Tabernulosine	C7-2
398.2205	$C_{23}H_{30}N_2O_4$ Conopharyngine	I1-1
	Cylindrocarpidine	P2-5
400.1998	$C_{23}H_{28}N_2O_4$ Voacristine hydroxyindolenine	I1-46
	Voacristine pseudoindoxyl	I2-7
412.1998	$C_{23}H_{28}N_2O_5$ Hazuntinine	P2-9
	Isoreserpiline	C2-2
	3-Oxoconopharyngine	I1-3
	5-Oxocylindrocarpidine	P2-8
	Reserpiline	C2-1
412.2362	$C_{24}H_{32}N_2O_4$ Homocylindrocarpidine	P2-7
414.2154	$C_{23}H_{30}N_2O_5$ Conopharyngine hydroxyindolenine	I1-4
	Conopharyngine pseudoindoxyl	I2-1
	Crassanine	I2-8
	19-Hydroxyconopharyngine	I1-2
442.2256	$C_{25}H_{30}N_2O_5$ Tetraphyllicine monomethoxybenzoate	C6-3
472.2362	$C_{26}H_{32}N_2O_6$ Tetraphyllicine dimethoxybenzoate	C6-4
479.2546	$C_{27}H_{45}NO_6$ 20α-Aminopregn-5-en-3β-yl β-D-glucoside	M5-1
502.2468	$C_{26}H_{34}N_2O_7$ Tetraphyllicine trimethoxybenzoate	C6-5
564.3100	$C_{35}H_{40}N_4O_5$ Bonafousine	B6-1
	Isobonafousine	B6-2
616.3777	$C_{40}H_{48}N_4O_4$ (20*R*)-Capuvosidine	B2-1

TABLE 4 (*continued*)

Molecular weight	Molecular formula and alkaloid name	Class, group and individual no.
	Tabernamine	B2-22
618.3934	$C_{40}H_{50}N_4O_3$	
	Dehydroxycapuvosine	B2-4
	Dehydroxy-isocapuvosine	B2-6
	(20*R*)-Dihydrocapuvosidine	B2-2
	(20*S*)-1,2-Dihydrocapuvosidine	B2-37
	(20′*S*)-19′,20′-Dihydrotabernamine	B2-32
620.3726	$C_{39}H_{48}N_4O_3$	
	$N_{4'}$-Demethylcapuvosine	B2-5
628.3413	$C_{40}H_{44}N_4O_3$	
	Ervafolene	B4-1
634.3883	$C_{40}H_{50}N_4O_3$	
	Capuvosine	B2-3
644.3362	$C_{40}H_{44}N_4O_4$	
	Ervafoline	B4-3
	19′-Hydroxy-ervafolene	B4-2
644.3726	$C_{41}H_{48}N_4O_3$	
	Accedinisine	B1-2
646.3883	$C_{41}H_{50}N_4O_3$	
	16-Decarbomethoxyvoacamine	B2-25
648.4039	$C_{41}H_{52}N_4O_3$	
	16-Decarbomethoxy-19′,20′-dihydro-20′-*epi*-voacamine	B2-27
	16-Decarbomethoxy-19′,20′-dihydrovoacamine	B2-26
660.3311	$C_{40}H_{44}N_4O_5$	
	19′-Hydroxy-ervafoline	B4-4
660.3676	$C_{41}H_{48}N_4O_4$	
	Accedinine	B1-1
662.3468	$C_{40}H_{46}N_4O_5$	
	3-*epi*-Ervafolidine	B4-8
	Ervafolidine	B4-7
674.3832	$C_{43}H_{50}N_4O_4$	
	Ervahanine A	B2-33
	Ervahanine B	B2-34
	Ervahanine C	B2-35
678.3417	$C_{40}H_{46}N_4O_6$	
	(19′*S*)-19′-Hydroxy-3-*epi*-ervafolidine	B4-10
	(19′*R*)-19′-Hydroxy-ervafolidine	B4-9
680.4302	$C_{42}H_{56}N_4O_4$	
	(+)-15,20; 15′,20′-Tetrahydropresecamine	B7-1
690.3781	$C_{42}H_{50}N_4O_5$	
	$N_{4'}$-Demethylvoacamine	B2-28
	Gabunamine	B2-12
	Gabunine	B2-13
704.3938	$C_{43}H_{52}N_4O_5$	
	Conoduramine	B2-7
	Conodurine	B2-9

TABLE 4 (*continued*)

Molecular weight	Molecular formula and alkaloid name	Class, group and individual no.
	Voacamidine	B2-23
	Voacamine	B2-24
706.3730	$C_{42}H_{50}N_4O_6$	
	12,12′-Bis(11-Hydroxycoronaridinyl)	B5-1
	Tetrastachyne	B4-5
	Tetrastachynine	B4-6
706.4094	$C_{43}H_{54}N_4O_5$	
	Tabernaelegantine A	B2-14
	Tabernaelegantine B	B2-15
	Tabernaelegantine C	B2-16
	Tabernaelegantine D	B2-17
718.3730	$C_{43}H_{50}N_4O_6$	
	19′,20′-Epoxyconoduramine	B2-8
	3-Oxoconodurine	B2-10
	Vobtusine	B3-1
0.3887	$C_{43}H_{52}N_4O_6$	
	19-*epi*-Voacorine	B2-31
	Voacamine $N_{4'}$-oxide	B2-29
	Voacorine	B2-30
722.4043	$C_{43}H_{54}N_4O_6$	
	(19*R*)-19-Hydroxytabernaelegantine A	B2-36
731.4046	$C_{44}H_{53}N_3O_6$	
	Tabernaelegantinine C	B2-20
	Tabernaelegantinine D	B2-21
746.3679	$C_{44}H_{50}N_4O_7$	
	Pandicine	B8-1
7 .4199	$C_{44}H_{54}N_4O_6$	
	3-(2′-Oxopropyl)-conodurine	B2-11
762.4356	$C_{46}H_{58}N_4O_6$	
	Tabernaelegantinine A	B2-18
	Tabernaelegantinine B	B2-19

4.3. *List of the alkaloids and the plants in which they occur*

The alkaloids isolated from *Tabernaemontana* species are arranged below in the groups and subgroups of the biogenetic classification discussed in §3.2 and set out in Tables 1 and 2. Within each subgroup the alkaloids are listed in the following way: the names of the various alkaloids are derived from the names of certain parent alkaloids; these latter were put in alphabetical order, and all the alkaloid names based on the name of a given parent alkaloid were in turn listed alphabetically. However, the subsequent inclusion at the end of the appropriate subgroups of new alkaloids, described since the original listing was made, has to some extent obscured the arrangement. For

each alkaloid are indicated the molecular formula, the structure, and the species (named as accepted in § 2.5) and plant part(s) from which the alkaloid has been obtained. The literature references are likewise included. There is, of course, no guarantee as to the correctness of the botanical identification of most of the plant materials investigated, although where possible the identity of the vouchers specimens has been checked by one of the authors (A.J.M.L.). For example, the structural determination of the steroidal alkaloid 20α-aminopregn-5-en-3β-yl β-D-glucoside (M4-1) reported to have been isolated from *T. pachysiphon* is probably correct, but since this is the only example of the supposed occurrence of such an alkaloid in the genus the identity of the plant material examined is open to serious doubt.

The methods of determining the identity of the isolated alkaloids have not been taken into account, since it is a matter of personal opinion whether on the basis of the data presented a compound is to be considered as having been satisfactorily identified or not. Moreover, it is unfortunately becoming more and more common nowadays to give only the name of an isolated compound without further data, and this makes an immediate check on the adequacy of the identification methods used impossible.

All the reported isolations and identifications of *Tabernaemontana* alkaloids are included, even if there is reason to doubt the correctness of the identification, e.g. the identification of (+)-heyneanine [240] and (+)-ibogamine [130] solely on the grounds of the $[\alpha]_D$ value seems questionable. The use of ORD or CD would be necessary to clear up the doubt, since all 11 iboga alkaloids so far found in *Tabernaemontana* species occur in the (−)-form (coronaridine type) and the two reported isolations, if confirmed, would then be the only two examples of the occurrence of the (+)-form (catharanthine type) [276].

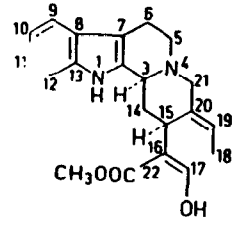
The use of the prefixes (+) and (−) to differentiate between enantiomers may lead to ambiguity where more than one asymmetric carbon atom is present. While, for example, in the case of vincamine there is no problem in distinguishing between the two parent compounds (+)-vincamine and (−)-vincamine, when the stereochemistry at one or more of its three asymmetric centers is inverted, this convention may cause confusion because as a result of the inversion in the stereochemistry the sign of the optical rotation may change. Thus, "(+)-21-*epi*-vincamine" can mean: (i) the C-21 epimer of (+)-vincamine — and the optical rotation happens to be positive; or (ii) the C-21 epimer of either (+)- or (−)-vincamine — and that the compound has an optical rotation which is positive. The objection to the use of (+) in (i) is that paradoxically a derivative of a (+)-compound may possess a negative optical rotation, while the objection to its use in (ii) is that without prior knowledge of the influence of the different asymmetric centers on the optical rotation it is not possible with certainty to draw the correct stereochemical structure. A further disadvantage of the (+)/(−) convention is that the sign of the optical rotation can change with a change in solvent; (+)-vincamine has a positive rotation in pyridine but a negative rotation in chloroform [151].

This introduces yet another difficulty, since strictly speaking optical rotations cannot be compared when the solvent(s) in which they were determined are not known. The more comprehensive ORD or CD data are to be preferred. In view of these considerations, it must always be made very clear what a particular alkaloid (or any other) name means. Following on from this, it must be borne in mind that there is also ambiguity between the names (+)-21-*epi*-vincamine and 21-*epi*-(+)-vincamine and that they do not necessarily represent the same stereoisomer.

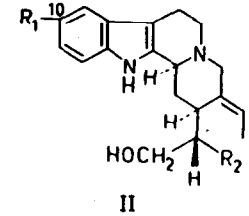
The abbreviations used in this and subsequent sections for the different parts of the plants investigated are: b = bark; fl = flowers; fr = fruits; l = leaves; la = latex; r = roots; rb = root bark; sb = stem bark; se = seeds; st = stems; sw = stem wood; tw = twigs; unk = unknown; wp = whole plant.

CORYNANTHEAN TYPE

Group C1



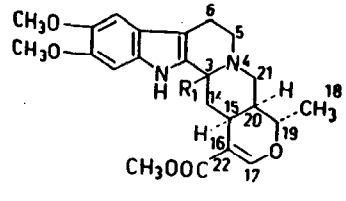
I



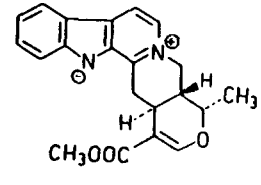
II

1. Geissoschizine (I): $C_{21}H_{24}N_2O_3$
   T. siphilitica: l [310,331,415].
2. Geissoschizol (II: $R_1 = R_2 = H$): $C_{19}H_{24}N_2O$
   T. bufalina: r [435]; *T. laeta:* l, tw [275].
3. 16-*epi*-Isositsirikine (II: $R_1 = H$, $R_2 = COOCH_3$): $C_{21}H_{26}N_2O_3$
   T. psychotrifolia: l [370,418]; *T. psorocarpa:* sb [441].
4. 10-hydroxygeissoschizol (II: $R_1 = OH$, $R_2 = H$): $C_{19}H_{24}N_2O_2$
   T. bufalina: r [435].

Group C2



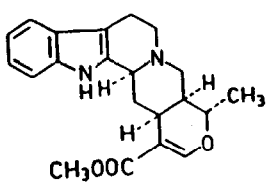
III



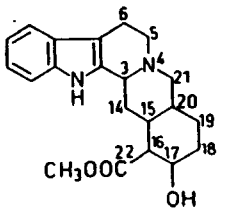
IV

1. Reserpiline (III: R_1 = β-H): $C_{21}H_{28}N_2O_5$
   T. coffeoides: sb [329].
2. Isoreserpiline (III: R_1 = α-H): $C_{21}H_{28}N_2O_5$
   T. coffeoides: sb [329].
3. Serpentine (IV): $C_{21}H_{20}N_2O_3$
   T. affinis: r [131].
4. Tetrahydroalstonine (V): $C_{21}H_{24}N_2O_3$
   T. psorocarpa: sb [441]; *T. siphilitica:* l [331,415].

Group C3



V

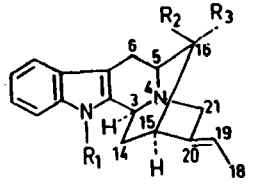


VI

1. Yohimbine (VI): $C_{21}H_{26}N_2O_3$, stereochemistry unknown
   T. affinis: r [131].

Group C4

Compounds which have a hydroxyl function at C-3 are considered to belong to group C5 (q.v.).



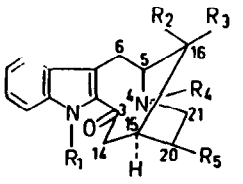
VII

1. Affinisine (VII: R_1 = CH_3, R_2 = H, R_3 = CH_2OH): $C_{20}H_{24}N_2O$
   T. affinis: rb [304], unk [156,158]; *T. fuchsiifolia:* sb [181].
2. Akuammidine (VII: R_1 = H, R_2 = $COOCH_3$, R_3 = CH_2OH): $C_{21}H_{24}N_2O_3$
   T. amblyocarpa: l [407]; *T. coffeoides:* l [367]; *T. humblotii:* l [279]; *T. laeta:* l, tw [344]; *T. olivacea:* st [379]; *T. orientalis:* unk [383]; *T. laeta:* l, tw [344]; *T. olivacea:* st [379]; *T. orientalis:* unk [383];
3. Normacusine B (VII: R_1 = R_2 = H, R_3 = CH_2OH): $C_{19}H_{22}N_2O$
   T. brachyantha: sb [263]; *T. coffeoides:* l, sb [329]; *T. laeta:* l, tw [344].

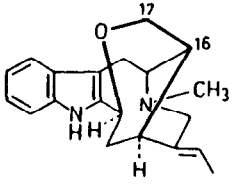
4. Pericyclivine (VII: R_1 = R_3 = H, R_2 = $COOCH_3$): $C_{20}H_{22}N_2O_2$
   T. coffeoides: l [389]; *T. crassa:* unk [168]; *T. pachysiphon:* r [334]; *T. pandacaqui:* l [235]; *T. stapfiana:* b, st [354].
5. Polyneuridine (VII: R_1 = H, R_2 = CH_2OH, R_3 = $COOCH_3$): $C_{21}H_{24}N_2O_3$
   T. coffeoides: l [367].
6. *O*-Acetylpolyneuridine (VII: R_1 = H, R_2 = CH_2OAc, R_3 = $COOCH_3$): $C_{23}H_{26}N_2O_4$
   T. crassa: b [201].
7. Voachalotine (VII: R_1 = CH_3, R_2 = CH_2OH, R_3 = $COOCH_3$): $C_{22}H_{26}N_2O_3$
   T. fuchsiifolia: sb [181,200].

Group C5

Compounds with a N—H function (VIII, R_4 = H) can occur as a tautomeric mixture of two forms, depending on the solvent, temperature, etc. Here only the acylindole form of each alkaloid is shown.



VIII

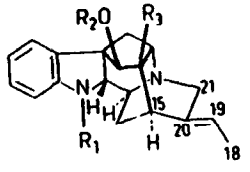


IX

1. Accedine (VIII: R_1 = CH_3, R_2 = R_4 = H, R_3 = CH_2OH, R_5 = =CH—CH_3): $C_{20}H_{24}N_2O_2$
   T. accedens: rb [283].
2. N_1-Demethyl-16-*epi*-accedine (VIII: R_1 = R_3 = R_4 = H, R_2 = CH_2OH, R_5 = =CH—CH_3): $C_{19}H_{22}N_2O_2$
   T. accedens: rb [306].
3. Affinine (VIII: R_1 = R_3 = H, R_2 = CH_2OH, R_4 = CH_3, R_5 = =CH—CH_3): $C_{20}H_{24}N_2O_2$
   T. affinis: unk [156,158]; *T. laeta:* l, tw [344]; *T. pachysiphon:* sb [191]; *T. psychotrifolia:* sb [239].
4. N_1-Methyl-16-*epi*-affinine (VIII: R_1 = R_2 = H, R_3 = CH_2OH, R_4 = CH_3, R_5 = =CH—CH_3): $C_{21}H_{26}N_2O_2$
   T. accedens: rb [283].
5. Dregamine (VIII: R_1 = R_3 = H, R_2 = $COOCH_3$, R_4 = CH_3, R_5 = α-C_2H_5): $C_{21}H_{26}N_2O_3$
   T. calcarea: l [274], sb, rb [274,303]; *T. coffeoides:* l [217,329,389], r [242], tw [217], sb, rb [217,329,367,389]; *T. debrayi:* l, sb, rb [274]; *T. divaricata:* l [302], st [132]; *T. elegans:* rb [289]; *T. mauritiana:* sb, rb [280]; *T. orientalis:* l, tw [388], b [294], unk [383]; *T. sessilifolia:* sb, rb [291]; *T. sphaerocarpa:* l, sb, st [212].

5. Perivine (VIII: $R_1 = R_3 = R_4 = H$, $R_2 = COOCH_3$, $R_5 = =CH-CH_3$): $C_{20}H_{22}N_2O_3$
   T. bufalina: r [435]; *T. crassa:* unk [168]; *T. dichotoma:* l [431]; *T. eglandulosa:* rb [284]; *T. fuchsiifolia:* unk [387]; *T. pachysiphon:* r [334]; *T. stapfiana:* b, st [354].
7. Tabernaemontanine (VIII: $R_1 = R_3 = H$, $R_2 = COOCH_3$, $R_4 = CH_3$, $R_5 = \beta\text{-}C_2H_5$): $C_{21}H_{26}N_2O_3$
   T. coffeoides: r [242], sb, rb [217,329,367,389], tw [217], l [217,329,389]; *T. divaricata:* sb, b, r [83], fl, l, st, r [183], l [281,302], b [89], st [132]; *T. elegans:* rb [289]; *T. mucronata:* b [180]; *T. orientalis:* l, tw [388], b [294], unk [383]; *T. pandacaqui:* l [235]; *T. sessilifolia:* l, sb, rb [291]; *T. sphaerocarpa:* l, sb, st [212].
8. Voacarpine (VIII: $R_1 = R_4 = H$, $R_2 = COOCH_3$, $R_3 = CH_2OH$, $R_5 = =CH-CH_3$): $C_{21}H_{24}N_2O_4$
   T. coffeoides: l [217,367], tw, sb, st [217].
9. Anhydrovobasindiol (IX): $C_{20}H_{24}N_2O$
   T. brachyantha: sb [263]; *T. crassa:* sb [222]: *T. psychotrifolia:* sb [209,239].
10. Vobasine (VIII: $R_1 = R_3 = H$, $R_2 = COOCH_3$, $R_4 = CH_3$, $R_5 = =CH-CH_3$): $C_{21}H_{24}N_2O_3$
    T. affinis: unk [156]; *T. bufalina:* r [435]; *T. cerifera:* l [360]; *T. coffeoides:* l [217,329,367,389], tw [217], sb, rb [217,329,367]; *T. crassa:* unk [168]; *T. dichotoma:* l [431]; *T. divaricata:* fl, l, st, r [183]; *T. eglandulosa:* rb [284]; *T. eusepala:* sb [298]; *T. fuchsiifolia:* sb [412]; *T. laeta:* l, tw [344]; *T. lundii:* l, b, st [225]; *T. mauritiana:* sb, rb [280]; *T. minutiflora:* l [297]; *T. orientalis:* l, tw [388], sb [294], unk [383]; *T. pachysiphon:* r [334]; *T. psychotrifolia:* l, rb [418].
11. 16-*epi*-Vobasinic acid (VIII: $R_1 = R_2 = H$, $R_3 = COOH$, $R_4 = CH_3$, $R_5 = =CH-CH_3$): $C_{20}H_{22}N_2O_3$
    T. psychotrifolia: sb [239].
12. Vincadiffine (VIII: $R_1 = H$, $R_2 = COOCH_3$, $R_3 = CH_2OH$, $R_4 = CH_3$, $R_5 = =CH-CH_3$): $C_{22}H_{26}N_2O_4$
    T. glandulosa: l, st [432].

Group C6

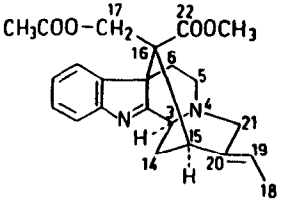


X

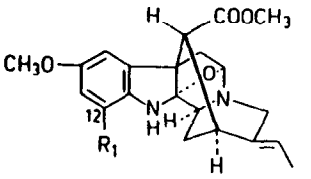
Quebrachidine (X: $R_1 = R_2 = H$, $R_3 = COOCH_3$): $C_{21}H_{24}N_2O_3$
T. undulata: sb [365].

2. Tetraphyllicine (X: $R_1 = CH_3$, $R_2 = R_3 = H$): $C_{20}H_{24}N_2O$
   T. coffeoides: sb [329].
3. Tetraphyllicine monomethoxybenzoate (X: $R_1 = CH_3$, $R_2 = COC_6H_4OCH_3$, $R_3 = H$): $C_{28}H_{30}N_2O_3$
   T. coffeoides: sb [329].
4. Tetraphyllicine dimethoxybenzoate (X: $R_1 = CH_3$, $R_2 = COC_6H_3(OCH_3)_2$, $R_3 = H$): $C_{29}H_{32}N_2O_4$
   T. coffeoides: sb [329].
5. Tetraphyllicine trimethoxybenzoate (X: $R_1 = CH_3$, $R_2 = COC_6H_2(OCH_3)_3$, $R_3 = H$): $C_{30}H_{34}N_2O_5$
   T. coffeoides: sb [329].

Group C7



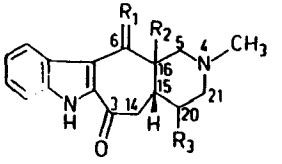
XI



XII

1. Akuammiline (XI): $C_{23}H_{26}N_2O_4$
   T. crassa: sb [222].
2. Tabernulosine (XII: $R_1 = OCH_3$): $C_{22}H_{26}N_2O_5$
   T. glandulosa: l, st [381,432].
3. 12-Demethoxytabernulosine (XII: $R_1 = H$): $C_{21}H_{24}N_2O_4$
   T. glandulosa: l, st [432].

Group C8



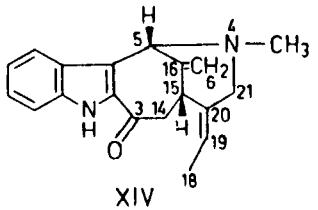
XIII

1. Ervatamine (XIII: $R_1 = H_2$, $R_2 = \beta\text{-}COOCH_3$, $R_3 = \beta\text{-}C_2H_5$): $C_{21}H_{26}N_2O_3$
   T. orientalis: l, sb [294], l, tw [388].
2. 19,20-Dehydro-ervatamine (XIII: $R_1 = H_2$, $R_2 = \beta\text{-}COOCH_3$, $R_3 = =CH-CH_3$): $C_{21}H_{24}N_2O_3$

T. mocquerysii: unk [362]; *T. orientalis:* l, sb [294].

3. 20-*epi*-Ervatamine (XIII: $R_1 = H_2$, $R_2 = \beta$-$COOCH_3$, $R_3 = \alpha$-C_2H_5): $C_{21}H_{26}N_2O_3$
   T. orientalis: l, tw [388], sb [294].
4. Methuenine (XIII: $R_1 = H_2$, $R_2 = \beta$-H, $R_3 = =CH—CH_3$): $C_{19}H_{22}N_2O$
   T. coffeoides: l [329,389], sb, rb [329,367,389]; *T. mocquerysii:* rb [327,362].
5. Isomethuenine (XIII: $R_1 = H_2$, $R_2 = \alpha$-H, $R_3 = =CH—CH_3$): $C_{19}H_{22}N_2O$
   T. coffeoides: sb [367], rb [329,367]; *T. dichotoma:* l [438].
6. 6-Oxomethuenine (XIII: $R_1 = O$, $R_2 = \beta$-H, $R_3 = =CH—CH_3$): $C_{19}H_{20}N_2O_2$
   T. coffeoides: sb [329].
7. Silicine (XIII: $R_1 = H_2$, $R_2 = \beta$-H, $R_3 = \alpha$-C_2H_5) [429]: $C_{19}H_{24}N_2O$
   T. calcarea: l, sb, rb [303]; *T. coffeoides:* l [329,389], sb, rb [329,367,389], r [361].
8. 20-*epi*-Silicine (XIII: $R_1 = H_2$, $R_2 = \beta$-H, $R_3 = \beta$-C_2H_5) [429]: $C_{19}H_{24}N_2O$
   T. coffeoides: sb [329].
9. 6-Oxosilicine (XIII: $R_1 = O$, $R_2 = \beta$-H, $R_3 = \alpha$-C_2H_5): $C_{19}H_{22}N_2O_2$
   T. coffeoides: sb [367,389], sb [329,367,389], r [361].
10. 6-Oxo-16-*epi* silicine (XIII: $R_1 = O$, $R_2 = \alpha$-H, $R_3 = \alpha$-C_2H_5): $C_{19}H_{22}N_2O_2$
    T. coffeoides: sb, rb [389].

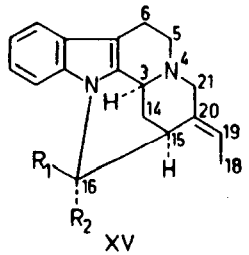
Group C9



XIV

1. Ervitsine (XIV): $C_{19}H_{20}N_2O$
   T. mocquerysii: rb [327,362].

Group C10



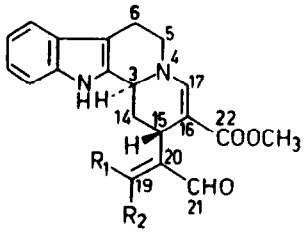
XV

1. Pleiocarpamine (XV: $R_1 = COOCH_3$, $R_2 = H$): $C_{20}H_{22}N_2O_2$
   T. psychotrifolia: l, sb [417]; *T. siphilitica:* l [331,415].

2. 16-*epi*-Pleiocarpamine (XV: $R_1 = H$, $R_2 = COOCH_3$): $C_{20}H_{22}N_2O_2$
   T. attenuata: l [426].

VALLESIACHOTAMAN TYPE

Group V1

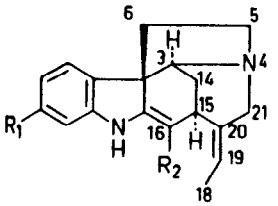


XVI

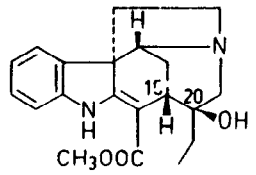
1. Vallesiachotamine (XVI: $R_1 = CH_3$, $R_2 = H$): $C_{21}H_{22}N_2O_3$
   T. psorocarpa: sb [441].
2. Isovallesiachotamine (XVI: $R_1 = H$, $R_2 = CH_3$): $C_{21}H_{22}N_2O_3$
   T. psorocarpa: sb [441].

STRYCHNAN TYPE

Group S1



XVII

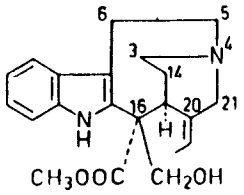


XVIII

1. Akuammicine (XVII: $R_1 = H$, $R_2 = COOCH_3$): $C_{20}H_{22}N_2O_2$
   T. humblotii: l, sb, rb [279].
2. 20-*epi*-Lochneridine (XVIII): $C_{20}H_{24}N_2O_3$
   The configuration of H-15 in 20-*epi*-lochneridine is the opposite of that of the equivalent H in secologanin. According to Kisakürek and Hesse [405], the alkaloid may well be an artefact arising from an isomerization at C-15.
   T. pandacaqui: l [187].
3. Vincanidine (XVII: $R_1 = OH$, $R_2 = CHO$): $C_{19}H_{20}N_2O_2$
   T. coffeoides: l [329].

ASPIDOSPERMATAN TYPE

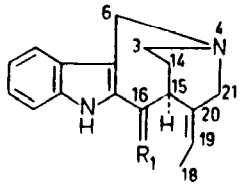
Group A1



XIX

1. (+)-Stemmadenine (XIX): $C_{21}H_{26}N_2O_3$
   T. minutiflora: l [297]; *T. coffeoides:* l [329].

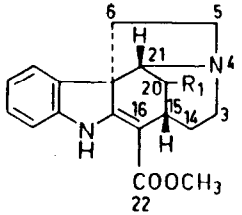
Group A2



XX

1. Apparicine (XX: R_1 = C(22)H_2): $C_{18}H_{20}N_2$
   T. calcarea: l [274]; *T. cerifera:* l [360]; *T. citrifolia:* l [371]; *T. coffeoides:* l [389], sb, rb [367,389]; *T. crassa:* sb [126], rb [153]; *T. dichotoma:* l [431]; *T. divaricata:* fl [416]; *T. eusepala:* sb [298]; *T. heyneana:* sb, st [396]; *T. humblotii:* l [279]; *T. orientalis:* l [294]; *T. pachysiphon:* l [153,233]; *T. sessilifolia:* l, sb, rb [291]; *T. siphilitica:* l [331,415].
2. Vallesamine (XX: R_1 = C(17)H_2OH, C(22)OOCH_3): $C_{20}H_{24}N_2O_3$
   T. amblyocarpa: st [407]; *T. coffeoides:* l [389].
3. *O*-Acetylvallesamine (XX: R_1 = C(17)H_2OAc, C(22)OOCH_3): $C_{22}H_{26}N_2O_4$
   T. heyneana: sb, st [396].

Group A3

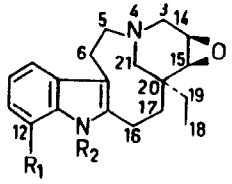


XXI

1. (+)-Condylocarpine (XXI: R_1 = =CH—CH_3): $C_{20}H_{22}N_2O_2$
   T. minutiflora: l [297].
2. Condylocarpine N_4-oxide (XXI: R_1 = =CH—CH_3, N_4^+—O^-): $C_{20}H_{22}N_2O_3$
   T. olivacea: tw (379].
3. (+)-Tubotaiwine (XXI: R_1 = α-C_2H_5): $C_{20}H_{24}N_2O_2$
   T. amblyocarpa: st [407]; *T. attenuata:* l [426]; *T. eusepala:* sb [298]; *T. heyneana:* sb, st [396]; *T. humblotii:* sb, rb [279]; *T. mauritiana:* l, sb, rb [280]; *T. minutiflora:* l [297]; *T. mocquerysii:* unk [362]; *T. psychotrifolia:* l [418]; *T. siphilitica:* l [331,415]; *T. stapfiana:* rb [253].
4. Tubotaiwine N_4-oxide (XXI: R_1 = α-C_2H_5, N_4^+—O^-): $C_{20}H_{24}N_2O_3$
   T. pachysiphon: r [333]; *T. stapfiana:* rb [253].

PLUMERAN TYPE

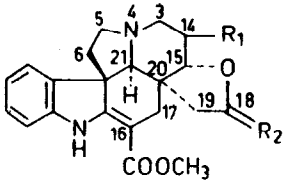
Group P1



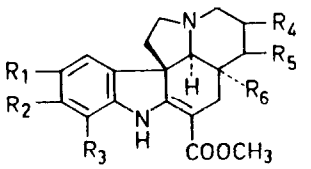
XXII

1. Voaphylline (XXII: R_1 = R_2 = H): $C_{19}H_{24}N_2O$
   T. chippii: l [206]: *T. coffeoides:* l [367]; *T. divaricata:* fl [416], l [281,313]; *T. heterophylla:* l [397]; *T. longiflora:* l, sb [199]; *T. macrocarpa:* se [337]; *T. retusa:* se [278]; *T. undulata:* se [248], sb [365].
2. N_1-Methylvoaphylline (XXII: R_1 = H, R_2 = CH_3): $C_{20}H_{26}N_2O$
   T. divaricata: fl [348,416], l [313].
3. 12-Methoxyvoaphylline (XXII: R_1 = OCH_3, R_2 = H): $C_{20}H_{26}N_2O_2$
   T. dichotoma: l [431].

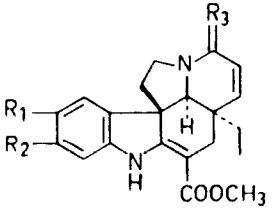
Group P2



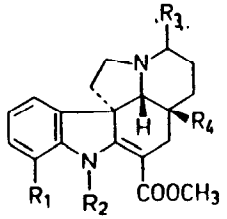
XXIII



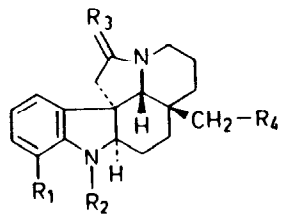
XXIV



XXV



XXVI



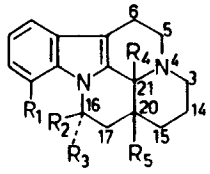
XXVII

1. Apodine (XXIII: R_1 = H, R_2 = O): $C_{21}H_{22}N_2O_4$, stereochemistry uncertain
   T. apoda: l [293].
2. Desoxo-apodine (XXIII: R_1 = H, R_2 = H_2): $C_{21}H_{24}N_2O_3$, stereochemistry uncertain
   T. apoda: l [292]; *T. coffeoides:* l [389].
3. Apodinine (XXIII: R_1 = OH, R_2 = H_2): $C_{21}H_{22}N_2O_5$, stereochemistry uncertain
   T. apoda: l [372].
4. (+)-Demethylaspidospermine (XXVII: R_1 = OH, R_2 = $COCH_3$, R_3 = H_2, R_4 = CH_3): $C_{21}H_{28}N_2O_2$
   T. amygdalifolia: r [412].
5. Cylindrocarpidine (XXVII: R_1 = OCH_3, R_2 = $COCH_3$, R_3 = H_2, R_4 = $COOCH_3$): $C_{23}H_{30}N_2O_4$
   T. amygdalifolia: r [197].
6. 12-Demethoxycylindrocarpidine (XXVII: R_1 = H, R_2 = $COCH_3$, R_3 = H_2, R_4 = $COOCH_3$): $C_{22}H_{28}N_2O_3$
   T. amygdalifolia: r [196].
7. Homocylindrocarpidine (XXVII: R_1 = OCH_3, R_2 = COC_2H_5, R_3 = H_2, R_4 = $COOCH_3$): $C_{24}H_{32}N_2O_4$
   T. amygdalifolia: r [196].
8. 5-Oxocylindrocarpidine (XXVII: R_1 = OCH_3, R_2 = $COCH_3$, R_3 = O, R_4 = $COOCH_3$): $C_{23}H_{28}N_2O_5$
   T. amygdalifolia: r [197].
9. Hazuntine (XXIV: R_1 = R_3 = H, R_2 = OCH_3, R_4 + R_5 = epoxy (stereochemistry uncertain), R_6 = C_2H_5): $C_{22}H_{26}N_2O_4$
   T. coffeoides: l [217].
10. Hazuntinine (XXIV: R_1 = R_2 = OCH_3, R_3 = H, R_4 + R_5 = β-epoxy, R_6 = C_2H_5): $C_{23}H_{28}N_2O_5$
    T. coffeoides: l [217,269].
11. Lochnericine (XXIV: R_1 = R_2 = R_3 = H, R_4 + R_5 = α-epoxy, R_6 = C_2H_5): $C_{21}H_{24}N_2O_3$
    T. coffeoides: l [389]; *T. divaricata:* l [281].
12. (+)-Minovincine (XXVI: R_1 = R_2 = H, R_3 = H_2, R_4 = $COCH_3$): $C_{21}H_{24}N_2O_3$
    T. riedelii: l, tw, st [210].

13. (+)-3-Oxominovincine (XXVI: R_1 = R_2 = H, R_3 = O, R_4 = $COCH_3$): $C_{21}H_{22}N_2O_4$
    T. riedelii: l, tw, st [210].
14. Pachysiphine (XXIV: R_1 = R_2 = R_3 = H, R_4 + R_5 = β-epoxy, R_6 = C_2H_5): $C_{21}H_{24}N_2O_3$
    T. pachysiphon: se [191]; *T. retusa:* se [278].
15. *O*-Demethylpalosine (XXVII: R_1 = OH, R_2 = COC_2H_5, R_3 = H_2, R_4 = CH_3): $C_{22}H_{30}N_2O_2$
    T. amygdalifolia: r [182].
16. Tabersonine (XXV: R_1 = R_2 = H, R_3 = H_2): $C_{21}H_{24}N_2O_2$
    T. alba: se [144]; *T. arborea:* se [391]; *T. coffeoides:* l [389]; *T. crassa:* se [198]; *T. dichotoma:* fr [175]; *T. divaricata:* fl [416]; *T. longipes:* se [368]; *T. macrocalyx:* se [365]; *T. retusa:* se [278].
17. 10-Hydroxy-11-methoxytabersonine (XXV: R_1 = OH, R_2 = OCH_3, R_3 = H_2): $C_{22}H_{26}N_2O_4$
    T. coffeoides: l [367].
18. 3-Oxotabersonine (XXV: R_1 = R_2 = H, R_3 = O): $C_{21}H_{22}N_2O_3$
    T. coffeoides: l [389].
19. (+)-Vincadifformine (XXVI: R_1 = R_2 = H, R_3 = H_2, R_4 = C_2H_5): $C_{21}H_{26}N_2O_2$
    T. minutiflora: l [297]; *T. riedelii:* l, tw, st [210].
20. (−)-Vincadifformine (XXIV: R_1 = R_2 = R_3 = R_4 = R_5 = H, R_6 = C_2H_5): $C_{21}H_{26}N_2O_2$
    T. riedelii: l, tw, st [210].
21. 14,15-Dihydroxyvincadifformine (XXIV: R_1 = R_2 = R_3 = H, R_4 = R_5 = OH, R_6 = C_2H_5): $C_{21}H_{26}N_2O_4$
    T. coffeoides: l [389].
22. 12-Hydroxyvincadifformine (XXIV: R_1 = R_2 = R_4 = R_5 = H, R_3 = OH, R_6 = C_2H_5): $C_{21}H_{26}N_2O_3$
    T. siphilitica: l [331,415].

EBURNAN TYPE

Group E



XXVIII

1. (+)-Vincamine[a] (XXVIII: R_1 = H, R_2 = OH, R_3 = $COOCH_3$, R_4 = α-H,

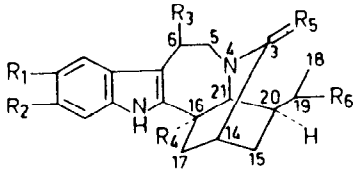
[a] Optical rotation recorded in pyridine.

R_5 = α-C_2H_5): $C_{21}H_{26}N_2O_3$
T. rigida: sb [210].

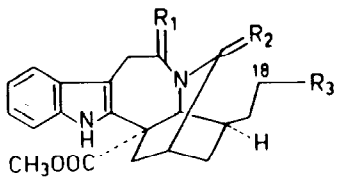
2. (−)-Vincamine[a] (XXVIII: R_1 = H, R_2 = $COOCH_3$, R_3 = OH, R_4 = β-H, R_5 = β-C_2H_5): $C_{21}H_{26}N_2O_3$
T. rigida: sb [210].
3. (+)-Apovincamine[b] (XXVIII: R_1 = H, R_2, R_3 = $COOCH_3$, Δ^{16}, R_4 = α-H, R_5 = α-C_2H_5): $C_{21}H_{24}N_2O_2$
T. rigida: sb [210].
4. (+)-16-*epi*-Vincamine[b] (XXVIII: R_1 = H, R_2 = OH, R_3 = $COOCH_3$, R_4 = β-H, R_5 = β-C_2H_5): $C_{21}H_{26}N_2O_3$
T. rigida: sb [210].
5. (−)-16-*epi*-Vincamine[b] (XXVIII: R_1 = H, R_2 = $COOCH_3$, R_3 = OH, R_4 = α-H, R_5 = α-C_2H_5): $C_{21}H_{26}N_2O_3$
T. rigida: sb [210].
6. (+)-21-*epi*-Vincamine[b] (XXVIII: R_1 = H, R_2 = OH, R_3 = $COOCH_3$, R_4 = β-H, R_5 = α-C_2H_5): $C_{21}H_{26}N_2O_3$
T. rigida: sb [210].
7. (−)-21-*epi*-Vincamine[b] (XXVIII: R_1 = H, R_2 = $COOCH_3$, R_3 = OH, R_4 = α-H, R_5 = β-C_2H_5): $C_{21}H_{26}N_2O_3$
T. rigida: sb [210].
8. (+)-14,15-Dehydro-16-*epi*-vincamine[b] (XXVIII: R_1 = H, R_2 = $COOCH_3$, R_3 = OH, R_4 = α-H, R_5 = α-C_2H_5, Δ^{14}): $C_{21}H_{24}N_2O_3$
T. humblotii: l [279].
9. 14,15-Dehydro-12-methoxyvincamine (XXVIII: R_1 = OCH_3, R_2 = OH, R_3 = $COOCH_3$, R_4 = α-H, R_5 = α-C_2H_5, Δ^{14}): $C_{22}H_{26}N_2O_4$
T. psorocarpa: sb [441].

IBOGAN TYPE

Group I1

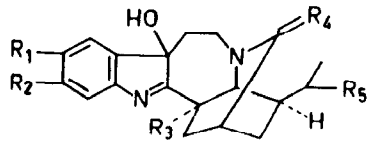


XXIX

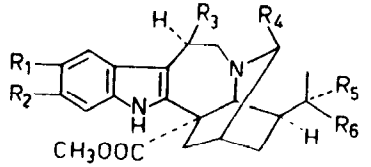


XXX

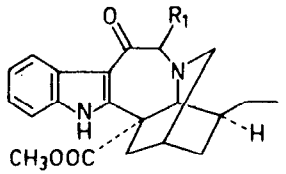
[a]See footnote p. 61.
[b]Optical rotation recorded in chloroform.



XXXI



XXXII



XXXIII

1. Conopharyngine (XXIX: R_1 = R_2 = OCH_3, R_3 = R_6 = H, R_4 = $COOCH_3$, R_5 = H_2): $C_{23}H_{30}N_2O_4$
T. attenuata: sb [426]; *T. contorta:* sb [205]; *T. crassa:* sb [126,145], rb [126], fr, l, tw, b [211]; *T. eglandulosa:* sb [205]; *T. fuchsiifolia:* sb [412]; *T. longiflora:* sb [199], unk [173]; *T. orientalis:* l, tw [388], [383]; *T. pachysiphon:* l [155,258], sb [191,205]; *T. penduliflora:* sb [205].
2. 19-Hydroxyconopharyngine (XXIX: R_1 = R_2 = OCH_3, R_3 = H, R_4 = $COOCH_3$, R_5 = H_2, R_6 = OH): $C_{23}H_{30}N_2O_5$
T. crassa; fr, l, tw, b [211], b [201], unk [202]; *T. pachysiphon;* l [258].
3. 3-Oxoconopharyngine (XXIX: R_1 = R_2 = OCH_3, R_3 = R_6 = H, R_4 = $COOCH_3$, R_5 = O): $C_{23}H_{28}N_2O_5$
T. crassa: sb [216].
4. Conopharyngine hydroxyindolenine (XXIX: R_1 = R_2 = OCH_3, R_3 = $COOCH_3$, R_4 = H_2, R_6 = H): $C_{23}H_{30}N_2O_5$
T. attenuata: sb [426]; *T. crassa:* b [201]; *T. pachysiphon:* l [232].
5. Coronaridine (XXX: R_1 = R_2 = H_2, R_3 = H): $C_{21}H_{26}N_2O_2$
T. affinis: rb [304]; *T. alba:* se [144]; *T. albiflora:* sb [402]; *T. amblyocarpa:* l, st [407]; *T. amygdalifolia:* r [412]; *T. apoda:* fr [335], l [322], r [301]; *T. attenuata:* sb, rb [426]; *T. bufalina:* r [435]; *T. citrifolia:* l [371], r [132]; *T. coffeoides:* r [361]; *T. contorta:* sb [205]; *T. crassa:* se [198], sb [161], unk [168]; *T. dichotoma:* fr [150], rb [186]; *T. divaricata:* se [400], l [281,302], sb [312], st [132], rb [223,408], unk [249]; *T. eglandulosa:* sb [205,277], rb [284]; *T. fuchsiifolia:* sb [412]; *T. heyneana:* se [193], fr [245], sb, st [396], b, r [184], r [261], wp [194]; *T. longipes:* se [368], l [414]; *T. lundii:* l, b, st [225]; *T. macrocalyx:* se [365]; *T. macrocarpa:* se [337]; *T. minutiflora:* l [297]; *T. moc-*

querysii: rb [286]; *T. mucronata:* b [180]; *T. olivacea:* st [379]; *T. orientalis:* l, tw [388], unk [383]; *T. pachysiphon:* sb [205], r [334]; *T. pandacaqui:* b [154,157,167]; *T. penduliflora:* sb [205]; *T. psorocarpa:* sb [441]; *T. psychotrifolia:* sb [418], r [132]; *T. quadrangularis:* r [378]; *T. retusa:* se [278] l, sb [264], rb [234]; *T. sananho:* b [338]; *T. sessilifolia:* l, sb, rb [291]; *T. siphilitica:* l [311]; *T. stellata:* rb [234]; *T. undulata:* se [248], sb [365]; *T. wallichiana:* l, sb [323].

6. 3-Ethoxycoronaridine (XXX: $R_1 = H_2$, $R_2 = H$, OC_2H_5, $R_3 = H$): $C_{23}H_{30}N_2O_3$
   T. glandulosa: b, st [381].
7. 3-Hydroxycoronaridine (XXX: $R_1 = H_2$, $R_2 = H$, OH, $R_3 = H$): $C_{21}H_{26}N_2O_3$
   T. eglandulosa: rb [284]; *T. glandulosa:* l, st [382]; *T. sananho:* b [338].
8. 10-Hydroxycoronaridine (XXIX: $R_1 = OH$, $R_2 = R_3 = R_6 = H$, $R_4 = COOCH_3$, $R_5 = H_2$): $C_{21}H_{26}N_2O_3$
   T. heyneana: sb, st [396]; *T. psychotrifolia:* l [418].
9. 18-Hydroxycoronaridine (XXX: $R_1 = R_2 = H_2$, $R_3 = OH$): $C_{21}H_{26}N_2O_3$
   T. albiflora: sb [422].
10. 5-Hydroxy-6-oxocoronaridine (XXXIII: $R_1 = OH$) $C_{21}H_{24}N_2O_4$
    T. divaricata: rb [408].
11. 3-Oxocoronaridine (XXX: $R_1 = H_2$, $R_2 = O$, $R_3 = H$): $C_{21}H_{24}N_2O_3$
    T. bufalina: r [435]; *T. crassa:* sb [216]; *T. divaricata:* rb [408], unk [249]; *T. heyneana:* r [261]; *T. pachysiphon:* r [334]; *T. quadrangularis:* r [378].
12. 5-Oxocoronaridine (XXX: $R_1 = O$, $R_2 = H_2$, $R_3 = H$): $C_{21}H_{24}N_2O_3$
    T. crassa: sb [161]; *T. divaricata:* rb [408].
13. 6-Oxocoronaridine (XXXIII: $R_1 = H$): $C_{21}H_{24}N_2O_3$
    T. divaricata: rb [408].
14. 3-Oxo-6-hydroxycoronaridine (XXIX: $R_1 = R_2 = R_6 = H$, $R_3 = OH$, $R_4 = COOCH_3$, $R_5 = O$): $C_{21}H_{24}N_2O_4$
    T. eglandulosa: sb [277]; *T. sessilifolia:* l, sb, rb [291].
15. 3-(2′-Oxopropyl)-coronaridine (XXX: $R_1 = H_2$, $R_2 = H,CH_2COCH_3$, $R_3 = H$): $C_{24}H_{30}N_2O_3$, probably an artefact
    T. divaricata: unk [249].
16. (6*R*)-3,6-Oxidocoronaridine (XXXII: $R_1 = R_2 = R_5 = R_6 = H$, $R_3 + R_4 = O$): $C_{21}H_{24}N_2O_3$
    T. attenuata: rb [426]; *T. eglandulosa:* sb [277]; *T. sessilifolia:* l, sb, rb [291].
17. Coronaridine hydroxyindolenine (XXXI: $R_1 = R_2 = R_5 = H$, $R_3 = COOCH_3$, $R_4 = H_2$): $C_{21}H_{26}N_2O_3$
    T. attenuata: sb [426]; *T. bufalina:* r [435]; *T. crassa:* se [198]; *T. divaricata:* rb [408]; *T. olivacea:* st [379]; *T. quadrangularis:* r [378]; *T. retusa:* rb [234].
18. 3-Oxocoronaridine hydroxyindolenine (XXXI: $R_1 = R_2 = R_5 = H$, $R_3 = COOCH_3$, $R_4 = O$): $C_{21}H_{24}N_2O_3$
    T. crassa: sb [215].
19. (+)-Heyneanine (Enantiomer of I1-20): $C_{21}H_{26}N_2O_3$
    T. divaricata: rb [408].
20. (−)-Heyneanine (XXXII: $R_1 = R_2 = R_3 = R_4 = H$, $R_5 = CH_3$, $R_6 = OH$): $C_{21}H_{26}N_2O_3$
    T. apoda: rb [342]; *T. attenuata:* sb, rb [426]; *T. bufalina:* r [435]; *T. coffeoides:* l [367]; *T. crassa:* b [201]; *T. dichotoma:* rb [186]; *T. divaricata:* rb [408]; *T. heyneana:* fr [245], sb, st [396], b [170]; *T. mocquerysii:* rb [286]; *T. olivacea:* st [379]; *T. quadrangularis:* r [378]; *T. retusa:* l, sb [264], rb [234]; *T. sananho:* b [338].
21. (−)-19-*epi*-Heyneanine (XXXII: $R_1 = R_2 = R_3 = R_4 = H$, $R_5 = OH$, $R_6 = CH_3$): $C_{21}H_{26}N_2O_3$
    T. affinis: rb [304]; *T. attenuata:* sb, rb [426]; *T. coffeoides:* l [367], r [361]; *T. mocquerysii:* l, sb, rb [286]; *T. quadrangularis:* r [378]; *T. undulata:* sb [365].
22. (−)-3-Oxoheyneanine (XXIX: $R_1 = R_2 = R_3 = H$, $R_4 = COOCH_3$, $R_5 = O$, $R_6 = OH$, stereochemistry at C-19 uncertain): $C_{21}H_{24}N_2O_4$
    T. crassa: sb [216].
23. Ibogaine (XXIX: $R_1 = OCH_3$, $R_2 = R_3 = R_4 = R_6 = H$, $R_5 = H_2$): $C_{20}H_{26}N_2O$
    T. cerifera: l [314]; *T. contorta:* sb [205]; *T. eusepala:* l, sb, rb [298]; *T. eusepaloides:* rb [234]; *T. humblotii:* l, sb, rb [279], l, sb, rb [296][c]; *T. lundii:* l, b, st [225]; *T. olivacea:* st [379]; *T. orientalis:* l [294]; *T. psychotrifolia:* sb, rb [418]; *T. quadrangularis:* r [378].
24. Ibogaine hydroxyindolenine (XXXI: $R_1 = OCH_3$, $R_2 = R_3 = R_5 = H$, $R_4 = H_2$): $C_{20}H_{26}N_2O_2$
    T. apoda: fr [315,363]; *T. eusepala:* sb [298]; *T. psychotrifolia:* sb [418].
25. Ibogaline (XXIX: $R_1 = R_2 = OCH_3$, $R_3 = R_4 = R_6 = H$, $R_5 = H_2$): $C_{21}H_{28}N_2O_2$
    T. humblotii: l [279].
26. (+)-Ibogamine (Enantiomer of I1-27): $C_{19}H_{24}N_2$
    T. retusa: rb [234].
27. (−)-Ibogamine (XXIX: $R_1 = R_2 = R_3 = R_4 = R_6 = H$, $R_5 = H_2$): $C_{19}H_{24}N_2$
    T. amblyocarpa: l [407]; *T. apoda:* fr [335], l [373], r [301]; *T. bufalina:* r [435]; *T. citrifolia:* r [132]; *T. coffeoides:* sb, rb [329, 367,389], r [242]; *T. crassa:* unk [168]; *T. crassifolia:* sb [234]; *T. divaricata:* sb [312], rb [408]; *T. heyneana:* r [261]; *T. olivacea:* st [379]; *T. pandacaqui:* b [167]; *T. quadrangularis:* r [378]; *T. retusa:* rb [234]; *T. sananho:* b [338]; *T. stapfiana:* b, st [354].

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[c]The botanical identity of this material is uncertain.

28. (19*R*)-19-Hydroxy-ibogamine (XXIX: $R_1 = R_2 = R_3 = R_4 = H$, $R_5 = H_2$, $R_6 = OH$): $C_{19}H_{24}N_2O$
    T. quadrangularis: r [378].
29. Iboxygaine (XXIX: $R_1 = OCH_3$, $R_2 = R_3 = R_4 = H$, $R_5 = H_2$, $R_6 = OH$, (19*S*)-configuration): $C_{20}H_{26}N_2O_2$
    T. humblotii: sb [296][c]; *T. lundii:* l, b, st [225]; *T. orientalis:* l [294], unk [383]; *T. pandacaqui:* b [167].
30. 19-*epi*-Iboxygaine (XXIX: $R_1 = OCH_3$, $R_2 = R_3 = R_4 = H$, $R_5 = H_2$, $R_6 = OH$, (19*R*)-configuration): $C_{20}H_{26}N_2O_2$
    T. dichotoma: l [431]; *T. humblotii:* l [279].
31. Iboxygaine hydroxyindolenine (XXXI: $R_1 = OCH_3$, $R_2 = R_3 = H$, $R_4 = H_2$, $R_5 = OH$): $C_{20}H_{26}N_2O_3$
    T. lundii: l, b, st [225].
32. 19-*epi*-Iboxygaline (XXIX: $R_1 = R_2 = OCH_3$, $R_3 = R_4 = H$, $R_5 = H_2$, $R_6 = OH$, (19*R*)-configuration): $C_{21}H_{28}N_2O_3$
    T. humblotii: l [279].
33. Tabernanthine (XXIX: $R_1 = R_3 = R_4 = R_6 = H$, $R_2 = OCH_3$, $R_5 = H_2$): $C_{20}H_{26}N_2O$
    T. crassifolia: sb [234]; *T. pandacaqui:* b [167].
34. Voacangine (XXIX: $R_1 = OCH_3$, $R_2 = R_3 = R_6 = H$, $R_4 = COOCH_3$, $R_5 = H_2$): $C_{22}H_{28}N_2O_3$
    T. amblyocarpa: st [407]; *T. amygdalifolia:* r [412]; *T. apoda:* fr [315,335], l [373], r [301]; *T. arborea:* se [391], dried trunk sap [352]; *T. attenuata:* sb [426]; *T. aurantiaca:* b [171]; *T. australis:* st [132]; *T. cerifera:* l [314]; *T. citrifolia:* l [371], r [132]; *T. coffeoides:* r [361]; *T. contorta:* sb [205]; *T. divaricata:* l [281], sb [312]; *T. eglandulosa:* sb [205], wp [116]; *T. fuchsiifolia:* sb [200,412]; *T. heterophylla:* l [397]; *T. heyneana:* sb, st [396], r [261]; *T. humblotii:* l, sb, rb [296][c]; *T. killipii:* sb [300]; *T. longiflora:* sb [199], unk [173]; *T. longipes:* se [368]; *T. lundii:* l, b, st [225]; *T. macrocarpa:* se [337]; *T. mocquerysii:* rb [286]; *T. olivacea:* st [379]; *T. orientalis:* l, tw [388], unk [383]; *T. pachysiphon:* se [191], sb [205]; *T. penduliflora:* sb [205]; *T. psorocarpa:* sb [441]; *T. psychotrifolia:* l, sb, rb [418], r [132], *T. quadrangularis:* r [378]; *T. retusa:* se [278], l, sb [264]; *T. sananho:* b [338]; *T. siphilitica:* l [311]; *T. undulata:* sb [365]; *T. wallichiana:* l, sb [323].
35. 3-Hydroxy-isovoacangine (XXIX: $R_1 = R_3 = R_6 = H$, $R_2 = OCH_3$, $R_4 = COOCH_3$, $R_5 = H,OH$): $C_{22}H_{28}N_2O_4$
    T. eglandulosa: rb [284].
36. Isovoacangine (XXIX: $R_1 = R_3 = R_6 = H$, $R_2 = OCH_3$, $R_4 = COOCH_3$, $R_5 = H_2$). $C_{22}H_{28}N_2O_3$
    T. amblyocarpa: l [407]; *T. apoda:* l [373], r [301]; *T. arborea:* se [391]; *T. attenuata:* sb [426]; *T. coffeoides:* l, sb, rb [329]; *T. crassa:* sb, rb [126], unk [168]; *T. divaricata:* sb [312]; *T. eglandulosa:* rb [284]; *T. longiflora:* unk [203]; *T. orientalis:* unk [383];

[c]See footnote p. 65.

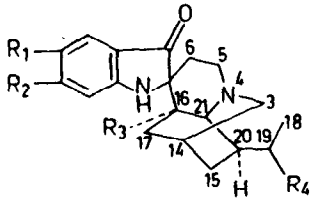
T. pandacaqui: b [167]; *T. sessilifolia:* l, sb, rb [291]; *T. siphilitica:* l [311]; *T. stapfiana:* b, st [354]; *T. wallichiana:* l [323].

37. 3-Oxovoacangine (XXIX: $R_1 = OCH_3$, $R_2 = R_3 = R_6 = H$, $R_4 = COOCH_3$, $R_5 = O$): $C_{22}H_{26}N_2O_4$
    T. psychotrifolia: sb [418]; *T. quadrangularis:* r [378]; *T. retusa:* l [264].
38. 6-Hydroxy-3-oxo-isovoacangine (XXIX: $R_1 = R_6 = H$, $R_2 = OCH_3$, $R_4 = COOCH_3$, $R_5 = O$): $C_{22}H_{26}N_2O_5$
    T. sessilifolia: l, sb, rb [291].
39. (19*S*)-3,19-Oxidovoacangine (XXXII: $R_1 = OCH_3$, $R_2 = R_3 = R_5 = H$, $R_4 + R_6 = O$): $C_{22}H_{26}N_2O_4$
    T. heyneana: sb, st [396].
40. (6*R*)-3,6-Oxido-isovoacangine (XXXII: $R_1 = R_5 = R_6 = H$, $R_2 = OCH_3$, $R_3 + R_4 = O$). $C_{22}H_{26}N_2O_4$
    T. sessilifolia: l, sb, rb [291].
41. Voacangine hydroxyindolenine (XXXI: $R_1 = OCH_3$, $R_2 = R_5 = H$, $R_3 = COOCH_3$, $R_4 = H_2$): $C_{22}H_{28}N_2O_4$
    T. amygdalifolia: r [412]; *T. apoda:* fr [315,336,363], rb [342]; *T. cerifera:* l [314]; *T. heterophylla:* l [397]; *T. heyneana:* sb, st [396]; *T. macrocarpa:* se [337]; *T. olivacea:* st [379]; *T. psychotrifolia:* l, sb, rb [418]; *T. quadrangularis:* r [378].
42. (6*R*)-3,6-Oxidovoacangine N_4-oxide (XXXII: $R_1 = OCH_3$, $R_2 = R_5 = R_6 = H$, $R_3 + R_4 = O$, $N_4^+—O^-$): $C_{22}H_{26}N_2O_5$
    T. heyneana: st, sb [396].
43. Voacristine (XXIX: $R_1 = OCH_3$, $R_2 = R_3 = H$, $R_4 = COOCH_3$, $R_5 = H_2$, $R_6 = OH$, (19*S*)-configuration): $C_{22}H_{28}N_2O_4$
    T. amblyocarpa: st [407]; *T. apoda:* fr [336], l [322]; *T. crassa:* b [201]; *T. contorta:* sb [205]; *T. divaricata:* l [302]; *T. heyneana:* sb, st [396]; *T. humblotii:* l, sb [296][c]; *T. longiflora:* unk [173]; *T. lundii:* l, b, st [225]; *T. mocquerysii:* rb [286]; *T. olivacea:* st [379]; *T. orientalis:* b [294]; *T. pandacaqui:* b [204]; *T. psychotrifolia:* l [418]; *T. retusa:* l [264]; *T. wallichiana:* l, sb [323].
44. 19-*epi*-Voacristine (XXIX: $R_1 = OCH_3$, $R_2 = R_3 = H$, $R_4 = COOCH_3$, $R_5 = H_2$, $R_6 = OH$, (19*R*)-configuration): $C_{22}H_{28}N_2O_4$
    T. dichotoma: l [431]; *T. eusepala:* sb [298]; *T. lundii:* l, b, st [225]; *T. mocquerysii:* rb [286]; *T. psychotrifolia:* l [418].
45. Isovoacristine (XXIX: $R_1 = R_3 = H$, $R_2 = OCH_3$, $R_4 = COOCH_3$, $R_5 = H_2$, $R_6 = OH$): $C_{22}H_{28}N_2O_4$
    T. amblyocarpa: l [407]; *T. divaricata:* fl, l [374]; *T. heyneana:* l [374]; *T. pandacaqui:* b [167].
46. Voacristine hydroxyindolenine (XXXI: $R_1 = OCH_3$, $R_2 = H$, $R_3 = COOCH_3$, $R_4 = H_2$, $R_5 = OH$): $C_{22}H_{28}N_2O_5$
    T. apoda: fr [336], l [322]; *T. dichotoma:* rb [218].
47. 19-Oxovoacangine (XXXII: $R_1 = OCH_3$, $R_2 = R_3 = R_4 = H$, $R_5 + R_6 = O$): $C_{22}H_{26}N_2O_4$
    T. heyneana: sb, st [396].

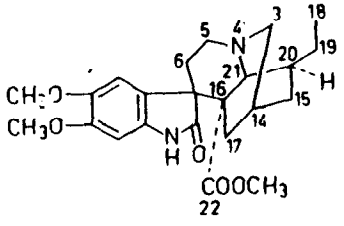
[c]See footnote p. 65.

48. 11-Hydroxycoronaridine (XXIX: $R_1 = R_3 = R_6 = H$, $R_2 = OH$, $R_4 = COOCH_3$, $R_5 = H_2$): $C_{21}H_{26}N_2O_3$
    T. attenuata: l [426].
49. 10-Hydroxyheyneanine (XXXII: $R_1 = R_5 = OH$, $R_2 = R_3 = R_4 = R_6 = H$): $C_{21}H_{26}N_2O_4$
    T. attenuata: l [426]; *T. bufalina:* r [435]; *T. psychotrifolia:* l [418].
50. 11-Hydroxyheyneanine (XXXII: $R_1 = R_3 = R_4 = R_6 = H$, $R_2 = R_5 = OH$): $C_{21}H_{26}N_2O_4$
    T. attenuata: l [426].
51. (6*R*)-3,6-Oxidovoacangine (XXXII: $R_1 = OCH_3$, $R_2 = R_5 = R_6 = H$, $R_3 + R_4 = O$): $C_{22}H_{26}N_2O_4$
    T. psychotrifolia: sb [418,439].
52. (3*S*)-3-(β-Hydroxyethyl)-coronaridine (XXX: $R_1 = H_2$, $R_2 = H$,$CHOHCH_3$, $R_3 = H$): $C_{23}H_{30}N_2O_3$
    T. bufalina: r [435].

Group I2



XXXIV

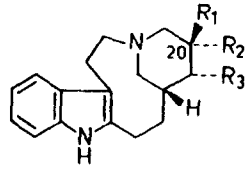


XXXV

1. Conopharyngine pseudoindoxyl (XXXIV: $R_1 = R_2 = OCH_3$, $R_3 = COOCH_3$, $R_4 = H$): $C_{23}H_{30}N_2O_5$
   T. pachysiphon: l [258].
2. Coronaridine pseudoindoxyl (XXXIV: $R_1 = R_2 = R_4 = H$, $R_3 = COOCH_3$,): $C_{21}H_{26}N_2O_3$
   T. affinis: rb [304]; *T. olivacea:* st [379]; *T. quadrangularis:* r [378].
3. Ibogaine pseudoindoxyl (XXXIV: $R_1 = OCH_3$, $R_2 = R_3 = R_4 = H$): $C_{20}H_{26}N_2O_2$
   T. apoda: fr [315,363]; *T. aurantiaca:* fr, l, b [171]; *T. humblotii:* sb, rb [279], sb [296].
4. Ibogamine pseudoindoxyl (XXXIV: $R_1 = R_2 = R_3 = R_4 = H$): $C_{19}H_{24}N_2O$
   T. quadrangularis: r [378].
5. (19*R*)-19-Hydroxy-ibogamine pseudoindoxyl (XXXIV: $R_1 = R_2 = R_3 = H$, $R_4 = OH$): $C_{19}H_{24}N_2O_2$
   T. quadrangularis: r [378].
6. Voacangine pseudoindoxyl (XXXIV: $R_1 = OCH_3$, $R_2 = R_4 = H$, $R_3 = COOCH_3$): $C_{22}H_{28}N_2O_4$
   T. apoda: fr [315,363], rb [342]; *T. aurantiaca:* fr, l, b [171,172];

   T. heyneana: r [261]; *T. killipii:* sb [300]; *T. olivacea:* st [379]; *T. psychotrifolia:* sb [418]; *T. rupicola:* l, tw [190].
7. Voacristine pseudoindoxyl (XXXIV: $R_1 = OCH_3$, $R_2 = H$, $R_3 = COOCH_3$, $R_4 = OH$): $C_{22}H_{28}N_2O_5$
   T. apoda: fr [336]; *T. lundii:* l, b, st [225]; *T. rupicola:* l, tw [190].
8. Crassanine (XXXV): $C_{23}H_{30}N_2O_5$
   T. crassa: fr, l, tw, b [211].

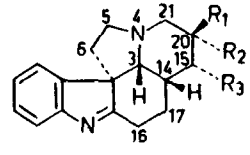
Group I3



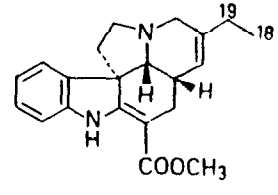
XXXVI

1. Capuronine (XXXVI: $R_1 = H$, $R_2 = C_2H_5$, $R_3 = OH$): $C_{19}H_{26}N_2O$
   T. capuronii: l, sb [287,346].
2. (+)-(20*R*)-15,20-Dihydrocleavamine (XXXVI: $R_1 = R_3 = H$, $R_2 = C_2H_5$): $C_{19}H_{26}N_2$
   T. eusepala: sb [298]; *T. mocquerysii:* unk [362].
3. (−)-(20*S*)-15,20-Dihydrocleavamine (XXXVI: $R_1 = C_2H_5$, $R_2 = R_3 = H$): $C_{19}H_{26}N_2$
   T. eusepala: sb [298]; *T. mocquerysii:* unk [362].

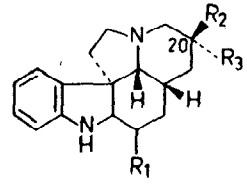
Group I4



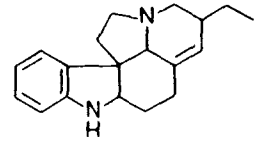
XXXVII



XXXVIII



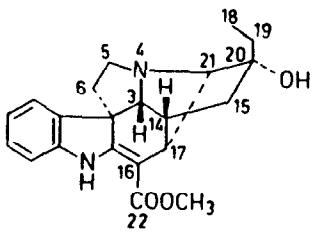
XXXIX



XL

1. (+)-(20*R*)-Pseudo-aspidospermidine (XXXIX: $R_1 = R_2 = H$, $R_3 = C_2H_5$): $C_{19}H_{26}N_2$
   T. mocquerysii: unk [362].
2. (−)-(20*S*)-Pseudo-aspidospermidine (XXXIX: $R_1 = R_3 = H$, $R_2 = C_2H_5$): $C_{19}H_{26}N_2$
   T. mocquerysii: unk [362].
3. (+)-(20*S*)-1,2-Dehydro-pseudo-aspidospermidine (XXXVII: $R_1 = C_2H_5$, $R_2 = R_3 = H$): $C_{19}H_{24}N_2$
   T. eusepala: sb [298]; *T. mocquerysii:* unk [362].
4. Capuronidine (XXXVII: $R_1 = H$, $R_2 = C_2H_5$, $R_3 = OH$): $C_{19}H_{24}N_2O$
   T. capuronii: l, sb [287,346].
5. 14,15-Anhydrocapuronidine (XL: Δ^1): $C_{19}H_{22}N_2$
   T. capuronii: l, sb [346].
6. 14,15-Anhydro-1,2-Dihydrocapuronidine (XL): $C_{19}H_{24}N_2$
   T. capuronii: l, sb [346].
7. Pandoline (XXXIX: $R_1 = COOCH_3$, $R_2 = C_2H_5$, $R_3 = OH$, $\Delta^{2,16}$): $C_{21}H_{26}N_2O_3$
   T. calcarea: l [274,303,321]; *T. debrayi:* l [274]; *T. heterophylla:* l [397]; *T. orientalis:* l, tw [388], unk [383].
8. 20-*epi*-Pandoline (XXXIX: $R_1 = COOCH_3$, $R_2 = OH$, $R_3 = C_2H_5$, $\Delta^{2,16}$): $C_{21}H_{26}N_2O_3$
   T. calcarea: l [303]; *T. orientalis:* l, tw [388], unk [383].
9. (+)-19-Hydroxy-20-*epi*-pandoline (XXXIX: $R_1 = COOCH_3$, $R_2 = OH$, $R_3 = CHOHCH_3$, $\Delta^{2,16}$): $C_{21}H_{26}N_2O_4$
   T. albiflora: sb [423].
10. Pseudotabersonine (XXXVIII): $C_{21}H_{24}N_2O_2$
    T. calcarea: l [303]
11. (+)-(20*R*)-Pseudovincadifformine (XXXIX: $R_1 = COOCH_3$, $R_2 = H$, $R_3 = C_2H_5$, $\Delta^{2,16}$): $C_{21}H_{26}N_2O_2$
    T. calcarea: l [303].
12. (+)-(20*R*)-18,19-Dihydroxy-pseudovincadifformine (XXXIX: $R_1 = COOCH_3$, $R_2 = H$, $R_3 = CHOHCH_2OH$, $\Delta^{2,16}$): $C_{21}H_{26}N_2O_4$
    T. albiflora: sb [423].

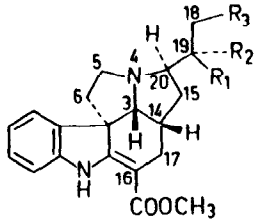
Group I5



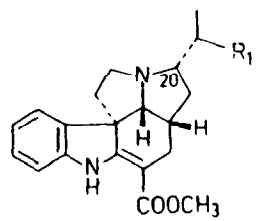
XLI

1. Pandine (XLI): $C_{21}H_{24}N_2O_3$
   T. calcarea: l [274,303]; *T. debrayi:* l [274]; *T. heterophylla:* l [397]; *T. orientalis:* l, tw [388], unk [383].

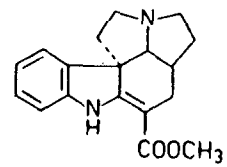
Group I6



XLII



XLIII

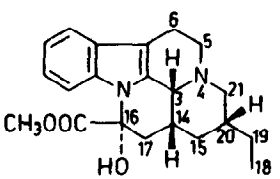


XLIV

1. Ibophyllidine (XLIII: $R_1 = H$): $C_{20}H_{24}N_2O_2$
   T. albiflora: sb [402]; *T. attenuata:* sb [426]; *T. flavicans:* st [380].
2. Desethyl-ibophyllidine (XLIV): $C_{18}H_{20}N_2O_2$
   T. albiflora: sb [402]; *T. disticha:* unk [402].
3. 20-*epi*-Ibophyllidine (XLII: $R_1 = R_2 = R_3 = H$): $C_{20}H_{24}N_2O_2$
   T. albiflora: sb [402].
4. 19-Hydroxy-ibophyllidine (XLIII: $R_1 = OH$): $C_{20}H_{24}N_2O_3$
   T. albiflora: sb [403].
5. 18-Hydroxy-20-*epi*-ibophyllidine (XLII: $R_1 = R_2 = H$, $R_3 = OH$): $C_{20}H_{24}N_2O_3$
   T. albiflora: sb [403].
6. (19*R*)-19-Hydroxy-20-*epi*-ibophyllidine (XLII: $R_1 = OH$, $R_2 = R_3 = H$): $C_{20}H_{24}N_2O_3$
   T. albiflora: sb [403].
7. (19*S*)-19-Hydroxy-20-*epi*-ibophyllidine (XLII: $R_1 = R_3 = H$, $R_2 = OH$): $C_{20}H_{24}N_2O_3$
   T. albiflora: sb [403].
8. Ibophyllidine N_4-oxide (XLIII: $R_1 = H$, $N_4^+-O^-$): $C_{20}H_{24}N_2O_3$
   T. flavicans: st [380].

TACAMAN TYPE

Group T1

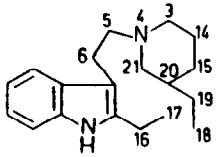


XLV

1. Tacamine (XLV): $C_{21}H_{26}N_2O_3$
   T. eglandulosa: l [434], tw, sb [442].

MISCELLANEOUS

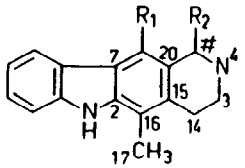
Group M1



XLVI

1. Decarbomethoxy-15,20;16,17-tetrahydrosecodine (XLVI): $C_{19}H_{28}N_2$
   T. pachysiphon: l [213].

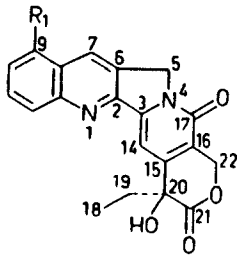
Group M2



XLVII

1. 3,14-Dihydro-ellipticine[d] (XLVII: $R_1 = CH_3$, $R_2 = H$, $\Delta^{4,21}$): $C_{17}H_{16}N_2$
   T. coffeoides: sb [329,367,389], rb [367,389].
2. Olivacine[d] (XLVII: $R_1 = H$, $R_2 = CH_3$, $\Delta^{3,14,4,19}$): $C_{17}H_{14}N_2$
   T. affinis: rb [272,304]; *T. cerifera:* l [360]; *T. lundii:* l, b, st [225]; *T. psychotrifolia:* sb, rb [418], r [132].
3. 3,14;4,19-Tetrahydro-olivacine (XLVII: $R_1 = H$, $R_2 = CH_3$): $C_{17}H_{18}N_2$
   T. divaricata: fl [348].

Group M3

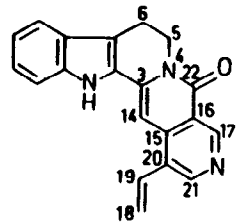


XLVIII

[d]The numbering follows the biogenetic numbering system of Le Men and Taylor [176]. In the original publications, a chemical numbering system was used.

1. Camptothecine (XLVIII: $R_1 = H$): $C_{20}H_{16}N_2O_4$
   T. heyneana: sb, st [369].
2. 9-Methoxycamptothecine (XLVIII: $R_1 = OCH_3$): $C_{21}H_{18}N_2O_5$
   T. heyneana: sb, st [369].

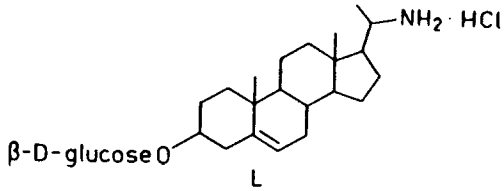
Group M4



XLIX

1. Angustine (XLIX): $C_{20}H_{15}N_3O$
   T. attenuata: l [426]; *T. psychotrifolia:* l [418].

Group M5

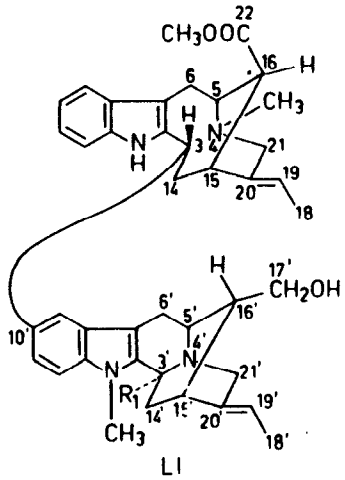


L

1. 20α-Amino-pregn-5-en-3β-yl β-D-glucoside (L): $C_{27}H_{45}NO_6$
   T. pachysiphon: r [133].

BIS-INDOLE TYPE

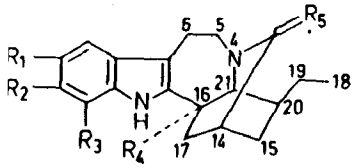
Group B1 (C-C type)



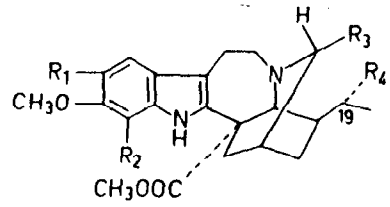
LI

1. Accedinine (LI: R_1 = OH, attachment at C-10′ uncertain): $C_{41}H_{48}N_4O_4$
   T. accedens: rb [305].
2. Accedinisine (LI: R_1 = H): $C_{41}H_{48}N_4O_3$
   T. accedens: rb [305].

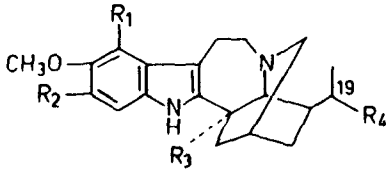
Group B2 (C-I type)



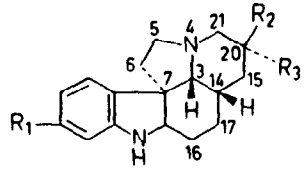
LII



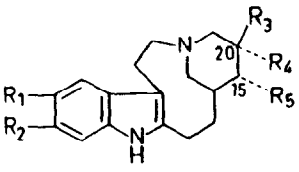
LIII



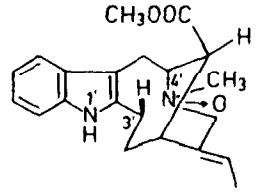
LIV



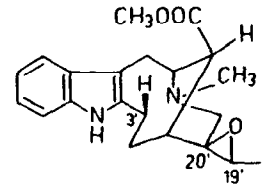
LV



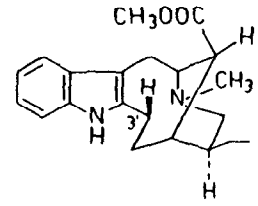
LVI



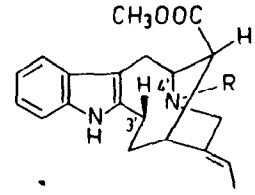
3′-(N$_4$′-OXIDE) VOBASINYL



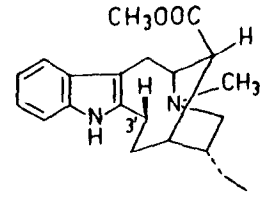
3′-(19′,20′epoxy) VOBASINYL



3′-TABERNAEMONTANYL



R=H : 3′-PERIVINYL
R=CH_3 : 3′-VOBASINYL



3′-DREGAMINYL

1. (20*R*)-Capuvosidine (LV: R_1 = 3′-vobasinyl, R_2 = H, R_3 = C_2H_5, Δ^1): $C_{40}H_{48}N_4O_2$
   T. capuronii: l, sb [346,351]; *T. mocquerysii:* unk [351,362,439].

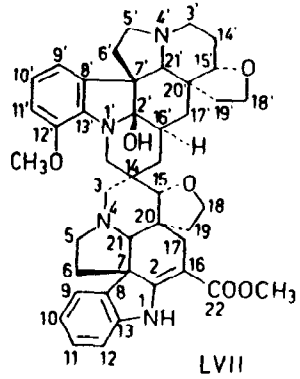
2. (20*R*)-1,2-Dihydrocapuvosidine (LV: R_1 = 3′-vobasinyl, R_2 = H, R_3 = C_2H_5): $C_{40}H_{50}N_4O_2$
   T. capuronii: l, sb [351]; *T. mocquerysii:* unk [351].
3. Capuvosine (LVI: R_1 = R_3 = H, R_2 = 3′-vobasinyl, R_4 = C_2H_5, R_5 = OH): $C_{40}H_{50}N_4O_3$
   T. capuronii: l, sb [346,351].
4. Dehydroxy-capuvosine (LVI: R_1 = R_3 = R_5 = H, R_2 = 3′-vobasinyl, R_4 = C_2H_5): $C_{40}H_{50}N_4O_2$
   T. capuronii: l, sb [346,351]; *T. mocquerysii:* unk [351,362].
5. N_1-Demethylcapuvosine (LVI: R_1 = R_3 = H, R_2 = 3′-vobasinyl, R_4 = C_2H_5, R_5 = OH): $C_{39}H_{48}N_4O_3$
   T. capuronii: l, sb [346].
6. Dehydroxy-isocapuvosine (LVI: R_1 = 3′-vobasinyl, R_2 = R_3 = R_5 = H, R_4 = C_2H_5): $C_{40}H_{50}N_4O_2$
   T. mocquerysii: unk [362].
7. Conoduramine (LII: R_1 = 3′-vobasinyl, R_2 = OCH_3, R_3 = H, R_4 = $COOCH_3$, R_5 = H_2): $C_{43}H_{52}N_4O_5$
   T. crassa: rb [126]; unk [168]; *T. elegans:* rb [289]; *T. pachysiphon:* [334]; *T. stapfiana:* st, b [354].
8. 19′,20′-Epoxyconoduramine (LII: R_1 = 3′-(19′,20′-epoxy)-vobasinyl, R_2 = OCH_3, R_3 = H, R_4 = $COOCH_3$, R_5 = H_2): $C_{43}H_{50}N_4O_6$
   T. stapfiana: st, b [354].
9. Conodurine (LII: R_1 = H, R_2 = OCH_3, R_3 = 3′-vobasinyl, R_4 = $COOCH_3$, R_5 = H_2): $C_{43}H_{52}N_4O_5$
   T. crassa: rb [126], unk [168]; *T. laeta:* l, tw [344]; *T. pachysiphon:* r [334]; *T. stapfiana:* st, b [354].
10. 3-Oxoconodurine (LII: R_1 = H, R_2 = OCH_3, R_3 = 3′-vobasinyl, R_4 = $COOCH_3$, R_5 = O): $C_{43}H_{50}N_4O_6$
    T. pachysiphon: r [334].
11. 3-(2′-Oxopropyl)-conodurine (LII: R_1 = H, R_2 = OCH_3, R_3 = 3′-vobasinyl, R_4 = $COOCH_3$, R_5 = H,CH_2COCH_3): $C_{46}H_{56}N_4O_6$, probably an artefact
    T. pachysiphon: r [334].
12. Gabunamine (LII: R_1 = 3′-perivinyl, R_2 = OCH_3, R_3 = H, R_4 = $COOCH_3$, R_5 = H_2): $C_{42}H_{50}N_4O_5$
    T. stapfiana: st, b [354].
13. Gabunine (LII: R_1 = H, R_2 = OCH_3, R_3 = 3′-perivinyl, R_4 = $COOCH_3$, R_5 = H_2): $C_{42}H_{50}N_4O_5$
    T. crassa: unk [168]; *T. pachysiphon:* r [334]; *T. stapfiana:* st, b [354].
14. Tabernaelegantine A (LII: R_1 = H, R_2 = OCH_3, R_3 = 3′-tabernaemontanyl, R_4 = $COOCH_3$, R_5 = H_2): $C_{43}H_{54}N_4O_5$
    T. coffeoides: rb [329,430], r [361]; *T. elegans:* rb [289,308].

15. Tabernaelegantine B (LII: R_1 = 3′-tabernaemontanyl, R_2 = OCH_3, R_3 = H, R_4 = $COOCH_3$, R_5 = H_2): $C_{43}H_{54}N_4O_5$
    T. elegans: rb [289,308].
16. Tabernaelegantine C (LII: R_1 = H, R_2 = OCH_3, R_3 = 3′-dregaminyl, R_4 = $COOCH_3$, R_5 = H_2): $C_{43}H_{54}N_4O_5$
    T. elegans: rb [289,308].
17. Tabernaelegantine D (LII: R_1 = 3′-dregaminyl, R_2 = OCH_3, R_3 = H, R_4 = $COOCH_3$, R_5 = H_2): $C_{43}H_{54}N_4O_5$
    T. elegans: rb [289,308].
18. Tabernaelegantinine A (LII: R_1 = R_4 = H, R_2 = 3′-tabernaemontanyl, R_3 = CH_2COCH_3): $C_{46}H_{58}N_4O_6$, probably an artefact
    T. elegans: rb [308].
19. Tabernaelegantinine B (LIII: R_1 = 3′-tabernaemontanyl, R_2 = R_4 = H, R_3 = CH_2COCH_3): $C_{46}H_{58}N_4O_6$, probably an artefact
    T. elegans: rb [308].
20. Tabernaelegantinine C (LIII: R_1 = R_4 = H, R_2 = 3′-dregaminyl, R_3 = CN): $C_{44}H_{53}N_5O_5$
    T. elegans: rb [394].
21. Tabernaelegantinine D (LIII: R_1 = 3′-dregaminyl, R_2 = R_4 = H, R_3 = CN): $C_{44}H_{53}N_5O_5$
    T. elegans: rb [394].
22. Tabernamine (LII: R_1 = R_3 = R_4 = H, R_2 = 3′-vobasinyl, R_5 = H_2): $C_{40}H_{48}N_4O_2$
    T. stapfiana: sb [316].
23. Voacamidine (LIV: R_1 = 3′-vobasinyl, R_2 = R_4 = H, R_3 = $COOCH_3$): $C_{43}H_{52}N_4O_5$
    T. accedens: rb [305]; *T. fuchsiifolia:* unk [387]; *T. psychotrifolia:* rb [418].
24. Voacamine (LIV: R_1 = R_4 = H, R_2 = 3′-vobasinyl, R_3 = $COOCH_3$): $C_{43}H_{52}N_4O_5$
    T. accedens: rb [305]; *T. arborea:* dried trunk sap [352]; *T. australis:* st [132]; *T. citrifolia:* r [132]; *T. divaricata:* rb [408]; *T. eglandulosa:* rb [284]; *T. fuchsiifolia:* sb [200,412]; *T. laeta:* l, tw [344]; *T. longiflora:* unk [173]; *T. mocquerysii:* unk [362]; *T. orientalis:* b [294]; *T. psychotrifolia:* sb, rb [418], r [132].
25. 16-Decarbomethoxyvoacamine (LIV: R_1 = H, R_2 = 3′-vobasinyl, R_3 = R_4 = H): $C_{41}H_{50}N_4O_3$
    T. fuchsiifolia: unk [387]; *T. humblotii:* sb, rb [296][c]; *T. longiflora:* unk [173], *T. mocquerysii:* unk [362]; *T. orientalis:* b [294]; *T. psychotrifolia:* sb, rb [418].
26. 16-Decarbomethoxy-19′,20′-dihydrovoacamine (LIV: R_1 = R_3 = R_4 = H, R_2 = 3′-dregaminyl): $C_{41}H_{52}N_4O_3$
    T. orientalis: b [294].
27. 16-Decarbomethoxy-19′,20′-dihydro-20′-*epi*-voacamine (LIV: R_1 = R_3 = R_4 = H, R_2 = 3′-tabernaemontanyl): $C_{41}H_{52}N_4O_3$
    T. orientalis: b [294].

[c]See footnote p. 65.

28. $N_{4'}$-Demethylvoacamine (LIV: R_1 = R_4 = H, R_2 = 3′-perivinyl, R_3 = $COOCH_3$): $C_{42}H_{50}N_4O_5$
    T. accedens: rb [305]; *T. fuchsiifolia:* unk [387]; *T. psychotrifolia:* sb, rb [418].
29. Voacamine $N_{4'}$-oxide (LIV: R_1 = R_4 = H, R_2 = 3′-($N_{4'}$-oxide)-vobasinyl, R_3 = $COOCH_3$): $C_{43}H_{52}N_4O_6$
    T. accedens: rb [305].
30. Voacorine (LIV: R_1 = H, R_2 = 3′-vobasinyl, R_3 = $COOCH_3$, R_4 = OH, (19*S*)-configuration): $C_{43}H_{52}N_4O_6$
    T. brachyantha: sb [263]; *T. longiflora:* unk [173].
31. 19-*epi*-Voacorine (LIV: R_1 = H, R_2 = 3′-vobasinyl, R_3 = $COOCH_3$, R_4 = OH, (19*R*)-configuration): $C_{43}H_{52}N_4O_6$
    T. arborea: dried trunk sap [352].
32. (20′*S*)-19′,20′-Dihydrotabernamine (LII: R_1 = R_3 = R_4 = H, R_2 = 3′-tabernaemontanyl, R_5 = H_2: $C_{40}H_{50}N_4O_2$
    T. coffeoides: rb [430].
33. Ervahanine A (LII: R_1 = R_3 = H, R_2 = 3′-vobasinyl, R_4 = $COOCH_3$ R_5 = H_2): $C_{42}H_{50}N_4O_4$
    T. bufalina: r [417].
34. Ervahanine B (LII: R_1 = 3′-vobasinyl, R_2 = R_3 = H, R_4 = $COOCH_3$, R_5 = H_2): $C_{42}H_{50}N_4O_4$
    T. bufalina: r [417].
35. Ervahanine C (LII: R_1 = R_2 = H, R_3 = 3′-vobasinyl, R_4 = $COOCH_3$, R_5 = H_2): $C_{42}H_{50}N_4O_4$
    T. bufalina: r [417].
36. (19*R*)-19-Hydroxytabernaelegantine A (LIII: R_1 = R_3 = H, R_2 = 3′-tabernaemontanyl, R_4 = OH): $C_{43}H_{54}N_4O_6$
    T. coffeoides: sb [329,430].
37. (20*S*)-1,2-Dihydrocapuvosidine (LV: R_1 = 3′-vobasinyl, R_2 = C_2H_5, R_3 = H): $C_{40}H_{50}N_4O_2$
    T. mocquerysii: unk [362,439].

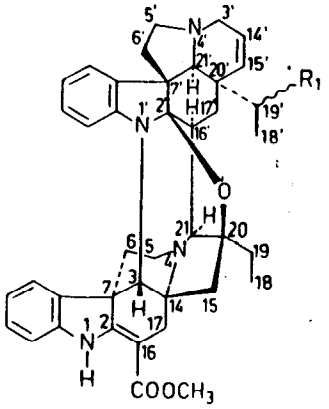
Group B3 (P-P type)



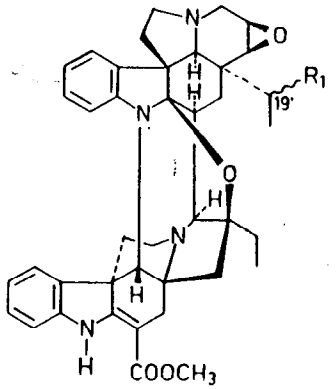
LVII

1. Vobtusine (LVII): $C_{43}H_{50}N_4O_6$
   T. aurantiaca: fr, l, b [171]; *T. longiflora:* unk [173].

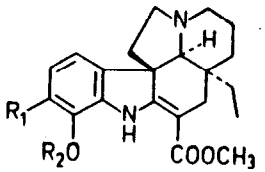
Group B4 (P-I type)



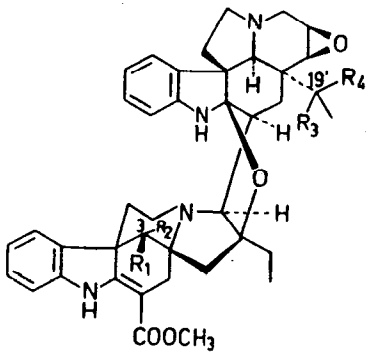
LVIII



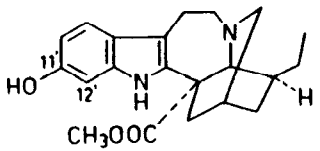
LIX



LX



LXI

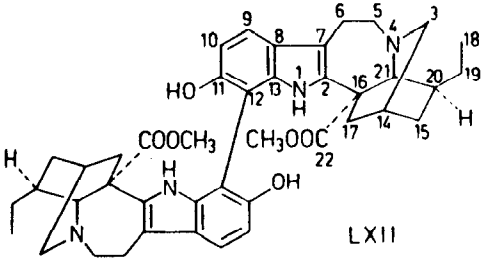


11'- HYDROXYCORONARIDINYL

1. Ervafolene (LVIII: R_1 = H): $C_{40}H_{44}N_4O_3$
   T. heterophylla: l [397].
2. 19'-Hydroxy-ervafolene (LVIII: R_1 = OH): $C_{40}H_{44}N_4O_4$
   T. heterophylla: l [397].
3. Ervafoline (LIX: R_1= H): $C_{40}H_{44}N_4O_4$
   T. heterophylla: l [349,397]; *T. pandacaqui:* l [235,349,397].
4. 19'-Hydroxy-ervafoline (LIX: R_1 = OH): $C_{40}H_{44}N_4O_5$
   T. heterophylla: l [397].
5. Tetrastachyne (LX: R_1 = H, R_2 = 12'-(11'-hydroxycoronaridinyl)): $C_{42}H_{50}N_4O_6$
   T. siphilitica: l [331,415].

6. Tetrastachynine (LX: R_1 = 12'-(11'-hydroxycoronaridinyl), R_2 = H): $C_{42}H_{50}N_4O_6$
   T. siphilitica: l [331,415].
7. Ervafolidine (LXI: R_1 = R_3 = R_4 = H, R_2 = OH): $C_{40}H_{46}N_4O_5$
   T. heterophylla: l [436]; *T. pandacaqui:* l [235,436].
8. 3-*epi*-Ervafolidine (LXI: R_1 = OH, R_2 = R_3 = R_4 = H): $C_{40}H_{46}N_4O_5$
   T. heterophylla: l [436]; *T. pandacaqui:* l [235,436].
9. (19'*R*)-19'-Hydroxy-ervafolidine (LXI: R_1 = R_4 = H, R_2 = R_3 = OH): $C_{40}H_{46}N_4O_6$
   T. heterophylla: l [436].
10. (19'*S*)-19'-Hydroxy-3-*epi*-ervafolidine (LXI: R_1 = R_4 = OH, R_2 = R_3 = H): $C_{40}H_{46}N_4O_6$
    T. heterophylla: l [436].

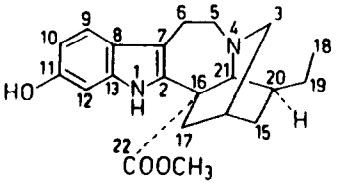
Group B5 (I-I type)

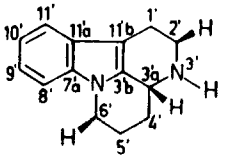


LXII

1. 12,12'-Bis(11-Hydroxycoronaridinyl) (LXII): $C_{42}H_{50}N_4O_6$
   T. siphilitica: l [311].

Group B6 (I-M type)

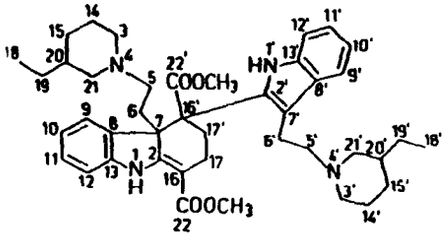




LXIII

1. Bonafousine (LXIII: 12,6'-bond): $C_{35}H_{40}N_4O_3$
   T. siphilitica: l [309].
2. Isobonafousine (LXIII: 12,2'-bond): $C_{35}H_{40}N_4O_3$
   T. siphilitica: l [393].

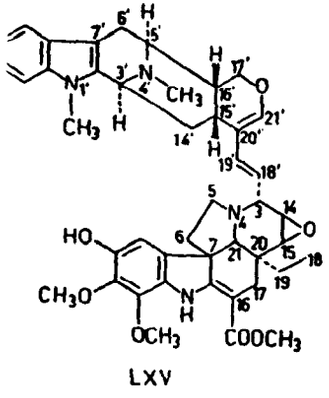
Group B7 (M-M type)



LXIV

1. (+)-15,20;15',20'-Tetrahydropresecamine (LXIV): $C_{42}H_{56}N_4O_4$
   T. minutiflora: l [231,297].

Group B8 (P-M type)



LXV

1. Pandicine (LXV): $C_{44}H_{50}N_4O_7$
   Pandacastrum saccharatum[e]: l [424].

l.4. Chemically investigated Tabernaemontana species and their alkaloids

In Table 5 the *Tabernaemontana* species which have been chemically investigated are listed alphabetically, again under the species names accepted in § 2.5. For each species, the alkaloids that have been isolated are arranged according to the groups of the biogenetic classification set out in § 3. Table 5 also includes the number given to each alkaloid, the part of the plant from which the alkaloid has been isolated, the country of origin of the plant

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[e] The required nomenclatural change has not yet been made.

TABLE 5
LIST OF CHEMICALLY INVESTIGATED TABERNAEMONTANA SPECIES AND THE ALKALOIDS ISOLATED FROM THEM

Species	Plant part	Country of origin	Alkaloids isolated	No.	Reference
T. accedens	rb	S. America	Accedine	C5-1	283
	rb	S. America	N_a-Demethyl-16-*epi*-accedine	C5-2	306
	rb	S. America	N_1-Methyl-16-*epi*-affinine	C5-4	283
	rb	S. America	Accedinine	B1-1	305
	rb	S. America	Accedinisine	B1-2	305
	rb	S. America	Voacamidine	B2-23	305
	rb	S. America	Voacamine	B2-24	305
	rb	S. America	Demethylvoacamine	B2-28	305
	rb	S. America	Voacamine N_a-oxide	B2-29	305
T. affinis	r	Brazil	Serpentine	C2-3	131
	r	Brazil	Yohimbine	C3-1	131
	rb	Brazil	Affinisine	C4-1	304
	unk	Brazil	Affinisine	C4-1	156,158
	unk	Brazil	Affinine	C5-3	156,158
	unk	Brazil	Vobasine	C5-10	156
	rb	Brazil	Coronaridine	I1-5	304
	rb	Brazil	(−)-19-*epi*-Heyneanine	I1-21	304
	rb	Brazil	Coronaridine pseudoindoxyl	I2-2	304
	rb	Brazil	Olivacine	M2-2	272,304
	rb	Brazil	Unidentified iboga base (APA)	1	272
T. alba	se	Mexico	Tabersonine	P2-16	144
	se	Mexico	Coronaridine	I1-5	144
T. albiflora	sb	French Guiana	Coronaridine	I1-5	402
	sb	French Guiana	18-Hydroxycoronaridine	I1-9	422
	sb	French Guiana	(+)-19-Hydroxy-20-*epi*-pandoline	I4-9	423
	sb	French Guiana	(20*R*)-18,19-Dihydroxy-pseudovincadifformine	I4-12	423
	sb	French Guiana	Ibophyllidine	I6-1	402
	sb	French Guiana	Desethyl-ibophyllidine	I6-2	402
	sb	French Guiana	20-*epi*-Ibophyllidine	I6-3	402
	sb	French Guiana	19-Hydroxyibophyllidine	I6-4	403
	sb	French Guiana	18-Hydroxy-20-*epi*-ibophyllidine	I6-5	403
	sb	French Guiana	(19*R*)-19-Hydroxy-20-*epi*-ibophyllidine	I6-6	403

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	sb	French Guiana	(19*S*)-19-Hydroxy-20-*epi*-ibophyllidine	I6-7	403
T. amblyocarpa	l	Cuba	Akuammidine	C4-2	407
	st	Cuba	Vallesamine	A2-2	407
	st	Cuba	(+)-Tubotaiwine	A3-3	407
	l,st	Cuba	Coronaridine	II-5	407
	l	Cuba	(−)-Ibogamine	II-27	407
	st	Cuba	Voacangine	II-34	407
	l	Cuba	Isovoacangine	II-36	407
	st	Cuba	Voacristine	II-43	407
	l	Cuba	Isovoacristine	II-45	407
T. amygdalifolia	r	Colombia	(+)-Demethyl-aspidospermine	P2-4	412
	r	Colombia	Cylindrocarpidine	P2-5	197
	r	Colombia	12-Demethoxycylindrocarpidine	P2-6	196
	r	Colombia	Homocylindrocarpidine	P2-7	196
	r	Colombia	5-Oxocylindrocarpidine	P2-8	197
	r	Colombia	*O*-Demethylpalosine	P2-15	182
	r	Colombia	Coronaridine	II-5	412
	r	Colombia	Voacangine	II-34	412
	r	Colombia	Voacangine hydroxyindolenine	II-41	412
T. angulata	—	—	Contains alkaloids		230
T. apoda	l	Cuba	Apodine	P2-1	293,363
	l	Cuba	Desoxo-apodine	P2-2	292,363
	l	Cuba	Apodinine	P2-3	372
	fr;l;r	Cuba	Coronaridine	II-5	335;322;301
	rb	Cuba	(−)-Heyneanine	II-20	342
	fr	Cuba	Ibogaine hydroxyindolenine	II-24	315,363
	fr;l;r	Cuba	(−)-Ibogamine	II-27	335;373;301
	fr;l;r	Cuba	Voacangine	II-34	315,335,363;373;301
	fr;rb	Cuba	Voacangine hydroxyindolenine	II-41	336;342
	l;r	Cuba	Isovoacangine	II-36	373;301
	fr;l	Cuba	Voacristine	II-43	336;322
	fr;l	Cuba	Voacristine hydroxyindolenine	II-46	336;322
	fr	Cuba	Ibogaine pseudoindoxyl	I2-3	315,363
	fr;rb	Cuba	Voacangine pseudoindoxyl	I2-6	315,363;342
	fr	*Cuba*	Voacristine pseudoindoxyl	I2-7	336
T. arborea	se	Costa Rica	Tabersonine	P2-16	391
	la;se	Costa Rica	Voacangine	II-34	352;391
	se	Costa Rica	Isovoacangine	II-36	391
	la	Costa Rica	Voacamine	B2-24	352
	la	Costa Rica	19-*epi*-Voacorine	B2-31	352
T. attenuata	l	Guyana	16-*epi*-Pleiocarpamine	C10-2	426
	l	Guyana	(+)-Tubotaiwine	A3-3	426
	sb	Guyana	Conopharyngine	II-1	426
	sb	Guyana	Conopharyngine hydroxyindolenine	II-4	426
	sb,rb	Guyana	Coronaridine	II-5	426
	rb	Guyana	(6*R*)-3,6-Oxidocoronaridine	II-16	426
	sb,rb	Guyana	(−)-Heyneanine	II-20	426
	sb,rb	Guyana	19-*epi*-Heyneanine	II-21	426
	sb	Guyana	Coronaridine hydroxyindolenine	II-17	426
	sb	Guyana	Voacangine	II-34	426
	sb	Guyana	Isovoacangine	II-36	426
	l	Guyana	11-Hydroxycoronaridine	II-48	426
	l	Guyana	10-Hydroxyheyneanine	II-49	426
	l	Guyana	11-Hydroxyheyneanine	II-50	426
	sb	Guyana	Ibophyllidine	I6-1	426
	l	Guyana	Angustine	M4-1	426
	l	Guyana	Dimeric alkaloid M^{++} 706	B	426
	sb	Guyana	Alkaloid M^{++} 296		426
	rb	Guyana	Alkaloids M^{++} 352 and 354		426
T. aurantiaca	b	New Guinea	Voacangine	II-34	171
	fr,l,b	New Guinea	Ibogaine pseudoindoxyl	I2-3	171
	fr,l,b	New Guinea	Voacangine pseudoindoxyl	I2-6	171,172
	fr,l,b	New Guinea	Vobtusine	B3-1	171
T. australis	st	Argentina	Voacangine	II-34	132
	st	Argentina	Voacamine	B2-24	132
T. brachyantha	sb	Cameroon	Normacusine B	C4-3	263
	sb	Cameroon	Anhydrovobasindiol	C5-9	263
	sb	Cameroon	Voacorine	B2-30	263
	sb	Cameroon	Isomer of voacorine	B2	263
T. bufalina	r	Hainan, China	Suitable for isolating conopharyngine	II-1	145
	r	Hainan, China	Geissoschizol	C1-2	435
			10-Hydroxygeissoschizol	C1-4	435

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	r	Hainan, China	Perivine	C5-6	435
	r	Hainan, China	Vobasine	C5-10	435
	r	Hainan, China	Coronaridine	I1-5	435
	r	Hainan, China	3-Oxocoronaridine	I1-11	435
	r	Hainan, China	Coronaridine hydroxyindolenine	I1-17	435
	r	Hainan, China	(−)-Heyneanine	I1-20	435
	r	Hainan, China	Ibogamine	I1-27	435
	r	Hainan, China	10-Hydroxyheyneanine	I1-49	435
	r	Hainan, China	(3*S*)-3-(β-Hydroxyethyl)-coronaridine	I1-52	435
	r	Hainan, China	Ervahanine A	B2-33	417
	r	Hainan, China	Ervahanine B	B2-34	417
	r	Hainan, China	Ervahanine C	B2-35	417
T. calcarea	l,sb,rb	Madagascar	Dregamine	C5-5	274
	tw,r	Madagascar	Dregamine	C5-5	303
	l,tw,r	Madagascar	Silicine	C8-7	303
	l,tw,r	Madagascar	Isomer of silicine	C8	303
	l	Madagascar	Apparicine	A2-1	274
	l	Madagascar	Pandoline	I4-7	274,303
	l	Madagascar	20-*epi*-Pandoline	I4-8	303
	l	Madagascar	Pseudotabersonine	I4-10	303
	l	Madagascar	(+)-(20*R*)-Pseudovincadifformine	I4-11	303
	l	Madagascar	Pandine	I5-1	274,303
	l	Madagascar	4 Unidentified bis-indole alkaloids	B	303
T. capuronii	l,sb	Madagascar	Capuronine	I3-1	287,346
	l,sb	Madagascar	Capuronidine	I4-4	287,346
	l,sb	Madagascar	14,15-Anhydrocapuronidine	I4-5	346
	l,sb	Madagascar	14,15-Anhydro-1,2-dihydro-capuronidine	I4-6	346
	l,sb	Madagascar	(20*R*)-Capuvosidine	B2-1	346,351
	l,sb	Madagascar	(20*R*)-1,2-Dihydrocapuvosidine	B2-2	351
	l,sb	Madagascar	Capuvosine	B2-3	346,351
	l,sb	Madagascar	Dehydroxycapuvosine	B2-4	346,351
	l,sb	Madagascar	N_a-Demethylcapuvosine	B2-5	346
T. cerifera	l	New Caledonia	Vobasine	C5-10	360
	l	New Caledonia	Apparicine	A2-1	360
	l	New Caledonia	Ibogaine	I1-23	314
	l	New Caledonia	Voacangine	I1-34	314
	l	New Caledonia	Voacangine hydroxyindolenine	I1-42	314
	l	New Caledonia	Olivacine	M2-2	360
T. chippii	l	Ghana	Voaphylline	P1-1	206
T. citrifolia	l	Cuba	Suitable for isolating conopharyngine	I1-1	145
	l;r	Cuba; Trinidad	Apparicine	A2-1	371
	r	Cuba	Coronaridine	I1-5	371;132
	l;r	Cuba; Trinidad	Ibogamine	I1-27	132
	r	Cuba	Voacangine	I1-34	371;132
T. coffeoides	sb	Madagascar	Voacamine	B2-24	132
	sb	Madagascar	Reserpiline	C2-1	329
	l	Madagascar	Isoreserpiline	C2-2	329
	l,sb	Madagascar	Akuammidine	C4-2	367
	l	Madagascar	Normacusine B	C4-3	329
	l	Madagascar	Pericyclivine	C4-4	389
	l;tw,st;	Madagascar	Polyneuridine	C4-5	367
	sb;	Madagascar	Dregamine	C5-5	217,329,389;217;
	rb;r	Madagascar	Dregamine	C5-5	217,329,367,389
	l;tw,st;	Madagascar	Dregamine	C5-5	329,367,389;242
	sb;	Madagascar	Tabernaemontanine	C5-7	217,329,389;217;
	rb;r	Madagascar	Tabernaemontanine	C5-7	217,329,367,389
	l;tw,sb,st	Madagascar	Tabernaemontanine	C5-7	329,367,389;242
	l;	Madagascar	Voacarpine	C5-8	217,367;217
	tw,st;sb;	Madagascar	Vobasine	C5-10	217,329,367,389;
	rb	Madagascar	Vobasine	C5-10	217;217,329,367
	sb	Madagascar	Vobasine	C5-10	329,367
	sb	Madagascar	Tetraphyllicine	C6-2	329
	sb	Madagascar	Tetraphyllicine monomethoxy-benzoate	C6-3	329
	sb	Madagascar	Tetraphyllicine dimethoxybenzoate	C6-4	329
	l;	Madagascar	Tetraphyllicine trimethoxybenzoate	C6-5	329
	sb,rb	Madagascar	Methuenine	C8-4	329,389;
	sb;rb	Madagascar	Methuenine	C8-4	329,367,389
	sb	Madagascar	Isomethuenine	C8-5	367;329,367
	l;	Madagascar	6-Oxomethuenine	C8-6	329
	sb,rb;r	Madagascar	Silicine	C8-7	329,389;
	rb	Madagascar	Silicine	C8-7	329,367,389;361
			20-*epi*-Silicine	C8-8	329

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	sb;	Madagascar	6-Oxosilicine	C8-9	367,389;
	rb;r	Madagascar	6-Oxosilicine	C8-9	329,367,389;361
	sb,rb	Madagascar	6-Oxo-16-*epi*-silicine	C8-10	389
	l	Madagascar	Vincanidine	S1-3	329
	l	Madagascar	(+)-Stemmadenine	A1-1	329
	l;sb,rb	Madagascar	Apparicine	A2-1	389;367,389
	l	Madagascar	Vallesamine	A2-2	389
	l	Madagascar	Voaphylline	P1-1	367
	l	Madagascar	Desoxo-apodine	P2-1	389
	l,tw	Madagascar	Hazuntine	P2-9	217
	l,tw	Madagascar	Hazuntinine	P2-10	217
	l	Madagascar	Lochnericine	P2-11	389
	l	Madagascar	Tabersonine	P2-16	389
	l	Madagascar	10-Hydroxy-11-methoxytabersonine	P2-17	367
	l	Madagascar	3-Oxotabersonine	P2-18	389
	l	Madagascar	14,15-Dihydroxytabersonine	P2-21	389
	r	Madagascar	Coronaridine	I1-5	361
	l	Madagascar	(−)-Heyneanine	I1-20	367
	l;r	Madagascar	(−)-19-*epi*-Heyneanine	I1-21	367;361
	rb;r	Madagascar	(−)-Ibogamine	I1-27	329,367,389;242
	r	Madagascar	Voacangine	I1-34	361
	l,sb,rb	Madagascar	Isovoacangine	I1-36	329
	sb,rb	Madagascar	3,14-Dihydro-ellipticine	M2-1	329,367,389
	r;rb	Madagascar	Tabernaelegantine A	B2-14	361;329,430
	rb	Madagascar	(20′*S*)-19′,20′-Dihydrotabernamine	B2-32	430
	sb	Madagascar	(19*R*)-19-Hydroxytabernaelegantine A	B2-36	329,430
	l	Madagascar	Unknown bases M$^{+\cdot}$ 378 and 382		367,329
	l,rb	Madagascar	Unknown base M$^{+\cdot}$ 366		329
	l	Madagascar	5 Unknown bis-indole alkaloids	B	367
	rb	Madagascar	Unknown alkaloid M$^{+\cdot}$ 312		329
T. contorta	sb	Nigeria	Conopharyngine	I1-1	205
	sb	Nigeria	Coronaridine	I1-5	205
	sb	Nigeria	Ibogaine	I1-23	205
	sb	Nigeria	Voacangine	I1-34	205
	sb	Nigeria	Voacristine	I1-43	205
T. corymbosa	l,sb,b	Malaysia	Alkaloid tests strongly positive		114
T. crassa	b	Ivory Coast	*O*-Acetylpolyneuridine	C4-6	201
	unk	East Africa	Pericyclivine	C4-4	168
	unk	East Africa	Perivine	C5-6	168
	sb	Congo	Anhydrovobasindiol	C5-9	222
	unk	East Africa	Vobasine	C5-10	168
	sb	Congo	Akuammiline	C7-1	222
	se	Central Africa	Tabersonine	P2-16	198
	fr,l,tw,b	Tahiti	Conopharyngine	I1-1	211
	sb;rb	Ivory Coast	Conopharyngine	I1-1	126,145;126
	fr,l,tw,b	Tahiti	19-Hydroxyconopharyngine	I1-2	211
	b	Ivory Coast	19-Hydroxyconopharyngine	I1-2	201
	unk	Unknown	19-Hydroxyconopharyngine	I1-2	202
	sb	Ivory Coast	3-Oxoconopharyngine	I1-3	216
	b	Ivory Coast	Conopharyngine hydroxyindolenine	I1-4	201
	se	Central Africa	Coronaridine	I1-5	198
	sb	Ivory Coast	Coronaridine	I1-5	161
	unk	East Africa	Coronaridine	I1-5	168
	sb	Ivory Coast	3-Oxocoronaridine	I1-10	216
	sb	Ivory Coast	5-Oxocoronaridine	I1-12	161
	se	Central Africa	Coronaridine hydroxyindolenine	I1-17	198
	sb	Unknown	3-Oxocoronaridine hydroxyindolenine	I1-18	215
	b	Ivory Coast	(−)-Heyneanine	I1-20	201
	sb	Ivory Coast	(−)-3-Oxoheyneanine	I1-22	216
	unk	East Africa	(−)-Ibogamine	I1-27	168
	sb,rb	Ivory Coast	Isovoacangine	I1-36	126
	unk	East Africa	Isovoacangine	I1-36	168
	b	Ivory Coast	Voacristine	I1-43	201
	fr,l,tw,b	Tahiti	Crassanine	I2-8	211
	rb	Ivory Coast	Conoduramine	B2-7	126
	unk	East Africa	Conoduramine	B2-7	168
	rb	Ivory Coast	Conodurine	B2-9	126
	unk	East Africa	Conodurine	B2-9	168
	unk	East Africa	Gabunine	B2-13	168
T. crispa	rb	India (?)	Contains an alkaloid		94
T. crassifolia	sb	Madagascar	(−)-Ibogamine	I1-27	234
	sb	Madagascar	Tabernanthine	I1-33	234

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
T. debrayi	l,sb,rb	Madagascar	Dregamine	C5-5	274
	l	Madagascar	Pandoline	I4-7	274
	l	Madagascar	Pandine	I5-1	274
T. dichotoma	l	Sri Lanka	Perivine	C5-6	431
	l	Sri Lanka	Vobasine	C5-10	431
	l	Sri Lanka	Isomethuenine	C8-5	438
	l	Sri Lanka	Apparicine	A2-1	431
	l	Sri Lanka	12-Methoxyvoaphylline	P1-3	431
	fr	India	Tabersonine	P2-16	175
	fr;rb	India	Coronaridine	I1-5	150;186
	rb	India	(−)-Heyneanine	I1-20	186
	l	Sri Lanka	19-*epi*-Iboxygaine	I1-30	431
	l	Sri Lanka	19-*epi*-Voacristine	I1-44	431
	rb	India	Voacristine hydroxyindolenine	I1-46	218
T. disticha	unk	South America	Desethyl-ibophyllidine	I6-2	402
	unk	South America	Stereoisomer of 19-hydroxyibophyllidine	I6	403
T. divaricata	l;st	India; Florida	Dregamine	C5-5	302;132
	l;sb.b.r;b	India; Pakistan	Tabernaemontanine	C5-7	281,302;83;89
	st;fl,l,st,r	Florida; Egypt	Tabernaemontanine	C5-7	132;183
	fl,l,st,r	Egypt	Vobasine	C5-10	183
	fl	Cuba	Apparicine	A2-1	416
	fl;l;l	Cuba; India	Voaphylline	P1-1	416; 313;281
	fl;l	Cuba	N_1-Methylvoaphylline	P1-2	348,416;313
	l	India	Lochnericine	P2-11	281
	fl	Cuba	Tabersonine	P2-16	416
	l;rb;	India	Coronaridine	I1-5	281,302;223,4(
	sb;st;	Cuba; Florida	Coronaridine	I1-5	312;132;
	se	Bangladesh	Coronaridine	I1-5	400
	unk	Brazil	Coronaridine	I1-5	249
	rb	India	5-Hydroxy-6-oxocoronaridine	I1-10	408
	rb;unk	India; Brazil	3-Oxocoronaridine	I1-11	408;249
	rb	India	5-Oxocoronaridine	I1-12	408
	rb	India	6-Oxocoronaridine	I1-13	408
	unk	Brazil	3-(2'-Oxopropyl)-coronaridine	I1-15	249
	rb	India	Coronaridine hydroxyindolenine	I1-17	408
	rb	India	(+)-Heyneanine	I1-19	408
	rb	India	(−)-Heyneanine	I1-20	408
	rb;sb	India; Cuba	(−)-Ibogamine	I1-27	408;312
	l;sb	India; Cuba	Voacangine	I1-34	281;312
	sb	India	Isovoacangine	I1-36	312
	l	India	Voacristine	I1-43	302
	fl,l	India	Isovoacristine	I1-45	374
	fl	Cuba	3,14;4,19-Tetrahydro-olivacine	M2-3	348
	rb	India	Voacamine	B2-24	408
T. eglandulosa	rb	Tanzania	Perivine	C5-6	284
	rb	Tanzania	Vobasine	C5-10	284
	sb	Nigeria	Conopharyngine	I1-1	205
	sb	Central Africa	Coronaridine	I1-5	277
	sb	Nigeria	Coronaridine	I1-5	205
	rb	Tanzania	Coronaridine	I1-5	284
	rb	Tanzania	3-Hydroxycoronaridine	I1-7	284
	sb	Central Africa	6-Hydroxy-3-oxocoronaridine	I1-14	277
	sb	Central Africa	(6*R*)-3,6-Oxidocoronaridine	I1-16	277
	sb;wp	Nigeria; Unknown	Voacangine	I1-34	205;116
	rb	Tanzania	3-Hydroxyisovoacangine	I1-35	284
	rb	Tanzania	Isovoacangine	I1-36	284
	l,tw,sb	Holland	Tacamine	T1-1	434
	rb	Tanzania	Voacamine	B2-24	284
T. elegans	rb	Mozambique	Dregamine	C5-5	289
	rb	Mozambique	Tabernaemontanine	C5-7	289
	rb	Mozambique	Conoduramine	B2-7	289
	rb	Mozambique	Tabernaelegantine A	B2-14	289,308
	rb	Mozambique	Tabernaelegantine B	B2-15	289,308
	rb	Mozambique	Tabernaelegantine C	B2-16	289,308
	rb	Mozambique	Tabernaelegantine D	B2-17	289,308
	rb	Mozambique	Tabernaelegantinine A	B2-18	308
	rb	Mozambique	Tabernaelegantinine B	B2-19	308
	rb	Mozambique	Tabernaelegantinine C	B2-20	394
	rb	Mozambique	Tabernaelegantinine D	B2-21	394
T. eusepala	sb	Madagascar	Suitable for extraction of conopharyngine	I1-1	145
	sb	Madagascar	Vobasine	C5-10	298
			Apparicine	A2-1	298

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	sb	Madagascar	(+)-Tubotaiwine	A3-3	298
	l,sb,rb	Madagascar	Ibogaine	I1-23	298
	sb	Madagascar	Ibogaine hydroxyindolenine	I1-24	298
	sb	Madagascar	19-*epi*-Voacristine	I1-44	298
	sb	Madagascar	(+)-(20*R*)-Dihydrocleavamine	I3-2	298
	sb	Madagascar	(−)-(20*S*)-Dihydrocleavamine	I3-3	298
	sb	Madagascar	(+)-(20*S*)-1,2-Dehydropseudo-aspidospermidine	I4-3	298
T. eusepaloides	rb	Madagascar	Ibogaine	I1-23	234
T. flavicans	st	Peru	Ibophyllidine	I6-1	380
	st	Peru	Ibophyllidine N_4-oxide	I6-8	380
T. fuchsiifolia	sb	Brazil	Affinisine	C4-1	181
	sb	Brazil	Voachalotine	C4-7	181
	sb	Argentina	Voachalotine	C4-7	200
	unk	Brazil	Perivine	C5-6	387
	sb	Brazil	Vobasine	C5-10	412
	sb	Brazil	Conopharyngine	I1-1	412
	sb	Brazil	Coronaridine	I1-5	412
	sb	Brazil	Voacangine	I1-34	412
	sb	Argentina	Voacangine	I1-34	200
	unk	Brazil	Voacamidine	B2-23	387
	sb	Brazil	Voacamine	B2-24	412
	sb	Argentina	Voacamine	B2-24	200
	unk	Brazil	16-Decarbomethoxyvoacamine	B2-25	387
	unk	Brazil	Demethylvoacamine	B2-28	387
T. glandulosa	l,st	Ghana	Vincadiffine	C5-12	432
	l,st	Ghana	Tabernulosine	C7-2	381,432
	l,st	Ghana	12-Demethoxytabernulosine	C7-3	432
	l,st	Ghana	3-Ethoxycoronaridine	I1-6	381
	l,st	Ghana	3-Hydroxycoronaridine	I1-7	382
T. haematosticta?	b	Indonesia	Contains much alkaloid		24,120
T. heterophylla	l	French Guiana	Voaphylline	P1-1	397
	l	French Guiana	Voacangine	I1-34	397
	l	French Guiana	Voacangine hydroxyindolenine	I1-41	397
	l	French Guiana	Vincadifformine	I4-7	397
	l	French Guiana	Pandine	I6-1	397
	l	French Guiana	Ervafolene	B4-1	397
	l	French Guiana	19′-Hydroxy-ervafolene	B4-2	397
	l	French Guiana	Ervafolidine	B4-5	436
	l	French Guiana	3-*epi*-Ervafolidine	B4-6	436
	l	French Guiana	(19′*R*)-19′-Hydroxy-ervafolidine	B4-7	436
	l	French Guiana	(19′*S*)-19′-Hydroxy-3-*epi*-ervafolidine		
	l	French Guiana	Ervafoline	B4-3	349,397
			19′-Hydroxy-ervafoline	B4-4	397
T. heyneana	sb,st	India	Apparicine	A2-1	396
	sb,st	India	O-Acetylvallesamine	A2-3	396
	sb,st	India	(+)-Tubotaiwine	A3-3	396
	se;fr;sb,st; b;r;wp	India	Coronaridine	I1-5	193;245;396;
		India	Coronaridine	I1-5	184;184,261; 194
	sb,st	India	10-Hydroxycoronaridine	I1-8	396
	r	India	3-Oxocoronaridine	I1-11	261
	fr;sb,st;b,r	India	(−)-*Heyneanine*	I1-20	245;396;170
	r	India	(−)-*Ibogamine*	I1-27	261
	sb,st;r	India	Voacangine	I1-34	396;261
	sb,st	India	(19*S*)-3,19-Oxidovoacangine	I1-39	396
	sb,st	India	Voacangine hydroxyindolenine	I1-41	396
	sb,st	India	(6*R*)-3,6-Oxidovoacangine N_4-oxide	I1-42	396
	sb,st	India	Voacristine	I1-43	396
	l	India	Isovoacristine	I1-45	374
	sb,st	India	19-Oxovoacangine	I1-47	396
	r	India	Voacangine pseudoindoxyl	I2-6	261
	sb,st	India	Camptothecine	M3-1	369
	sb,st	India	9-Methoxycamptothecine	M3-2	369
T. humblotii	l	Madagascar	Akuammidine	C4-2	279
	l,sb,rb	Madagascar	Akuammicine	S1-1	279
	l	Madagascar	Apparicine	A2-1	279
	sb,rb	Madagascar	(+)-Tubotaiwine	A3-3	279
	l	Madagascar	(+)-16-*epi*-14,15-Dehydro-vincamine	E1-8	279
	l,sb,rb	Madagascar	Ibogaine	I1-23	279,296[a]
	l	Madagascar	Iboxygaline	I1-25	279
	sb	Madagascar	Iboxygaine	I1-29	296[a]
	l	Madagascar	19-*epi*-Iboxygaine	I1-30	279
	l	Madagascar	19-*epi*-Iboxygaline	I1-32	279

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	l,sb,rb	Madagascar	Voacangine	I1-34	296[a]
	l,sb	Madagascar	Voacristine	I1-43	296[a]
	sb;rb	Madagascar	Ibogaine pseudoindoxyl	I2-3	279,296[a];279
	sb,rb	Madagascar	16-Decarbomethoxyvoacamine	B2-25	296[a]
T. killipii	sb	S. America	Voacangine	I1-34	300
	sb	S. America	Voacangine pseudoindoxyl	I2-6	300
T. laeta	l,tw	Brazil	Geissoschizol	C1-2	275
	l,tw	Brazil	Akuammidine	C4-2	344
	l,tw	Brazil	Normacusine B	C4-3	344
	l,tw	Brazil	Affinine	C5-3	344
	l,tw	Brazil	Vobasine	C5-10	344
	l,tw	Brazil	Conodurine	B2-9	344
	l,tw	Brazil	Voacamine	B2-24	344
	l,tw	Brazil	Voaphylline	P1-1	199
T. longiflora	l,sb	Unknown	Conopharyngine	I1-1	199
	sb	Ivory Coast	Conopharyngine	I1-1	173
	unk	Unknown	Voacangine	I1-34	199
	sb	Ivory Coast	Voacangine	I1-34	173
	unk	Unknown	Isovoacangine	I1-36	203
	unk	Ivory Coast	Voacristine	I1-43	173
	unk	Unknown	Voacamine	B2-24	173
	unk	Unknown	16-Decarbomethoxyvoacamine	B2-25	173
	unk	Unknown	Voacorine	B2-30	173
	unk	Unknown	Vobtusine	B3-1	173
T. longipes	se	Costa Rica	Tabersonine	P2-16	368
	se;l	Costa Rica	Coronaridine	I1-5	368;414
	se	Costa Rica	Voacangine	I1-34	368
T. lundii	l,st,b	Brazil	Vobasine	C5-10	225
	l,st,b	Brazil	Coronaridine	I1-5	225
	l,st,b	Brazil	Ibogaine	I1-23	225
	l,st,b	Brazil	Iboxygaine	I1-29	225
	l,st,b	Brazil	Iboxygaine hydroxyindolenine	I1-31	225
	l,st,b	Brazil	Voacangine	I1-34	225
	l,st,b	Brazil	Voacristine	I1-43	225
	l,st,b	Brazil	19-*epi*-Voacristine	I1-44	225
	l,st,b	Brazil	Voacristine pseudoindoxyl	I2-7	225
	l,st,b	Brazil	Olivacine	M2-5	225
T. macrocalyx	se	Guyana	Tabersonine	P2-16	365
	se	Guyana	Coronaridine	I1-5	365
T. macrocarpa	se	Sabah	Voaphylline	P1-1	337
	se	Sabah	Coronaridine	I1-5	337
	se	Sabah	Voacangine	I1-34	337
	se	Sabah	Voacangine hydroxyindolenine	I1-41	337
T. malaccensis	st	Malaysia	0.1% weak bases, having 4—5 components; the main one had m.p. 209—211°C and possible formula $C_{21}H_{26}N_2O_2$		123
	l	Malaysia	0.1% weak bases with at least 6 components, the main one having properties similar to those of the compound from the stems		123
	l,st,r	Malaysia	Alkaloids are present		138
T. mauritiana	sb,rb	Réunion	Dregamine	C5-5	280
	sb,rb	Réunion	Vobasine	C5-10	280
	l,sb,rb	Réunion	(+)-Tubotaiwine	A3-3	280
	l	Réunion	Unidentified bis-indole base ($M^{+\cdot}$ 644)	B	280
T. minutiflora	l	Madagascar	Vobasine	C5-10	297
	l	Madagascar	(+)-Stemmadenine	A1-1	297
	l	Madagascar	(+)-Condylocarpine	A3-1	297
	l	Madagascar	(+)-Tubotaiwine	A3-3	297
	l	Madagascar	(+)-Vincadifformine	P2-19	297
	l	Madagascar	Coronaridine	I1-5	297
	l	Madagascar	(+)-15,20;15'20'-Tetrahydro-presecamine	B7-1	231,297
T. mocquerysii	unk	Madagascar	19,20-Dehydro-ervatamine	C8-2	362
	rb	Madagascar	Methuenine	C8-4	327,362
	rb	Madagascar	Ervitsine	C9-1	327,362
	unk	Madagascar	(+)-Tubotaiwine	A3-3	362
	rb	Madagascar	Coronaridine	I1-5	286
	rb	Madagascar	(−)-Heyneanine	I1-20	286
	l,sb,rb	Madagascar	(−)-19-*epi*-Heyneanine	I1-21	286
	rb	Madagascar	Voacangine	I1-34	286

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	rb	Madagascar	Voacristine	I1-43	286
	rb	Madagascar	19-*epi*-Voacristine	I1-44	286
	unk	Madagascar	(+)-(20*R*)-15,20-Dihydrocleavamine	I3-2	362
	unk	Madagascar	(−)-(20*S*)-15,20-Dihydrocleavamine	I3-3	362
	unk	Madagascar	(+)-(20*R*)-Pseudoaspidospermidine	I4-1	362
	unk	Madagascar	(−)-(20*S*)-Pseudoaspidospermidine	I4-2	362
	unk	Madagascar	(+)-(20*S*)-1,2-Dehydro-pseudo-aspidospermidine	I4-3	362
	unk	Madagascar	(20*R*)-Capuvosidine	B2-1	351,362,439
	unk	Madagascar	(20*R*)-1,2-Dihydrocapuvosidine	B2-2	351
	unk	Madagascar	(20*S*)-1,2-Dihydrocapuvosidine	B2-37	362,439
	unk	Madagascar	Dehydroxycapuvosine	B2-4	351,362
	unk	Madagascar	Dehydroxy-isocapuvosine	B2-6	362
	unk	Madagascar	Voacamine	B2-24	362
	unk	Madagascar	16-Decarbomethoxyvoacamine	B2-25	362
T. mucronata	b	Philippines	Tabernaemontanine	C5-7	180
	b	Philippines	Coronaridine	I1-5	180
T. muricata		Colombia	Schultes, Raffauf and Soejarto 24249 Dragendorff positive		375
T. olivacea	st	Peru	Akuammidine	C4-2	379
	st	Peru	Condylocarpine N_4-oxide	A3-2	379
	st	Peru	Coronaridine	I1-5	379
	st	Peru	Coronaridine hydroxyindolenine	I1-17	379
	st	Peru	(−)-Heyneanine	I1-20	379
	st	Peru	Ibogaine	I1-23	379
	st	Peru	(−)-Ibogamine	I1-27	379
	st	Peru	Voacangine	I1-34	379
	st	Peru	Voacangine hydroxyindolenine	I1-41	379
	st	Peru	Voacristine	I1-43	379
	st	Peru	Coronaridine pseudoindoxyl	I2-2	379
	st	Peru	Voacangine pseudoindoxyl	I2-6	379
T. orientalis	unk	Queensland	Akuammidine	C4-2	383
	l,tw	Is.Loyautés	Dregamine	C5-5	388
	b	Queensland	Dregamine	C5-5	294
	l,tw	Is.Loyautés	Tabernaemontanine	C5-7	383
	b	Queensland	Tabernaemontanine	C5-7	388
	unk	New Hebrides	Tabernaemontanine	C5-7	294
	l,tw	Is.Loyautés	Ervatamine	C8-1	383
	l,sb	Queensland	Ervatamine	C8-1	388
	l,sb	Queensland	19,20-Dehydro-ervatamine	C8-1	294
	l,tw	Is.Loyautés	20-*epi*-Ervatamine	C8-2	294
	sb	Queensland	20-*epi*-Ervatamine	C8-3	388
	l	Queensland	Apparicine	C8-3	294
	l,tw	Is.Loyautés	Conopharyngine	A2-1	294
	unk	New Guinea	Conopharyngine	I1-1	388
	unk	Queensland	Conopharyngine	I1-1	383
	l,tw	Is.Loyautés	Coronaridine	I1-1	383
	unk	New Hebrides	Coronaridine	I1-5	388
	l	Queensland	Ibogaine	I1-5	383
	l;unk	Queensland	Iboxygaine	I1-23	294
	l,tw	Is.Loyautés	Voacangine	I1-29	294;383
	unk	Queensland	Voacangine	I1-34	388
	unk	New Guinea	Voacangine	I1-34	383
	unk	New Hebrides	Isovoacangine	I1-34	383
	b	Queensland	Voacristine	I1-36	383
	l,tw	Is.Loyautés	Pandoline	I1-43	294
	unk	New Guinea	Pandoline	I4-7	388
	l,tw	Is.Loyautés	20-*epi*-Pandoline	I4-7	383
	unk	New Hebrides	20-*epi*-Pandoline	I4-8	388
	l,tw	Is.Loyautés	Pandine	I4-8	383
	unk	New Guinea	Pandine	I5-1	388
	b	Queensland	Voacamine	I5-1	383
	b	Queensland	16-Decarbomethoxyvoacamine	B2-24	294
	b	Queensland	16-Decarbomethoxy-19′,20′-dihydrovoacamine	B2-25	294
	b	Queensland	16-Decarbomethoxy-19′,20′-dihydro-20-*epi*-voacamine	B2-26	294
T. pachysiphon	r	Kenya	Pericyclivine	B2-27	294
	sb	Nigeria	Affinine	C4-4	334
	r	Kenya	Perivine	C5-3	191
	r	Kenya	Vobasine	C5-6	334
	l	Africa	Apparicine	C5-10	334
	r	Kenya	Tubotaiwine N_4-oxide	A2-1 A3-4	153,233 333

Species	Plant part	Country of origin	Alkaloids isolated	No.	Reference
	se	Nigeria	Pachysiphine	P2-14	191
	l;sb	Ghana; Nigeria	Conopharyngine	I1-1	155,258;191,205
	l	Ghana	19-Hydroxyconopharyngine	I1-2	258
	l	Unknown	Conopharyngine hydroxyindolenine	I1-4	232
	r;sb	Kenya; Nigeria	Coronaridine	I1-5	334;205
	r	Kenya	3-Oxocoronaridine	I1-11	334
	se;sb	Nigeria	Voacangine	I1-34	191;205
	l	Ghana	Conopharyngine pseudoindoxyl	I2-1	258
	l	Unknown	Decarbomethoxy-15,20;16,17-tetrahydrosecodine	M1-1	213
	r	Principe Is.	20α-Aminopregn-5-en-3β-yl β-D-glucoside	M5-1	133
	r	Kenya	Conoduramine	B2-7	334
	r	Kenya	Conodurine	B2-9	334
	r	Kenya	3-Oxoconodurine	B2-10	334
	r	Kenya	3-(2'-Oxopropyl)-conodurine	B2-11	334
	r	Kenya	Gabunine	B2-13	334
T. pandacaqui	l	Philippines	Pericyclivine	C4-4	235
	l	Philippines	Tabernaemontanine	C5-7	235
	l	Philippines	(+)-20-*epi*-Lochneridine	S1-2	187
	b	Jamaica	Coronaridine	I1-5	167
	b	Philippines	Coronaridine	I1-5	154,157
	b	Jamaica	(−)-Ibogamine	I1-27	167
	b	Jamaica	Iboxygaine	I1-29	167
	b	Jamaica	Tabernanthine	I1-33	167
	b	Jamaica	Isovoacangine	I1-36	167
	b	Jamaica (?)	Voacristine	I1-43	204
	l	Philippines	Ervafoline	B4-3	235,349,397
	l	Philippines	Ervafolidine	B4-7	235,436
	l	Philippines	Isoervafolidine	B4-8	235,436
T. pedunculatis	l,r	Malaysia	Considered to contain alkaloids		138
T. penduliflora	sb	Nigeria	Conopharyngine	I1-1	205
	sb	Nigeria	Coronaridine	I1-5	205
	sb	Nigeria	Voacangine	I1-34	205
T. pentastieta	l	Indonesia	Contains an alkaloid		24,120
T. psorocarpa	sb	Ivory Coast	16-*epi*-Isositsirikine	C1-3	441
	sb	Ivory Coast	Tetrahydro-alstonine	C2-[illegible]	441
	sb	Ivory Coast	Vallesiachotamine	V1-1	441
	sb	Ivory Coast	Isovallesiachotamine	V1-2	441
	sb	Ivory Coast	12-Methoxy-14,15-dehydrovincamine	E1-9	441
	sb	Ivory Coast	Coronaridine	I1-5	441
	sb	Ivory Coast	Voacangine	I1-34	441
T. psychotrifolia	l	Guyana	16-*epi*-Isositsirikine	C1-3	418
	sb	Venezuela	Affinine	C5-3	239
	sb	Venezuela	Anhydrovobasindiol	C5-9	209,239
	l,rb	Guyana	Vobasine	C5-10	418
	sb	Venezuela	16-*epi*-Vobasinic acid	C5-11	239
	l,sb	Guyana	Pleiocarpamine	C10-1	418
	l	Guyana	(+)-Tubotaiwine	A3-3	418
	r;sb	Trinidad; Guyana	Coronaridine	I1-5	132;418
	l	Guyana	10-Hydroxycoronaridine	I1-8	418
	sb,rb	Guyana	Ibogaine	I1-23	418
	sb	Guyana	Ibogaine hydroxyindolenine	I1-24	418
	l,sb,rb;r	Guyana; Trinidad	Voacangine	I1-34	418;132
	sb	Guyana	3-Oxovoacangine	I1-37	418
	l,sb,rb	Guyana	Voacangine hydroxyindolenine	I1-41	418
	l	Guyana	Voacristine	I1-43	418
	l	Guyana	19-*epi*-Voacristine	I1-44	418
	l	Guyana	10-Hydroxyheyneanine	I1-49	418
	sb	Guyana	(6*R*)-3,6-Oxidovoacangine	I1-51	418
	sb	Guyana	Voacangine pseudoindoxyl	I2-6	418
	sb,rb;r	Guyana; Trinidad	Olivacine	M2-2	418;132
	l	Guyana	Angustine	M4-1	418
	rb	Guyana	Voacamidine	B2-23	418
	r	Trinidad	Voacamine	B2-24	132
	sb,rb	Guyana	Voacamine	B2-24	418
	sb,rb	Guyana	16-Decarbomethoxyvoacamine	B2-25	418
	sb,rb	Guyana	N_a-Demethylvoacamine	B2-28	418
T. pubescens	l	Australia	Alkaloid tests weakly positive		95
	se,l,b[a]	Moluccas	Alkaloid tests positive		112
T. quadrangularis[b]	r	Peru	Coronaridine	I1-5	378
	r	Peru	3-Oxocoronaridine	I1-11	378
	r	Peru	Coronaridine hydroxyindolenine	I1-17	378

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	r	Peru	(−)-Heyneanine	I1-20	378
	r	Peru	(−)-19-*epi*-Heyneanine	I1-21	378
	r	Peru	Ibogaine	I1-23	378
	r	Peru	(−)-Ibogamine	I1-27	378
	r	Peru	(19*R*)-19-Hydroxy-ibogamine	I1-28	378
	r	Peru	Voacangine	I1-34	378
	r	Peru	3-Oxovoacangine	I1-37	378
	r	Peru	Voacangine hydroxyindolenine	I1-41	378
	r	Peru	Coronaridine pseudoindoxyl	I2-2	378
	r	Peru	Ibogamine pseudoindoxyl	I2-4	378
	r	Peru	(19*R*)-19-Hydroxy-ibogamine pseudoindoxyl	I2-5	378
T. retusa	se	Madagascar	Voaphylline	P1-1	278
	se	Madagascar	Pachysiphine	P2-14	278
	se	Madagascar	Tabersonine	P2-16	278
	se;l,sb;rb	Madagascar	Coronaridine	I1-5	278;264;234
	rb	Madagascar	Coronaridine hydroxyindolenine	I1-17	234
	l,sb;rb	Madagascar	(−)-Heyneanine	I1-20	264;234
	rb	Madagascar	(+)-Ibogamine	I1-26	234
	rb	Madagascar	(−)-Ibogamine	I1-27	234
	se;l,sb	Madagascar	Voacangine	I1-34	278;264
	l	Madagascar	3-Oxovoacangine	I1-37	264
	l	Madagascar	Voacristine	I1-43	264
	l	Madagascar	3 Isomers of heyneanine	I1	264
T. riedelii	l,tw,st	Brazil	(+)-Minovincine	P2-12	210
	l,tw,st	Brazil	(+)-3-Oxominovincine	P2-13	210
	l,tw,st	Brazil	(+)-Vincadifformine	P2-19	210
	l,tw,st	Brazil	(−)-Vincadifformine	P2-20	210
T. rigida	sb	Brazil	(+)-Vincamine	E1-1	210
	sb	Brazil	(−)-Vincamine	E1-2	210
	sb	Brazil	(+)-Apovincamine	E1-3	210
	sb	Brazil	(+)-16-*epi*-vincamine	E1-4	210
	sb	Brazil	(−)-16-*epi*-vincamine	E1-5	210
	sb	Brazil	(+)-21-*epi*-vincamine	E1-6	210
	sb	Brazil	(−)-21-*epi*-vincamine	E1-7	210
T. rupicola	*l,tw*	*S. America*	Voacangine pseudoindoxyl	I2-6	190
	l,tw	*S. America*	Voacristine pseudoindoxyl	I2-7	190
T. sulzmannii	*fr,l,b*	Brazil	Unknown alkaloid from all 3 plant parts		94
T. sananho	b	Peru	Coronaridine	I1-5	338
	b	Peru	3-Hydroxycoronaridine	I1-7	338
	b	Peru	(−)-Heyneanine	I1-20	338
	b	Peru	(−)-Ibogamine	I1-27	338
	b	Peru	Voacangine	I1-34	338
T. sessilifolia	sb,rb	Madagascar	Dregamine	C5-5	291
	l,sb,rb	Madagascar	Tabernaemontanine	C5-7	291
	l,sb,rb	Madagascar	Apparicine	A2-1	291
	l,sb,rb	Madagascar	Coronaridine	I1-5	291
	l,sb,rb	Madagascar	6-Hydroxy-3-oxocoronaridine	I1-14	291
	l,sb,rb	Madagascar	(6*R*)-3,6-Oxidocoronaridine	I1-16	291
	l,sb,rb	Madagascar	Isovoacangine	I1-36	291
	l,sb,rb	Madagascar	6-Hydroxy-3-oxo-isovoacangine	I1-38	291
	l,sb,rb	Madagascar	(6*R*)-3,6-Oxido-isovoacangine	I1-40	291
T. siphilitica	l	Guyana	10 Unknown dimeric indole alkaloids	B	291
	l	Guyana	Geissoschizine	C1-1	310
	l	Guyana	Tetrahydro-alstonine	C2-4	331,415
	l	Guyana	Pleiocarpamine	C10-1	331,415
	l	Guyana	Apparicine	A2-1	331,415
	l	Guyana	(+)-Tubotaiwine	A3-3	331,415
	l	Guyana	Vincadifformine	P2-20	331,415
	l	Guyana	12-Hydroxyvincadifformine	P2-22	331,415
	l	Guyana	Coronaridine	I1-5	311
	l	Guyana	Voacangine	I1-34	311
	l	Guyana	Isovoacangine	I1-36	311
	l	Guyana	Tetrastachyne	B4-5	331,415
	l	Guyana	Tetrastachynine	B4-6	331,415
	l	Guyana	12,12'-Bis-(11-hydroxycoronaridinyl)	B5-1	311
	l	Guyana	Bonafousine	B6-1	309
	l	Guyana	Isobonafousine	B6-2	393
T. sphaerocarpa	l,st,sb	India	Dregamine	C5-5	212
	l,st,sb	India	Tabernaemontanine	C5-7	212
	se,r	Indonesia	Alkaloids present		17
T. stapfiana	b,st	Kenya	Pericyclivine	C4-4	354

TABLE 5 (*Continued*)

Species	Plant part	Country of origin	Alkaloids isolated	No.	References
	b,st	Kenya	Perivine	C5-6	354
	rb	Zaire	(+)-Tubotaiwine	A3-3	253
	rb	Zaire	Tubotaiwine N_4-oxide	A3-4	253
	b,st	Kenya	(−)-Ibogamine	I1-27	354
	b,st	Kenya	Isovoacangine	I1-36	354
	b,st	Kenya	Conoduramine	B2-7	354
	b,st	Kenya	19',20'-Epoxyconoduramine	B2-8	354
	b,st	Kenya	Conodurine	B2-9	354
	b,st	Kenya	Gabunamine	B2-12	354
	b,st	Kenya	Gabunine	B2-13	354
	sb	Kenya	Tabernamine	B2-22	316
			Suitable for extracting conopharyngine	I1-1	145
T. stellata	rb	Madagascar	Coronaridine	I1-5	234
T. undulata	sb	Guyana	Quebrachidine	C6-1	365
	se;sb	Guyana	Voaphylline	P1-1	248;365
	se;sb	Guyana	Coronaridine	I1-5	248;365
	sb	Guyana	(−)-19-*epi*-Heyneanine	I1-21	365
	sb	Guyana	Voacangine	I1-34	365
	se	Guyana	Unknown base ($M^{+\cdot}$ 382)		248
T. ventricosa			Suitable for extracting conopharyngine	I1-1	145
T. wallichiana	l,sb	India	Coronaridine	I1-5	323
	l,sb	India	Voacangine	I1-34	323
	l	India	Isovoacangine	I1-36	323
	l,sb	India	Voacristine	I1-43	323
Pandacastrum saccharatum[c]	l	Madagascar	Pandicine	B8-1	424

[a] The botanical identity of the plant material investigated is uncertain.
[b] This name is not found in the botanical literature.
[c] The required nomenclatural combination in *Tabernaemontana*, or identification with an accepted *Tabernaemontana* species, has not yet been made.

material, and the appropriate literature references. The abbreviations used for the parts of the plants are explained in § 4.3.

4.5. Biogenesis and chemotaxonomy of the indole alkaloids present in the genus Tabernaemontana

4.5.1. Biogenesis

Except for the primary precursor strictosidine, all the important intermediates shown in Scheme 1a–d have been found in at least one *Tabernaemontana* species in one form or another. Geissoschizine is present in one species, (+)-stemmadenine in two species, and decarbomethoxy-15,20; 16,17-tetrahydrosecodine, which may be derived from the intermediate 3,4-dehydrosecodine, in one species. Because these compounds are simply intermediates and readily converted to more evolved but less reactive structures, their concentration is usually low and this makes them difficult to isolate. In contrast, other intermediates, such as vobasine and coronaridine, are much more stable; they have been isolated from 17 and 39 species, respectively, and they probably occur more commonly in the genus *Tabernaemontana* than in any other alkaloid-containing genus of the Apocynaceae.

The co-occurrence of certain groups of alkaloids provides support for the biogenetic pathways presented in Scheme 1a–d (Table 6). Class A alkaloids have been isolated from 21 species; in 18 of them class C alkaloids and in 20 of them class I alkaloids are present as well. In none of the species do class A alkaloids occur alone. This is consistent with the alkaloids of this class having a position intermediate between those of the C and I classes, as shown in Scheme 1c. In nine of the 12 cases where alkaloids of the group C4 have been isolated, alkaloids of the group C5 have also been found, which points to a relationship between these two groups. Bases of the groups C8/C9 have been obtained from five species and in four of them they co-occur with bases of the much more common groups C4/C5; this suggests that the C8/C9 bases may be formed from the C4/C5 bases. Alkaloids of the group I2, assuming they are not artefacts, are probably derived from those of the group I1, since in over 90% of the species from which the group I2 alkaloids have been obtained, group I1 alkaloids also occur. In half the species containing alkaloids of the group B2 they are present together with alkaloids of the groups C4/C5 and I1; in only one case do group B2 alkaloids occur without the simultaneous presence of alkaloids of one of these two types.

4.5.1.1. Artefacts: Whether hydroxyindolenine, pseudoindoxyl, and oxindole iboga type alkaloids really are naturally occurring compounds or not is still doubtful. These compounds are easily formed by aerial oxidation in, for example, chloroform [201].

The 2'-oxopropyl derivatives of coronaridine and conodurine are almost

TABLE 6

CO-OCCURRENCE OF CERTAIN GROUPS OF ALKALOIDS

Alkaloid group or class	No. of species in which the group occurs	Alkaloid group or class	No. of species in which the group occurs	No. of species in which the groups co-occur	% Co-occurrence	Expected % of co-occurrence
C	36	A	21	18	86	54[a]
I	58	A	21	20	95	87
C5	27	C4	12	9	75	40
C4/C5	31	C8/C9	5	4	80	46
I1	52	I2	12	11	92	78
C4/C5 + I1	22	B2	20	10	50	33

[a] Calculated as follows: So far, 67 *Tabernaemontana* species have been examined for their alkaloids. Class C alkaloids occur in 36 of them, i.e. 54%. If there is no connection between class C and class A alkaloids, it would be reasonable to expect that class C alkaloids would occur in the same proportion, i.e. 54%, of the species carrying class A alkaloids, i.e. 11 species. In fact, class C alkaloids occur in 18 of the 21 species, i.e. 86%, in which class A alkaloids are present. It is likely, therefore, that there is a connection between the two classes of alkaloids.
The subsequent examples are calculated similarly.

certainly artefacts, formed by reaction between acetone and the (reactive) hydroxyl group at C-3 [284]. *N*-Oxides and 3-hydroxyl derivatives may be formed when certain types of alkaloids are left for a period of time in contact with chloroform or dichloromethane [252].

4.5.2. Chemotaxonomy

4.5.2.1. Chemical characterisation of the genus Tabernaemontana: Although there is no uniform pattern by which each species can be identified with certainty as belonging to the genus *Tabernaemontana*, the information given in Tables 7 and 8 provides a good over-all view of the genus. Table 7 shows the number of different alkaloids found in each subgroup and pinpoints the more evolved groups of species. The data afford no indication of the number of species from which any given compound has been isolated. This aspect is covered in Table 8, which lists individual alkaloids that have been obtained from five or more *Tabernaemontana* species; the table thus also indicates the most frequently occurring alkaloid groups in the genus.

Alkaloids of the group I1 have been found in 52 of the 67 chemically investigated *Tabernaemontana* species. Although representatives of this group have been isolated from other genera, e.g. *Voacanga*, *Tabernanthe* and *Stemmadenia*, the presence of simple iboga bases is fairly characteristic of the genus *Tabernaemontana* because they occur in most species. Alkaloids of the groups C4 and C5 are less characteristic, not only because they are less often present (in less than half the species examined) but also because they turn up in many other genera of the Apocynaceae. Highly characteristic of *Tabernaemontana*, since they have so far been obtained almost exclusively from species of this genus, are alkaloids of groups C8 (5 species), C9 (1 species), I4 (8 species), I5 (4 species), I6 (3 species), and T1 (1 species).

4.5.2.2. Chemotaxonomy in taxonomic revisions: Table 9 displays the results of chemical studies relating to *T. coffeoides*. The findings are set out under the plant names used when the work was originally published. The first column indicates the different plant parts studied. The 12 taxa listed are considered by one of the present authors (A.J.M.L.) all to be synonyms of *T. coffeoides*. For clarity, only the code numbers of the different alkaloids are given.

It is evident that none of the taxa has the same alkaloid composition, although they all represent one and the same species. The differences found may be due to a number of factors: the existence of chemical races, variation within the species, soil, climate, the time of collection of the plant material, and the methods used during the isolation and identification of the alkaloids. Nevertheless, in the composition of the root and stem-bark alkaloid mixtures some similarities can be discerned, viz. the presence in both of the alkaloids C5-5, C5-7, C5-10, C8-4, C8-7, I1-27, and M2-1, as well as of a number of minor compounds. All this does not prove that the material investigated originated from the same species, but it does provide some evidence, at least, in support of the botanical revision.

TABLE 7

NUMBER OF DIFFERENT ALKALOIDS FOUND IN EACH TYPE

Alkaloid group	No. of alkaloids	Alkaloid group	No. of alkaloids	Alkaloid group	No. of alkaloids	Alkaloid group	No. of alkaloids
C1	4	V1	2	I1	52	B1	2
C2	4	S1	3	I2	8	B2	37
C3	1	A1	1	I3	3	B3	1
C4	7	A2	3	I4	12	B4	10
C5	12	A3	4	I5	1	B5	1
C6	5	P1	3	I6	8	B6	2
C7	3	P2	22	T1	1	B7	1
C8	10	E1	9	M1	1	B8	1
C9	1			M2	3		
C10	2			M3	2		
				M4	1		
				M5	1		

TABLE 8

INDIVIDUAL ALKALOIDS OCCURRING IN FIVE OR MORE *TABERNAEMONTANA* SPECIES

Alkaloid	No. of species from which isolated	Alkaloid	No. of species from which isolated	Alkaloid	No. of species from which isolated	Alkaloid	No. of species from which isolated
C4-2	6	A3-3	11	I1-20	13	I1-43	16
C4-4	5	P1-1	8	I1-21	6	I1-44	5
C5-5	9	P2-16	9	I1-23	10	I2-6	7
C5-6	7	I1-1	9	I1-27	15	B2-24	12
C5-7	8	I1-5	39	I1-34	35	B2-25	6
C5-10	17	I1-11	6	I1-36	15		
A2-1	14	I1-17	7	I1-41	9		

TABLE 9

ALKALOID COMPOSITION OF *TABERNAEMONTANA COFFEOIDES*

H. coffeoides [329]	*H. costata* [329]* [430]**	*H. membranacea* [329]	*H. membranacea fa pilifera* [329]	*H. modesta* [242]* [361]**	*H. modesta* var. *methuenii* subvar.	
					methuenii [329]* [430]**	*velutina* [217]
Leaves						
C5-7	*C5-7 C8-7 A1-1	S1-3	S1-3 $M^{+\cdot}$ 366	—	*C4-3 C5-5 C5-7 C5-10 C8-4 C8-7 I1-36 $M^{+\cdot}$ 382	C5-5 C5-7 C5-8 C5-10 P2-9 P2-10
Stem bark						
C5-5 C5-7 C5-10 C8-4 C8-7 I1-27	*C5-5 C5-7 C5-10 C8-4 C8-7 I1-27 *,**B2-36	C5-5 C5-7 C5-10 C8-4 C8-7	C2-1 C2-2 C5-10 C6-2 C6-3 C6-4 C6-5 C8-4 C8-7 II-27 M2-1	—	*C5-5 *C5-7 C5-10 C8-4 C8-6 C8-7 I1-27	C5-5 C5-7 C5-8 C5-10
Root bark						
C5-5 C5-7 C5-10 C8-4 C8-7 I1-27	*C5-5 C5-7 C8-4 C8-7 I1-27 I1-36 *,**B2-14	C5-5 C5-7 C5-10 C8-4 C8-7	—	*C5-5 C5-7 I1-27 **C8-7 C8-9 I1-5 I1-21 I1-34 B2-14	*C5-5 C5-7 C5-10 C8-7 C8-8 I1-27 **B2-32	—

H. modesta var. *modesta* subvar.				*H. silicola*
modesta [329]	*divaricata* [367]	*brevituba* [367]	*montana* [389]	[329]
C4-3 C5-7 C5-10 C8-4 C8-7 I1-36	C4-5 C5-10 P1-1 I1-20 I1-21 $M^{+\cdot}$ 378 5 Dimers	C4-2 C5-8 P2-17	C4-4 C5-5 C5-7 C5-10 C8-4 C8-7 A2-1 A2-2 P2-2 P2-11 P2-16 P2-18 P2-21	$M^{+\cdot}$ 382
C4-3 C5-5 C5-7 C5-10 C8-4 C8-7 I1-36	C5-5 C5-7 C8-4 C8-5 C8-7 C8-9 A2-1 I1-27 M2-1	C5-5 C5-7 C5-10 C8-4 C8-5 C8-7 C8-9 I1-27 M2-1	C5-5 C5-7 C8-4 C8-7 C8-9 C8-10 A2-1 I1-27 M2-1	C5-5 C5-7 C5-10 C8-4 C8-7
C5-5 C5-7 C5-10 C8-4 C8-7 I1-27 I1-36 $M^{+\cdot}$ 366	C5-5 C5-7 C8-4 C8-5 C8-7 C8-9 A2-1 I1-27 M2-1	C5-5 C5-7 C5-10 C8-4 C8-5 C8-7 C8-9 I1-27 M2-1	C5-5 C5-7 C8-4 C8-7 C8-9 C8-10 A2-1 I1-27 M2-1	C5-5 C5-7 C5-10 C8-4 C8-5 C8-7 C8-9 I1-27 M2-1 $M^{+\cdot}$ 312

4.5.2.3. Distribution of alkaloid types in Tabernaemontana species from different geographical areas: Table 10 summarizes the occurrence in *Tabernaemontana* species from different regions of the world of the 10 main classes of indole alkaloids found in the genus. In order to enable this to be done, the distribution range of the genus has been divided into four areas, each represented by a number: (1) North, Central, and South America; (2) Africa, including Madagascar and Mauritius; (3) Continental Asia; (4) Malaysia (Indonesia, Borneo, Philippines, New Guinea), Australia and the Pacific.

No conclusions can be drawn regarding the vallesiachotaman, strychnan, eburnan, tacaman and miscellaneous classes. The plumeran and ibogan classes are distributed uniformly over the different areas, while the corynanthean, aspidospermatan and bis-indole classes appear to occur somewhat more frequently in Africa.

5. Non-alkaloidal constituents of the genus *Tabernaemontana*

Although most of the phytochemical work on the genus *Tabernaemontana* has been concerned with the alkaloidal constituents and most of the ethnomedicinal uses are probably related to the pharmacological activity of these substances, some non-alkaloidal constituents, mostly triterpenes, have also been isolated. Table 11 lists the species and plant parts from which these constituents have been obtained, together with the literature references. Again, it is to be noted that there is no guarantee as to the correctness of the botanical identification of most of the plant materials examined. Where possible, however, the identity of any documenting herbarium specimens has been checked by one of the authors (A.J.M.L.).

Evidently, the occurrence of the two amyrins and lupeol, and their acetates, as well as other triterpenes, is common in *Tabernaemontana* species. Other compounds found which have some pharmacological interest are: salicylic acid, benzoic acid, various flavonoids, a bacteriolytic enzyme, and two cardiac glycosides (?). The presence of a large amount of sweroside, a secoiridoid closely related to secologanin (see § 3.1), in the alkaloid-free leaves of *T. psorocarpa* may well be of biogenetic significance. At the same time, this occurrence poses the question of what other roles seco-iridoids may play besides taking part in the biogenesis of indole alkaloids.

6. Ethnobotany of *Tabernaemontana* species

This section outlines the ethnobotany of the genus *Tabernaemontana*. The data have been compiled from many different sources — ethnobotanical books, journals and scientific papers — dating from the late 17th century (Van Rheede tot Drakestein, *Flora Malabarica)* up to the present day, but no attempt has been made to present an exhaustive account. Annotations attached to sheets in the herbaria at Leiden, Kew and the Department of

TABLE 10

DISTRIBUTION OF ALKALOID TYPES IN *TABERNAEMONTANA* SPECIES FROM DIFFERENT GEOGRAPHICAL AREAS

Geographical area	No. of species investigated	No. of species from which alkaloids of the indicated classes have been isolated									
		C	V	S	A	P	E	I	T	M	B
1	31	11	—	—	7	11	1	27	—	5	10
2	27	18	1	2	10	7	2	22	1	2	15
3	6	4	—	—	2	2	—	5	—	1	2
4	6	4	—	1	2	1	—	6	—	1	3

TABLE 11

NON-ALKALOIDAL CONSTITUENTS OF THE GENUS *TABERNAEMONTANA*

Plant species	Plant part	Constituent	References
T. affinis	rb	β-Amyrin	304
	rb	Lupeol and its acetate	304
	rb	Sitosterol	304
T. arborea	fr	Lupeol acetate	390
T. aurantiaca	fr,b	β-Amyrin	171
	fr,la	β-Amyrin aliphatic esters	101
	fr,la	Lupeol and its acetate and other aliphatic esters	101
	b	Sitosterol	171
T. brachyantha	sb	α-Amyrin acetate (?)	263
T. crassa	sb,r	α-Amyrin, β-amyrin, and lupeol acetates	143,160
	sb,r	Clionasterol	160
T. crispa	rb	Compound $C_{12}H_{20}O$	94
T. dichotoma	sb,rb	Compound $C_{30}H_{50}O$	98
T. divaricata	tw,la	Unidentified amino acids	192
	tw,la	Milk-clotting and proteolytic enzymes	192
	la	2 Proteins	149,177
	la	Bacteriolytic enzyme	149
	tw,la	Galactose and glucose	192
	fl;l (?)	Kaempferol	124;347
	l (?)	Salicylic, *p*-hydroxybenzoic, protocatechuic, vanillic and syringic acids	347
	l (?)	Sinapic acid	347
	l (?)	Quercetin	347
	l;sb;rb	α-Amyrin and lupeol and their acetates	268,302;117;408
	l;sb;rb	β-Sitosterol	268,302;117;408
	r	D-Mannitol	165
	rb	Benzoic acid	408
	rb	Aurantiamide acetate	408
	rb	Cycloartenol	408
	rb	Sterol and sterol glucoside	80
	rb	Campesterol	408
	rb	Palmitic, oleic and linoleic acids	80
T. heyneana	fr	α-Amyrin	106
	fr	β-Amyrin acetate	241
	sb,sw	β-Amyrin and its acetate	396
	b	Lupeol	103
	fr	Lupeol acetate	241
	sb,sw	Ursolic acid	396
	fr;b	2 Triterpenes	106;103
	fr	2 Cardiac glycosides (?)	107
T. killipii	sb	Lupeol acetate	300
T. longipes	se	Palmitic, stearic, oleic and linoleic acids	368
	fr	Bauerenol acetate	414
	fr	Cycloeucalenol	414
	fr	Multiflorenol acetate and palmitate	414
	fr	Campesterol, β-sitosterol and stigmasterol	414
T. orientalis	l,st,b,r	β-Amyrin and lupeol and their acetates	227
	b,la	Lupeol acetate	101
	l	Ursolic acid	227
	l	Aliphatic hydrocarbons ($C_{26}H_{54}$ to $C_{33}H_{68}$)	227
	l,st,b,r	β-Sitosterol	227
T. pachysiphon	se	Linoleic, myristic, oleic, palmitic and stearic acids	413
	la	Lupeol acetate	101
T. pacifica	st,b,r	α-Amyrenone	226
	st,b,r	α- and β-amyrin and lupeol and their acetates	226
	st,b,r	Cycloartenone	226
	st,b,r	Lupenone	226
	st,b,r	φ-Taraxasterol and its acetate	226
	st,b,r	β-Sitosterol	226
	st,b,r	Palmitic, heptadecanoic, stearic, nonadecanoic, arachidic and oleic acids	226
	b	Aliphatic hydrocarbons ($C_{25}H_{52}$ to $C_{33}H_{68}$)	226
T. peduliflora	se	Myristic, palmitic, stearic, oleic and linoleic acids	413
T. psorocarpa	l,sb,sw	Sweroside	433
T. sphaerocarpa	la	α- and β-amyrin and lupeol acetates	36,101
	la	Triterpene long-chain fatty-acid esters	101
T. wallichiana	l,sb	Bauerenol acetate	207
	l	β-Sitosterol	207
	l	*n*-Nonacosane, *n*-hentriacontane, *n*-tritriacontane	207

Botany, British Museum (Natural History) have also been included. The information relating to the individual species is presented under the currently accepted botanical name, and the synonyms are to be found in the list given in § 2.5. It must again be stressed that there is no guarantee as to the correctness of the identity of the plants whose use is mentioned. For each species, the uses encountered, medicinal or other, are given, together with references. In addition, the country or area of origin and remarks about the toxicity, if any, are presented. More recent literature that only repeats information found in earlier references is not cited. The section ends with a general discussion and summary of the purposes for which the different *Tabernaemontana* species are used.

6.1. *Ethnobotany of the individual species*

T. acapulcensis

Mexico: The sap, like that of *T. amygdalifolia* (q.v.), is used to treat wounds [420].

T. affinis

Brazil: The leaves have been proved experimentally to be poisonous to cattle [188]. The wood is used for planks and as firewood [47]. The plant is cultivated as an ornamental [28].

T. alba

Mexico: Occasionally, latex is applied to warts to destroy them [44, cf. 420].

Brazil: The leaves of this aromatic plant have febrifugal and purgative properties, and they are sometimes used in baths. Its bark is used as a tonic and febrifuge [47]. The plant is also used as an anthelmintic, especially against *Taenia* [81].

T. amygdalifolia

Mexico: Although the plant is suspected to contain some active principle, it is not considered toxic. The latex or resin produced in the autumn is a purgative — a few drops are poured into hot sugared water and drunk; the effect is quick but is sometimes accompanied by vomiting. Blepharitis granulosa is treated by carefully touching the affected parts with the resin [125].

Colombia: Here the plant is considered to be very toxic. The latex is used for healing warts and the leaves as a cataplasm for treating tumors and healing serious wounds [285].

Puerto Rico and Central America: The latex of this very toxic plant is used against warts and a decoction of the bark against fevers and syphilis; it is used externally with success against ulcers [21].

T. arcuata

Peru: The Lamista Indians take small glasses of a macerate of the bark and roots in brandy over a period of 15 days in order to cure rheumatism [236].

T. aurantiaca

Bougainville Island: Sap of the plant is added to coconut oil and rubbed on the skin to make it blister [54].

T. australis

Paraguay: The latex is used for healing warts [35].

T. borbonica

Réunion: The plant [26] and its latex [87] are considered to be poisonous. The wood is used for domestic purposes, such as making trunks [12, 21].

T. bovina

South Vietnam: The roots are a source of rubber [127]. The sticky latex is applied externally to soften the skin [10].

T. brachyantha

Southern Nigeria: The bark is used to make cloth.

Cameroon: Twigs are crushed and mixed with "fever leaf" (*Ocimum*) for use as a vermifuge [75].

T. bufalina

Indo-China: The plant is used for its emollient and laxative properties. Latex from the fruit is used especially for the gentle extraction of sharp points or thorns from the flesh [3].

Vietnam: The mild, sticky latex is applied externally to soften the skin [10]. The very bitter roots are used to cure stomach disorders [68,97].

China, Guangxi: the roots are applied in the treatment of dislocations [343]; Guangdong (Hainan): Chewing the roots cures a sore throat and applying the boiled crushed leaves heals boils [266]. It is used against rheumatoid arthritis and is applied to boils and swellings, sprains and bruises [343].

T. callosa

Madagascar: The latex is poisonous and is a strong purgative [79].

T. catharinensis

Brazil: The wood is used as firewood and for making planks [47].

T. cerifera

New Caledonia: The wax covering the buds is readily collected for use by melting it with hot water [21,265]. The macerate of the bark is a drastic purgative [265].

T. chippii

Liberia, Ghana: The latex was formerly permitted as an ingredient in paste rubber [75,137].

T. citrifolia

Mexico: The resin is used to remove warts [420].

Antilles: The leaves are used in baths as a febrifuge and also to make a wash for wounds, while the bitter bark is used as a tonic, febrifuge, and anthelmintic. The latex stops the bleeding of wounds [7]. The plant has been employed as a remedy for fevers [44]. The acrid latex from the twigs allays the pain in an aching tooth [115].

Martinique, Guadeloupe: The leaves are used in baths as a febrifuge and a purgative. The bark of this aromatic plant is considered to be a tonic and febrifuge [12].

Cuba: The leaves are believed to be febrifugal and purgative. The bark is a tonic and febrifuge, used in baths or externally. Latex when used in baths is a febrifuge and when applied topically heals warts and stops bleeding [15]. The caustic latex is used against herpes, warts and as a hemostatic [85].

T. coffeoides

Comores: The leaves and fruits are used to coagulate the rubber of other plants [320].

Seychelles: Spoons are made out of the wood [31].

Madagascar: A decoction of the stem bark is given to nursing mothers to strengthen them. Roasted and powdered roots are applied to suppurating and festering wounds [240]. The very bitter leaves and bark are popular remedies against fatigue and stomach cramps; they are also used to suppress hunger [217]. An infusion of the leaves is taken in order to lose weight and the fresh bitter bark when chewed helps to suppress hunger [320].

T. corymbosa

Thailand: The bark and roots are utilised in making arrow poison [119].

Malaysia: The latex is used to treat tertiary syphilitic ulceration [67]. The sap from the leaves is used against sores [51]. A decoction of the bark is highly praised in the treatment of tertiary syphilis, while the pounded roots are used against hydrocele and orchitis [25]. An infusion of the inner bark or root is drawn into the nostrils in treating ulceration due to syphilis, and a poultice of the leaves may also be applied [53]. During and after confinement the roots are used. The plant is pounded and a poultice made for use in orchitis. It may have been the bark and roots of this species which entered into the composition of the dart poison made by the Mantra (Temuan or Belanda) of Malacca [67].

T. crassa

Sierra Leone: After scraping the surface of the lesion, the latex is applied in cases of ringworm. The latex, useless by itself, is used to coagulate good rubber (also in Liberia, Ivory Coast, Ghana, and southern Nigeria), although at one time it was thought to be the source of West African rubber [75].

Liberia: The wood is used for making boxes, etc. [75].

Ivory Coast: The Ebrié give a decoction of the leaves to mentally retarded children and tired adults as a tonic. The bitter latex is applied as a wound disinfectant and a few drops in the nose helps against violent headaches. It is also very caustic and one drop in the eye causes blindness. The Attié say that the effect of this plant is similar to that of *Strophanthus* [74]. The Shien use the latex against leprosy. The plant is also an arrow poison ingredient in the Daola region [90]. The latex is applied to wounds as a styptic and the juice of the bark is instilled into the nose to relieve violent headaches. It is also used by medicine-men to calm the insane. A decoction of the bark applied as an enema relieves pains in the back and rheumatism and is also indicated in cases of constipation [270].

Central African Republic and Congo: A paste of the fruit is applied topically in treating contusions and sprained backs. Latex from the bark and fruit is used against coryza and to heal wounds. A decoction of the roots and bark is drawn into the nose to treat coryza and sinusitis [179].

Gabon: The flowers are ornamental, and leaves are used for thatching because their bitter taste keeps cockroaches away [140].

Zaïre: Leprous wounds, after being rubbed with the leaves of *Ficus exasperata* and having long incisions made in them with a sugarcane leaf, are treated with latex from the fruit [185]. The bark, together with *Aframomum* fruit, is used against intestinal worms. A decoction of the bark is drunk against stomach disorders [77]. A potion prepared by mixing pieces of root in water with *Aframomum* fruits and straining is drunk against blenorrhea or diarrhea [185].

Réunion: The latex is used for healing wounds and for treating abscesses, boils and carbuncles. A decoction of the bark is employed as a laxative, for ovarian conditions, hematuria and blenorrhagia. Given orally, the plant is believed to have an anthelmintic action [364].

T. crispa

India: An infusion of the bark or root is stated to be used against dysentery and as an astringent [21]. The yellow, bitter root contains much latex

and has a burning taste; it is used against diarrhea, dysentery and externally against abscesses [7].

T. cylindrocarpa

Malaysia: The leaves are pounded with turmeric and rice as a poultice for skin conditions such as itch and eczema; the leaves are also used against beri-beri [52]. A poultice of the root mixed with other plants is rubbed over the whole body as a treatment for the nodular gummata met with in late syphilis and a steam-bath with the leaves is used for the same purpose [53].

T. cymosa

Colombia: The plant is said to have cardiotonic properties [437].

T. dichotoma

India: It is noted [16] that the vernacular names and uses of the plant are similar to those of *T. divaricata* (q.v.) [16]. The fruit, known in English as "Eve's apple" or "forbidden fruit", is edible according to some [23], but others say that although it looks nice and tastes good it is a deadly poison [21,169]. The seeds are a powerful narcotic and poisonous and give rise to delirium and other symptoms like those caused by *Datura* [20,71]. In addition, the seeds act as a purgative, this being a property shared by the latex, leaves and bark. All parts of the plant are included in remedies for snake bite, while the bark and roots are used in combination with other drugs for treating scorpion stings. However, experimental evidence indicates that the plant is not an effective antidote against either [71].

Sri Lanka: The fruits, as well as a preparation made by boiling the leaves, bark and stems with other ingredients in oil, are used in the treatment of ulcers and fistulae [57]. Latex from the leaves and stems is said to be poisonous, but at the same time is applied to wounds [57, cf. 37]. The tender leaves and latex are much used by 'boil doctors' to soften and ripen boils and carbuncles [37]. The pounded leaves and bark are applied externally to the bites of snakes and centipedes. A preparation of the bark is placed on abraded skin as an antiseptic and astringent [57]. Chewing the roots is said to relieve toothache. The plant is used as a cooling application in cases of eye affections; the plant part used is not indicated [37].

T. dinhensis

South Vietnam: An infusion of the roots is prescribed for indigestion and colic [97].

T. disticha

French Guiana and Brazil: The bark is a febrifuge and the latex can be used a kind of milk [21].

T. divaricata

Western India: The latex has the reputation of being very cooling and is applied to wounds to prevent inflammation [16].

Southern India: The juice expressed from the plant is mixed with oil and applied to the head in order to soothe pains in the eyes. Chewing the root relieves tooth-ache. Decocted with oil and applied to the head it relieves all indispositions, especially pains, of the head. Again, the root rubbed up with water and drunk kills intestinal worms and rubbed up with lemon juice it removes opacities from the eyes [1]. An infusion of the root is believed to have febrifugal properties. An infusion of the bark and root is used against dysentery [6]. The flowers are used to treat inflammation of the cornea [16].

India: The plant is a constituent of various medicines for the treatment of eye conditions. Applied as a face plaster, it is a remedy against poisons. In clarified butter and boiled in water together with other ingredients it cures coughs, asthma, catarrh, fevers, mania, ulceration, morbid secretion of urine, leprosy, hiccough, vomiting, swellings, suppression of urine, disorders of semen and womb. It predisposes women to pregnancy. It destroys poisons. The plant is used in the treatment of the spleen, piles and abdominal tumours. In a medicated oil as a clyster, enema, liniment or in the ear, it is also administered for most of the conditions just listed; in addition, it is given for diarrhea, heat in the head, epilepsy and emprosthotonos. In oil together with other constituents is relieves diseases and gives strength in a beneficial and excellent liniment. It promotes the growth of hair, conception and ensures long life. Given as a poultice with other ingredients, it relieves headache. It is also a constituent of a remedy to cure leprosy or pityriasis. It is a constituent of an oil said to be a remedy for every disease. The drug is administered as an errhine, draught, liniment, enema or linctus [19]. The juice from the flowers is dropped into the eyes in cases of ophthalmia; it is supposed to be of a very cooling nature [4], but at the same time it is said to be very toxic [21]. The aril gives a red color which is occasionally used as a dye by the hill people. The wood is employed medicinally as a refrigerant and also in incense and perfumery [20]. The root has a bitter taste and is used as an emmenagogue, aphrodisiac, tonic and purgative. It acts as a tonic for the brain, liver and spleen; it removes bad humors and is useful in paralysis, weakness of the limbs and in strangury; it lessens pains in the limbs and joints and cures scorpion stings and epilepsy. Charcoal made from it is good in ophthalmia and the oil is good for epilepsy (Yunani). The root is acrid, bitter and heating, astringent to the bowels, alexipharmic, digestible, useful in "kapha", biliousness and diseases of the blood (Ayurveda) [71].

Pakistan: The plant is cultivated as an ornamental throughout the Punjab. The bark, leaves and flowers are popular household remedies, the flowers especially being valued by Yunani practitioners for their analgesic properties [89].

Sri Lanka: The latex is said to be cooling and is applied to sore eyes. It is also a remedy for toothache. The plant is commonly cultivated and its uses are similar to those of *T. dichotoma* [37].

Burma: The root is an emmenagogue and a tonic [152]. An unspecified part of the plant is used in making cakes of yeast for brewing rice beer [330].

Vietnam: The roots are used against jungle fever [97].

China: The juice of the leaves is antihypertensive and diuretic, and it clears edema; it is also used for treating eye conditions, boils, ulcers and other sores, as well as rabies, headache, fractures, etc. [343].

Malaysia: The root is applied against lumbago, urinary stones and poisoning [2]. The leaves are pounded with sugar candy and water to give a drink for curing coughs, and the ground roots are used to treat eye conditions [25]. The leaves are used against convulsions. For ulceration of the nose, the pounded roots are mixed with the roots of another (unidentified) *Tabernaemontana* species, the roots and leaves of *Sauropus albicans* and the young leaves of *Ficus hispida*; the mixture is then sniffed into the nostrils [52].

Indonesia: Throughout the country the plant is cultivated for its white, sweet-scented flowers [8,51]. The leaves, bark and twigs may form the main components of an arrow poison used on the Mentawei Islands; the roots are a local medicine [33,39,50]. Water in which the flowers have been soaked is sprinkled on smallpox patients [50]. The dried root is used as a powder or as a decoction against stomach troubles [29]. The sap and flowers are said to be poisonous [29, cf. 26].

T. eglandulosa

Zaire: The root is used against snake bites [185].

T. elegans

Malawi: The wood is used to make bows and arrows [113].

Zimbabwe, Mozambique: The fruit is eaten [113,147]. The Tonga use the latex as a styptic and the root as a remedy for pulmonary diseases [113,147,326].

Southern Africa: The fruit pulp, which is bright orange and slimy with a pleasant flavor, is highly esteemed by the local population and is also eaten by monkeys, baboons, rhinoceroses and various birds [251,339]. Zulus put the fruit into milk they wish to curdle in order to speed up the process. The seeds are burnt, ground and mixed with tobacco for chewing and smoking. The milky latex is sometimes used as a birdlime or as a glue for arrowheads [251]. The coagulated latex is rubber-like but of inferior quality; it is used as a styptic. The root is a remedy for pulmonary diseases [339].

T. fuchsiifolia

Brazil: The wood is used for planks and firewood [47].

T. cf. *gentilii*

Zaire: The plant is used as a fish poison [72].

T. harmandiana

Thailand: For an internal abscess the roots, leaves and fruit are made into a poultice and they are also taken internally [46].

T. heterophylla

Brazil (Amazonas): The leaves of this vine are believed to be a valuable component of a tea for "old people who are slow and forgetful".

Peru: The species has many medicinal uses in the Amazonian region [375].

T. heyneana

India: According to the *Pharmacographia Indica* [16] and *Indian Medicinal Plants* [71], the uses of this species are the same as for *T. divaricata* (q.v.). It has been noted additionally that in southern peninsular India a decoction of the leaves is used to cure sores on the teats of cows and that the bark is used against fevers [330].

T. hilariana

Brazil: The leaves are poisonous, although they can be eaten by horses [32]. The wood is used for planks and firewood [47].

T. hirta

Malaysia: The plant is used for ulceration of the nose. This species may have been a constituent of the dart poison prepared by the Mantra (probably Temuan or Belanda) of Malacca [67].

T. hystrix

Brazil, Paraguay, Argentina: The leaves are used against poisonous bites and the bark is used as a bitter [21].

Paraguay: This plant and related species are used externally against a slipped disk [23].

T. killipii

South America: Medicinal [300].

T. laeta

Brazil (Rio de Janeiro, Espirito Santo, Minas): An infusion of the leaves taken orally or the latex applied topically is used to treat skin disorders [28]. The bark has febrifugal properties and is also used for healing wounds [47]. The wood is white and easily worked; spoons and other tools are made from it. The bitter root is taken in small doses as a tonic, but in larger doses it is toxic [28].

T. longiflora

Senegal, Sierra Leone, Liberia: The plant is cultivated for its strongly

scented white flowers and it has been introduced into other countries [75].

Cameroon: The leaves are used against elephantiasis as follows: the leg is beaten until it bleeds, then it is put in hot sand until it hurts, next it is put in cold water to cool it, and finally the leg is wrapped with fresh leaves of the plant. This is repeated three times a day until the leg is healed. The roots are macerated in water and a few drops of the liquid are put into the nostrils against headache [136].

T. longipes

Belize: The plant is used as a source of rubber and also as a cure for beef worm [266].

T. luensis

Thailand: There are said to be two varieties, both considered to be highly medicinal [48].

T. macrocarpa

Eastern Malaysia, Sabah: The fruit is medicinal [266]; it is used to relieve the pain of toothache [82].

Indonesia: The abundant sticky latex serves as birdlime [51], while the fine, whitish, very soft wood is used for making kris scabbards [50,51].

T. malaccensis

Malaysia: The leaves and sap or the pounded roots are applied as a poultice for boils. A decoction of the bark is used like that of *T. corymbosa* (q.v.) for the treatment of syphilis [25]. The juice is administered or the plant may be boiled and the steam inhaled for ulceration of the nose resulting from tertiary syphilis. A decoction of root shavings has been included in the (*ipoh*) dart poison prepared by the Mantra (Temuan or Belanda) of Malacca [67, cf. 25]. The plant is considered to be poisonous and is not eaten by cattle [121].

T. markgrafiana

Brazil: The leaves are used in febrifugal baths. The bark is mixed with water and applied to wounds as a disinfectant and to aid healing [257].

T. mauritiana

Mauritius, Réunion: The very toxic latex is used as an anthelmintic and a fish poison [12,21,26,87]. A weak decoction of the bark is employed against dysentery and blenorrhea [87]. The astringent root also finds use against dysentery and intestinal worms and as a fish poison [21].

Réunion: Use is made of the astringent properties of the plant and it is also applied as a vermifuge [364].

Mauritius: The plant is used against dysentery and blenorrhagia [364].

T. microphylla

Thailand: This small shrub is medicinal and is widely used internally [41,45]. It has a peppery taste [41,45].

T. muricata

Colombia: Flowers and leaves of the shrub are dried in the sun and added to *chicha* (fermented *Manihot esculenta*) as a stimulant, especially for the aged and sick. This practice seems to be common to most Indians along the lower Río Vaupes [375].

T. novo-guineensis

Solomon Islands: This tree and its fruits are much feared because it is believed that they are able to distort the hands and fingers as leprosy does [55]. The sap is medicinal and with coconut oil is rubbed on the skin to raise blisters [266].

T. orientalis

China, Guangdong (Hainan): The roots (of *T. officinalis*) are used against stomach ache [343].

Papua-New Guinea: In the Sepik district when the fruit is red it is opened and the sap rubbed on to "grille" (*Tinea imbricata*) [332]. The latex of the plant is applied like iodine to cure skin lesions [154]. In Hula the root is scraped and rubbed on a sore nose [332,421]. The plant is suspected of causing sudden death in horses and cattle [88]. A decoction is used to cause abortion [76].

Australia: The aborigines apply the latex to ulcers and sores. The plant is suspected of poisoning horses and cows [88]. A decoction of the intensely bitter bark is sometimes sold as "bitters" [14].

New Caledonia: The plant is reported to have a very toxic latex [265].

Fiji: In the form of a poultice the plant is used to reduce swellings, abscesses, etc. [59,63]. A decoction of the leaves is said to be used for stomach ache [62], while the bark is a medicine for headache [66].

Samoa: The leaves are an ingredient of an arrow poison called *na suafa* or *putu* [32].

Tonga: For treating toothache, the root is powdered and wrapped in a leaf of the nut-palm; it is then put in a cup with hot or warm water and the liquid obtained after wringing out the contents of the leaf is taken as a mouthwash [255]. An infusion of the grated root is used in the same way for the same purpose, and the mouthwash is said to be effective in relieving the pain [246].

T. pachysiphon

Togo: The pulp of the pounded leaves is used by women for the hair [75].

Benin, Nigeria: The white latex does not coagulate and it is used to adulterate good rubber [34,75, cf. 27]. The bark yields fiber for making "lifa" (Asaba) or "dodo" cloths [34,75, cf. 30,40]. The wood is yellow and hard, and the sapwood and heartwood are not differentiated; it resembles boxwood, but is softer, and is used locally for making combs. The roots are applied medicinally [75]. The latex from this tree is used to snare birds and it may also be one of the gums used in repairing pots and calabashes [142].

Tropical Africa: The juice from the tree is used as birdlime. The leaves afford a black substance applied by women for coloring their hair [127].

Uganda: The latex is sometimes used for making birdlime [93]. The wood is very hard [34].

Tanzania: The latex is used as a styptic and is applied to wounds for healing [78]. It is dropped into a sore eye as a cure [443]; it is also used as a birdlime. The Shambaia use the latex as a glue and the wood for axe handles. A watery extract of the fruit is used as a galactagogue for goats and a concentrated extract of the wood is a poison [147].

East Africa: The latex is applied directly to sore eyes. It is used to treat minor cuts or abrasions on the body, merely by allowing it to drop from the cut end of the fruit on to the injured surface; because of the presence of a rubber-like substance in the milky sap a film or "skin" forms over the injured part. For headaches, the head is washed with an infusion of the leaves. A decoction of the roots is used against stomach ache, constipation, flatulence, headache and as a hypnotic [317].

T. paisavelensis

Mexico: The resin is used to remove warts [420].

T. pandacaqui

Philippines: The milky juice, placed directly on the affected part, is widely employed for healing wounds and to reduce swellings [86,358]. A decoction of the leaves is used against dysentery and snakebite [6]. As a cataplasm, the leaves are placed on the abdomen to induce menstruation; it is also said that they are applied to hasten parturition [92], and women have a decoction of the leaves in their bath water after childbirth [358]. The leaves, mixed with powdered rice husks and fried, are rubbed over the body of a person suffering a relapse following any kind of illness. The pounded leaves are heated and placed on the navel and the small of the back to combat sudden sickness causing severe stomach ache and cramps [96]. The leaves are used as a bleaching agent [86]. A decoction of the bark and roots is used to cure disorders of the stomach and intestines, including gastro-enteritis, and women also use it during childbirth [86,358].

T. peduncularis

Malaysia: The roots are boiled and the decoction used against abscesses in the nose [52]. A decoction is drunk in treating ulceration of the nose in tertiary syphilis; other methods of administration are probably also used [67]. The plant is poisonous [266].

T. penduliflora

Central African Republic: The black juice from the berries is used for the healing of wounds and the bark is made into a rough kind of rope [91]. The latex of the fruit is applied in colds and for the healing of wounds. Externally, the fruits are put on a sprained ankle. A decoction of the root bark is injected [77].

T. persicariifolia

Réunion: The plant and its latex are considered poisonous [6,26]. The wood is used for domestic purposes [6].

Mauritius: The latex is believed to be acrid and caustic [10].

T. polysperma

Eastern Malaysia Sabah: The plant is used medicinally for headache [64].

T. psychotrifolia

Colombia: The latex is employed medicinally [359].

Venezuela: The greenish brown, slightly streaked wood is said to be used for making furniture and musical instruments [122].

T. retusa

Madagascar: The latex is often used to prepare lime-twigs. The aril of the fruit is much appreciated by bats and other animals [320].

Mauritius: The plant finds use as an emollient and against lung conditions [21].

T. rimulosa

Colombia: Venezuelan settlers in the vicinity of San Felipe report that a few leaves of the shrub boiled in milk act as a sleep-inducing draught [375].

T. rubro-striolata

Brazil: Two or three drops of the latex with sugar are taken for stomach disorders. The bitter leaves are used as a tonic [28].

T. salzmannii

Brazil: The powdered seeds are used against intestinal worms. The latex is used to heal fractures. An infusion of the leaves is given as a diuretic, while a concentrated decoction is added to a bath against pains in the hips.

The white, readily worked wood is used for making kitchen and other implements. The sawdust is smoked to repel insects. Powdered root is taken orally against stomach cramps and colic. The somewhat caustic root bark is boiled down with mandioc flour and used as a warm cataplasm against paronychia [28].

T. sananho

Colombia: A mixture of latex and water can be used to cure eye wounds [375].

Peru: In the upper part of the Amazon the plant has long been considered a panacea, the name *sanango* signifies a more or less all-purpose medicinal plant. In the Leticia area it is employed as a febrifuge, emetic, diuretic, calmative and for various minor ailments. A tepid decoction of the leaves and bark is used to wash wounds and afterwards powdered bark is put over the wound; this is repeated three times a day for 10 days. A water extract of the root is drunk three times a day during 15 days against rheumatism and for wounds [375].

Peru, Brazil: An infusion of the roots is used against rheumatic pains [376].

T. siphilitica

Colombia: The Makuna Indians put drops of the latex into the eyes to prevent sleep.

Ecuador: The Kofán Indians eat the pulp surrounding the seeds [375].

Peru: The root is taken in water for rheumatism [56,375].

T. sphaerocarpa

Eastern Malaysia: Sarawak: The latex is of commercial value, while the wood is used for planks, coffins, clogs, etc. [43]. Sabah: The fruit is medicinal [58]; it relieves the pain of toothache [82].

Indonesia, Kalimantan: The chopped root is an ingredient of *siren* arrow poison [39]. The plant is considered very poisonous [9]. Java: The plant, including its fruits and latex, are believed to be poisonous [8,10,18]. It is often planted in gardens as an ornamental [11] and in cemeteries [18]. A decoction of the leaves and bark is rubbed on the skin against fever. The crushed leaves are mixed with chalk and applied to the forehead against eye infections [11]. Sunda Islands: The latex is used against skin conditions. The leaves are applied externally to sprained ankles [18].

T. (Ervatamia) species

Eastern Malaysia, Sabah: The plant is a medicine for headache [64].

T. (Gabunia) species

Tanzania: The plant is used against eruptions of the skin of the head; the aching parts are covered with latex. An infusion of the root is drunk to hasten parturition and is also used as an arrow poison [159].

T. (Rejoua anguinea) species

Solomon Islands: This tree and its fruit are much feared because it is believed that they are able to distort the hands and fingers as leprosy does [55].

T. sralensis

Kampuchea: The fruits are used in treating eruptions of the skin. A piece of the root may be added to the betel quid [244]. The roots are used directly against snake bites [97].

T. stapfiana

East Africa: The milky latex is used as birdlime [38].

T. stenosiphon

Saint Thomé: The plant is used for the production of rubber [23]. The latex induces vomiting and is also purgative. The root is a tonic and febrifuge [22].

Nigeria: Here also the plant is used for the production of rubber [34].

T. undulata

Colombia: The Taiwano Indians boil the crushed leaves with those of *Manihot esculenta* in preparing a tea which is thought an excellent vermifuge; the use of this tea is common [375].

Venezuela: The plant gives a white latex which is said to be poisonous [163].

Trinidad and Tobago: The shredded root boiled and taken internally is said to alleviate mapepire bite [65].

Brazil: The leaves are used in baths against dysentery [257].

T. ventricosa

Tanzania: When the latex is dropped on fresh or cold wounds, they heal within two days [78].

East Africa: The latex from the stem is put on old wounds against secondary infections and to aid healing [317].

South Africa: Rubber has been prepared from the latex [147] and boys sometimes use it, especially that of the fruits, for birdlime [251]. The bitter bark has been used for treating fevers [60], but antifebrile properties have never been confirmed experimentally and the extracts are not antimalarial. The yellow wood is very hard [147]. The timber is light-colored, dense, looks well when varnished, and is suitable for planking and such purposes when big enough [251].

TABLE 12

CLASSIFIED USES OF *TABERNAEMONTANA* SPECIES THROUGHOUT THE WORLD

No. Uses	Times found	Geographical area 1	2	3	4
1. Poisonous	18	6	3	7	2
a Man	15	5	3	6	1
b Animals	3	1	—	1	1
2. Non-medicinal uses	71	14	34	13	10
a Source of wood	16	7	6	—	3
b Source of rubber	8	2	5	1	—
c Source of fiber	2	—	2	—	—
d Source of food	3	2	1	—	—
e Source of dyes	3	—	1	2	—
f Birdlime	6	—	5	—	1
g Appetiser (bitter)	2	1	—	—	1
h Ornamental	6	1	2	2	1
i Insect repellant	2	1	1	—	—
j Fish poison	3	—	3	—	—
k Arrow poison	8	—	2	4	2
l Softening the skin	3	—	1	2	—
m Miscellaneous (wax, oil, perfume, incense, glue)	9	—	5	2	2
3. Antimicrobial	46	12	10	22	2
a Inflamation (throat, eyes, nails)	17	4	2	10	1
b Wounds (washing, disinfecting and healing)	18	7	6	4	1
c Syphilis	6	1	—	5	—
d Hansen's disease (leprosy)	4	—	1	3	—
e Gonorrhea	1	—	1	—	—
4. Antiparasitic	35	7	10	12	6
a Intestinal worms	12	5	4	2	1
b Filariasis (elephantiasis)	1	—	1	—	—
c Dysentery, diarrhea, malaria, stomach disorders	22	2	5	10	5
5. "Antitumor"	33	7	3	17	6
a Warts (and blistering agents)	9	5	1	2	1
b Tumors	5	1	—	4	—
c Ulcers (skin), sores, abscesses	19	1	2	11	5
6. Analgesic	32	6	8	11	7
a Toothache	8	1	—	4	3
b Headache	10	—	6	2	2
c Rheumatic pains	7	4	2	1	—
d Other pains	7	1	—	4	2
7. Hormonal action	10	—	3	4	3
a Abortion, hastening childbirth	3	—	1	—	2
b Aphrodisiac	1	—	—	1	—
c Menstrual disorders	5	—	1	3	1
d Galactagogue	1	—	1	—	—
8. CNS action	25	11	5	9	—
a Epilepsy	3	—	—	3	—
b Insanity	4	—	1	3	—
c Hypnotic, narcotic	3	2	1	—	—
d Tonic, stimulant	15	9	3	3	—
9. Action on the blood	9	1	3	4	1
a Styptic (after childbirth, for wounds)	7	1	3	2	1
b Blood diseases	2	—	—	2	—
10. Action on the kidney	5	2	—	3	—
a Diuretic	4	2	—	2	—
b Urinary calculi	1	—	—	1	—
11. Against poisonous bites (snakes, scorpions, insects)	7	2	—	4	1
12. Purgative	12	4	4	3	1
13. Emetic	3	3	—	—	—
14. Febrifuge	20	10	1	7	2
15. Beri-beri	1	—	—	1	—
16. "General medicine"	13	4	1	6	2

6.2. Discussion

Ethnobotanical data is available for about 75 species. The findings are summarised in Tables 12—14, which deal with information about the kind of use, the form in which used, and the plant part used, respectively. In order to allow conclusions to be drawn between one part of the world and another, the material is treated on the basis of the four geographical areas indicated in § 4.5.2.3.

TABLE 13

THE FORMS IN WHICH *TABERNAEMONTANA* SPECIES ARE USED IN ETHNOMEDICINE

Route of administration	Form used	Total (%)	Geographical area % 1	2	3	4
Internal	Infusion, macerate, decoction, suspension, solution	30	26	35	30	9
	Powder	2	50	—	50	—
External	Poultice, wash, ointment, powder, solution	28	25	19	30	26
	Bath	4	88	—	—	12
Lungs	Steam-bath	1	—	—	100	—
Mouth	Chewing, mouth wash	3	—	—	83	17
—	Not specified	31	31	17	43	9

TABLE 14

THE PARTS OF *TABERNAEMONTANA* PLANTS USED IN ETHNOMEDICINE

Plant part used	% of total use	Geographical area			
		1	2	3	4
Seeds, fruits	5	9	36	27	27
Flowers	3	14	—	86	—
Leaves	19	36	10	36	19
Oil, sap	1	—	—	67	33
Latex	18	40	32	15	13
Stem (bark), twigs	16	34	23	31	11
Root (bark)	25	16	23	55	5
Whole plant, not specified	13	27	3	57	13

6.2.1. Kind of use

In Table 12 the uses are divided into different categories, and for each use, medicinal and non-medicinal, the number of times it is described in the literature pertaining to the four geographical areas is recorded.

6.2.2. Form used

The forms in which the plant materials are used are shown in Table 13. The percentages in the total column show the proportions of the total medicinal uses recorded which the particular form of use represents. The last four columns give an indication of the geographical distribution of the various forms of use.

6.2.3. Plant part employed

Table 14 sets out the uses of the various plant parts, expressed as a percentage of the total number of medicinal uses described in § 6.1. Again, the last four columns break down the data according to the four geographical regions.

6.2.4. Ethnobotanical conclusions

(a) Types of use: Many *Tabernaemontana* species are used for non-medicinal purposes, the wood in particular being used as timber or firewood. Other uses are varied and often ingenious. The incorporation of certain species into arrow poisons suggests the presence of strong and perhaps rapidly acting constituents. However, only a few species are described as being toxic.

Of the medicinal uses reported, those which rely on an antimicrobial action are the most common. *Tabernaemontana* species are nevertheless often used in curing illnesses involving parasites or protozoa and in dealing with warts; they are also applied as analgesics, stimulants and febrifuges.

Curiously, up until now few substances active against micro-organisms have been discovered in the genus, and the same applies to anti-parasitic principles (see § 7). On the other hand, many compounds of the iboga type are known to act as stimulants (§ 7) and this could help to explain the use of *Tabernaemontana* species as tonics. It could thus well be worthwhile to investigate the genus more closely, not only for compounds with an antimicrobial action but also for those with activity against rheumatic conditions; these could have an analgesic or an anti-inflammatory action.

(b) *Tabernaemontana* preparations are almost equally divided between forms for internal and for external use, mostly as decoctions, infusions, washes, and poultices. Particularly in South America, baths are often used to combat fevers.

(c) The plant part most frequently used for medicinal purposes is the root bark. Since this is the part of the plant which is usually richest in alkaloids, it would seem that these substances may play an important role in the medicinal value of the root bark. The next most frequently used plant parts are the latex and leaves; they carry less alkaloids and it is possible that part of their therapeutic effect is due to some of the other substances present. In the latex, for example, enzymes, as well as certain secondary plant substances, occur. The stem bark, used in about one-sixth of the applications recorded, is also a relatively rich source of alkaloids. Plant parts other than those just mentioned are little used.

7. Pharmacology of crude extracts and alkaloids from *Tabernaemontana* species

In this section is recorded the results of pharmacological studies, on extracts from the plants themselves and also on some of the alkaloids which have been isolated. However, as already stressed in the Introduction, the pharmacology of the alkaloids is seldom examined, probably because the amount of substance isolated is usually insufficient and also because phytochemical laboratories are not usually equipped for the necessary pharmacological work. It is certainly not due to the absence of pharmacologically interesting compounds in the genus. Among the alkaloids present in *Tabernaemontana* species that are currently of interest are: camptothecine and 9-methoxycamptothecine, which have antitumor activity; olivacine, which has antitumor and antiprotozoal activity; serpentine, which has antitumor activity; and (+)-vincamine, which is used for cerebral sclerosis.

The pharmacology of the species is dealt with first and then individual alkaloids are discussed, together with medical uses, if any, which have been developed. Literature references are also given.

7.1. Pharmacological studies on extracts from Tabernaemontana species

T. affinis

The crude extract had antitumor activity [224]. Both ethanolic and aqueous extracts were highly toxic to mice and fish; they decreased the blood pressure in cats and, according to tests on the rabbit duodenum

and guinea-pig ileum, had spasmolytic activity [229]. The activity was related to the presence of 19-*epi*-heyneanine [272].

T. arborea

A chloroform extract of a crude aqueous extract from the trunk had cytotoxic activity against *P*-388 lymphocytic leukemia, which was evidently related to the presence of the alkaloids voacangine, voacamine, and 19-*epi*-voacorine [352].

T. crassa

A crude ethanolic extract decreased motor activity and brought about muscle relaxation in mice. A dose of 250 mg/kg extract proved to be lethal within 30 min [440].

T. dichotoma

An alkaloidal fraction had hypotensive and sedative activity, while another fraction showed tumor-inhibiting activity [259].

T. divaricata

Crude extracts had anticancer activity [281]. Alkaloids from the seeds, roots and pod depressed bone-marrow activity in rats, resulting in temporary leukopenia [400].

T. eglandulosa

Ethanolic extracts of the leaves, bark, root bark and seeds had no cardiac activity when tested on the isolated toad heart [162].

T. heyneana

Extracts appear to exhibit promising activity against certain types of cancer [328]. An aqueous ethanolic extract of the roots displayed both cytotoxic and antitumor activity [250].

T. malaccensis

The crude alkaloids from the leaves had slight but lasting hypotensive effects [123].

T. orientalis

In the dog, small intravenous doses of a stem-bark aqueous extract led to an increase in the rate of respiration; large doses, however, decreased the rate and also enhanced the hypertensive action of adrenaline and depressed the accompanying bradycardia [108]. The latex has proteolytic activity [134].

T. pandacaqui

Crude chloroform extracts showed a high degree of inhibition against

P-388 lymphocytic leukemia [355].

An aqueous extract completely inhibited the growth of *Micrococcus aureus* but had no effect on that of *Escherichia coli;* the ethanolic extract had no inhibitory activity [102]. Crude leaf extracts gave 133% (*T/C*) survival time for mice inoculated with *P*-388 tumor cells. Further tests were therefore carried out with the total leaf alkaloids to determine the acute and sub-acute toxicity in mice, dogs and monkeys. Histopathological studies on the vital organs of both control and test animals indicated some of the activity and toxicity expected of an anticancer agent. The results were found to be encouraging, because they suggested a relatively lower degree of toxicity than the currently used vincristine and vinblastine. Further phase I human tolerance studies of the drug in a few volunteer cancer cases have been strongly recommended [377].

Various extracts from the plant have been tested on mice with the following results. Hexane fraction: at 1 mg/kg there was temporary weakness of the limbs and body, but at 1000 mg/kg massive convulsions occurred, together with tremors and salivation, leading to rapid death. Chloroform extract: at 100 mg/kg motor activity decreased, while higher doses, 300 and 1000 mg/kg, brought about convulsions and death. Total alkaloid fractions: low doses caused general weakness and altered posture, with lachrymation; doses in the 300—1000 mg/kg range caused the rapid appearance of convulsions, tremors, Straub tail, exophthalmos, followed by death. Quaternary alkaloid picrates: after 30 mg/kg there was decreased awareness, motor activity and muscle tonus, as well as pilo-erection; with 1000 mg/kg there were convulsions, tremors, Straub tail and body, and weakness, ending in death [404].

T penduliflora

A crude ethanolic extract was lethal to mice at a dose level of 175 mg/kg [440].

T. ventricosa

Bark extracts gave negative results in tests against malaria [147].

7.2. Pharmacological activities of individual Tabernaemontana alkaloids

Affinine (C5-3)

Only slight CNS depression was caused by 200 mg/kg p.o. in mice, whereas 300 mg/kg produced delayed intention tremors, marked depression of the CNS, ataxia, hypothermia and bradypnea. No overt effects were observed in the unanesthetised cat receiving 25 mg/kg i.p. of the compound. In the anesthetised cat, after a cumulative dose of 19 mg/kg i.v., affinine produced only transient lowering of the mean arterial blood pressure. Some evidence of toxicity was uncovered, since bradycardia, respiratory depression and cardiac arrhythmias were observed as dose levels were increased. The

alkaloid was almost inactive when examined for analgesic, antipyretic and anti-edema activity in the Randall-Selitto anti-inflammatory test. No diuretic action was produced in the saline-hydrated cat [156].

Affinisine (C4-1)

In the mouse, 50 mg/kg p.o. of the alkaloid produced CNS depression, lachrymation and tremors. However, no side effects were observed in the unanesthetised cat following a dose of 10 mg/kg i.p. In the ether-chloralose anesthetised cat, 1.0 mg/kg i.v. affinisine caused respiratory toxicity, while 10 mg/kg i.v. proved lethal. It showed moderate analgesic activity in rats given doses of 25 mg/kg p.o.; the effect was not accompanied by edema and skin temperature was not affected. There was no evidence of diuretic activity when 25 mg/kg of the compound was administered p.o. to the saline-loaded cat [156].

Apodine (P2-1)

The base reduced mobility and reaction capacity in mice and caused slight relaxation of the isolated trachea contracted by a depolarising solution. It was weakly antagonistic to acetylcholine, bradykinin, histamine, nicotine and serotonin when tested on the guinea-pig ileum. Apodine depressed the frequency and amplitude of contractions of the isolated guinea-pig auricle and it caused moderate arterial hypotension in cats [340].

Apparicine (A2-1)

Apparicine showed activity against Polio III virus in vitro in concentrations of 250 μg/ml and greater; there was no activity against Vaccinia VI virus [214]. At a concentration of 1.2%, the alkaloid exhibited antimicrobial activity against *Shigella*, *Salmonella*, *Pseudomonas*, *Escherichia*, *Proteus*, *Staphylococcus* and *Corynebacterium* [341]. The ED_{50} of apparicine against *P*-388 lymphocytic leukemia when tested in vitro was 3.8 μg/ml [396].

Camptothecine (M3-1)

The compound inhibits herpes and other mammalian viruses [256,290]. It has potent antileukemic and antitumor properties [195,290] and showed *T/C* values of 181% and 175% at dose levels of 1.56 and 0.78 mg/kg, respectively, in the *P*-388 lymphocytic leukemia test system. It was cytotoxic in the KB and *P*-388 test systems in cell culture, ED_{50} being 0.17 and 0.53 μg/ml, respectively [369]. For a review of camptothecine and its analogs, together with a discussion of the antitumor spectrum and structure-activity relationships (see Ref. 411). Camptothecine is being used clinically in the People's Republic of China for the treatment of psoriasis. A mixture containing 3—8% crude camptothecine (from a 80% aq. ethanolic extract of *Camptotheca* seeds) and 1.0% diphenhydramin hydrochloride in 70% DMSO is applied topically to the lesions 2—3 times daily. All cases of psoriasis guttata and pustulosa were cured, while 13 of 25 cases of psoriasis vulgaris were cured and 12 greatly improved [288].

Camptothecine, 9-methoxy- (M3-2)

This compound showed substantial activity in the L-1210 lymphoid leukemia, B16 melanoma, Lewis lung carcinoma and *P*-388 lymphocytic leukemia test systems in vivo at doses in the range 0.5—2.0 mg/kg [369]. The ED_{50} against *P*-388 lymphocytic leukemia in vitro was 0.036 μg/ml [396].

Conoduramine (B2-7)

The alkaloid was inactive in the *P*-388 and KB test systems in cell culture [354].

Conodurine (B2-9)

The alkaloid was inactive in the *P*-388 and KB test systems in cell culture [354].

Conodurine, 3-(2'-oxopropyl)- (B2-11)

The compound showed significant cytotoxicity in the *P*-388 cell-culture system [334].

Conopharyngine (I1-1)

In a general pharmacological screening, conopharyngine exhibited a slight central-stimulating effect. The LD_{50} i.v. in the mouse was 145 mg/kg [164]. When administered i.v. to anesthetised guinea pigs, it produced bradycardia that was resistant to vagotomy and atropine sulfate (4 mg/kg i.m.). At the same time, the blood pressure was lowered, but the ECG was unaffected [221].

Coronoaridine (I1-5)

The alkaloid has been tested in the mouse, cat, dog, monkey and rat by a variety of pharmacological procedures. It showed autonomic and CNS activity. In mice it produced analgesia and was effective in suppressing rage caused by foot-shock. Toxicity in the anesthetised cat appeared to be associated with respiratory depression. Coronaridine was inactive in the 9 KB system in cell culture [150]. In a general pharmacological screening, the compound exhibited little activity [164]. A single 30 mg/kg p.o. dose of coronaridine prevented pregnancy in rats when given on day 1, 2, 3 or 4 after coitus. When given on day 5, 6, 7 or 8 of pregnancy, the results were only partially successful. The substance showed estrogenic activity, and it was this activity which appeared to be responsible for the antifertility action. However, the alkaloid was devoid of anti-estrogenic, androgenic, anti-androgenic, progestational, anti-progestational and uterine-stimulant

activities, although there was partial inhibition of oxytocin-induced uterine response [356]. The alkaloid was active against the *P*-388 test system in cell culture, the ED_{50} being 0.43 μg/ml [396].

Coronaridine, 3-hydroxy- (I1-7)

The substance had strong antibiotic activity [382].

Coronaridine, 10-hydroxy- (I1-8)

This compound was inactive in the *P*-388 test system in cell culture [396].

Dregamine (C5-5)

In a general pharmacological screening, dregamine showed little activity except for causing jactatio capitis when given s.c. simultaneously with Rigidyl[f] i.p. [128,164]. The LD_{50} i.v. in the mouse was 25 mg/kg [164]. The alkaloid had convulsant and respiratory-stimulant properties. It also inhibited muscular fatigue in vitro and in vivo in an ibogaine-like way [228]. Dregamine had no activity against A2 Hong Kong virus, but it showed local-anesthetic activity half as strong as that of cocaine in the rabbit-cornea test [350].

Ervatamine (C8-1)

Ervatamine hydrochloride (2.8×10^{-4} M) blocked frog atrial-fiber action potentials without altering the resting membrane potential. It blocked peak Na^+ inward current (dissociation constant 2.35×10^{-5} M) with a 1:1 relationship between it and the Na^+ channel; but it did not affect apparent Na^+ equilibrium potential. The alkaloid prolonged the rate of reactivation of the Na system, acting on open Na^+ channels; it thus has to enter the channel or cross the membrane to produce the block. Ervatamine inhibited slow Na^+ inward current in Ca^{2+}-free, tetrodotoxin-containing solutions and it moderately decreased inward Ca^{2+} current in Na^+-free solutions. Background K^+ current was increased but time-dependent K^+ current was unaffected [409]. In frog nerve fibers the alkaloid hydrochloride blocked Na^+ channels in a frequency-dependent fashion. In its presence (3 μM), the presence (0.5 mM) or absence of benzocaine led to a non-monotonic further increase or relief of the block, respectively. This strong interaction was interpreted as competition of the two drugs for the same binding site, the receptor of classical local anesthetics [428].

Gabunamine (B2-12)

The ED_{50} in the *P*-388 and KB systems in cell culture was 1.3 and 5.8 μg/ml, respectively [354].

[f]Diethylaminoethyl benzhydryl ether.

Gabunine (B2-13)

The ED_{50} in the *P*-388 system in cell culture was 3.2 μg/ml. The compound was not active in the KB system in cell culture [354].

(−)-Heyneanine (I1-20)

This alkaloid was not active in the *P*-388 system in cell culture [396].

(−)-19-epi-Heyneanine (I1-21)

The compound was shown to have antispasmodic properties [272,395].

Ibogaine (I1-23)

In cats and dogs the alkaloid has distinct central-stimulating properties, different from those of strychnine, which can be abolished by atropine. In mice, it has weak but definite anticonvulsant properties [118]. Ibogaine has a transient hypotensive effect. It acts as a true hallucinogenic agent, and it can be used as a stimulant to overcome fatigue and sleepiness. It could perhaps be used as a substitute for cocaine [139]. In a general pharmacological screening, ibogaine induced tremors in mice and jactatio capitis when given s.c. together with Rigidyl i.p. The LD_{50} i.v. in the mouse was 42 mg/kg [128,164]. When administered i.v. to anesthetised guinea pigs, the alkaloid produced bradycardia that was resistant to vagotomy and atropine sulfate (4 mg/kg i.m.). Blood pressure was lowered, but there was no alteration in the ECG [221].

Ibogaline (I1-25)

In a general pharmacological screening, the substance exhibited strong central-stimulating properties and when given s.c. together with Rigidyl i.p. it produced jactatio capitis. In anesthetised cats it caused hypotension and marked bradycardia. The LD_{50} i.v. in the mouse was 46 mg/kg [164]. When injected i.v. into anesthetised guinea pigs, the effects caused by ibogaline were similar to those brought about by ibogaine (q.v.) [221].

(−)-Ibogamine (I1-27)

Central-stimulating properties were observed in a general pharmacological screening, and in mice, when administered s.c. together with Rididyl i.p., the alkaloid produced jactatio capitis [164]. On i.v. injection into anesthetised guinea pigs, the effects observed were the same as with ibogaine (q.v.) [221]. Ibogamine was not active in the *P*-388 or KB test systems in cell culture [354].

Iboxygaine (I1-29)

Apart from causing hypotension and bradycardia, the alkaloid showed little activity in a general pharmacological screening in anesthetised cats. The LD_{50} i.v. in the mouse was 42 mg/kg [164]. Injected i.v. into anesthetised guinea pigs the effects were the same as with ibogaine (q.v.) [221].

Lochnericine (P2-11)

The compound was inactive in vitro against Vaccinia VI and Polio III viruses at the 1 mg/ml level [214].

Normacusine B (C4-3)

The alkaloid is a non-tranquilising, sympatholytic compound with pharmacological properties resembling those of yohimbine. It was hypotensive in the cat, it induced contractions in the smooth fibers of the rat duodenum, and it showed local-anesthetic action in the rabbit-cornea test [146]. The LD_{50} i.v. in the mouse was 70 mg/kg [164].

Olivacine (M2-2)

The alkaloid inhibited the growth of the protozoa *Crithidia fasciculata* and *Trypanosoma cruzi* in culture [395]. In the KB test system in cell culture, the ED_{50} was 0.4 μg/ml [189]. The compound was also active against L-1210 leukemia in mice, the survival time being 130% (*T/C*) at 10 mg/kg [189,282].

Pericyclivine (C4-4)

The substance was inactive in the *P*-388 and KB test systems in cell culture [354].

Perivine (C5-6)

At the 1 mg/ml level in vitro, the compound was inactive against Vaccinia VI and Polio III viruses [214]. It is inactive against A2 Hong Kong virus [350]. In the rabbit-cornea test perivine had twice the local-anesthetic activity shown by cocaine [350]. The alkaloid showed no activity in the *P*-388 and KB test systems in cell culture [354].

Polyneuridine (C4-5)

No cytotoxic activity was seen when the substance was tested in vitro in the KB and *P*-388 systems [427].

20α-Amino-pregn-5en-3β-yl β-D-glucoside (M4-1)

In animals this compound lowered the blood pressure by 60 mmHg and more when administered i.v. at a dose of 40 μg/kg. Orally, it had no activity [133].

Serpentine (C2-3)

When treated with 400 μg serpentine/day for 15 days, mice infected with mammary cancer MS-301 had a mean tumor weight of 1.6—1.7 g as compared with 3.2 g for the controls [384]. Cancer cells and tumors were killed on administration of a freshly prepared mixture of alstonine and serpentine and cyclophosphamide [385].

Silicine (C8-7)

This alkaloid has been tested pharmacologically in mice, rabbits and dogs. From the results it is suggested that the compound may be useful against dizziness, tinnitus, headache, loss of concentration, chronic cerebral sclerosis, unconsciousness, fractures of the skull and hypertension in man [254].

Tabernamine (B2-22)

The ED_{50} for this alkaloid in the *P*-388 system in cell culture was 2.1 μg/ml. It was inactive in the KB test system [354].

Tabernanthine (I1-33)

In a general pharmacological screening the alkaloid showed central-stimulating properties, lowered the blood pressure and heart rate in cats, and when given s.c. together with Rigidyl i.p. caused jactatio capitis in mice. The LD_{50} i.v. in the mouse was 38 mg/kg [164]. The central effects of tabernanthine on noradrenaline and dopamine turnover times have been studied in the hypothalamus, the striatum, and the remainder of the brain of normal and hypobaric hypoxic rats [392]. When injected i.v. into anesthetised guinea pigs, the effects noted were the same as with ibogaine [221].

Tabersonine (P2-16)

The alkaloid was shown to be inactive against the 9 KB system when tested for tumor-inhibitory activity [175]. In anesthetised cats, tabersonine at 2 mg/kg had the same hypotensive effect as 0.5 mg/kg reserpine [299].

(+)-Tubotaiwine (A3-3)

The compound was inactive in the *P*-388 test system in cell culture [396].

Tubotaiwine N_4-oxide (A3-4)

The ED_{50} of the alkaloid in the *P*-388 test system in cell culture was 1.8 μg/ml. It was inactive in the 9 KB system [333].

O-Acetylvallesamine (A2-3)

This compound was inactive in the *P*-388 test system in cell culture [396].

Vallesiachotamine (V1-1)

The alkaloid showed cytotoxic activity: in vitro the ED_{50} was 3.56 μg/ml in the KB system and 1.1 μg/ml in the *P*-388 system [427].

(+)-Vincadifformine (P2-19)

A dose of 2 mg/kg had the same hypotensive effect in anesthetised cats as 1 mg/kg reserpine [299].

(−)-Vincadifformine (P2-20)

This alkaloid exhibited no hypotensive effects in anesthetised cats [299].

(+)-Vincamine (E1-1)

In a long-term double-blind trial in which 50 patients with advanced cerebral sclerosis were treated with placebo and vincamine, non-parametric (x^2, Wilcoxon) tests of the data demonstrated that the administration of vincamine was indeed an effective form of treatment. The overall EEG pattern of the vincamine-treated patients improved, as did also disturbances of attention, memory and mood [262]. The alkaloid increases cerebral blood flow in both man and animals. Recent animal studies suggest that vincamine stimulates neuronal metabolism, thereby increasing glucose utilisation and CO_2 production. The resulting rise in the pCO_2 of the perivascular neurones is believed to be the real vasodilating stimulus.

Voacamine (B2-24)

The alkaloid sulfate has pharmacological properties comparable with those exhibited by *Digitalis* and the cardiac glycosides such as digitalin, strophanthin and convallatoxin. However, it is less toxic and does not accumulate. Voacamine may therefore be of use in the treatment of heart conditions [104, cf. 178]. On the fatigued, isolated frog heart voacamine exerts a cardiotonic action much like that due to ouabain [111]. It is possible to markedly increase the penetration rate and cardiotonic activity of strophanthin by giving simultaneous doses of voacamine. The alkaloid has relatively low toxicity (LD_{50} 360 mg/kg) and it may be useful in treating cardiac insufficiency accompanied by tachycardia, since the required dose of the toxic strophanthin can be reduced [130]. In a human clinical trial, voacamine sulfate improved the condition of patients suffering from chronic cardiac insufficiency. At the dose levels used, the cardiac frequency and arterial pressure were only slightly changed. The alkaloid can be given i.v. or p.o.; its excretion is rapid [100]. In cardiotonic doses, the compound does not affect blood coagulation [110]. In mice and rabbits, voacamine had a mild analgesic effect [105]. The ED_{50} in the *P*-388 test system in cell culture was 2.6 μg/ml. In the KB system, the substance was inactive [353].

$N_{4'}$-Demethylvoacamine (B2-28)

The ED_{50} of this compound in the *P*-388 test system in cell culture was 0.3 μg/ml and in the KB test system 0.35 μg/ml [353].

Voacangine (I1-34)

In a general pharmacological screening, voacangine exhibited a slight central stimulating effect. The LD_{50} i.v. in the mouse was 54 mg/kg [164]. When injected i.v. into anesthetised guinea pigs it produced the same effects as did ibogaine (q.v.) [221]. Voacangine had no effect on the heart [178]. The alkaloid was not active in the *P*-388 and KB test systems in cell culture [353].

Voacangine hydroxyindolenine (I1-41)

This derivative was inactive in the *P*-388 test system in cell culture [396].

(6R)-3,6-Oxidovoacangine N_4-oxide (I1-42)

The ED_{50} of the substance in the *P*-388 test system in cell culture was 3.2 μg/ml [396].

(19S)-3,19-Oxidovoacangine (I1-39)

The ED_{50} of this compound in the *P*-388 test system in cell culture was 1.6 μg/ml [396].

19-Oxovoacangine (I1-47)

This alkaloid was not active in the *P*-388 test system in cell culture [396].

Isovoacangine (I1-36)

In a general pharmacological screening, isovoacangine showed a weak central-stimulating effect. The LD_{50} i.v. in the mouse was 75 mg/kg [164]. The compound on i.v. injection into anesthetised guinea pigs produced effects similar to ibogaine (q.v.) [221].

No activity was observed in the *P*-388 and KB test systems in cell culture [353].

Voacorine (B2-30)

The alkaloid has cardiotonic properties [178].

19-epi-Voacorine (B2-31)

This compound had ED_{50} 1.7 μg/ml in the *P*-388 test system in cell culture [353].

Voacristine

In a general pharmacological screening voacristine exhibited a weak central stimulating effect. In mice, head-shaking occurred when the compound was administered s.c. at the same time as Rigidyl i.p. It lowered the heart rate in cats. The LD_{50} in the mouse was 77 mg/kg [164]. When injected into anesthetised guinea pigs its effects were like those of ibogaine (q.v.) [221].

Isovoacristine (I1-45)

The alkaloid hydrochloride caused slowing of the heart rate in the frog and rabbit. The skeletal muscles of the rabbit were relaxed, through an acetylcholinergic mechanism. When tested on the guinea-pig ileum, both anticholinergic and antihistaminic activities were observed [374].

Vobasine (C5-10)

The compound exhibited little activity in a general pharmacological screen-

ing. The LD_{50} i.v. in the mouse was 58 mg/kg [164]. With a dose of 200 mg/kg p.o. in mice, the hydrochloride caused weak but significant CNS depression and ataxia; 300 mg/kg caused lachrymation, mydriasis and respiratory depression, as well as a progressive increase in the central depressant activity. In cats receiving 15 mg/kg i.p., no overt effects were noted, but following doses of 35 mg/kg it caused vocalisation, mydriasis and short-lived tonic-clonic convulsions. Injection i.v. into the ether-chloralose anesthetised cat of doses in the range 0.5—5.0 mg/kg produced a transient depressor action. A dose of 10 mg/kg i.v. proved lethal as a result of respiratory depression. No significant changes were observed with the standard test agents (epinephrine, nor-epinephrine, DMPP, or furfuryl-trimethyl-ammonium iodide) which measure alterations in the autonomic nervous system after drug treatment. No diuretic activity was observed in the saline-hydrated rat given 25 mg/kg p.o. Using a modification of the Randall-Selitto method as presumptive evidence for anti-inflammatory activity, it was determined that 25 mg/kg p.o. produced a very weak analgesia and a moderate antipyretic action; this dose failed to reduce edema in the rat paw. Doses of 100 mg/kg p.o. in the rat gave rise to symptoms of toxicity [156]. Vobasine was not active in the KB test system in cell culture [353].

Vobtusine (B3-1)

The alkaloid is a cardiac depressor. The LD_{50} i.v. in mice was 33.75 mg/kg. It had no effect on the autonomic nervous system and the hypotension it provoked was due to peripheral vasodilation and a direct action on the heart. In mice, i.v. injection of 25 mg/kg caused agitation followed later by calmness. Larger doses could lead to convulsions and death. The compound potentiated the sleep induced by barbiturates. Vobtusine is of no clinical interest [178].

Yohimbine (C3-1)

The substance is an adrenergic blocking agent. It has been, and is, used as an aphrodisiac, local anesthetic and mydriatic, and it has been prescribed in cases of angina pectoris and arteriosclerosis [219].

7.3. Discussion

The pharmacological actions exhibited by alkaloids present in *Tabernaemontana* species are summarised in Table 15.

The pharmacological studies themselves can be roughly divided into two groups: those which include general experiments on intact animals or organ preparations and those which comprise tests for cytotoxic, antiviral, antiprotozoal and antimicrobial activity. Of the 32 alkaloids screened for cytotoxic-antitumor activity, 16 were found to be active and 16 inactive. Camptothecine and 9-methoxycamptothecine are of particular interest and the first of these two alkaloids has had several clinical trials. However, it

TABLE 15

PHARMACOLOGICAL ACTIVITIES EXHIBITED BY THE ALKALOIDS PRESENT IN *TABERNAEMONTANA* SPECIES

Activity	Times found	Activity	Times found
Cytotoxicity/antitumor	16	Cerebral sclerosis	3
Antiviral	2	Cardiotonic	2
Antimicrobial	2	Sympathicolytic	2
Antiprotozoan	1	Convulsant	2
Antipsoriasis	1	Respiratory depression	2
Bradycardia/hypotension	19	Respiratory stimulation	1
Central nervous system	13	Anticonvulsant	1
Analgesic	7	Antifertility	1
Spasmolytic	4		

has been isolated from only one *Tabernaemontana* species. Other cytotoxic compounds which are active in low concentrations are coronaridine, olivacine and N_4-demethylvoacamine. It is noteworthy that only a very few compounds have been screened for antiviral, antiprotozoal and antimicrobial activity. It may well be worth while carrying out further tests in this area.

The number of alkaloids which bring about bradycardia and hypotension is large. Most of them are of the iboga type. Many alkaloids of this type also exhibit CNS activity in an ibogaine-like fashion. (+)-Vincamine is used to treat cerebral sclerosis in some countries.

The other activities which have been observed are of no special interest, except for the unexpected estrogenicity of coronaridine. This is something of a surprise and may point the way to new types of compounds with an estrogenic action.

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