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FURTHER ALKALOIDS OF *ALSTONIA MUELLERIANA**

DAVID E. BURKE, GLORIA A. COOK, JAMES M. COOK, KATHLEEN G. HALLER, HARVEY A. LAZAR and PHILIP W. LE QUESNE[1]

Department of Chemistry, University of Michigan, Ann Arbor, Michigan, MI 48104, U.S.A.

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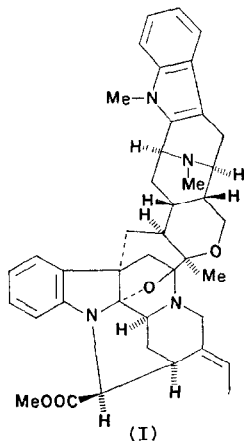
Key Word Index—*Alstonia muelleriana*; Apocynaceae; bisindole alkaloids; macroline unit; biomimetic synthesis.

Abstract—Five further alkaloids, des-N'_a-methylanhydromacralstonine, quebrachidine, vinervinine, pleiocarpamine, and 2,7-dihydropleiocarpamine, have been isolated from *Alstonia muelleriana* bark. Phytochemical problems in the genus *Alstonia* are considered, especially with reference to the 'macroline-derived' indole and bis-indole alkaloids.

INTRODUCTION

THE AERIAL bark of the Australian tree *Alstonia muelleriana* Domin. (Apocynaceae) has been shown by Elderfield and Gilman[2] to contain a complex mixture of indole alkaloids. The



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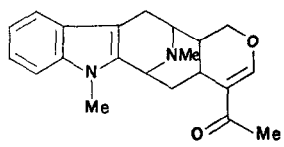

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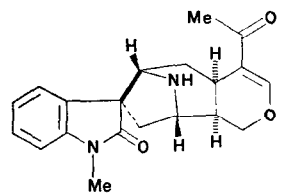

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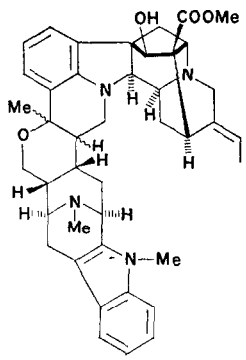

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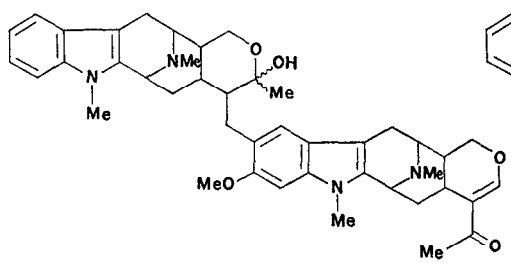

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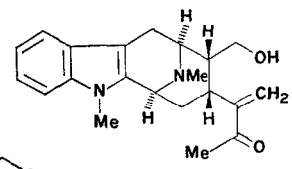

(VI)

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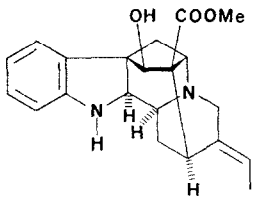
[1] To whom correspondence should be addressed.

[2] ELDERFIELD, R. C. and GILMAN, R. E. (1972) *Phytochemistry* **11**, 339.

four major components of the mixture, which they isolated, are villalstonine (I),[3,4] alstonerine (II),[5] alstonisine (III),[6] and alstonisidine (IV).[7,8] Macralstonine (V)[9] has also been obtained.[10] The common structural element in all these alkaloids is represented by the base macroline (VI), which was prepared by Schmid *et al.* during the degradation of villalstonine (I).[4] Although macroline has not itself been isolated as a natural product, its functional groups suggest that the *Alstonia* bisindole alkaloids[11] could arise biogenetically by acid-catalyzed Michael or vinylogous Michael-type reactions between macroline (or some very closely-related 'equivalent') and the other 'monomeric' species involved. This concept has been strikingly endorsed by recent syntheses of alstonisidine (IV)[7,13] and villalstonine (I)[12,13] from macroline and, respectively, quebrachidine (VII) and pleiocarpamine (VIII). In these syntheses the stereochemical features of the new rings and asymmetric centres are shown to arise purely by asymmetric induction from the chiral precursors in the acidic reaction media.



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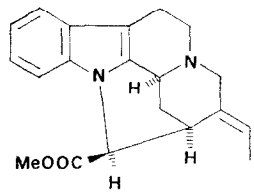


(VIII)

In considering such bisindole alkaloids phytochemically, one must therefore consider first the monomeric species as structural types, and their biogenetic inter-relationships, and secondly the combination reactions between monomeric alkaloids to give bisindoles. These questions, and those pertaining to the natural macroline unit, give special importance to the minor alkaloids of *Alstonia* species. We now report our extraction procedure, discuss five further alkaloidal constituents, and consider phytochemical implications of the results.

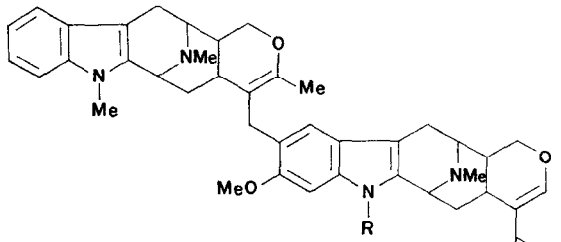
RESULTS

The alkaloidal fraction contained ~85% villalstonine, which was partially removed by chromatography on overloaded alumina. The minor alkaloids were then obtained by

[3] NORDMAN, C. E. and KUMRA, S. K (1965) *J. Am. Chem. Soc.* **87,** 2059.
[4] (a) HESSE, M , HURZELER, H., GEMENDEN, C. W , JOSHI, B. S., TAYLOR, W. I and SCHMID, H. (1965) *Helv. Chim Acta* **48,** 689; (b) HESSE, M , BODMER, F , GEMENDEN, C W., JOSHI, B S., TAYLOR, W I. and SCHMID, H (1966) *Helv. Chim. Acta* **49,** 1173.
[5] COOK, J M., LE QUESNE, P W and ELDERFIELD, R. C. (1969) *Chem. Commun* 1306
[6] NORDMAN, C E and NAKATSU, K. (1962) *J. Am. Chem Soc* **85,** 353.
[7] BURKE, D. E , COOK, J M. and LE QUESNE, P. W (1972) *J. Chem. Soc. Chem Commun.* 697.
[8] COOK, J. M and LE QUESNE, P. W. (1971) *J Org Chem.* **36,** 582.
[9] KISHI, T., HESSE, M , VETTER, W., GEMENDEN, C. W , TAYLOR, W. I. and SCHMID, H (1966) *Helv Chim. Acta* **49,** 946.
[10] COOK, J. M. and LE QUESNE, P. W. (1971) *Phytochemistry* **10,** 437.
[11] (a) SAXTON, J. E. (1970) in *The Alkaloids* (MANSKE, R. H. F , ed) Vol. XII, p. 200, Academic Press, New York; (b) GORMAN, A. A , HESSE, M. and SCHMID, H. (1971) in *The Alkaloids*, (SAXTON, J E , ed), Vol. I, p. 200 (Specialist Periodical Reports), The Chemical Society, London.
[12] BURKE, D. E. and LE QUESNE, P. W. (1972) *J. Chem. Soc. Chem. Commun.* 678.
[13] BURKE, D. E., COOK, J. M. and LE QUESNE, P. W. (1973) *J Am Chem Soc.* **95,** 546

column and preparative TLC of the remaining material. They are taken in order of increasing polarity in TLC.

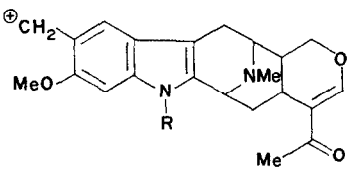
In the least polar fraction were found alstonisine (III), alstonerine (IV), macralstonine (V), and a group of new alkaloids present in very small amounts. Work on the most abundant of these is now described, and structure (IX), des-N'_a-methylanhydromacralstonine, is assigned to it. The alkaloid, m.p. 240–8° (d), $[\alpha]_D$ +10·2°, has molecular formula $C_{42}H_{48}N_4O_4$ from high resolution MS. (M^+ at *m/e* 672·367. $C_{42}H_{48}N_4O_4$ requires: 672·368).



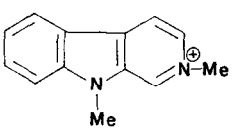
(IX) R = H
(X) R = Me

The UV spectrum is in accord with the presence of indole and substituted methoxy-indole nuclei, and the IR spectrum (ν_{max} 3450 (broad), 1650, 1615 cm^{-1}] suggests the presence of –OH or –NH and acetyl enol ether groups. The enol ether proton gives an NMR singlet at δ7·63, and the 1,4-relationship of two of the six aromatic protons is the same as in macralstonine (V). One indolic –NMe (δ3·58) and two aliphatic –NMe groups (δ2·25, 2·21) are present, and the enol ether acetyl methyl signal is seen at δ2·15. The signal at highest field (3H, *s*, δ1·41) arises from the allylic –Me group of (IX).

The MS closely resembles that of anhydromacralalstonine (X) and unequivocally supports structure (IX). A pair of peaks at *m/e* 307·180 ($C_{20}H_{23}N_2O$ requires: 307·181) and 308·189 ($C_{20}H_{24}N_2O$ requires: 308·189) arises from the unmethoxylated macroline part of the molecule, as in macralstonine (V).[9] The rest of the molecule is represented by a fragment at *m/e* 365·186 ($C_{22}H_{25}N_2O_3$ requires: 365·187) which must have structure (XI). This ion is analogous to the ion (XII) in the MS of macralstonine. The base peak in the spectrum is at *m/e* 197·109 ($C_{13}H_{13}N_2$ requires: 197·108) and represents the well-known ion (XIII).



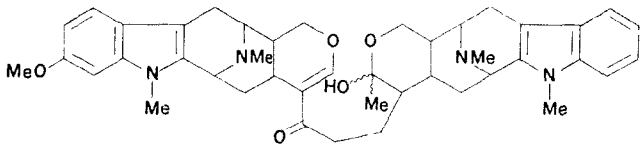
(XI) R = H
(XII) R = Me



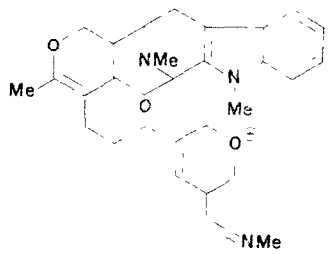
(XIII)

Schmid *et al.*[9] observed in the MS of macralstonine (V) and anhydromacralstonine (X) a peak at *m/e* 486, whose accurate mass corresponded to the formula $C_{30}H_{36}N_3O_3$. They suggested a less likely alternative structure (XIV) for macralstonine on the basis of a possible structure (XV) for this fragment. The MS of our alkaloid contains a peak at *m/e* 472·262 ($C_{29}H_{34}N_3O_3$ requires: 472·260) which seems analogous. No fragment at *m/e* 486 is seen. This suggests that these fragments contain both indolic nitrogen atoms, which would rule out structure (XV) for the *m/e* 486 fragment from macralstonine, and thus Schmid's

less favoured structure (XIV) for macralstonine itself. Chromatographic data suggest that the trace alkaloids accompanying this compound in the fractions may have related structures. Work on them will be reported later.

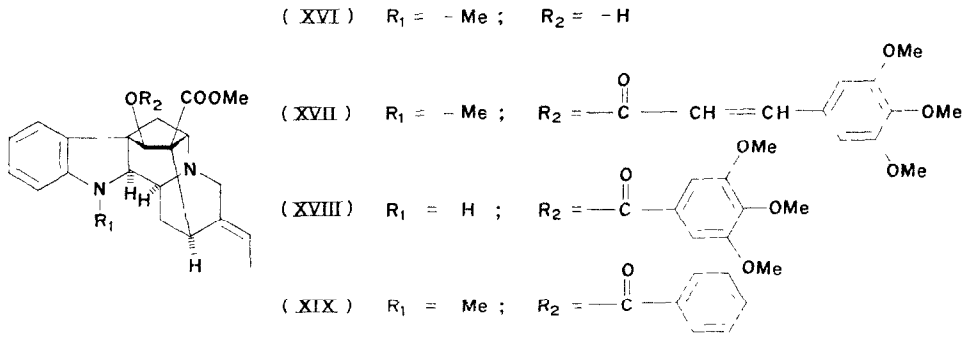


(XIV)



(XV)

The main alkaloid of the next more polar fraction was alstonisidine (IV). This was accompanied by very small amounts of an alkaloid giving an orange colour with ceric sulphate spray reagent. This alkaloid was identical in chromatographic properties and MS with quebrachidine (VII).[14] The isolation of quebrachidine is important in conjunction with the occurrence in the root bark of *A. constricta* of the related ajmaline alkaloids vincamajine (XVI),[15,16] *O*-3,4,5-trimethoxycinnamoylvincamajine (XVII),[16] and *O*-3,4,5-trimethoxybenzoylquebrachidine (XVIII),[16] and of *O*-benzoylvincamajine (XIX) in the leaves of *A. macrophylla*.[17] It also strongly supports the idea that alstonisidine (IV) arises biogenetically by a reaction very similar to its *in vitro* synthesis.[7,13]



(XVI) R_1 = -Me ; R_2 = -H

(XVII) R_1 = -Me ; R_2 = 3,4,5-trimethoxycinnamoyl

(XVIII) R_1 = H ; R_2 = 3,4,5-trimethoxybenzoyl

(XIX) R_1 = Me ; R_2 = benzoyl

A further, more polar, fraction of the alkaloids on resolution by preparative TLC gave three compounds of interest. First, pleiocarpamine (VIII)[18] was identified by comparison of its chromatographic properties and mass spectrum with those of authentic material. Pleiocarpamine has also been isolated from the bark[19] and leaves[20] of *A. macrophylla*, and

[14] GORMAN, M., BURLINGAME, A. L. and BIEMANN, K. (1963) *Tetrahedron Letters* 39.

[15] TROJANEK, J. and HODKOVA, J. (1962) *Coll. Czech. Chem. Commun* **27**, 2981; JANOT, M.-M., LE MEN, J., GROSSET, J. and LÉVY, J. (1962) *Bull. Soc. Chim. Fr.* 1079; see also TAYLOR, W. I. (1957) in *The Alkaloids*. (MANSKE, R. H. F., ed.) Vol. VIII, p. 788, Academic Press, New York.

[16] CROW, W. D., HANCOX, N. C., JOHNS, S. R. and LAMBERTON, J. A. (1970) *Australian J. Chem* **23**, 2489.

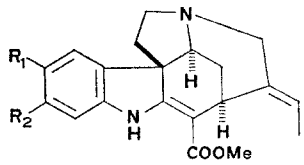
[17] MUKHERJEE, B., RAY, A. B., CHATTERJEE, A. and DAS, B. C. (1969) *Chem Ind. (London)* 1387

[18] HESSE, M., VON PHILIPSBORN, W., SCHUMANN, D., SPITELLER-FRIEDMANN, M., TAYLOR, W. I., SCHMID, H. and KARRER, P. (1964) *Helv. Chim. Acta* **47**, 878

[19] WALDNER, E. E., HESSE, M., TAYLOR, W. I. and SCHMID, H. (1967) *Helv. Chim. Acta* **50**, 1926

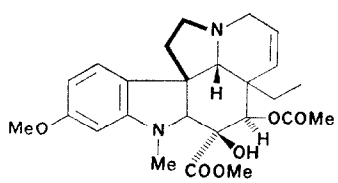
[20] MANALO, G. D. (1968) *Philippine J. Sci* **97** (3), 259.

is obviously the most likely immediate biogenetic precursor of villalstonine (I), as suggested both by degradative[4] and our recent synthetic[12,13] work.

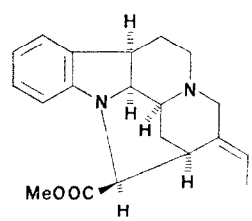


(XX) $R_1 = R_2 = H$
(XXI) $R_1 = OH$; $R_2 = H$
(XXIII) $R_1 = H$; $R_2 = OMe$
(XXIV) $R_1 = H$; $R_2 = OH$

The UV spectrum of the second alkaloid (2-methylene-indoline chromophore) and the high negative optical rotation immediately suggested an akuammicine (XX) or closely related skeleton. The NMR spectrum showed three methoxyl protons in addition to the three of the carbomethoxy-group; that these are from an aromatic methoxy-group was confirmed by the characteristic 1,2,4-pattern of the three aromatic protons (see below). The MS (M^+ at *m/e* 352; $C_{21}H_{24}N_2O_3$ requires: 352) is analogous to that of sewarine (XXI), which has recently been analyzed in detail.[21] The fine structure of the NMR 1,2,4-pattern mentioned above ruled out, however, a sewarine derivative, but was quite similar to that of vindoline (XXII).[21] This suggests that the alkaloid is identical with vinervinine (XXIII), which has been obtained with its parent phenol vinervine (XXIV) from *Vinca erecta*.[22,23] The identity was confirmed by reduction of our alkaloid with zinc dust and sulphuric acid[24] to give the 2,16-dihydroderivative, whose MS was in full accord with the literature.[22,25] The occurrence of this *Strychnos* alkaloid in *A. muelleriana* is interesting in the light of the presence of N_a-methyl-2,16-dihydroakuammicine in *A. macrophylla*.[26]



(XXII)



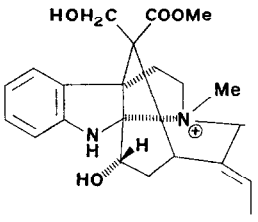
(XXV)

Also obtained from the most polar fraction was an alkaloid having R_f 0·13, giving a red colour with ceric sulphate. This was identified as 2,7-dihydropleiocarpamine (XXV)[18] by direct comparison with authentic material prepared from reduction of pleiocarpamine derived from villalstonine;[4] this compound appears not to have been identified previously in nature.

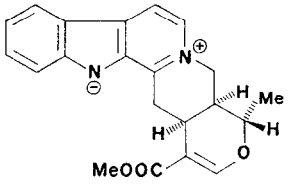
[21] AHMAD, Y., LE QUESNE, P W. and NEUSS, N. (1971) *J. Pharm. Sci* **60,** 1581
[22] YULDASHEV, P K , UBALV, U., KUCHENKOVA, M. A. and YUNUSOV, S YU. (1965) *Khim Prirod. Soedin.* **1,** 34
[23] ABDURAKHIMOVA, N., YULDASHEV, P. K. and YUNUSOV, S YU. (1967) *Dokl Akad. Nauk SSSR* **173,** 87.
[24] GILBERT, B , DUARTE, A P., NAKAGAWA, Y , JOULE, J. A , FLORES, S. E , BRISSOLESE, J. A., CAMPELLO, J , CARRAZZONI, E P , OWELLEN, R. J , BLOSSEY, E. C , BROWN, JR , K S and DJERASSI, C (1965) *Tetrahedron* **21,** 1141.
[25] BUDZIKIEWICZ, H., WILSON, J. M , DJERASSI, C., LEVY, J , LE MEN, J. and JANOT, M -M (1963) *Tetrahedron* **19,** 1265.
[26] KAHN, Z. M , HESSE, M. and SCHMID, H. (1967) *Helv. Chim. Acta* **50,** 1002.

DISCUSSION

Despite a relatively rich body of data from alkaloidal investigations, the phytochemistry of the Apocynaceae is strikingly incomplete. Points made here are regarded as tentative, and as guidelines for further work.

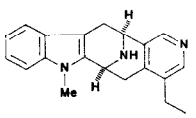


(XXVI)

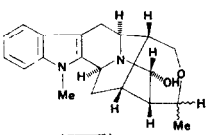


(XXVII)

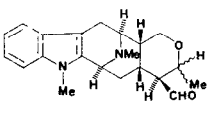
The genus *Alstonia* is accompanied in the tribe Alstonieae (subfamily Plumerioideae) of the Apocynaceae by other genera which are also important sources of indole alkaloids, e.g. *Aspidosperma*, *Catharanthus*, and *Rhazya*.[27] Within *Alstonia*, Monachino[28] made five sectional grouping of the 39 species and 12 varieties he discussed. Pichon's approximately contemporaneous treatment[29] of the genus is generally in good accord with this. Sharp in 1934 had made the first correlation[30] between alkaloidal constituents and geographical distribution in *Alstonia* species, dividing them into three groups: (1) those containing echitamine (XXVI), being many species from Africa, the East Indies, and Australia; (2) those containing villalstonine (I), a number of species from Australia and the East Indies; and (3), *A. constricta*, which contains alstonine (XXVII). The literature of *Alstonia* constituents[11,31] accumulated since 1934 generally supports Sharp's divisions. His first group corresponds well with species in Monachino's sections Pala and Blaberopus. The section Monuraspermum contains all the bisindole alkaloid-bearing species so far delineated, except for *A. constricta* (Dissuraspermum), which produces a bisindole alkaloid whose structure is under investigation.[32]



(XXVIII)



(XXIX)



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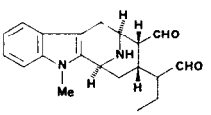

(XXXI)

Our work so far establishes a very close relationship between *A. muelleriana* and *A. macrophylla*. The former species, however, like *A. constricta*, produces ajmaline alkaloids as well as the sarpagine-related macroline group. Much more will need to be known about the minor constituents of other species before a definitive picture of relationships at the infrasectional level can emerge. The structural relationships of the alkaloids—all 'Class I' compounds in Schmid's recent classification[33]—will be valuable here.

[27] HEGNAUER, R. (1964) *Chemotaxonomie der Pflanzen*, Bd. 3, S. 136, Birkhauser, Basel.
[28] MONACHINO, J. (1949) *Pacific Sci.* **3**, 133.
[29] PICHON, M. (1949) *Mem. Mus. Hist Natl. (Paris)*, N.S. **27**, 153.
[30] SHARP, T. M. (1934) *J. Chem. Soc.* 1227.
[31] COOK, J. M. (1971) Ph.D. Thesis, University of Michigan, Ann Arbor, Michigan.
[32] LAMBERTON, J. A., COOK, J. M. and LE QUESNE, P. W., unpublished work.
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It is interesting that several compounds characteristically regarded as *Alstonia* alkaloids have recently been obtained from other genera. In addition to the instances cited by Saxton[11a] involving *Catharanthus roseus* and *Rauwolfia vomitoria*, it is notable that the macroline-related alkaloid suaveoline (XXVIII) has been isolated from *Rauwolfia suaveolens*,[34] while talpinine (XXIX) and talcarpine (XXX) have been obtained from *Pleiocarpa talbotii*.[35] Suaveoline seems not to be an artefact of isolation,[34] although the amount obtained is greater when ammonia is used in the extraction procedure. This suggests that perhaps a 1,5-dioxygenated precursor such as (XXXI) may exist in the plant as well; this possibility has sound precedent.[36]

The isolation of macroline alkaloids from genera other than *Alstonia* is important because these characteristic compounds, still of restricted occurrence, may serve as excellent markers in chemotaxonomic studies. A related question of prime interest is the occurrence and nature of biogenetic precursors of the macroline alkaloids encountered so far. Further work on minor constituents of macroline alkaloid-bearing plants will be needed and will relate to current biogenetic hypotheses.[31,33] We hope to report further results in due course.

EXPERIMENTAL

Microanalyses were performed by Spang Microanalytical Laboratory, Ann Arbor, Michigan. M.ps were taken in a Thomas-Hoover capillary apparatus and are uncorrected. NMR spectra were recorded on Varian A-60, A-60A, T-60, and HA-100 spectrometers Analytical TLC plates used were E. Merck-Brinkmann or Eastman UV-active silica gel on plastic. Preparative TLC plates were E. Merck-Brinkmann 2 mm or 0·5 mm silica gel on glass. Colour reactions (CR) were obtained by spraying plates with a saturated solution of cerium (IV) sulphate in 1:1 (v/v) aq. H_2SO_4.

Extraction of Alstonia muelleriana Bark. The dried, ground bark (100 kg) was mixed with heptane (120 l.) and allowed to soak for 6 days. After the heptane had been filtered off the bark was soaked, with occasional warming and mixing, in MeOH (80 l.) for 5 days. The methanolic extract, which contained some H_2O and heptane, was concentrated to *ca.* 8 l. (wt 16 kg). This extract (300 g) was dissolved in MeOH (1·2 l.) and 0·2 N H_2SO_4 (2 l.) added. The resulting dark suspension was filtered through celite, and the filtrate basified with ammonia to pH 9 and extracted with $CHCl_3$ (3 × 1 l.). The $CHCl_3$ layer was dried ($MgSO_4$), filtered through celite, and concentrated under reduced pressure to give a brown, friable glass (75 g). This material (50 g) was quickly refined by chromatography on alumina (Merck and Co.; alumina for chromatography; 450 g) with $CHCl_3$. Rapid development with this solvent gave the alkaloidal constituents, mixed, as a colorless foam (33·5 g). Elution of the column with MeOH gave unidentified intractable polar non-alkaloidal material (~6 g).

Isolation of villalstonine (I). The mixed refined alkaloidal constituents (4·0 g) were placed on an alumina column (75 g, heated at 200° for 12 hr) packed in C_6H_6. The column was eluted in 40 ml fractions with C_6H_6 (600 ml); 10% $CHCl_3$–C_6H_6 (100 ml); 20% $CHCl_3$–C_6H_6 (100 ml); 30% $CHCl_3$–C_6H_6 (100 ml); and 40% $CHCl_3$–C_6H_6 (100 ml). The fractions shown by analytical TLC (SiO_2 gel, acetone) to contain only villalstonine (Nos. 3–37) were combined and solvent removed to give pure amorphous villalstonine (2·8 g) as a colourless foam, which crystallized from the minimum amount of hot acetone to give material of properties identical with those previously recorded.[2,4] Beginning with fraction 38, when the other alkaloids began to elute as judged by analytical TLC, the solvent was changed to pure $CHCl_3$, and the remaining alkaloids, together with a small amount of villalstonine, were obtained after removal of solvent as a pale tan-coloured foam (1·2 g).

Separation of the minor alkaloids. Chromatography of the above material on 2·0 mm SiO_2 gel plates with acetone gave several groups of bands. These were treated as follows: *Least polar compounds*. The band of highest R_f (~0·75) on the above plate was excised, and stirred with 5% MeOH–$CHCl_3$ for 8 hr at 20°. This mixture of alkaloids (200 mg/per plate) was rechromatographed on a 2·0 mm SiO_2 gel plate with 10% acetone–CH_2Cl_2. After several developments, optimum resolution was achieved, and the bands were excised and extracted as above. The following alkaloids were obtained: alstonerine (II)[2] (CR pale blue), alstonisine (III)[2] (CR red → blue) and macralstonine (V)[9,10] (CR blue → brown), of identical properties to those given

[34] MAJUMDAR, S. P., POTIER, P. and POISSON, J. (1972) *Tetrahedron Letters* 1563.
[35] NARANJO, J., PINAR, M., HESSE, M. and SCHMID, H. (1972) *Helv. Chim. Acta* **55**, 752.
[36] See, for example, WILDMAN, W. C., LE MEN, J. and WIESNER, K. (1969) in Cyclopentanoid Terpene Derivatives (TAYLOR, W. I. and BATTERSBY, A. R., eds.), p. 239, Marcel Dekker, New York.

in the literature, and N'_a-desmethylanhydromacralstonine (X) (CR blue → brown). This compound crystallized from MeOH as needles: m.p. 240–8° (d); $[\alpha]_D$ + 10·2 (*c* 0·58, in $CHCl_3$) UV λ_{max}^{EtOH} 230, 285, 305, 318 nm (ϵ 67 600, 19 000, 10 400, 5 650); IR $\nu_{max}^{CHCl_3}$ 3480 (N–H, *b*), 1660 (α,β-unsaturated ketone), 1630 (enol ether, –C=C); NMR given in text. MS. M^+ *m/e* 672·367; ($C_{42}H_{48}N_4O_4$ requires: 672 368); 658(48), 657(60), 603(46), 602(48), 533(52), 521(44), 473(44), 472(74), 404(76), 403(94), 366(50), 365(80), 364(74), 337(48), 336(84), 309(68), 308(88), 307(78), 274(28), 266(44), 265(50), 253(64), 252(46), 251(76), 250(72), 248(26), 241(80), 240(84), 239(94), 238(92), 237(66), 236(30), 227(62), 226(92), 225(93), 224(52), 223(56), 222(30), 220(38), 213(70), 212(84), 211(64), 210(71), 209(51), 208(82), 200(46), 199(71), 198(90), 197(100), 196(80), 195(77), 194(94), 192(52), 186(28), 184(68), 183(82), 182(88), 181(83), 180(76), 172(40), 171(90), 170(92), 169(56), 168(64), 167(50), 158(74), 157(48), 154(46). At least three other compounds were seen in small quantities near the band for this alkaloid and gave the same colour reaction.

Compounds of intermediate polarity. A second group of bands in the analytical TLC of the original mixture of bases from which villalstonine had been removed occurred at R_f ~0·45. This band was excised from the preparative TLC, and the alkaloids removed by stirring the adsorbent with EtOAc for several hours at 20°. Rechromatography of the fraction on a 2·0 mm SiO_2 gel plate with acetone gave alstonisidine (IV)[2] (CR cherry red) R_f 0·49 (150 mg from 4 g of the original complex alkaloid mixture) and very small amounts (2–3 mg) of quebrachidine (VII),[14,37] (CR orange) (R_f 0·42) of identical properties to those published, and to authentic samples.

More polar compounds. The most polar group of bands in the original preparative layer chromatogram (R_f ~0·25 in the analytical TLC) was isolated by extraction with EtOAc (Soxhlet, 7 hr), and was rechromatographed with acetone on a 2·0 mm SiO_2 gel plate. Three compounds were obtained by extraction of the bands as above; pleiocarpamine (3 mg) (VIII)[18] (CRpink, R_f 0·29), (5 mg), identified by comparison with authentic material prepared from villalstonine (I);[4] 2,7-dihydropleiocarpamine (XXV)[18] (CR red, R_f 0·13) (3 mg), identified by comparison with authentic material;[18] and a third alkaloid (CR dark blue, R_f 0·20) (3 mg.) This was identified as vinervinine (XXIII),[22,23] from the data below, but not by direct comparison. The alkaloid had $[\alpha]_D$ EtOAc −505°; UV λ_{max}^{MeOH} 232, 305, 324 (ϵ 11 500, 5620, 6525) λ_{min} 273 (ϵ 2295); IR $\nu_{max}^{CHCl_3}$ 3380 (N–H), 1670 (C=O), 1600 (C=C–N) cm^{-1}; NMR (CD_3COCD_3) δ 1·6 (3H, *d*, *J* 7 Hz), 3·75 (6H, *s* 2 × OMe), 5·3 (1H, q), 6·5 (1H, *d* of *d*, *J* 8 Hz, *J* 2 Hz), 6·7 (1H, *d*, *J* 2 Hz), 7·35 (1H, *d*, *J* 8 Hz); NMR ($CDCl_3$) δ 6·7 (2H, *m*), and 7·0 (1H, *d*, *J* 8 Hz). MS. M^+ 352 (21·8), 337(3), 321(3), 293(4), 282(7), 277(4), 268(3), 265(3), 264(4), 263(3), 255(3), 250(7), 246(8), 239(3), 238(4), 237(3), 236(5), 232(4), 224(6), 223(8), 222(7), 220(4), 211(5), 210(5), 205(7), 199(5), 194(7), 193(6), 192(7), 186(12), 180(10), 176(7), 167(13), 160(5), 154(9), 153(6), 152(7), 141(5), 140(5), 139(6), 135(9), 121(100), 106(9), 97(10). The alkaloid (2 mg) was reduced with Zn/H_2SO_4 as described,[22] and the product, which was homogeneous, on TLC (analytical SiO_2 gel plates, R_f 0·1, CR magenta), subjected to MS. MS. M^+ 354(42, 339(6), 323(11), 295(10), 282(10), 281(35), 265(10), 224(9), 215(12), 210(10), 200(15), 199(19), 198(11), 197(18), 196(14), 195(21), 194(100), 186(27), 174(90), 173(65), 160(80), 139(60), 130(27), 122(25), 117(30). Although the alkaloid was obtained in minute amount and an authentic sample was not at hand, the above data are fully consistent with the structure (XXIII).

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[37] HESSE, M. (1964) *Indolalkaloide in Tabellen*, Springer, Berlin.