NMR, and UV analysis to be polygodial (1).

Reduction of Olepupuane (3) with Lithium Aluminum Hydride. Lithium aluminum hydride (10 mg) was added to a solution of olepupuane (3; 0.5 mg, 0.002 mmol) in dry THF (5 mL), and the reaction mixture was stirred at 0 °C for 35 min. excess reagent was destroyed with ethyl acetate, and the reaction products were partitioned between dichloromethane (4 × 5 mL) and 5% aqueous hydrochloric acid (10 mL). The combined dichloromethane extracts were dried over sodium sulfate, and the solvent was evaporated to yield a crude product that was purified by LC on Partisil with ethyl acetate as the eluant to yield the diol 6: 0.3 mg (85% theoretical); IR (neat) 3340 cm^{-1}; ^1H NMR (CCl_4) δ 5.70 (m, 1 H, J = 3, 3, 1 Hz), 4.20 (dd, 1 H, J = 12, 1 Hz), 3.87 (d, 1 H, J = 12 Hz), 3.78 (dd, 1 H, J = 11, 2 Hz), 3.57 (dd, 1 H, J = 11, 8 Hz), 0.88 (s, 6 Hz), 0.75 (s, 3 H); mass spectrum, m/z (relative intensity) 238 (M^+, 10), 220 (5), 207 (8), 191 (90), 190 (100).

Reduction of Methoxy Acetal 4 with Lithium Aluminum Hydride. By use of the method described above, a solution of methoxy acetal 4 (1 mg, 0.003 mmol) in tetrahydrofuran (5 mL) was reduced with lithium aluminum hydride (10 mg) at 0 °C to yield the diol 6 (0.7 mg, 91% theoretical), having spectral data identical with those of the authentic material.[12]

Acknowledgment. We thank Scott Johnson (Hawaii) and James R. Lance (La Jolla) for identification of the nudibranchs. P.J.S. thanks Dr. Gary Schulte for collection, Drs. Schulte and Robin Kinnel for helpful discussions, Lars Bergknut and Karl Yanagihara for mass spectral determinations, and the Southern California Regional NMR Facility (W. Croasmun, Director) for an NOE experiment. This research was supported by grants from the National Science Foundation (to P.J.S. and D.J.F.) and from the University of Hawaii Sea Grant College Program.

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Occurrence of Longicaudatine, a New Type of Bis-Indole Base and Bisnor-C-alkaloid H in *Strychnos* Species

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The structure of longicaudatine, a novel bis-indole alkaloid isolated from several *Strychnos* species, has been elucidated chiefly by 400-MHz ^1H NMR and ^{13}C NMR spectroscopy. In some species this alkaloid co-occurs with bisnor-C-alkaloid H, an isomeric base which has similar chromatographic and chromogenic properties.

During the screening of Asian *Strychnos* material, tertiary alkaloid extracts from the root bark of *S. axillaris* Colebr., *S. ignatii* Berg., and *S. nux-vomica* L. were observed to include several minor components which on thin-layer chromatograms immediately colored blue when sprayed with iron(III) chloride–perchloric acid reagent.[1] One of these blue-coloring bases was later isolated from the root bark of *S. nux-vomica*,[2] but the minute amount obtained at the time precluded any attempt to determine the structure. A further quantity of the compound has now been obtained from the root bark of *S. lucida* R.Br.,[3] and it is also present in *S. wallichiana* Steud. ex DC.[4] The substance appears to be identical with an alkaloid occurring in greater amount in the stem bark of the African species *S. dolichothyrsa* Gilg ex Onochie et Hepper[5] and also detected in *S. urceolata* Leeuwenberg,[6] *S. afzelii* Gilg,[7] and *S. chrysophylla* Gilg.[4]

The various products have proved to be closely related to, if not identical with, each other. Initially, the spec-

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(1) (a) Bisset, N. G.; Phillipson, J. D. *Lloydia* **1976**, *39*, 263. (b) Bisset, N. G.; Başer, K. H. C.; Phillipson, J. D.; Bohlin, L.; Sandberg, F. *Ibid.* **1977**, *40*, 546.
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(7) Verpoorte, R.; Kodde, E. W.; van Doorne, H.; Baerheim Svendsen, A. *Planta Med.* **1978**, *33*, 237.

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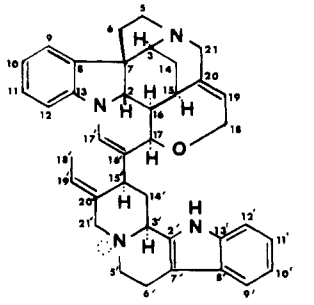
troscopic data were interpreted as indicating that the compound had the structure of the dimeric base bisnor-C-alkaloid H, but acid hydrolysis experiments established that, in fact, two dimeric alkaloids were involved. Reevaluation of the data was in progress when the draft of a proposed paper by the French group was received. This independent study revealed that the root bark of *S. longicaudata* Gilg from Zaire is an important source of the two blue-coloring dimeric alkaloids: one was identified as a novel type of dimer, for which the name longicaudatine is proposed, and the other as bisnor-C-alkaloid H.[8] Longicaudatine has also been isolated from the root bark of *S. ngouniensis* Pellegr.[8] Subsequent comparison have shown that the various research groups have been working with one or the other or both of these compounds, and in order to avoid unnecessary duplication in the literature, this joint paper is being published.

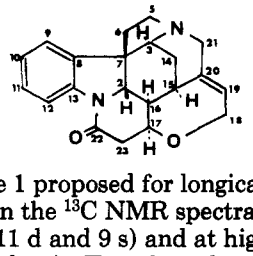
Results and Discussion

Longicaudatine (1). In its mass spectrum this alkaloid shows a molecular ion at m/z 568 which analyses for $C_{38}H_{40}N_4O$ (calcd m/z 568.320, found m/z 568.318). Major fragments are seen at m/z 249, 250, 251, and 319; the first three of these peaks are typical for indoloquinolizidines such as usambarensine.[9] In the IR spectrum there are absorption bands due the the presence of NH (3420 and 3290 cm^{-1}) and double bonds (1630 and 1600 cm^{-1}).



1

A more detailed understanding of the structure of the molecule has been gained from its 400-MHz ^1H NMR spectrum in which most of the hydrogens give separated resonances. Signals for eight aromatic hydrogens, an exchangeable NH (at δ 9.6), and an ethylidene side chain (q, δ 5.60; d, δ 1.50) are observed. Other lower field signals are those assigned to H-17′ (s, δ 6.06) and to the system of mutually coupled hydrogens CH(19)–CH_2(18)–O (brt, δ 6.08; 2 dd, δ 4.25 and 4.45) previously recognized in the spectra of strychnine (2)[10] and related alkaloids. The assignments of the ^1H NMR spectrum presented in Table I are based on extensive decoupling experiments.



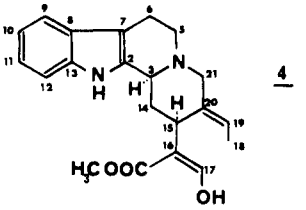
2

The structure 1 proposed for longicaudatine is based to a great extent on the ^{13}C NMR spectra. At low field there are 20 signals (11 d and 9 s) and at higher field 18 signals (1 q, 9 t, 7 d, and 1 s). Together, these account for the 38 carbons in the molecule. Apart from the slight discrepancies caused by the attachment between the two halves of the molecule, there is general agreement between the ^{13}C NMR spectra of the pertinent parts of strychnine (2), geissoschizine (4), and longicaudatine (1) (Table II). The

Table I. Longicaudatine (1) and Strychnine (2) 400-MHz ^1H NMR Spectral Data (Selected Values Only)

atoms	chemical shift,[a] δ (2)	(1)
H-2	3.85	3.62 (d, 14)
H-3	3.92	3.83 (br t)
H-5a	3.18	3.15 (dd, 15, 5)
H-5b	2.86	2.64 (ddd, 15, 7, 1.5)
H-6a	1.87	1.67 (dd, 12, 5)
H-6b		1.60 (ddd, 12, 7, 1.5)
H-14a	2.34	2.30 (m)
H-14b	1.43	1.41 (br d)
H-15	3.13	3.17 (m)
H-16	1.25	1.48 (dt, 12, 2.5)
H-17	4.27	4.10 (d, 2.5)
H-18a	4.05	4.25 (dd, 14, 6)
H-18b	4.13	4.45 (dd, 14, 7)
H-19	5.88	6.08 (br t)
H-21a	3.69	3.75 (br d, 15)
H-21b	2.71	2.80 (br d, 15)
H-3′		4.20 (bt)
H-15′		3.40 (t, 5)
H-17′		6.06 (s)
H-18′		1.50 (d, 7)
H-19′		5.60 (q, 7)
H-21′a		3.07 (br d, 13)
H-21′b		3.60 (br d, 13)

[a] Multiplicities and coupling constants (in hertz) are given in parentheses.



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signals due to the strychnan half also show much similarity with the spectrum of bisnordihydrotoxiferine (3a) (Table II).[11]

The absence of low-field aminomethylene signals suggests a *cis*-quinolizidine arrangement for the corynanthean part of longicaudatine, as in geissoschizine,[12] geissospermine,[13] and various other yohimbine- and heteroyohimbine-type alkaloids.[14] That the relative configuration of the strychnan part is the same as in strychnine is clear from the NMR spectra: by the excellent agreement between the chemical shifts of C-2, C-3, C-7, and C-15 in longicaudatine and strychnine and by the observation of the appropriate coupling constants between H-2, H-16, and H-17.[10]

Bisnor-C-alkaloid H (3b). The second blue-coloring alkaloid isolated is isomeric with longicaudatine. Its mass spectrum shows a molecular ion at m/z 568 and fragments are observed at m/z 550 ($M^{+\cdot}$ – 18), 537 ($M^{+\cdot}$ – 31), and 430 ($M^{+\cdot}$ – 138); this fragmentation pattern is similar to

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Table II. ^{13}C NMR Spectral Data of Longicaudatine (1), Strychnine (2), Bisnordihydrotoxiferine (3a), and Geissoschizine (4)

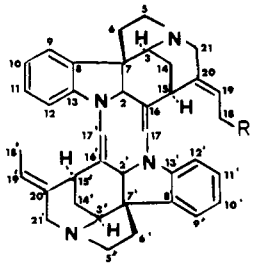
atom	chemical shift,[e] δ 1	2	3a	atom	chemical shift,[e] δ 1	4
C-2	60.5	60.1	72.3	C-2′	134.3[a]	132.8
C-3	59.9	60.1	68.0	C-3′	54.7	53.6
C-5	51.4[b]	50.2	52.8[c]	C-5′	51.4[b]	50.5
C-6	39.9	42.8[d]	42.6	C-6′	18.3	20.4
C-7	51.0	51.9	54.3	C-7′	108.1	108.1
C-8	136.9[a]	132.6	137.2	C-8′	127.8	126.4
C-9	119.4	122.3	119.1	C-9′	117.9	118.2
C-10	122.6	124.3	122.6	C-10′	118.9	119.6
C-11	128.1[e]	128.6	128.2	C-11′	121.8	121.9
C-12	108.5	116.3	107.0	C-12′	110.5	110.9
C-13	147.0	142.2	146.1	C-13′	135.6[a]	136.5
C-14	27.1	26.8	24.5	C-14′	32.3	33.8
C-15	32.2	31.5	29.8	C-15′	38.6	27.7
C-16	42.7	48.2	117.8	C-16′	116.5	107.5
C-17	82.6	77.5	129.9	C-17′	127.0[e]	161.5
C-18	64.9	64.6	12.9	C-18′	13.1	13.1
C-19	126.2	127.7	115.8	C-19′	120.7	121.9
C-20	142.1	140.3	141.1	C-20′	132.0[a]	133.1
C-21	53.2[b]	52.7	54.8[c]	C-21′	55.4[b]	59.1
C-22		42.3[d]				

[a-d] These values may be interchanged. [e] Chemical shifts are relative to Me_4Si.

Table III. Occurrence of Longicaudatine and Bisnor-C-alkaloid H in *Strychnos* Species

species	longicaudatine identified by TLC	UV	IR	MS	^1H NMR	^{13}C NMR	bisnor-C-alkaloid H identified by TLC	UV	IR	MS	^1H NMR
S. longicaudata	+	+	+	+	+	+	+	+	+	+	+
S. ngouniensis	+	+	+	+	+						
S. lucida	+	+	+	+	+						
S. ignatii	+	+		+	+						
S. nux-vomica	+	+	+	+							
S. wallichiana	+	+	+	+	+	+					
S. chrysophylla	+										
S. dolichothyrsa	+	+	+	+	+	+	+	+		+	+
S. afzelii	+	+	+	+	+	+	+	+		+	+
S. urceolata	+	+		+			+				

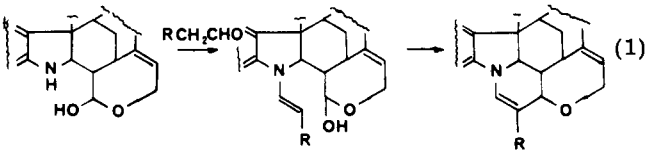
that given by the toxiferine derivative alcuronium.[15] The UV spectrum of bisnor-C-alkaloid H shows the presence of the typical toxiferine-type chromophore, and the IR spectrum is like that of longicaudatine in having absorption bands at 1640 and 1600 cm^{-1} (enamine system). The ^1H NMR spectrum has two singlets at δ 6.27 and 6.33 (H-17 and H-17′), a triplet at δ 5.57 (H-19), a quartet at δ 5.36 (H-19′), a singlet at δ 5.34 (H-2 and H-2′), a doublet at δ 4.33 (H-18), and a multiplet at δ 3.70 (H-15 and H-15′). These data accord well with those for bisnordihydrotoxiferine (**3a**), taking into account the effects of the hydroxyl group introduced at C-18.[16] Further evidence for the structure **3b** has been obtained by acid hydrolysis,



3 a R=H
b R=OH

which yields two monomers, Wieland–Gumlich aldehyde and 18-deoxy Wieland–Gumlich aldehyde, both identified by co-TLC with reference samples and by using various solvent systems and the selective spray reagents iron(III) chloride in perchloric acid and cerium(IV) sulfate in sulfuric acid. Similar treatment of longicaudatine does not result in any noticeable hydrolysis.

The occurrence of the two isomeric alkaloids is summarized in Table III. Longicaudatine (1) is found in species containing mainly toxiferine-type alkaloids but also in those having only strychnine-type alkaloids. It is the first bis-indole alkaloid similar to geissospermine to be isolated from the genus *Strychnos* and is probably formed by an enamine coupling between geissoschizal and Wieland-Gumlich aldehyde (see eq 1); both alkaloids are



(1)

known to be present in *S. nux-vomica*.[17] Bisnor-C-alkaloid H (**3b**) occurs in plants together with the other two tertiary toxiferine-type dimers bisnordihydrotoxiferine (**3a**) and caracurine V. Only longicaudatine has been detected in the Asian species of *Strychnos*, and there is no evidence as yet for the concomitant presence of bisnor-C-alkaloid H. The blue-coloring alkaloid noted on the chromatograms of *S. axillaris* extracts is more polar than either of the two compounds described here, and the elucidation of its structure awaits more detailed investigation.

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Longicaudatine has strong reserpine-like activity, which is different from the activities described by Sandberg et al.[18] for fractionated extracts of *S. longicaudata*.

Experimental Section

Longicaudatine (1): mp 350 °C dec; $[\alpha]_D$ +141° (*c* 0.5, $CHCl_3$); UV λ_{max} 223 nm (log ϵ 4.66), 270 (sh), 284 (4.28), 290 (4.26), 307 (sh, 3.97); in perchloric acid a strong absorption maximum appears at 268 nm; IR λ_{max} (KBr) 3420, 2900, 1630, 1600, 1480, 740 cm^{-1}. The 400-MHz ^1H NMR spectrum was recorded in $CDCl_3$ on material containing 0.25 molecule of acetone of crystallization (Table I). ^{13}C NMR spectra were recorded at 62 and 25.15 MHz, in $CDCl_3$. Proton-noise-decoupled, off-resonance-decoupled, and selective decoupled (δ 9.6, 6.06, and 4.27 in the ^1H NMR spectrum) spectra were determined (see Table II). On TLC plates a blue color is obtained with the spray reagents 0.2 M iron(III) chloride in 35% aqueous perchloric acid and 1% cerium(IV) sulfate in 10% aqueous sulfuric acid.

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Bisnor-C-alkaloid H (3b): UV λ_{max} 293, 322 nm (sh); IR ν_{max} (KBr) 2920, 1640, 1600, 1480, 1460, 740 cm^{-1}. The 300-MHz ^1H NMR spectrum was recorded in $CDCl_3$ (see text). On TLC plates a blue color was obtained with the spray reagent 0.2 M iron(III) chloride in 35% aqueous perchloric acid and a purple color with 1% cerium(IV) sulfate in 10% aqueous sulfuric acid.

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Photodimerization of Coumarins in Micelles: Limitations of Alignment Effect

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Organized media such as micelles have shown great promise in achieving regio- and stereoselectivity in photochemical cycloaddition reactions as has been shown by recent reports. 7-Alkoxy- and 4-methyl-7-alkoxycoumarins dimerize in organic solvents to give the syn head–tail dimer. However, dimerization of these coumarins in SDS and CTAB micelles did not show any reversal in this trend. The results probably indicate that the micellar orientational effect is most effective only in those systems where the forces that control regiochemistry are weaker than hydrophobic association energies.

Photochemical cycloaddition is a useful synthetic tool which has been frequently exploited.[1] The two possible orientations commonly referred to as the head–head and head–tail regioisomers are formed in a variable ratio during the photoannelation of cyclopentenones and cyclohexenones.[2] Some control may be achieved by substitution in the enone or by variation of solvent polarity. Very recently, micellar alignment effects have been utilized to bring about regioselectivity during photoannelation reactions. This has been demonstrated in the case of cyclopentenones,[3] cyclohexenones,[4] and pyridinones.[5] Enhancement of regioselectivity during the dimerization of 9-(hydroxymethyl)anthracene has recently been observed.[6] Thus, the feasibility of exploiting preorientational effects of the micellar structure for selective synthesis has been demonstrated. Results of our study on 7-alkyl- and 4-methyl-7-alkoxycoumarins presented below demonstrate the limitations of micellar effects on photoannelation reactions.

Coumarins have been chosen for our investigation as their photochemical behavior is fairly well understood,[7,8] and therefore the environmental influence which is the subject of our concern would be easily understandable. Recently, we have demonstrated the use of micelles in enhancing the reactivity of coumarin and bringing about stereoselective dimerization.[9] This was attributed to the micellar polarity effect. Presently, we have chosen 7-alkoxy- and 4-methyl-7-alkoxycoumarins to study the micellar orientational effect. Our choice was dictated by the fact that 7-methoxy- and 4-methyl-7-methoxycoumarins generally give head–tail dimers upon excitation in organic solvents. Unlike the earlier systems studied,[3-5] these do not exhibit polarity-dependent product distribution, and therefore polarity effects of micelles can be excluded. Micellar solubilized 7-alkoxy- and 4-methyl-7-alkoxycoumarin molecules are expected to be arranged in such

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