that the other monocotyledons were derived from palms. He discusses the idea that palms exemplify the "features of monocotyledony" better than any other plants and concludes that while geologically there is little evidence concerning the antiquity of the Palmae, in morphological structure such evidence is found. The palm leaf is thought by Corner to betray in its morphological development the manner in which the monocotyledonous leaf is evolutionarily connected with the dicotyledonous leaf. The palm inflorescence, according to Corner, bespeaks an ancestry greater than the age of known fossil palms. The distribution pattern of the Palmae also suggests the antiquity of this family (*19*).

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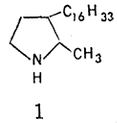
Alkaloid from Fire Ant Venom: Identification and Synthesis

Abstract. *An alkaloid,* trans-*2-methyl-6-*n*-undecylpiperidine (solenopsin A), has been isolated from the venom of the fire ant* Solenopsis saevissima. *The structure has been confirmed by an unambiguous synthesis.*

Reactions of human beings to the sting of the imported fire ant *Solenopsis saevissima* have demonstrated that the venom of this species is an unusual poison, which, in addition to being a potent necrotoxin (*1*), possesses pronounced hemolytic (*2*), phytotoxic (*3*), insecticidal, and antibiotic activities (*4*). The red form of this ant, which is distributed in the United States from North Carolina to Texas, produces a nonproteinaceous venom which is soluble in organic solvents but insoluble in water (*4*).

In 1966, Adrouny (*5*) proposed structures for the principal toxic components of the venom of the red form of the imported fire ant. The structures proposed were 2-methyl-3-hexadecylpyrrolidine (**1**) and the corresponding Δ^3-pyrroline (**2**). In 1967, Sonnet (*6*)



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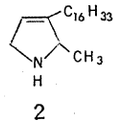

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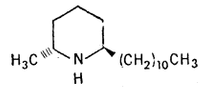
published a synthesis of **1**; gas chromatographic comparison with the ant venom, however, established that neither the *cis* nor the *trans* isomer of **1** was present.

Stimulated by Sonnet's findings, we have undertaken a thorough reexamination of the chemistry of the venom of this ant. We now present evidence that the component of lowest molecular weight (for which we propose the name solenopsin A) is *trans*-2-methyl-6-*n*-undecylpiperidine (**3**, or its mirror image).



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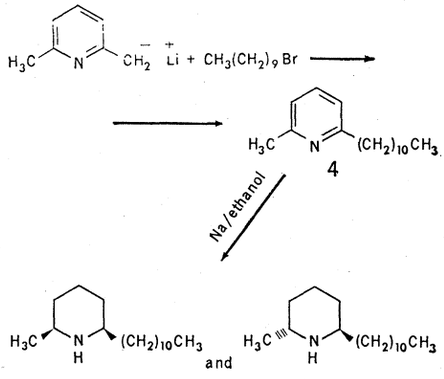
Pure venom was obtained in milligram amounts by "milking" worker ants (*4*); it was stored at about 5°C in hexane solution over anhydrous sodium sulfate. Spot tests suggested the presence of a secondary amine (*7*). The nuclear magnetic resonance (NMR) spectrum (*8*) of the total venom in CCl_4 was τ (tetramethylsilane): 4.73 (distorted triplet, olefinic protons); 6.4 (broad); 6.9 to 7.3, about 8.0, 8.43, and 8.69 (methylene protons); 8.92, 8.98, and 9.08 (triplet, methyl protons). No acidic, aldehydic, aromatic, or *N*-methyl protons were found. Gas chromatographic examination of the total venom indicated the presence of five components with retention times, under the conditions used (*8*), of 6.4, 11.6, 13.0, 23.9, and 27.0 minutes. The mass spectrum of solenopsin A, obtained from combined gas chromatography–mass spectrometry (*8*), exhibited a peak corresponding to the molecular ion at *m/e* (ratio of mass to charge) of 253 [confirmed by chemical ionization mass spectrometry (CH_4), whose most intense signal was at *m/e* 254] and signals at *m/e* 238 (parent ion minus CH_3), 224 (parent ion $- C_2H_5$), and 210 (parent ion $- C_3H_7$), representing cleavage at different points on the methylene chain down to the base peak at *m/e* 98 ($C_6H_{12}N$—confirmed by high resolution).

Both the mass spectrum and the NMR data indicate the presence of a long alkyl side chain. The carbon skeleton of solenopsin A was determined by the method developed by Beroza (*9*). Only normal hydrocarbons were detected among the hydrogenolysis products from the venom. *n*-Heptadecane was among the products and, for solenopsin A, rules out branching in the alkyl side chain and all substitution patterns on a five- or six-membered *N*-containing ring except for a 2,5-disubstituted pyrrolidine or a 2,6-disubstituted piperidine. The former possibility would require either a 2-ethyl- or a 1,2-dimethylpyrrolidine. The infrared spectrum (no solvent between AgCl plates) (*8*) between 3.35 and 3.42 μm favors

the six-membered ring structure (*10*). Also, the occurrence of the base peak at *m/e* 98 is taken in support of the piperidine structure (*11*). The structure arrived at, therefore, is an isomer of 2-methyl-6-*n*-undecylpiperidine.

2-Methyl-6-*n*-undecylpyridine (**4**) was synthesized by alkylation of the lithium salt of 2,6-lutidine with 1-bromodecane (*12*). The alkylated pyridine gave the following nuclear magnetic resonance spectrum (CCl_4, τ) (*8*): 9.12 (distorted triplet, 3 H, terminal methyl group), 8.71 (singlet, 18 H, methylene groups), 7.55 (singlet, 3 H, methyl group on ring), 7.35 (triplet, $J = 7.2$ hz, 2 H, methylene on ring), 3.23 (doublet, 2 H, protons in positions 3 and 5 on ring), and 2.72 (triplet, $J = 8.0$ hz, 1 H, proton in position 4 on ring). This data is in full accord with the expected structure (**4**). High-resolution mass spectrometry established the formula as $C_{17}H_{29}N$ (found, *m/e* 247.2300; calculated, *m/e* 247.2299). Compound **4** was



then reduced with sodium metal in absolute ethanol (*13*). The identity of the major isomer was confirmed by comparison with the product of catalytic hydrogenation (presumably *cis*). The separation of the *cis* and *trans* isomers was achieved by chromatography over alumina, the *cis* eluting in hexane-ether mixtures, and the *trans* eluting only in ether containing 20 percent ethanol. Although the mass spectra of the two isomers were virtually indistinguishable, the infrared spectra allowed easy differentiation: the *cis* isomer exhibits relatively strong absorption near 7.6 μm, the *trans* absorbs only weakly in this region. Except for double-bond absorption showing in the spectrum of the venom (attributable to other components), the infrared spectra of the venom and the synthetic *trans*-2-methyl-6-*n*-undecylpiperidine are superimposable, as are the spectra of the corresponding *N*-acetates (C = O, about 6.1 μm). The amines are eluted with identical retention times from polymethylsiloxane: 3 percent OV-1 (180° C), and 3 percent SE-52 (180°C). The acetates were also indistinguishable on the SE-52 column (200°C). The mass spectra of solenopsin A and the synthetic *trans* compound are identical.

To our knowledge, alkylated piperidines have not been described from venoms of animal origin. The venoms of stinging ants are typically proteinaceous (*14*). 2-Methyl-6-alkylpiperidines occur in some plants, such as pinidine (*15*), cassine (*16*), and carpaine (*17*), but in each case the alkyl groups are *cis* to each other.

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Antagonism by DDT of the Effect of Valinomycin on a Synthetic Membrane

Abstract. *The potassium conductance which is induced by 10^{-6} molar valinomycin in a lecithin-decane membrane is reversed by 3×10^{-6} molar DDT. Membranes not treated with valinomycin are not affected by DDT. This blockade of potassium conductance parallels the effect of DDT on axonic conduction. Dieldrin and lindane, whose physiological actions are in some ways like those of DDT, do not affect valinomycin-induced conductance of lecithin-decane membranes.*

The toxicity of DDT [2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane] is due to its excitatory effect on axons; it blocks the potassium flux associated with the falling phase of the action potential. It has been suggested that there is also an effect on the sodium flux associated with the rising phase (*1*). The prevailing view is that DDT accomplishes these effects by forming complexes in some way with the conducting membrane of the axon (*2*)—for example, perhaps by forming a charge transfer complex (*3*) with a hypothetical ion "gate."

Dieldrin and lindane are structurally quite unlike DDT, although all three are chlorinated hydrocarbons. Both dieldrin and lindane have excitatory effects on axons, and their toxicity is probably caused by such effects; but there are physiological differences in the relative rates of peripheral and central effects, in the form and sequence of excitatory axonic effects, and in temperature coefficients (*4*). There is evidence for complex formation between dieldrin and components of insect nerve (*5*).

We have been seeking ways to explore effects of DDT on membrane systems less complex than the whole axon. Valinomycin can render a synthetic lecithin membrane permeable to K^+ (*6*). We report here that DDT blocks this induced K^+ permeability, suggesting a parallel with its effect on the axon.

The apparatus was a modification of that used by Thompson (*7*) and del Castillo (*8*). Transmembrane resistance was determined by applying a square pulse (100 mv, 50 pulses per second), and by measuring the potential difference between each of two Ag-AgCl electrodes placed in each compartment. After amplification through