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NOVEL DIALKYLPIPERIDINES IN THE VENOM OF THE ANT *MONOMORIUM DELAGOENSE*

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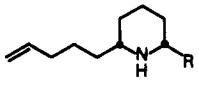
ABSTRACT.—New 2,6-dialkylpiperidines found in the venom of the ant *Monomorium delagoense* include *cis*- and *trans*-2,6-di(4-pentenyl)-piperidine [**2**], *cis*- and *trans*-2-(4-pentenyl)-6-pentylpiperidine [**4**], and *cis*- and *trans*-2-(6-heptenyl)-6-(4-pentenyl)-piperidine [**7**], whose structures were confirmed by synthesis. These compounds possess insecticidal and repellent properties.

A variety of saturated nitrogen heterocycles has been found in the venom of ants in the genera *Solenopsis* and *Monomorium*. The major components of the venoms of fire ants, *Solenopsis* (subgenus *Solenopsis*) species, are 2-alkyl-6-methyl-piperidines, compounds whose pharmacological properties include hemolytic, necrotoxic, and antibiotic activities (1). Species in other subgenera of *Solenopsis* also contain these alkaloids (2). In the same way that 2-alkyl-6-methylpiperidines are characteristic of the venoms of *Solenopsis* species, 2,5-dialkylpyrrolidines predominate in the venoms of *Monomorium* species. In certain species of both genera, the monocyclic alkaloids have been accompanied by 3,5-dialkylindolizidines, although in many *Monomorium* species, the pyrrolidines are concomitant with their 3,5-dialkylpyrrolizidine analogues (3,4).

In the present paper we report the elucidation of a novel group of 2,6-dialkylpiperidines produced by the workers of *Monomorium delagoense* Forel (Hymenoptera: Formicidae), a species whose distribution is limited to southern Africa (5). *M. delagoense* is one of eight species in the *salomonis* group, which is, for the most part, an Afrotropical group found in the southern part of Africa (5). These species, which are limited to xeric habitats, are scavengers or predators on small arthropods.

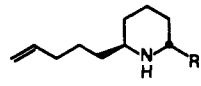
RESULTS

Initial gc-ms examination of the CH_2Cl_2 extracts of whole ant workers revealed the presence of at least seven nitrogen-containing compounds, summarized in Table 1. Because these mass spectra indicated the presence of more than one unit of unsaturation in these compounds, the mixture was hydrogenated over PtO_2. This provided a mixture consisting of at least 90% of a pair of isomers in a 1:3 ratio whose identical mass spectra, *m/z* 225 $[M]^+$ and 154 (100), indicating the presence of fifteen carbons, one unit of unsaturation as a ring, and only the loss of a C_5H_{11} fragment, seemed to indicate 2,6-dipentylpiperidine. This assignment was confirmed by gc-ms comparison with an authentic sample of 2,6-dipentylpiperidine.



cis

2 R=$(CH_2)_3CH{=}CH_2$
7 R=$(CH_2)_5CH{=}CH_2$



trans

4 R=*n*-C_5H_{11}
8 R=*n*-C_7H_{15}

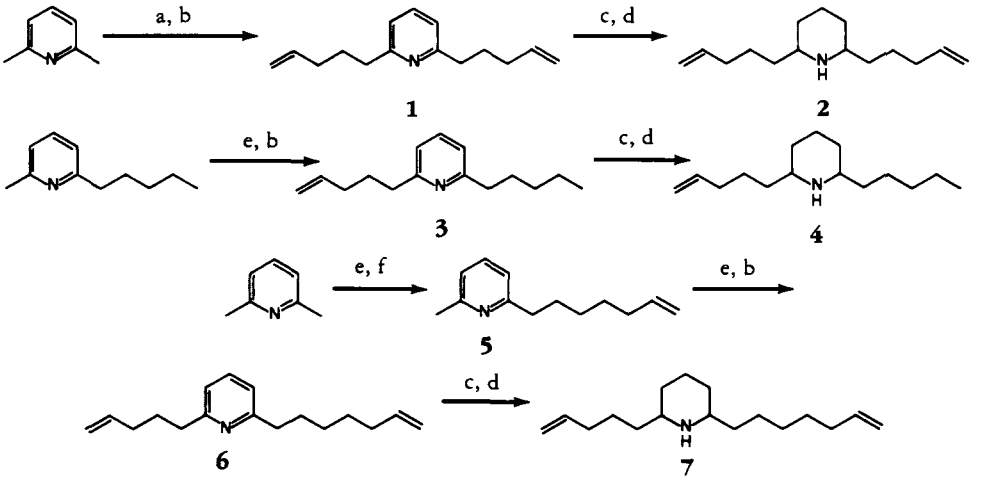
SCHEME 1. Formation and suggested interpretation of the ms of the dimethoxytrifluoroacetyl derivative of **2**.

In order to assign the double bond positions in the *M. delagoense* alkaloids, a small sample of the CH_2Cl_2 extract of the ants was treated with trifluoroacetic anhydride and pyridine, and the resulting mixture of *N*-trifluoroacetamides was subjected to the usual methoxymercuration-demercuration conditions (6). This sequence resulted in a 1:7:1 ratio of three derivatized products whose molecular ions at *m/z* 351, 381, and 409 indicate the incorporation of a trifluoroacetyl and one or two methoxy groups into the natural alkaloids and confirm their olefinic and secondary amine functionality. The molecular fragments that can be assigned from the mass spectrum of the dimethoxy-*N*-trifluoroacetamide derivative of the major *M. delagoense* alkaloid **2** are shown in Scheme 1. The base peak at *m/z* 59 $[CH_3CHOCH_3]^+$ indicates incorporation of the methoxy groups at the penultimate carbon atoms of the side chains, and there are no other fragments indicating the presence of methoxyl groups elsewhere on the side chains. Analogous fragmentation patterns were also observed for the monomethoxy-*N*-trifluoroacetamide derivative **4** of piperidine and for the dimethoxy-*N*-trifluoroacetamide derivative **7** of piperidine.

In order to assign their stereochemistry, synthetic samples of **2**, **4**, and **7** were prepared from the appropriate pyridines (Scheme 2). The 2,6-dialkylpyridines were obtained in moderate yield by alkylation of the lithium salt of 2,6-lutidine anion or, in the case of **1**, by dialkylation of the dilithium salt of 2,6-lutidine dianion (7,8). In these reactions, it was found that slow, inverse addition of the lutidine anion to a solution of the alkyl bromide improved the yield and reduced the number of side products.

Reduction of the dialkylpyridines with sodium in EtOH provided a mixture of cis and trans piperidines (8). In some cases, initial gc-ms examination of the product mixtures from the sodium/EtOH reductions of **1**, **3**, and **6** revealed the presence of small amounts of piperideines. These were completely reduced to piperidines without disturbing the side chain terminal double bonds by subsequent treatment of the acidified mixture with sodium cyanoborohydride. In this way, isomeric mixtures of **2**, **4**, and **7**, with gas chromatographic retention times and mass spectra identical to those of the alkaloids in *M. delagoense*, could be obtained in moderate yield.

The sodium/EtOH reduction of 2-alkyl-6-methylpyridines is known to provide a 6:1 ratio of cis and trans isomers, with the cis isomer eluting first (8). This reduction of **1** to **2** also produces two isomers in a 5:1 ratio with the major isomer eluting first. The



SCHEME 2. (a) 2 BuLi; (b) $CH_2=CHCH_2CH_2Br$; (c) Na/EtOH; (d) $NaCNBH_3$; (e) BuLi; (f) $CH_2=CHCH_2CH_2CH_2CH_2Br$.

stereochemistry of these isomers (major isomer cis, minor isomer trans) was confirmed by their ^{13}C-nmr spectra, in which the methine carbon resonance for the major isomer appears at 57.09 ppm and the methine carbon resonance for the minor isomer appears at 50.63 ppm. This observation is consistent with the values reported for the methine carbon of 2,6-dimethylpiperidine, in which the cis isomer methine appears at 52.6 ppm while the trans isomer methine appears at 46.0 ppm (9). Therefore, in the natural mixture, the major, later eluting isomers of **2**, **4**, and **7** have the trans stereochemistry. Unlike most other piperidine-producing ants however, *M. delagoense* yields a significant amount of the cis isomer (Table 1).

The synthetic cis/trans isomeric mixture of **2** possesses strong insecticidal activity against termite workers in the genus *Reticulitermes* (LD_{50} 150 μg/g termite) (10). Both isomers are slightly more toxic than *trans*-6-(*Z*-4′-tridecenyl)-2-methylpiperidine and *trans*-6-(*Z*-6′-pentadecenyl)-2-methylpiperidine, the major alkaloids present in the venom of the fire ant *Solenopsis invicta* (11). In addition, the isomers of **2** are powerful repellents for foraging ant workers in the genera *Pheidole* and *Iridomyrmex*, comparing favorably with other classes of ant-derived alkaloids that have been previously evaluated as deterrents (11).

DISCUSSION

The major component of the venom of *M. delagoense* is a 1:3 mixture of the cis and trans isomers of 2,6-di(4-pentenyl)-piperidine [**2**], accompanied by small amounts of its mono-unsaturated analogue **4** and its two-carbon homologue **7** as similar isomeric mixtures. A small amount of a mono-unsaturated analogue of **7**, compound **8**, was also present. The structures of **2**, **4**, and **7** have been confirmed by synthesis, which also permitted the assignment of their streochemistry and demonstrated that in *M. delagoense*, the trans stereoisomer predominates.

The dialkylpiperidines from *M. delagoense* constitute a new class of piperidine alkaloids with repellency and toxicity equal to or greater than any ant-derived alkaloids that have been evaluated (11). It may be significant that, as is the case with the 2,5-dialkylpyrrolidines, maximum repellency is identified with those compounds in which both alkyl groups contain terminal unsaturation. Additionally, the 2,6-dialkylpiperidines in the venom of *M. delagoense* are the first piperidines identified in a species of the genus *Monomorium*. Previously, all species in this genus have been demonstrated to produce 2,5-dialkylpyrrolidines along with their bicyclic analogues (2,4).

EXPERIMENTAL

CHEMICAL ANALYSES.—Gc analyses were carried out using a Shimadzu GC-9A equipped with a 30 m × 0.5 mm i.d. open DB-17 column (1 μm film thickness). The temperature for the analyses was programed from 60 to 215° at 10°/min, and the carrier gas flow rate was 15 ml/min. On a given day, retention temperatures were reproducible to 1°. Preparative gc was conducted with a Varian model 1400 gas chromatograph equipped with a 2 m × 5 mm i.d. column packed with 10% OV-17 on 100–120 mesh Supelcoport. ^{1}H- and ^{13}C-nmr spectra were obtained from $CDCl_3$ solutions using a Varian XL-200 spectrometer. Eims were obtained using a LKB-9000 GC/MS equipped with a 30 m × 0.5 mm i.d. open DB-17 column (1 μm film thickness) programed from 60 to 250° at 10°/min. Hrms was obtained using a VG 7070F instrument in the ei mode at an ionizing voltage of 70 eV.

ANALYSIS OF *M. DELAGOENSE*.—Eleven collections of workers of *M. delagoense* were obtained from separate nests at Pietermaritzburg ($n = 9$) and at the Mkuze Game Reserve ($n = 2$), South Africa. Each collection of 25–100 workers was placed in a separate vial of CH_2Cl_2. Specimens of these ants have been deposited in the collections of the South African Museum and the Los Angeles County Museum of Natural History, Los Angeles, California. The initial gc-ms analysis of the CH_2Cl_2 extracts of the ants is presented in Table 1, and was essentially the same for each collection. A gentle stream of H_2 was bubbled through a mixture containing PtO_2 (10 mg) in 0.25 ml of the *M. delagoense* extract for 10 min. Analysis by gc-ms revealed the presence of two peaks in a 1:3 ratio, constituting more than 90% of the mixture, with identical

TABLE 1. Gc-ms Analysis of *M. delagoense* Extracts.

Peak	Compound	Retention time (min)	Relative abundance	Ms *m/z* (rel. int.) Characteristic ions
1	*cis*-**4**	11.1	1	$[M]^+$ 223 (4), 222 (1), 180 (6), 178 (5), 154 (40), 152 (100), 98 (6), 96 (7), 82 (8), 81 (8), 69 (10), 67 (15), 57 (9), 56 (18), 55 (20), 43 (10), 41 (2).
2	*cis*-**2**	11.4	19.5	$[M]^+$ 221 (5), 220 (2), 180 (3), 178 (10), 152 (100), 98 (8), 96 (8), 82 (5), 81 (5), 67 (11), 56 (11), 55 (10), 41 (10).
3	*trans*-**4**	11.6	3	$[M]^+$ 223 (5), 222 (1), 180 (5), 154 (95), 152 (100), 96 (7), 82 (10), 81 (6), 69 (10), 67 (12), 56 (13), 55 (15), 43 (10), 41 (20).
4	*trans*-**2**	11.8	52.6	$[M]^+$ 221 (4), 220 (2), 180 (4), 178 (7), 152 (100), 98 (6), 96 (8), 82 (10), 81 (9), 67 (20), 56 (18), 55 (18), 41 (20).
5	*cis*-**7**	13.4	1	$[M]^+$ 249 (4), 248 (1), 208 (5), 206 (5), 180 (55), 152 (100), 96 (11), 82 (10), 81 (10), 67 (17), 57 (15), 56 (17), 55 (25), 43 (15), 41 (30).
6	**8**	13.6	1	$[M]^+$ 251 (3), 250 (1), 208 (5), 206 (5), 182 (28), 152 (100), 96 (7), 95 (6), 82 (9), 81 (7), 67 (15), 57 (15), 56 (20), 55 (25), 43 (15), 41 (25).
7	*trans*-**7**	14.2	2	$[M]^+$ 249 (4), 248 (1), 208 (5), 206 (5), 180 (60), 152 (100), 96 (11), 82 (10), 81 (10), 67 (15), 57 (15), 56 (15), 55 (25), 43 (15), 41 (30).

mass spectra: ms *m/z* (rel. int.) $[M]^+$ 225 (1), 224 (3), 155 (14), 154 (100), 96 (6), 95 (5), 82 (5), 81 (4), 69 (9), 56 (9), 55 (10), 43 (7), 41 (10).

Derivatization.—A mixture containing 3 drops of trifluoroacetic anhydride and one drop of pyridine in 0.25 ml of the *M. delagoense* extract was warmed to 80° for 0.5 h. The cooled solution was taken up in hexane (2 ml), carefully washed with saturated $NaHCO_3$, and dried over anhydrous $MgSO_4$. The crude hexane solution was reduced in volume to 1 ml, taken up in MeOH (2 ml), treated with mercuric acetate (0.5 g), and stirred in the dark for 18 h. The mixture was treated with a slight excess of $NaBH_4$ and, after 5 min, neutralized with a few drops of 10% HCl and 1 ml of H_2O. The hexane phase was separated and concentrated. Analysis by gc-ms revealed the presence of three components eluting above 210° in a 1:7:1 ratio with the following mass spectra. For peak 1 ms *m/z* (rel. int.) $[M]^+$ 351 (5), 338 (7), 292 (1), 265 (4), 250 (75), 248 (71), 222 (15), 180 (23), 178 (40), 152 (16), 137 (15), 135 (16), 95 (21), 81 (15), 69 (23), 67 (20), 59 (100), 55 (23), 43 (30), 41 (19); peak 2 $[M]^+$ 381 (2), 366 (2), 334 (1), 284 (1), 280 (4), 268 (8), 248 (50), 222 (10), 178 (35), 152 (9), 135 (12), 93 (10), 81 (13), 79 (12), 71 (10), 69 (10), 67 (22), 59 (100), 55 (23), 43 (10), 41 (19); peak 3 $[M]^+$ 409 (2), 394 (1), 308 (2), 296 (3), 280 (1), 276 (20), 250 (6), 248 (30), 222 (10), 180 (9), 178 (30), 71 (25), 69 (20), 67 (27), 59 (100), 57 (25), 55 (35), 43 (30), 41 (30).

SYNTHESES.—*2,6-Di(4-pentenyl)-pyridine* [**1**].—A 2.5 M solution of butyllithium in hexanes (8 ml) was slowly added to a solution containing 1.0 g (9.3 mmol) of 2,6-lutidine in anhydrous Et_2O (25 ml) under an N_2 atmosphere. After 1 h, the resulting mixture was added dropwise by syringe to a solution containing 3 ml of 4-bromo-1-butene in Et_2O (25 ml). After 4 h, H_2O (25 ml) was added to the mixture, and the organic phase was separated, dried over anhydrous $MgSO_4$, filtered, and evaporated in vacuo to provide 2.0 g of a 1:2 mixture of mono- and dialkylated lutidine. Pure samples of the major component were obtained by preparative gc and had the following spectral data: ^1H nmr δ 7.44 (1H, t, $J = 8$ Hz), 6.87 (2H, d, $J = 8$ Hz), 5.84 (2H, d of d of t, $J = 10$, 18, 6 Hz), 5.01 (2H, br d, $J = 18$ Hz), 4.95 (2H, br d, $J = 10$

Hz), 2.78 (4H, t, J = 8 Hz), 2.1 (4H, m), 1.8 (4H, m); ^{13}C nmr δ 161.57, 138.60, 136.39, 119.78, 114.71, 37.94, 33.46, 29.29; ms *m/z* (rel. int.) $[M]^+$ 215 (5), 214 (3), 175 (6), 174 (40), 162 (10), 161 (100), 160 (25), 119 (20), 107 (43), 106 (15), 77 (13), 65 (8), 41 (15); hrms *m/z* $[M]^+$ 215.1669 (calcd for $C_{15}H_{21}N$, 215.1674).

A solution containing 200 mg of the crude reaction product in 50 ml of EtOH was acidified and hydrogenated over 10 mg of PtO_2 at 3 atm pressure. The major component of the resulting mixture (ms *m/z* 225 $[M]^+$) had a mass spectrum and gc retention time identical to those of the first-eluting isomer of the major component of the hydrogenated extracts from *M. delagoense*.

2,6-Di(4-pentenyl)-piperidine [**2**].—A solution containing 0.5 g of pyridine and **1** in EtOH (150 ml) was heated to reflux under N_2 atmosphere while sodium (5.0 g) was added in small pieces. After the sodium had dissolved, the mixture was heated for 3 h and treated with H_2O (50 ml), and the EtOH was removed in vacuo. The residue was extracted with 3 × 50 ml of Et_2O, and the solvent was removed from the combined Et_2O extracts in vacuo. The residue was taken up in MeOH (50 ml), acidified to pH 6 with dilute HCl, treated with sodium cyanoborohydride (0.5 g), and stirred overnight at room temperature. After acidification with dilute HCl, the MeOH was removed from the mixture in vacuo, and the residue was made alkaline with a slight excess of 10% NaOH and extracted with 3 × 50 ml of Et_2O. The combined Et_2O extracts were dried over anhydrous K_2CO_3, and after filtration, the solvent was removed in vacuo to provide 0.4 g of a mixture containing 75% of two components in a 5:1 ratio with mass spectra and gc retention times identical to those of the second- and fourth-eluting alkaloids from *M. delagoense*: ^{1}H nmr δ 5.8 (2H, d of d of t, J = 10, 18, 6 Hz), 5.0 (2H, br d, J = 18 Hz), 4.95 (2H, br d, J = 10 Hz), 2.45 (2H, m), 2.08 (4H, m), 1.6–1.3 (14H, m); ^{13}C nmr δ 138.82 (2C), 114.49 (2C), 57.09 (2C), 37.04 (2C), 33.95 (2C), 33.89 (2C), 32.74 (2C), 25.38. In addition there were less intense resonances at δ 50.63, 31.27, 29.29, 25.77, 24.91, and 19.81 ppm. Hrms *m/z* $[M]^+$ 221.2130 (calcd for $C_{15}H_{27}N$, 221.2144).

2-(4-Pentenyl)-6-pentylpyridine [**3**].—In a manner similar to that described for **1** above, a solution containing 1.6 g of 2-methyl-6-pentylpyridine (12) (10 mmol) in Et_2O (25 ml) was lithiated with 2.5 M butyllithium (4.5 ml) and then added slowly to a solution containing 4-bromo-1-butene (1.35 g) in Et_2O (25 ml). The usual workup provided 1.9 g of a mixture containing 78% of a single component: ^{1}H nmr δ 7.44 (1H, t, J = 8 Hz), 6.94 (2H, br d, J = 8 Hz), 5.85 (1H, d of d of t, J = 10, 18, 6 Hz), 5.0 (1H, br d, J = 18 Hz), 4.95 (1H, br d, J = 10 Hz), 2.76 (4H, m), 2.12 (2H, m), 1.6–1.9 (4H, m), 1.35 (4H, m), 0.9 (3H, br t, J = 7.5 Hz); ^{13}C nmr δ 162.03, 161.47, 138.61, 136.35, 119.67 (2C), 114.68, 38.56, 37.94, 33.46, 31.66, 29.84, 29.31, 22.57, 14.02; ms *m/z* (rel. int.) $[M]^+$ 217 (4), 216 (4), 202 (3), 188 (21), 174 (40), 164 (14), 163 (100), 162 (14), 161 (95), 160 (20), 121 (12), 120 (39), 119 (23), 107 (50), 106 (25), 93 (11), 91 (11), 79 (10), 77 (17), 66 (8), 65 (16), 41 (23); hrms *m/z* $[M]^+$ 217.1835 (calcd for $C_{15}H_{23}N$, 217.1831).

2-(4-Pentenyl)-6-pentylpiperidine [**4**].—A sample of **3** (0.5 g) was reduced sequentially with sodium in EtOH and then with sodium cyanoborohydride in the manner described for the preparation of **2**. The usual workup provided 0.34 g of a mixture containing 30% of **3** and 60% of two components with mass spectra and gc retention times identical to those of the first- and third-eluting alkaloids from *M. delagoense*: ^{1}H nmr δ 5.8 (1H, d of d of t, J = 10, 18, 6 Hz), 5.0 (1H, br d, J = 18 Hz), 4.95 (1H, br d, J = 10 Hz), 2.45 (2H, m), 2.05 (2H, m), 1.8–1.2 (18H, m), 0.9 (3H, br t); ^{13}C nmr δ 138.82, 114.47, 57.25, 57.10, 37.48, 37.03, 33.95, 32.76 (2C), 32.09, 25.68, 25.38, 24.92, 22.62, 14.04; hrms *m/z* $[M]^+$ 223.2306 (calcd for $C_{15}H_{29}N$, 223.2300).

2-(6-Heptenyl)-6-methylpyridine [**5**].—In a manner similar to that described for **3** above, 2,6-lutidine (0.64 g, 6 mmol) was lithiated with 2.5 M butyllithium (2.4 ml) and then added slowly to a solution containing 1 g of 6-bromo-1-hexene in Et_2O (25 ml). After the usual workup, Kugelrohr distillation (120–130° at 0.3 mm Hg) provided 0.4 g of a pale yellow liquid that was >90% pure by glc analysis: ^{1}H nmr δ 7.48 (1H, t, J = 8 Hz), 6.94 (2H, d of d, J = 3, 8 Hz), 5.85 (1H, d of d of t, J = 10, 18, and 6 Hz), 5.01 (1H, br d, J = 18 Hz), 4.96 (1H, br d, J = 10 Hz), 2.75 (2H, t, J = 7.8 Hz), 2.52 (3H, s), 2.05 (2H, m), 1.7 (2H, m), 1.4 (4H, m); ^{13}C nmr δ 161.87, 157.70, 139.07, 136.42, 120.33, 119.42, 114.21, 38.57, 33.69, 30.05, 28.97, 28.81, 24.58; ms *m/z* (rel. int.) $[M]^+$ 189 (2), 188 (2), 164 (1), 150 (1), 148 (12), 146 (5), 134 (12), 120 (18), 108 (10), 107 (100), 93 (4), 92 (5), 79 (5), 77 (6), 66 (5), 65 (6), 41 (7); hrms *m/z* $[M]^+$ 189.1517 (calcd for $C_{13}H_{19}N$, 189.1518).

2-(6-Heptenyl)-6-(4-pentenyl)-pyridine [**6**].—In a manner similar to that described for **3** above, **5** (0.3 g, 1.6 mol) was lithiated with 2.5 M butyllithium (0.7 ml) and then added to a solution containing 2.2 g of 4-bromo-1-butene in anhydrous Et_2O (25 ml). The usual workup provided 0.4 g of a mixture comprised of 78% of a single component by glc analysis: ^{1}H nmr δ 7.48 (1H, t, J = 8 Hz), 6.95 (2H, d of d, J = 2, 8 Hz), 5.8 (2H, complex m), 4.95 (4H, complex m), 2.77 (4H, complex m), 2.1 (4H, m), 1.9–1.6 (4H, m), 1.4 (4H, m); ^{13}C nmr δ 161.87, 161.47, 139.04, 138.57, 136.34, 119.67 (2C), 114.67, 114.18, 38.48, 37.91, 33.67, 33.43, 29.95, 29.28, 28.89, 28.79; ms *m/z* (rel. int.) $[M]^+$ 243 (5), 242 (5), 202

(23), 189 (35), 188 (15), 174 (30), 162 (13), 161 (100), 160 (50), 146 (10), 120 (24), 119 (20), 107 (40), 106 (19), 93 (10), 91 (10), 79 (5), 77 (11), 65 (10), 41 (19); hrms *m/z* $[M]^+$ 243.1987 (calcd for $C_{17}H_{25}N$, 243.1987).

2-(6-Heptenyl)-6-(4-pentenyl)-piperidine [7].—A sample of **6** (0.3 g) was reduced sequentially with sodium in EtOH and then with sodium cyanoborohydride in the manner described for the preparation of **2**. The usual workup provided 0.25 g of a mixture containing 30% of **6** and 65% of two components with mass spectra and gc retention times identical with those of the fifth- and seventh-eluting alkaloids from *M. delagoense*: ^{1}H nmr δ 5.8 (2H, d of d of t, J = 10, 18, 6 Hz), 5.0 (2H, br d, J = 18 Hz), 4.95 (2H, br d, J = 10 Hz), 2.45 (2H, m), 2.08 (4H, m), 1.8–1.15 (18H, m); ^{13}C nmr δ 139.10, 138.81, 114.48, 114.20, 57.20, 57.10, 37.47, 37.04, 33.95, 33.73, 32.76 (2C), 29.32, 28.87, 25.84, 25.39, 24.92; hrms *m/z* $[M]^+$ 249.2473 (calcd for $C_{17}H_{31}N$, 249.2457).

TOXICITY DETERMINATIONS.—The insecticidal activity of the synthetic cis/trans mixture of **2** was determined against termite workers of *Reticulitermes flavipes* as previously described (10). The LD_{50} of the cis/trans mixture of **2** is 150 ± 20 μg/g termite, somewhat less than the LD_{50} of nicotine in the same assay (500 ± 20 μg/g termite) (10). The repellent activities of the cis/trans mixture of **2** were studied with a feeding preference bioassay utilizing colonies of two species of ants, *Iridomyrmex humilis* and *Pheidole dentata*. Alkaloids were presented to the ants by adding 1 μl of EtOH solutions containing 1 or 2 μg/μl of the alkaloids to 0.05 ml droplets of warm honey on microscope slides which were placed in the ants' foraging arenas. Droplets of honey treated with EtOH served as controls, and after 15 min, the numbers of ant workers feeding on the alkaloid-treated droplets and the EtOH-treated controls were compared. Twelve replicates were run for each alkaloid concentration for each species. The number of ants feeding on the alkaloid-treated droplets was always less than 20% of the number feeding on the controls.

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