Pergamon

Tetrahedron 54 (1998) 5259–5264

TETRAHEDRON

Synthesis of Myrimcarin 217, a Pyrrolo[2,1,5-cd]indolizine from Ants

Frank Schröder*[a], Wittko Francke[b]

[a]Baker Laboratory, Department of Chemistry,
Cornell University, Ithaca, NY 14853, USA.

[b]Institut für Organische Chemie der Universität,
Martin Luther King Platz 6, D-20146 Hamburg, Germany.

Received 17 February 1998; accepted 3 March 1998

Abstract: The ant alkaloid myrmicarin **217** (1-ethyl-3,4,4a,5,6,7-hexahydro-2-propylpyrrolo-[2,1,5-cd]indolizine, **1**) was synthesized using a new method for the direct cyclization of appropriately disubstituted piperidines. The mechanism for the formation of the pyrrolo[2,1,5-cd]indolizine system was investigated by ^{1}H-NMR spectroscopy, which showed the reaction to proceed through indolizidine intermediates. The course of this facile cyclization may parallel steps in the biosynthesis of mymicarin **217** and related alkaloids.

Recently, we reported the identification of a structurally novel group of oligocyclic alkaloids (**1-5**) as the major constituents of the poison gland secretion of *Myrmicara* ants [1-3]. Derived from the acetate pool, the carbon skeletons of these alkaloids consist of one, two or three unbranched chains of 15 carbon atoms. In the oligocyclic systems, each of the carbon chains is joined at two or three sites to a nitrogen atom forming indolizines, or more frequently, pyrrolo[2,1,5-cd]indolizines, which to our knowledge have not been described as natural compounds before.

Here we report the synthesis of myrmicarin **217** [1-ethyl-3,4,4a,5,6,7-hexahydro-2-propylpyrrolo-[2,1,5-cd]indolizine, **1**], illustrating a concise approach to substituted pyrrolo[2,1,5-cd]indolizines.

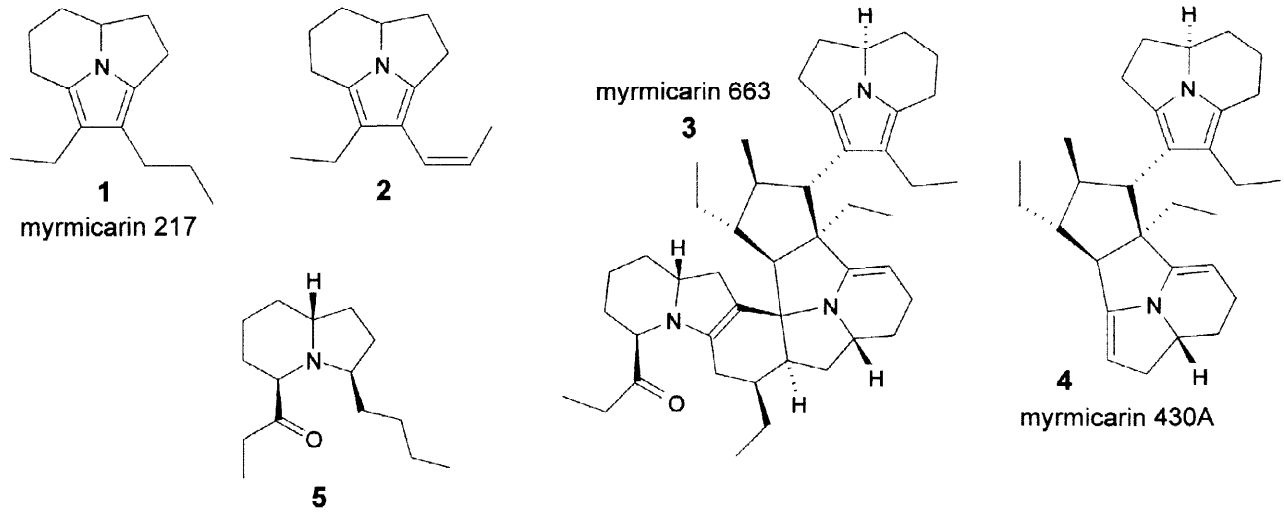


Fig 1.

PII: S0040-4020(98)00223-3

Starting from commercially available 6-methylpyridine-2-carbaldehyde (**5**), the synthetic intermediate **7** was prepared as previously described [2]. After conversion of the alcohol **7** into the corresponding ketone [4], protection of the keto group, and catalytic hydrogenation of the pyridine ring, the piperidine *cis*-**8** was obtained in 81 % overall yield (from **6**, 98% *cis*). Deprotection of *cis*-**8** with hydrochloric acid yielded the hydrochloride of *cis*-**9**, which, under basic conditions, was directly converted into myrmicarin 217 (**1**).

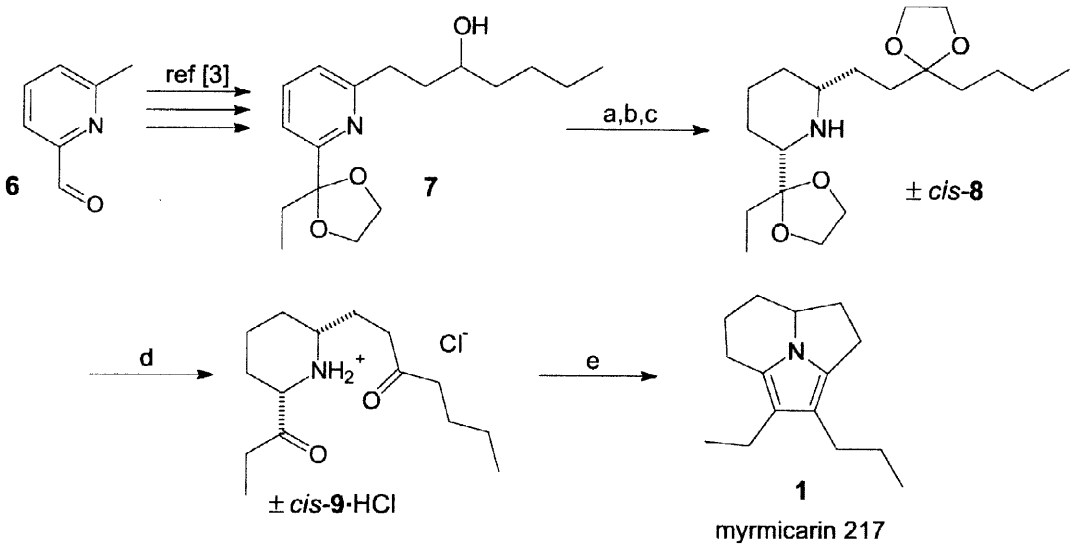


Fig. 2 a: PDC, molecular sieves, CH_2Cl_2. b: $(CH_2OH)_2$, TsOH, benzene, 80 °C. c: H_2. Pd/C, EtOH. d: 2N aq. HCl, acetone. e: 1. aq. $NaHCO_3$, Et_2O, N_2, 2. benzene, N_2, 40 °C.

To better understand the mechanism leading to the formation of pyrrolo[2,1,5-cd]indolizine **1** from *cis*-**9**, the progress of this reaction was directly monitored by ^{1}H-NMR spectroscopy. Figure 3 shows part of the ^{1}H-NMR spectra of a sample of freshly prepared *cis*-**9** in benzene-d_6 after 15 min, 40 min, 9 h, and 30 h. The relative configuration of the compounds involved was determined from a series of (^{1}H,^{1}H)-DQF-COSY, (^{1}H,^{1}H)-NOESY, and HSQC spectra [5] acquired at 2 h, 9 h, and 20 h after preparation of the sample.

Apparently, the reaction mechanism involves two stereoisomers of the indolizine **10** as intermediates (Figure 4). First, by intramolecular condensation of the piperidine NH-functionality and the 3-oxoheptyl-sidechain of *cis*-**9**, the *cis*-isomer (5S*,8aR*)-**10** is formed, which rapidly equilibrates to a mixture of both (5S*,8aR*)-**10** and the *trans*-isomer (5R*,8aR*)-**10** (Figures 3 and 4). In a much slower process, condensation of the enamine moiety with the keto group in **10** finally leads to the formation of the 3,4,4a,5,6,7-hexahydropyrrolo[2,1,5-cd]indolizine system in **1**.

Interestingly, the saturated analogue of **10**, 3-butyl-5-propionylindolizine (Figure 1, **5**), is the major component of the defensive secretion of *Myrmicaria eumenoides* [2]. Furthermore, traces of components showing mass spectra and GC-properties identical to those of the stereoisomers of **10** can be detected in the defensive secretions of *M. striata* and *M. opaciventris*, which contain the oligocyclic alkaloids **1-4** as major components [1a]. Since all of the C_{15}-chains in the oligocyclic alkaloids **1-4** are functionalized in a similar fashion, it appears that piperidine derivatives like the synthetic intermediate **9** may represent common biosynthetic precursors of the *Myrmicaria* alkaloids [6]. Related compounds, such as 2,6-dialkyl substituted piperidines, have been reported from *Solenopsis* ant species [7].

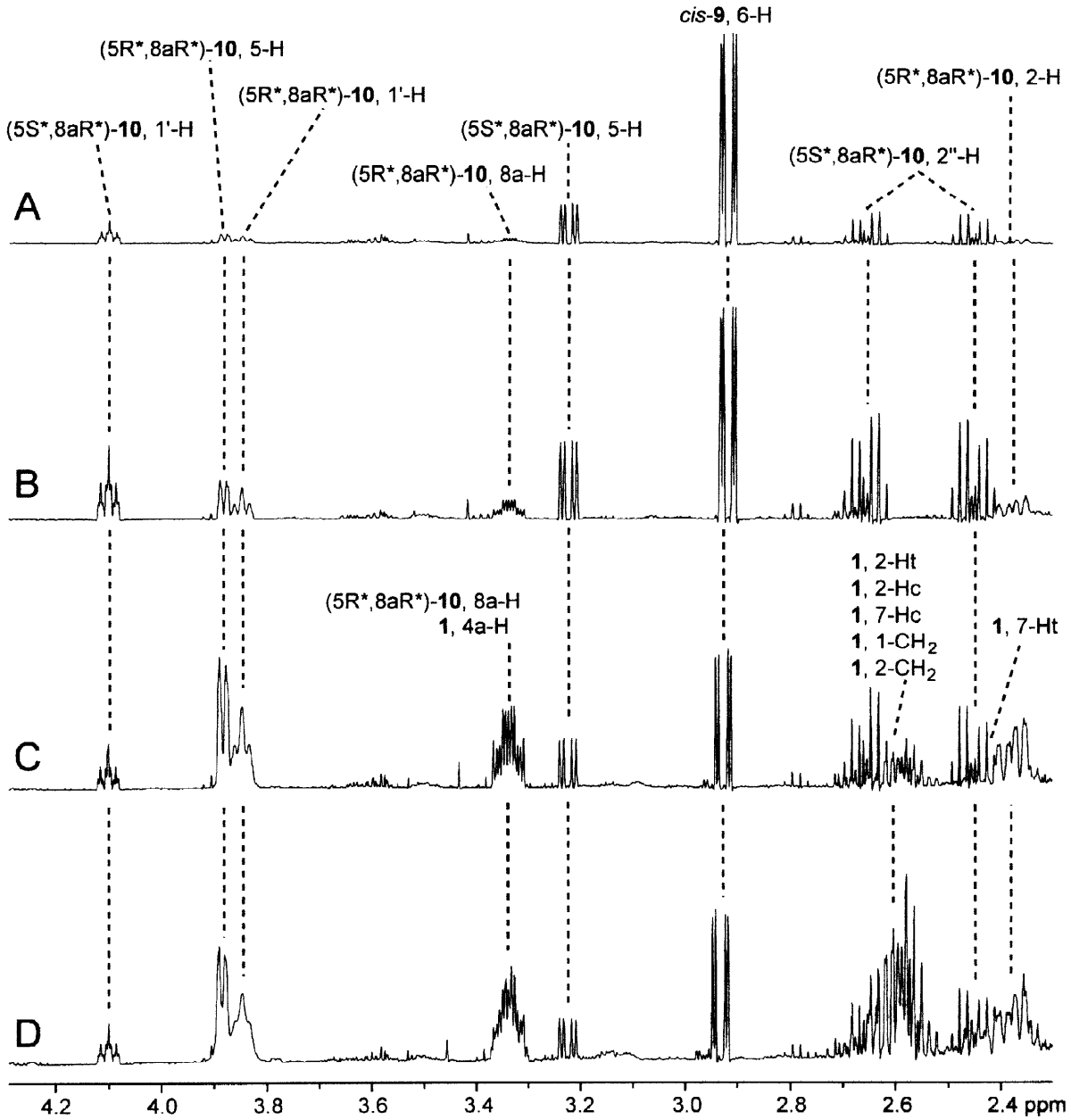
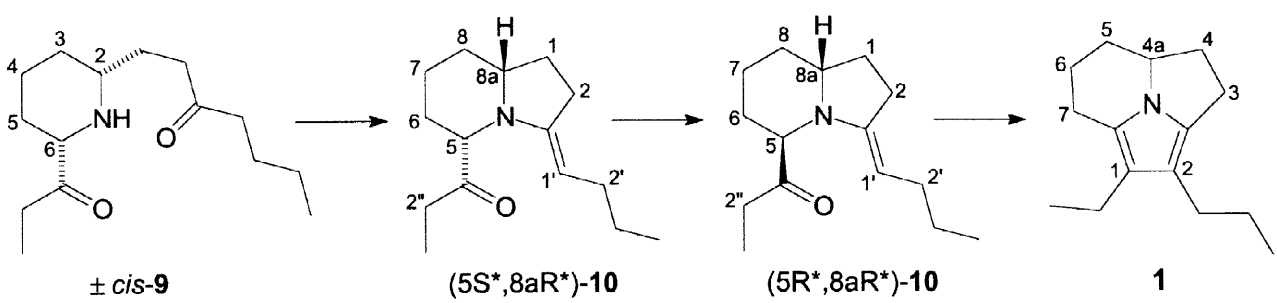


Fig. 3 Region (2.3-4.3 ppm) of the ^{1}H-NMR spectra of a freshly prepared sample of *cis*-**9** in benzene-d_6 after 15 min (**A**), 40 min (**B**), 9 h (**C**), and 30 h (**D**) at 300 K.



± *cis*-**9** (5S*,8aR*)-**10** (5R*,8aR*)-**10** **1**

Fig. 4 Indolizidine intermediates in the cyclization of piperidine *cis*-**9** to myrmicarin **217** (**1**).

EXPERIMENTAL

NMR: Bruker DRX 500 and Bruker AMX 400. - MS: Fisons VG70/250SE (high resolution 70 eV EI-MS) and Fisons MD800 (70 eV EI GC-MS). - Gas chromatography: Fisons GC 8008 with flame ionization detector and split injector. - Column chromatography: flash chromatography on silica gel (Merck Kieselgel 60, 240-400 mesh) and neutral aluminum oxide (Fluka, 100-125 mesh).

2-[2-(2-Butyl-1,3-dioxolan-2-yl)ethyl]-6-(2-ethyl-1,3-dioxolan-2-yl)pyridine:

A suspension of pyridinium dichromate (1.03 g, 2.73 mmol) and powdered molecular sieves (4 Å, 2 g) in dichloromethane was stirred under argon for 15 min at 20 °C. Subsequently, a solution of **7** (0.4 g, 1.36 mmol) in dichloromethane (10 ml) was added dropwise within 5 minutes. After stirring for 2 h, the mixture was diluted with diethyl ether (100 ml) and filtered over a short column of silica (100 g). The filtrate was concentrated, yielding 0.42 g of 1-[6-(2-ethyl-1,3-dioxolan-2-yl)pyrid-2-yl]-3-heptanone of 95% purity (^{1}H-NMR) as a pale oil. The crude ketone was dissolved in a mixture of toluene (50 ml), ethane-1,2-diol (2 ml), and *p*-toluene sulfonic acid (200 mg), and the resulting mixture was refluxed for 2 h with a Dean-Stark trap. Subsequently, the mixture was cooled to 0 °C, diluted with diethyl ether, and washed with two 100 ml portions of saturated $NaHCO_3$-solution. The aqueous layers were extracted with diethyl ether (50 ml), and the combined organic extracts were washed with saturated NaCl-solution (50 ml), dried with Na_2SO_4, and concentrated. Column chromatography of the residue (50 g silica, hexane:ethyl acetate = 3:1 {v/v}) yielded 380 mg (1.13 mmol, 83% from **7**) of 2-[2-(2-butyl-1,3-dioxolan-2-yl)ethyl]-6-(2-ethyl-1,3-dioxolan-2-yl)-pyridine as a colorless oil. - ^{1}H-NMR (C_6D_6; 500 MHz): δ = 0.87 (t, J = 7.4, 3 H, CH_3-ethyl), 0.90 (t, J = 7.1, 3 H, CH_3-butyl), 1.23-1.40 (m, 4 H), 1.63-1.68 (m, 2 H), 2.04-2.07 (m, 2 H), 2.09 (q, J = 7.4, 2 H, CH_2-ethyl), 2.88-2.94 (m, 2 H), 3.84-3.99 (m, 6 H), 4.02-4.10 (m, 2 H), 7.07 (dd, J = 7.6, J = 1.0, 1 H), 7.33 (dd, J = 7.6, J = 1.0, 1 H), 7.56 (t, J = 7.6, 1 H) ppm. - ^{13}C-NMR (C_6D_6; 126 MHz): δ = 7.66 (q), 14.07 (q), 23.01 (t), 25.94 (t), 31.10 (t), 32.72 (t), 36.84 (t), 37.24 (t), 65.03 (t,2 C), 65.12 (t, 2 C), 110.58 (s), 111.56 (s), 117.11 (d), 121.50 (d), 126.34 (d), 159.76 (s), 162.01 (s) ppm. - MS (m/z) [%]: 335 (3, M^+), 307 (4), 306 (14, M^+-C_2H_5), 292 (10), 290 (2), 279 (5), 278 (25, M^+-C_4H_9), 262 (3), 248 (7), 236 (2), 234 (5), 220 (4), 218 (3), 206 (9), 193 (4), 190 (8), 162 (7), 134 (14), 130 (10), 129 (84), 125 (7), 106 (10), 101 (100), 89 (10), 85 (7), 57 (37). - HR-MS ($C_{21}H_{35}NO_4$) calcd. 335.2097; found 335.2112.

(2R*,6S*)-2-[2-(2-Butyl-1,3-dioxolan-2-yl)ethyl]-6-(2-ethyl-1,3-dioxolan-2-yl)piperidine, *cis*-**8**:

A mixture of 2-[2-(2-butyl-1,3-dioxolan-2-yl)ethyl]-6-(2-ethyl-1,3-dioxolan-2-yl)pyridine (370 mg, 1.1 mmol) and 10 mg of catalyst (10% Pd/C) in 20 ml of dry ethanol was hydrogenated for 24 h at 25 atm. After filtration and concentration, 365 mg (1.07 mmol, 97%) of *cis*-**8** was obtained as a colorless, viscous oil. - ^{1}H-NMR (C_6D_6; 500 MHz): δ = 0.88 (t, 3 H, 7'-H), 1.01 (t, 3 H, $C\underline{H}_3CH_2CO_2$), 1.04 (ddt, 1 H, 3'-H_{ax}), 1.24 (m, 1 H, 4'-H_{ax}), 1.27 (sext. 2 H, 6-H), 1.31 (m, 1 H, 5'-H_{ax}), 1.42-1.49 (m, 2 H, 5-H), 1.51 (m, 1 H, 3'-H_{eq}), 1.552-1.620 (m, 2 H, 1-H), 1.64-1.67 (m, 2 H, 4-H), 1.68 (br. s, 1 H, N-H), 1.746 (m, 1 H, 4'-H_{eq}), 1.71-1.82 (m, 2 H, 2-H), 1.79 (m, 1 H, 5'-H_{eq}), 1.79 (dq, 1 H, $CH_3\underline{H}_aH_bCO$), 2.11 (dq, 1 H, $CH_3CH_a\underline{H}_bCO$), 2.43 (ddt, 1 H; 2'-H), 2.72 (dd, 1 H, 6'-H), 3.54-3.68 (m, 8 H) ppm. $J_{6,7}$ = 7.4, $J_{2',1}$ = 6.3, $J_{2',3'ax}$ = 10.8, $J_{2,3'eq}$ =2.5, $J_{3'ax,3'eq}$ = 12.8, $J_{3'ax,4'ax}$ = 12.8, $J_{3'ax,4'eq}$ = 3.9, $J_{5'ax,6'}$ = 11.2, $J_{5'eq,6'}$ = 2.5, $J_{CH3CHaHbCO,CH3CHaHbCO}$ = 14.6, $J_{CH3CH2CO,CH3CH2CO}$ = 7.1 Hz. - ^{13}C-NMR (C_6D_6; 126 MHz): δ = 7.48 (q, $\underline{C}H_3CH_2CO$), 14.31 (q, C-7), 23.40 (t, C-6), 25.25 (t, C-4'), 26.43 (t, C-5), 26.62 (t, $CH_3\underline{C}H_2CO$), 27.27 (t, C-5'), 32.20 (t, C-1), 32.91 (t, C-3'), 33.78 (t, C-2), 37.40 (t, C-4), 57.61 (xd, C-2'), 62.93 (d, C-6'), 64.93 (t, 2 C), 65.63 (t), 65.91 (t), 11.98 (s, CO_2), 112.89 (s, CO_2) ppm. - HR-MS ($C_{19}H_{35}NO_4$) calcd. 341.2566; found 341.2548.

Conversion of piperidine *cis*-**8** into myrmicarin **217** (**1**):

All steps were carried out under argon. A solution of *cis*-**8** (80 mg, 0.23 mmol) in 1 N aqueous HCl (15 ml) was stirred for 4 h at 70 °C. After cooling to 0 °C and addition of diethyl ether (50 ml) $NaHCO_3$ (2.0 g) was added over a period of 5 minutes with vigorous stirring. The aqueous phase was quickly separated and the organic phase was dried over Na_2SO_4, filtered and concentrated at 0-10 °C. Part of the residue (~10 mg, 20%), which consisted mostly of *cis*-**9**, was dissolved in benzene-d_6 and immediately submitted to NMR spectrometry. The remainder was dissolved in abs. benzene (10 ml) and stirred for 6 h at 40 °C. Subsequently, the reaction mixture was concentrated to a volume of 1 ml at 40-50 °C/200 hPa. After the addition of 10 ml of abs. benzene, the mixture was stirred for another 2 h at 40 °C and then concentrated. Column chromatography of the residue (50 g neutral alumina, activity grade III, pentane:diethyl ether = 20:1 {v/v}) yielded 21 mg (0.097 mmol, 53%) of myrmicarin **217** (**1**) as a colorless oil.

1-[(2R*,6S*)-6-(1-Oxopropyl)piperid-2-yl]-3-heptanone, (2R*,6S*)-**9**:

^{1}H-NMR (C_6D_6; 500 MHz): δ = 0.74 (ddt, 1 H, 3'-H_{ax}), 0.81 (t, 3 H, 7-H), 0.94 (m, 1 H, 5'-H_{ax}), 0.968 (t, 3 H, CH_3CH_2CO), 1.14 (m, 1 H, 4'-H_{ax}), 1.18 (m, 2 H, 6-H), 1.45 (m, 1 H, 1-H_a), 1.34 (m, 1 H, 3'-H_{eq}), 1.50 (m 2 H, 5-H), 1.54 (m, 1-H, 5'-H_{eq}), 1.60 (m, 1 H, 4'-H_{eq}), 1.66 (m, 1 H, 1-H_b), 2.03 (t, 2 H, 4-H), 2.07 (m, 2-H, CH_3CH_2CO), 2.185 (t, 2 H, 2-H), 2.26 (dddd, 1 H, 2'-H), 2.92 (dd, 1 H, 6'-H) ppm. $J_{6,7}$ = 7.4, $J_{4,5}$ = 7.4, $J_{1,2}$ = 7.2, $J_{1a,1b}$ = 14.0, $J_{1a,2'}$ = 7.7, $J_{1b,2'}$ = 5.1, $J_{2',3'eq}$ = 2.5, $J_{2',3'ax}$ = 10.8, $J_{3'ax,3'eq}$ = 12.9, $J_{3'ax,4'ax}$ = 12.9, $J_{3'ax,4'eq}$ = 3.8, $J_{3'eq,4'ax}$ = 3.5, $J_{3'eq,4'eq}$ = 3.0, $J_{4'ax,4'eq}$ = 13.1, $J_{4'eq,5'ax}$ = 3.5, $J_{4'eq,5'eq}$ = 3.4, $J_{4'ax,5'eq}$ = 3.7, $J_{4'ax,5'ax}$ = 13.0, $J_{5'eq,5'ax}$ = 12.3, $J_{5'ax,6'}$ = 11.7, $J_{5'eq,6'}$ = 2.8, $J_{CH3CH2CO,CH3CH2CO}$ = 7.1 Hz. - ^{13}C-NMR (C_6D_6; 126 MHz): δ = 7.73 (q, CH_3CH_2CO), 14.04 (q, C-7), 22.63 (t), 25.03 (t), 26.16 (t), 29.46 (t), 30.94 (t), 32,12 (t), 32.69 (t), 38.73 (t), 42.44 (t), 55.43 (d, C-2'), 65.56 (d, C-6'), 208.90 (q, C-3), 209.69 (q, CH_3CH_2CO) ppm.

(5*S**,8a*R**)-3*E*-Butyliden-5-(1-oxopropyl)indolizidine, (5S*,8aR*)-**10**:

^{1}H-NMR (C_6D_6; 500 MHz): δ = 0.887 (t, 3 H, 4'-H), 0.92-0.98 (m, 2 H, 7-H_{ax} and 8-H_{ax}), 1.131 (t, 3 H, CH_3CH_2CO), 1.155 (m, 1 H, 6-H_{ax}), 1.214 (m, 1 H, 1-H_a), 1.314 (m, 2 H, 3'-H), 1.42-1.46 (m, 2 H, 7-H_{eq} and 8-H_{eq}), 1.537 (m, 1 H, 1-H_b), 1.592 (m, 1 H, 6-H_{eq}), 1.902 (m, 2-H, 2'-H), 2.051 (m, 1 H, 2-H_a), 2.094 (m, 1 H, 8a-H), 2.222 (m, 1 H, 2-H_b), 2.452 (dq, 1 H, $CH_3CH_aH_bCO$), 2.656 (dq, 1 H, $CH_3CH_aH_bCO$), 3.224 (dd, 1 H, 5-H), 4.103 (tt, 1 H, 1'-H) ppm. $J_{1b,1a}$ = 11.8, $J_{1a,2a}$ = 9.5, $J_{1a,2b}$ = 10.5, $J_{1b,2a}$ = 5.0, $J_{1b,2b}$ = 1.0, $J_{2a,2b}$ = 15.4, $J_{1',2'a}$ = $J_{1',2'b}$ = 7.3, $J_{1',2a}$ = $J_{1',2b}$ = 3.3, $J_{3',4'}$ = 7.3, $J_{5,6ax}$ = 11.7, $J_{5,6eq}$ = 4.1, $J_{6ax,7eq}$ = 3.8, $J_{6ax,6eq}$ = 13.3, $J_{6ax,7ax}$ = 13.1, $J_{8a,8ax}$ = 11.0, $J_{8a,8eq}$ = 2.4, $J_{8a,1a}$ = 10.6, $J_{8a,1b}$ = 5.5, $J_{CH3CH2CO,CH3CH2CO}$ =7.4, $J_{CH3CHaHbCO,CH3CHaHbCO}$ =18.1 Hz. - ^{13}C-NMR (C_6D_6; 126 MHz): δ = 8.18 (q, CH_3CH_2CO), 13.87 (q, C-4'), 23.50 (t, C-7), 24.32 (t, C-3') 25.91 (t, C-2), 28.42 (t, C-1), 28.52 (t, C-6), 28,57 (t, CH_3CH_2CO), 30.48 (t, C-2'), 30.82 (t, C-8), 61.64 (d, C-8a), 67,89 (d, C-5), 95.99 (d, 1'-H), 146,66 (s, C-3), 213.16 (s, CH_3CH_2CO) ppm. - MS (m/z) [%]: 236 (1), 235 (4), 206 (3), 179 (12), 178 (100), 176 (2), 150 (6), 149 (3), 148 (8), 136 (2), 134 (2), 121 (2), 120 (5), 107 (2), 106 (3), 94 (2), 93 (2), 91 (2), 80 (2), 79 (3), 67 (3), 55 (3), 41 (3).

(5*R**,8a*R**)-3*E*-Butyliden-5-(1-oxopropyl)indolizidine, (5R*,8aR*)-**10**:

^{1}H-NMR (C_6D_6; 500 MHz): δ = 0.862 (ddt, 1 H, 8-H_{ax}), 0.981 (t, 3 H, 4'-H), 0.986 (t, 3 H, CH_3CH_2CO), 1.130 (m, 1 H, 1-H_a); 1.204 (m, 1 H, 7-H_{ax}), 1.367 (m, 1 H, 7-H_{eq}), 1.378 (m, 1 H, 6-H_{ax}), 1.449 (m, 2 H, 3'-H), 1.477 (m, 1 H, 8-H_{eq}), 1.661 (m 1 H, 1-H_b), 1.833 (m, 1 H, 6-H_{eq}), 2.077 (m, 2 H, 2'-H), 2.020 (m, 1 H, $CH_3CH_aH_bCO$), 2.191 (m, 1 H, 2-H_a), 2.198 (m, 1 H, $CH_3CH_aH_bCO$), 2.378 (m, 1 H, 2-H_b), 3.338 (dddd, 1 H, 8a-H), 3.882 (m, 1 H, 5-H), 3.846 (m, 1 H, 1'-H) ppm. $J_{1a,1b}$ = 12.1, $J_{2a,2b}$ = 16.0, $J_{1a,2a}$ = 10.5, $J_{1a,2b}$ = 9.3, $J_{1b,2a}$

= 8.8, $J_{1b,2b}$ = 2.0, $J_{5,6ax}$ = 6.7, $J_{5,6eq}$ = 2.2, $J_{6ax,6eq}$ = 13.1, $J_{6ax,7ax}$ = 12.7, $J_{6ax,7eq}$ = 3.2, $J_{6eq,7eq}$ = 3.1, $J_{6eq,8eq}$ = 1.0, $J_{6eq,7ax}$ = 4.0, $J_{7ax,7eq}$ = 13.2, $J_{7eq,8eq}$ = 3.5, $J_{7ax,8eq}$ = 3.5, $J_{7eq,8ax}$ = 4.0, $J_{7eq,8ax}$ = 13.1, $J_{8ax,8eq}$ = 13.3, $J_{8ax,8a}$ = 11.3, $J_{8eq,8a}$ = 2.8, $J_{8a,1a}$ = 8.5, $J_{8a,1b}$ = 5.7, $J_{2a,1'}$ = $J_{2b,1'}$ = 1.0, $J_{1',2'}$ = 7.2, $J_{2',3'}$ = $J_{3',4'}$ = 7.3, $J_{CH3CH2CO,CH3CH2CO}$ = 7.5, $J_{CH3CHaHbCO,CH3CHaHbCO}$ = 17.8 Hz. - ^{13}C-NMR (C_6D_6; 126 MHz): δ = 7.80 (q, CH_3CH_2CO), 13.97 (q, C-4'), 21.05 (t, C-7), 25.02 (t, C-3') 25.19 (t, C-6), 27.20 (t, C-2), 29.83 (t, C-1), 30.72 (t, C-2'), 32.01 (t, C-8), 33.84 (t, CH_3CH_2CO), 58.17 (d, C-8a), 59.78 (d, C-5), 87.90 (d, C-1'), 146.07 (s, C-3), 211.52 (s, CH_3CH_2CO) ppm.

1-Ethyl-3,4,4a,5,6,7-hexahydro-2-propylpyrrolo[2,1,5-cd]indolizine, myrmicarin **217** (**1**):
^{1}H-NMR (C_6D_6; 500 MHz): δ = 0.889 (ddt, 1 H, 5-H_t), 1.066 (t, 3 H, 2-$CH_2CH_2CH_3$), 1.302 (t, 3 H, 1-CH_2CH_3), 1.417 (m, 1 H, 6-H_c), 1.582 (m, 1 H, 5-H_c), 1.591 (m, 1 H, 4-H_t), 1.730 (m, 1 H, 6-H_t), 1.755 (m, 2 H, 2-CH_2CH_2), 2.025 (m, 1 H, 4-H_c), 2.441 (m, 1 H, 7-H_t), 2.562 (m, 1 H, 2-CH_aH_b), 2.569 (m, 1 H, 1-CH_aH_b), 2.597 (m, 1 H, 3-H_t), 2.612 (m, 1 H, 1-CH_aH_b), 2.621 (m, 1 H, 3-H_c), 2.637 (m, 1 H, 7-H_c), 2.638 (m, 1 H, 2-CH_aH_b), 3.334 (dddd, 1 H, 4a-H) ppm. - ^{13}C-NMR (C_6D_6; 126 MHz): δ = 14.56 (q, 2-$CH_2CH_2CH_3$), 16.52 (q, 1-CH_2CH_3), 18.89 (t, 1-CH_2), 20.79 (t, C-7), 22.98 (t, C-6), 25.04 (t, 2 C, 2-CH_2CH_2), 28.14 (t, C-3), 30.13 (t, C-5), 37.25 (t, C-4), 54.95 (d, C-4a), 113.78 (s, C-2), 118.00 (s, C-7a), 121.21 (s, C-1), 127.40 (s, C-2a) ppm. - MS (m/z) [%]: 218 (3), 217 (19), 216 (2), 203 (3), 202 (24), 189 (16), 188 (100), 174 (9), 173 (8), 172 (8), 170 (3), 161 (2), 160 (8), 159 (2), 158 (6), 156 (3), 146 (3), 145 (6), 144 (9), 143 (3), 132 (2), 131 (2), 130 (4), 118 (2), 117 (3), 115 (2), 91 (4), 77 (5), 65 (3), 53 (2), 41 (5), 39 (3). - HR-MS ($C_{15}H_{23}N$) calcd. 217.1830; found 217.1837.

REFERENCES AND NOTES

1. a: Schröder, F.; Franke, S.; Francke, W.; Baumann, H.; Kaib, M.; Pasteels, J. M.; Daloze, D. *Tetrahedron* **1996**, *52*, 13539. b: Schröder, F.; Sinnwell, V.; Baumann, H.; M. Kaib, M. *Chem. Commun.* **1996**, 2139. c: Schröder, F.; Sinnwell, V.; Baumann, H.; Kaib, M.; Francke, W. *Angew. Chem. Int. Ed. Engl.* **1997**, *36*, 77-80.
2. Francke, W.; Schröder, F.; Walter, F.; Sinnwell, V.; Baumann, H.; Kaib, M.; *Liebigs. Ann. Chem.* **1995**, 965-977.
3. Kaib, M.; Dittebrand, H. *Chemoecology* **1990**, *1*, 3-11.
4. Corey, E. J.; Schmidt, G. *Tetrahedron Lett.* **1979**, *20*, 399.
5. Palmer III, A. G.; Cavanagh, J.; Wright, P. E. ; Rance, M. *J. Magn. Reson.* **1991**, *93*, 151-170.
6. The biosynthesis of structurally related alkaloids produced by coccinellid beetles has recently been discussed: King, A. G.; Meinwald, J. *Chem. Rev.* **1996**, *96*, 1105-1122.
7. Braekman, J. C.; Daloze, D. in *Studies in Natural Products*, Vol. 6; Atta-ur-Rahman Ed.; Elsevier: Amsterdam, **1990**; pp. 421-466.

Support by the *Deutsche Forschungsgemeinschaft* (Fr 507/8-3) is gratefully acknowledged.