

The Biflavones of *Dicranum scoparium* (Dicranaceae)*

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From *Dicranum scoparium* 5',3'''-dihydroxyamentoflavone and 5',3'''-dihydroxyrobustaflavone were isolated. The compounds were identified spectroscopically.

Dicranum scoparium was the first moss from which a biflavone, namely 5',3'''-di-hydroxyamentoflavone (**1**), has been isolated [1]. In this early work only the biflavone **1** had been obtained from *D. scoparium*. Further research in the field of moss biflavonoids revealed however, that this biflavone is usually accompanied by the isomeric and biogenetically closely related 5',3'''-dihydroxyrobustaflavone (**2**) [2–4]. This is also the case with *Dicranoloma robustum* and *Dicranoloma billardieri* [5]. After these *Dicranoloma* species have been transferred recently to the genus *Dicranum* [6], it became desirable to reinvestigate the biflavonoid pattern of *D. scoparium*. This reinvestigation revealed that in this moss 5',3'''-dihydroxyamentoflavone (**1**) is also accompanied by the isomeric 5',3'''-

dihydroxyrobustaflavone (**2**). Surprisingly however the 2'-linked biluteolins that accompany **1** and **2** in the above mentioned *Dicranoloma* spp. [5] could not be found in *D. scoparium*, although they would have been easily detected in the course of our standard procedure of isolation (see for example ref. [4]). This is a significant difference between *D. scoparium* and the two *Dicranoloma* spp., and it suggests, that a study of chemical characters might help with the taxonomic problems within the *Dicranum-Dicranoloma* group.

Experimental

The plant material – gametophytes containing a few unripe sporophytes – was collected and identified by two of us (H. G. and J. A. L.-S.) in the Kirkeler Tal between Kirkel and Lautzkirchen, Saarland, F.R.G. A voucher specimen is deposited at the herbarium “SAAR” of the Universität des Saarlandes (Nr. 3887). The extraction and isolation of the biflavonoids was carried out as described loc. cit. [4]. 285 g air dried material yielded 62 mg **1** [¹H NMR DMSO-d₆, 400 MHz at 20° (ppm): 7.50 (1 H, d, *J* = 2 Hz, H-2'), 7.49 (1 H, d, *J* = 2 Hz, H-6'), 7.07 (1 H, d, *J* = 2 Hz, H-2'''), 7.05 (1 H, dd, *J* = 8 and 2 Hz, H-6'''), 6.69 (1 H, s, H-3), 6.67 (1 H, d, *J* = 8 Hz, H-5'''), 6.65 (1 H, s, H-3''), 6.43 (1 H, d, *J* = 2 Hz, H-8), 6.38 (1 H, s, H-6''), 6.18 (1 H, d, *J* = 2 Hz, H-6)] and 6 mg **2** [¹H NMR DMSO-d₆, 400 MHz at 20° (ppm): 7.44–7.43 (2 H, m, H-2'', H-6'''), 7.38 (1 H, d, *J* = 2 Hz, H-6'), 7.36 (1 H, d, *J* = 2 Hz, H-2'), 6.90 (1 H, d, *J* = 8 Hz, H-5'''), 6.68 (1 H, s, H-3''), 6.61 (1 H, s, H-3), 6.55 (1 H, s, H-8''), 6.44 (1 H, d, *J* = 2 Hz, H-8), 6.18 (1 H, d, *J* = 2 Hz, H-6)]. **1** and **2** were identified by comparison of their ¹H NMR spectra with published data [7], and by cochromatography with authentic samples.

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Further Analysis of Lipids from the Scent Gland Secretions of Dumeril's Ground Boa (*Acrantophis dumerili* Jan)

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Ground Boa, *Acrantophis dumerili*, Scent Gland Lipids, TLC, GC/MS

Cholesterol, cholestadiene, squalene, phenol, C₃–C₂₆ fatty acids, and C₁₆–C₂₂ amides were identified from the scent gland secretions of Dumeril's ground boa (*Acrantophis dumerili*). Three amines and a diterpene also were indicated, but the structures of these compounds were not determined.

Introduction

Analyses of the scent gland secretions of snakes by thin-layer chromatography (TLC) indicate free fatty acids, sterols, and other compounds [1–4]. More detailed analyses, primarily by gas chromatography-mass spectrometry (GC/MS), reveal cholesterol and C₁₂–C₂₅ fatty acids among the scent gland lipids of various snakes [2–8]. Amides [7] and glycerol monoethers [8] also have been reported in the secretions of the western diamond-back rattlesnake (*Crotalus atrox*, Viperidae).

A previous analysis of the scent gland secretions of Dumeril's ground boa (*Acrantophis dumerili*, Boidae) indicated cholesterol, 5-cholesten-3-one, and 2-hydroxypropanoic (lactic), hexadecanoic,

9-octadecenoic, and octadecanoic acids as the main components [5]. We report here the results of further analyses by GC/MS and TLC of lipids in the scent gland secretions of this species.

Materials and Methods

Scent gland secretions were obtained from adult *A. dumerili* by wiping the cloacal area with a paper towel, pressing the base of the tail, and allowing the glandular exudates to flow into glass vials. Samples were pooled according to sex. Samples used for lipid weight determinations were collected in vials without solvent. Ethyl ether was added to samples used for analysis of volatile components. Chloroform was added to samples for total lipid extraction and acid-base-neutral partitioning. The vials were transported on dry ice and stored at –90 °C.

Total lipids were extracted from the scent gland secretions of *A. dumerili* as described previously [5, 9]. Additional fractionation was done by acid-base-neutral partitioning using 4 N H₃PO₄ and 4 M NaOH for pH adjustment and extracting with CHCl₃. Extracts were concentrated by rotoevaporation.

Analytical and preparative TLC using glass plates coated with silica gel HF₂₅₄ (Merck, Darmstadt, F.R.G.) also was performed on secretion extracts. TLC plates were developed in benzene:hexane:acetic acid (50:50:2; v/v/v) and then in hexane:ethyl ether:acetic acid (80:20:2; v/v/v). Analytical plates were sprayed with 50% sulfuric acid in methanol or 5% phosphomolybdic acid in ethanol and heated to visualize the lipids. Lipids on the preparative plates were recovered by scraping zones corresponding to the following R_f ranges: 0–0.13 (zone 1), 0.13–0.25 (zone 2), 0.25–0.50 (zone 3), 0.50–0.67 (zone 4), and 0.67–1 (zone 5). Zone 1 was eluted with CH₃OH and then with ethyl ether; the other zones were eluted with ethyl ether.

Trimethylsilyl derivatives of lipids were obtained by placing secretion residues in Reacti-vials (Pierce Chemical Co., Rockford, Ill.) and adding TRI-SIL (Pierce Chemical Co.) silylating reagent. The total fatty acid content of the secretions was determined by hydrolysis followed by methylation using 14% BF₃ in methanol. Methyl esters were extracted with hexane. Fatty acids in the acid frac-

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tion and those eluted from TLC plates were esterified by reaction with diazomethane in ethyl ether [10].

Scent gland lipids subjected to GC/MS were identified by comparison of retention times and/or mass spectra with those of authentic standards, or by derivatization and identification of reaction products. GC/MS analysis of volatile scent gland components was performed on a 5970 Hewlett-Packard mass selective detector interfaced with an HP 5890 gas chromatograph. Separations were performed with a HP-1 cross-linked methyl silicone capillary column (12 m \times 0.2 mm i.d., 0.33 μ film thickness). The oven temperature was 40 °C for the first 4 min and then increased at a rate of 30 °C/min to a final temperature of 250 °C. The ionization mode was electron ionization at 70 eV, ion source temperature 200 °C, transfer line 260 °C, and scan sample time 0.69 sec over a mass range of m/z = 35–350. Mass calibration and mass spectrometer operating parameters were established with a perfluorotributylamine standard.

All other GC/MS analyses were performed on a HP 5995C interfaced with a HP 5890A gas chromatograph. Separations were performed on a DB-1701 fused silica bonded stationary phase capillary column (30 m \times 0.32 mm i.d., 0.25 μ film thickness). A typical temperature program was: 100–300 °C, 10 °C/min, holding at 300 °C for 10 min. The ionization mode was electron ionization at 70 eV, ion source temperature 200 °C, transfer line 300 °C, and scan cycle time 0.71 sec over a mass range m/z 20–620.

Results and Discussion

Lipids comprise from 3–5% of the total scent gland secretions of *A. dumerili*, as indicated by weights of the extract residues. TLC chromatograms of total lipid extracts indicate prominent bands consistent with sterols and free fatty acids in zones 2 and 3, respectively. A band migrating in zone 5 is more prominent in the TLC profiles of females than in those of males; this was the only evidence for sex differences in scent gland components.

Cholesterol is the most abundant lipid in the secretions of *A. dumerili*, accounting for more than 30% of the total ion current (TIC). This com-

pound has previously been identified by MS in the scent gland secretions of several snakes [2, 5–8].

5-Cholesten-3-one was reported in a previous analysis of the scent gland lipids of *A. dumerili* [5]. However, we failed to detect this compound among either the silylated products of the total lipids or the TLC eluants of this species' secretions. Cholestenone reported in the previous study of *A. dumerili* may have arisen in the GC injection port or on the column from a portion of cholesterol in the secretions that failed to react with the silylating agent.

Propanoic, 2-methylpropanoic, butanoic, 2-methylbutanoic, and 3-methylbutanoic acids and phenol were identified among the volatile components of the secretions; these compounds have not previously been indicated in snake scent gland secretions. Fatty acids (relative percentages in parentheses) detected as methyl esters in the total fatty acid and the acid-partitioned fractions include phenylacetic ($\leq 1\%$), 3-phenylpropanoic ($\leq 1\%$), hexadecanoic (14%), heptadecanoic (2%), 9-octadecenoic (3%), octadecanoic (17%), eicosanoic (8%), docosanoic (9%), tetracosanoic (7%), and hexacosanoic acids (6%). 2-Hydroxypropanoic acid, which had previously been reported in the scent gland secretions of *A. dumerili* [5], is also indicated in our analysis.

A homologous series of even-carbon C_{16} – C_{22} *n*-amides, primarily hexadecanamide and octadecanamide, was detected among the minor components of the total lipids and as eluants of TLC zone 1. These compounds are indicated by prominent ions in the mass spectra at m/z 59 and m/z 72, products of a McLafferty rearrangement and a β -cleavage, respectively. Minor amounts of C_{16} – C_{22} amides also have been reported in the scent gland secretions of the western diamondback rattlesnake (*Crotalus atrox*), a viperid [7].

GC/MS analysis of the base fraction of *A. dumerili* secretions indicates three peaks tentatively identified as amines. The mass spectrum of each compound displays a prominent m/z 30 ion (Fig. 1). Selected ion chromatograms indicate m/z 172, 186, and 200 as potential molecular ions for the respective GC peaks. These values are consistent with diamine compounds, however, authentic 1,8-, 1,10-, and 1,12-*n*-diamines matched neither the retention times nor mass spectra of the unknowns. Each mass spectrum contains a $[M-15]^+$

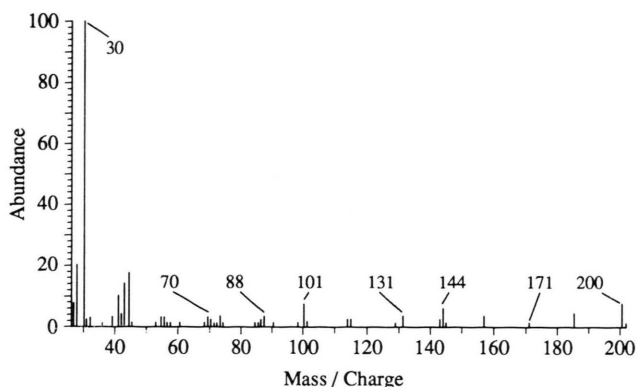


Fig. 1. Mass spectrum of one of three unknown amines detected in the base fraction of *A. dumerili* scent gland secretions.

ion, which is consistent with the loss of a methyl group, and a $[M-43]^+$ ion, which is consistent with the loss of C_3H_7 . The last two peaks to elute contain a $[M-29]^+$ ion, which suggests the loss of C_2H_5 . Further studies are needed to characterize these components.

Analyses by GC/MS of TLC zone 5 indicate cholestadiene, squalene, and an unknown isoprenoid eluting just before squalene in the TIC. The cholestadiene exhibits a molecular ion at m/z 368 and the same retention time as cholesta-3,5-diene, a common isomer of this compound. However, a cluster of peaks in the m/z 247 region of the spectrum of authentic cholesta-3,5-diene is not observed in that of the snake-derived compound, indicating that the latter is not the 3,5 isomer. The isoprenoid detected in the secretions is indicated by a prominent ion of $m/z = 69$ in its mass spec-

trum and by its R_f value. This compound migrates on TLC plates to the same region as squalene and may be a partially hydrogenated isomer of squalene.

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