Phytochemistry, 1974, Vol 13, pp 1547 to 1549 Pergamon Press Printed in England

THREE NEW TRITERPENES FROM THE LICHEN *XANTHORIA RESENDEI**

ANTONIO G. GONZÁLEZ, JULIO D. MARTÍN and CIRILO PÉREZ

Departamento de Química Orgánica, Universidad de La Laguna, Instituto de Investigaciones Químicas, C S I C, Tenerife, Spain

(*Received* 21 *November* 1973)

Key Word Index—*Xanthoria resendei*, lichen, triterpenes, migrated hopene type, 12α-acetoxy-3β-hydroxyfern-9(11)-ene, 3β,12α-dihydroxyfern-9(11)-ene, 3,12-diketofern-9(11)-ene; sterols; peroxyergosterol, anthraquinone pigments, physcion, fallacinal; fallacinol

Abstract—The three new migrated hopene type triterpenes 12α-acetoxy-3β-hydroxyfern-9(11)-ene, 3β,12α-dihydroxyfern-9(11)-ene and 3,12-diketofern-9(11)-ene have been isolated from the ether extracts of the lichen *Xanthoria resendei*, together with peroxyergosterol and the anthraquinone pigments physcion, fallacinal and fallacinol

IN A PREVIOUS communication[1] we reported the isolation of the anthraquinone pigments physcion, fallacinal and fallacinol from the lichen *Xanthoria resendei*.[2] The present paper gives a detailed account of the triterpenes found in this lichen.

RESULTS AND DISCUSSION

From the ether extract of *X. resendei* the three new migrated hopene type triterpenes 12α-acetoxy-3β-hydroxyfern-9(11)-ene (**1**), 3β,12α-dihydroxyfern-9(11)-ene (**2**) and 3,12-diketofern-9(11)-ene (**6**) have been isolated by silica gel chromatography. Interconversion among the three triterpenes was effected as follows: deacetylation of **1** gave the diol **2**; on acetylation both **1** and **2** yielded the diacetate **3**. **2** was oxidized with Jones reagent to give the diketone **6** as the only product.

From the MS and elemental analysis **1** has the molecular formula $C_{32}H_{52}O_3$ The IR spectrum showed absorption bands for OH (3560) and acetyl (1730 cm^{-1}). The NMR spectrum revealed the presence of six tertiary Me groups at τ 8·93, 9·03, 9·13 and 9·24; two Me doublets of an isopropyl group at 9·11 and 9·17 (both *d*, *J* 7 Hz); one acetyl methyl at 8·02 and a one-proton signal at 6·70 ($W_{1/2}$ 14 Hz; >CHOH). The two broad singlets of the vinylic H-C_{11} (at 4·89) and the H-C_{12} (at 4·98; shifted to 6·10 in the NMR spectrum of **2**) indicated that the H-C_{12} is axial.[3]

Oxidation of **1** with Jones reagent gave the ketone **4**. With CrO_3 **2** was partially oxidized to the α,β-unsaturated ketone **5** (UV: 246 nm, ε 9120; IR: 1672, 1611 cm^{-1}). Treatment of **1** with 2% HCl in boiling EtOH yielded the heteroannular diene **10** whose UV maxima

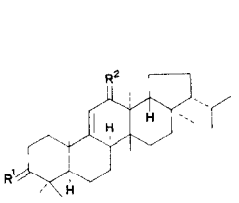
* Part III in the series "Chemical Studies on Lichens from the Canary Isles" For Part II see GONZÁLEZ, A G, MARTÍN, J D and MELIÁN, M (1973) *Anal Quím* **69**, 807

[1] GONZÁLEZ, A G., MARTÍN, J D and PÉREZ, C (1973) *Anal Quím* **68**, 805

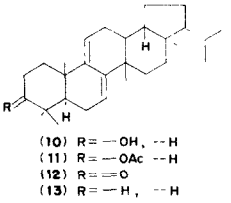
[2] POELT, J and TAVARES, C N (1968) *Portugaliae Acta Biologica* **9**, 300

[3] GREEN, G F H, PAGE, J E and STANIFORTH, S E (1966) *J Chem Soc* (*B*) 807.

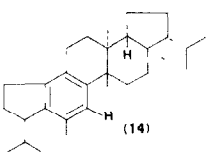
(233, 239, 247 nm; ε 19788, 21460, 13504) are characteristic for 7,9(11)-dienes with 13α,14β-Me groups [4] On acetylation **10** gave the monoacetate **11**.[5] Treatment of **10** with Jones reagent at 0° afforded the ketone **12** which was converted by reduction with anhydrous N_2H_4 to ferna-7,9(11)-diene (**13**).[6] That **1** has a 3β-OH group was further shown by the formation of the aromatic hydrocarbon **14**[7] upon treatment of **10** (or **11**) with 7% H_2SO_4–HOAc under reflux for 3 hr



(1) R^1 = —OH, —H, R^2 = —H, —OAc
(2) R^1 = —OH, —H, R^2 = —H, —OH
(3) R^1 = —OAc —H, R^2 = —H, —OAc
(4) R^1 = =O, R^2 = —H, —OAc
(5) R^1 = —OH, —H, R^2 = =O
(6) R^1 = =O R^2 = =O
(7) R^1 = =O, R^2 = —H, —H
(8) R^1 = —H, —H, R^2 = =O
(9) R^1 = —H, —H, R^2 = —H, —H



(10) R = —OH, —H
(11) R = —OAc —H
(12) R = =O
(13) R = —H, —H



(14)

The 9(11)-position of the double bond, which was inert to catalytic hydrogenation, in **1** was confirmed by the following reaction Reduction of **6** with anhydrous N_2H_4 gave a mixture of the partially reduced compounds 3-ketofern-9(11)-ene (**7**)[8] and 12-ketofern-9(11)-ene (**8**)[6] as well as fern-9(11)-ene.[6]

EXPERIMENTAL

The m ps were determined on a Kofler block and are uncorrected Solvent used for recrystallization was MeOH unless otherwise stated Optical rotations were measured in $CHCl_3$, UV spectra in EtOH and IR spectra in KBr if not otherwise indicated NMR spectra were taken on a 60 MHz instrument in $CDCl_3$ with TMS as internal standard, $W_{1/2}$ refers to the width of a band at half height Column and dry column chromatography was performed on silica gel 0 2–0 5 and 0 063–0 20 mm respectively, TLC and PLC on silica gel G, the spray reagent was 6 N H_2SO_4 Petrol refers to the fraction b p 40–60° Anh Na_2SO_4 was used for drying solns Acetates were prepared with Ac_2O in pyridine at room temp for 24 hr

Extraction and separation The lichen was collected at Punta del Hidalgo (Tenerife) in January 1971 Samples collected from several other localities and at different times of the year yielded the same compounds The air-dried lichen (7 2 kg) was finely ground and extracted (Soxhlet) with Et_2O (20 l) for 90 hr The red precipitate (12 7 g) was filtered off, concentration of the soln (3 l) gave more precipitate (14 4 g) Evaporation of the solvent yielded a dark yellow-brown residue (311 g) which was chromatographed on silica gel (1 5 kg) Elution with petrol–C_6H_6 (95 5) gave physcion (0 17%), with C_6H_6–$CHCl_3$ (1 1) fallacinal (0 05%), 3,12-diketofern-9(11)-ene (**6**, 0 0006%), 12α-acetoxy-3β-hydroxyfern-9(11)-ene (**1**, 0 02%) and peroxyergosterol (0 0007%), and with $CHCl_3$ fallacinol (0 06%) and 3,12-dihydroxyfern-9(11)-ene (**2**, 0 006%) Further elution with $CHCl_3$ gave no more crystalline substances

12α-*Acetoxy-3β-hydroxyfern*-9(11)-*ene* **1**, m p 268–270 , $[\alpha]_D$ 86° (*c* 0 22) (Found C, 79 12, H, 10 53 $C_{32}H_{52}O_3$ requires C, 79 33, H, 10 74%) IR 3560, 2930, 1730, 1450, 1380, 1260, 1195, 1020, 970, 960, 920 cm^{-1} NMR see text MS *m/e* (%) 484 (M^+, 11), 442 (18), 424 (100), 391 (8), 295 (18), 274 (43), 259 (54) 255 (42)

3β,12α-*Dihydroxyfern*-9(11)-*ene* **2**, m p 208–209 , $[\alpha]_D$ 0° (*c* 0 25) (Found C, 81 23, H, 11 56 $C_{30}H_{50}O_2$ requires C, 81 44, H, 11 31%) IR ($CHCl_3$) 3600, 3440, 1470, 1380, 1010, 920 cm^{-1} NMR τ 9 23, 9 18 (each 3H, *s*), 9 17 (3H, *d*, *J* 7 Hz), 9 12 (6H, *s*), 9 11 (3H, *d*, *J* 7 Hz), 9 03, 8 92 (each 3H, *s*), 6 70 (1H, *t*, *J* 8 Hz), 6 10, 4 80 (each 1H, *bs*) MS *m/e* (%) 442 (M^+, 100), 424 (12), 409 (8), 273 (48), 271 (54), 255 (22) Saponification of **1** (98 mg) with 2% methanolic KOH (50 ml) under reflux for 30 min gave **2** (84 mg), identical with the natural product (m m p , TLC IR, NMR)

3,12-*Diketofern*-9(11)-*ene* **6**, m p 250–251 °, $[\alpha]_D$ −45 (*c* 2 16) (Found C, 81 95, H, 10 61 $C_{30}H_{46}O_2$ requires C, 82 19, H, 10 52%) UV 246 nm (ε 10028) IR 1715, 1680, 1612, 1120, 870 cm^{-1} NMR τ 9 21 (3H, *s*), 9 15 (3H, *d*, *J* 7 Hz), 9 14 (3H, *s*), 9 08 (3H, *d*, *J* 7 Hz), 8 92, 8 83, 8 80, 8 62 (each 3H, *s*), 4 25 (1H, *d*, *J* 3 Hz) MS *m/e* (%) 438 (M^+, 100), 423 (58), 395 (56), 287 (5), 273 (20), 271 (34), 255 (3) Oxidation of **2** (48 mg) with Jones reagent at room temp gave **6** (44 mg), identical with the natural product (m m p , TLC IR, NMR)

[4] Nishimoto, K , Ito, M and Natori, S (1968) *Tetrahedron* **24**, 735
[5] Nakamura, S , Yamada T , Wada, H , Inoue, Y , Goto, T and Hirata, Y (1965) *Tetrahedron Letters* 2017
[6] Ageta, H , Iwata K and Natori, S (1963) *Tetrahedron Letters* 1447
[7] Fukuoka, M and Natori, S (1970) *Tetrahedron Letters* 4867
[8] Wada, H , Goto, G Goto, T and Hirata, H (1966) *Yakugaku Zasshi* **86**, 3461

3β,12α-Diacetoxyfern-9(11)-ene **3** Acetylation of **1** and **2** gave **3**, m p 186–188°, $[\alpha]_D$ 99° (*c* 0·24) (Found. C, 77 51; H, 10·39 $C_{34}H_{54}O_4$ requires C, 77·56; H, 10 27%) IR ($CHCl_3$) 1730(s), 1250, 920 cm^{-1} NMR τ 9·22 (3H, *s*), 9 17 (3H, *d*, *J* 7 Hz), 9 11 (6H, *s*), 9 11 (3H, *d*, *J* 7 Hz), 9·03 (6H, *s*), 8 89, 7 97, 7 91 (each 3H, *s*), 5 40 (1H, *t*, *J* 8 Hz), 4·80 (2H, *m*) MS *m/e* (%) 526 (M^+, 4), 484 (18), 466 (100), 451 (22), 423 (4), 391 (16), 316 (23), 301 (35), 295 (15), 255 (33)

12α-Acetoxy-3-ketofern-9(11)-ene **4** To a stirred soln of **1** (60 mg) in Me_2CO (20 ml) at room temp Jones reagent (0 2 ml) was added dropwise till a permanent orange colour resulted After a further 2 min stirring the mixture was worked up giving **4** (60 mg), m p 211°, $[\alpha]_D$ 77° (*c* 0 30) (Found· C, 79 86, H, 10 52 $C_{32}H_{50}O_3$ requires C, 79 66, H, 10 37%) IR 1730, 1710, 1020, 970, 860 cm^{-1} NMR· τ 9 23 (3H, *s*), 9 17 (3H, *d*, *J* 7 Hz), 9 11 (3H, *s*), 9 11 (3H, *d*, *J* 7 Hz), 9 06, 8·95, 8 87, 8 68 (each 3H, *s*), 4 95, 4 80 (each 1H, *bs*) MS· *m/e* (%) 482 (M^+, 5), 440 (11), 422 (68), 407 (100), 379 (4), 272 (54), 257 (46), 255 (15)

Partial oxidation of **2** A soln of **2** (120 mg) in Me_2CO (20 ml) was treated with CrO_3 (180 mg)-H_2O (0 15 ml)-H_2SO_4 (0 15 ml) at 0° and the ice-cooled mixture stirred for 40 min Multiple PLC (3 ×) of the resulting product (112 mg) with C_6H_6–EtOAc (96 4) gave, in order of increasing R_f value, starting material (15 mg), *3β-hydroxy-12-ketofern-9(11)-ene* (**5**, 56 mg) and **6** (32 mg) **5** had m p 254–256°, $[\alpha]_D$ −27° (*c* 1 54) (Found C, 81 81, H, 10·72. $C_{30}H_{48}O_2$ requires: C, 81 81, H, 10 90%) UV 246 nm (ε 9120) IR 3450, 1672, 1611, 870 cm^{-1} NMR: τ 9 21, 9 19 (each 3H, *s*), 9 17, 9 11 (each 3H, *d*, *J* 7 Hz), 9 10, 9 00, 8 88, 8·81 (each 3H, *s*), 6 72 (1H, *t*, *J* 8 Hz), 4 25 (1H, *d*, *J* 3 Hz)

Reduction of **6**. **6** (284 mg) in hexane (20 ml) was added to freshly distilled diethylene glycol (15 ml) By increasing the temp to 180° the hexane was distilled off Anhyd N_2H_4 (5 ml) was added till the soln was refluxing freely at 180° (soln temp) for 3 hr After adding KOH (0 5 g) and removing the excess N_2H_4 the mixture was refluxed for 1 hr more (bath temp 240–243°), poured into ice-water and extracted with Et_2O The residue (124 mg) was chromatographed on silica gel (100 g) Petrol eluted *fern-9(11)-ene* (**9**, 32 mg), m p 173°, $[\alpha]_D$ −18° (*c* 1 25) (lit [6] m p 170–171°, $[\alpha]_D$ −16 5°) (Found C, 87 58, H, 12 33 Calc for $C_{30}H_{50}$· C, 87 80, H, 12 19%) C_6H_6 eluted first *3-ketofern-9(11)-ene* (**7**; 16 mg), m p 198°, $[\alpha]_D$ −40° (*c* 0 48) (lit [8] m p 196°, $[\alpha]_D$ −60°) (Found C, 84 88, H, 11 30 Calc for $C_{30}H_{48}O$ C, 84 90; H, 11 32%), IR 1700, 1635, 1005, 980, 860 cm^{-1}, and then *12-ketofern-9(11)-ene* (**8**, 14 mg), m p 222–223°, $[\alpha]_D$ −30° (*c* 0 25) (lit [6] m p 221 5–223°, $[\alpha]_D$ −28°) (Found C, 84·86, H, 11 34 Calc for $C_{30}H_{48}O$ C, 84·90, H, 11 32%), UV 246 nm (ε 9140), IR 1674, 1613, 870 cm^{-1}

3β-Hydroxyferna-7,9(11)-diene **10** **1** (56 mg) was refluxed with EtOH (25 ml) and conc HCl (1 ml) for 1 hr The soln was concentrated and poured into ice–water Dry column chromatography of the precipitate on silica gel (5 g) with hexane–C_6H_6 (1 1) gave **10** (47 mg), m p 220–221°, $[\alpha]_D$ − 189° (*c* 0 72) (Found C, 84 92, H, 11·44 $C_{30}H_{48}O$ requires· C, 84 90, H, 11 32%); UV. 233, 239, 247 nm (ε 19788, 21460, 13504); IR 3560, 1640, 1610, 820, 815, 790 cm^{-1}, NMR τ 9 31, 9 24 (each 3H, *s*), 9 17 (3H, *d*, *J* 7 Hz), 9 13 (3H, *s*), 9 09 (6H, *s*), 9 09 (3H, *d*, *J* 7 Hz), 9 03 (3H, *s*), 6 70 (1H, *m*, $W_{1/2}$ 14 Hz), 4 85, 4 55 (each 1H, *bs*), MS *m/e* (%) 424 (M^+, 100), 409 (15), 391 (15), 271 (22), 255 (18) *Acetate* **11**, m p. 239–242°, $[\alpha]_D$ −138° (*c* 1 27) (lit [5] m p 238°, $[\alpha]_D$ −144°). (Found C, 82 55, H, 11 03 Calc for $C_{32}H_{50}O_2$ C, 82 40, H, 10 80%)

3-Ketoferna-7,9(11)-diene **12** A soln of **10** (112 mg) in Me_2CO (20 ml) was stirred at 0° while Jones reagent (0 2 ml) was added dropwise until the orange colour persisted. Dry column chromatography of the product with C_6H_6–petrol (2 1) gave **12** (104 mg), m p. 178–179°, $[\alpha]_D$ −226° (*c* 0 58) (Found· C, 85 40, H, 10 81 $C_{30}H_{46}O$ requires C, 85 30, H, 10 90%) UV 233, 239, 247 nm (ε 18730, 20560, 12850) IR 1710, 1600, 1270, 1115, 990, 780 cm^{-1}. NMR· τ 9 33, 9 24 (each 3H, *s*), 9·17, 9 09 (each 3H, *d*, *J* 7 Hz), 9 08, 9 00, 8·92, 8·83 (each 3H, *s*), 4 80, 4 52 (each 1H, *bs*) MS *m/e* (%) 422 (M^+, 100), 407 (28), 337 (15), 284 (15), 271 (24), 255 (18).

Ferna-7,9(11)-diene **13** A soln of **12** (98 mg) in diethylene glycol (8 ml) was refluxed with anhyd N_2H_4 (1 5 ml) for 2 hr KOH (150 mg) was added and the excess N_2H_4 distilled off till the mixture refluxed freely at 238° It was kept at this temp. for 4 hr Usual work-up gave **13** (35 mg), m p 197–198°, $[\alpha]_D$ −165° (*c* 2 38) (lit [6] 198–199°, $[\alpha]_D$ −157 3°) (Found C, 88 38, H, 11 53 Calc for $C_{30}H_{48}$ C, 88 23, H, 11 76%), UV: 233, 239, 247 nm (ε 9700, 21320, 13470), IR 1640, 1610, 820, 815, 790 cm^{-1}; identical with an authentic sample (m m p , TLC, IR, NMR)

Acid-catalyzed rearrangement of **10** **10** (58 mg) was refluxed with 7% H_2SO_4–HOAc (18 ml) for 2 hr Usual work-up and dry column chromatography of the product gave **14** (20 mg), m p 159–160° (Me_2CO), $[\alpha]_D$ −16·5° (*c* 1·24) (lit [7] m p 157–159°, $[\alpha]_D$ −16°) (Found· C, 88 58; H, 11 29 Calc for $C_{30}H_{46}$ C, 88·67, H, 11 33%) Identical treatment of **11** gave also **14** (m m p , TLC, IR)

Acknowledgements—The authors thank Dr W Wildpret (Dept of Botany, University of La Laguna) for identifying the lichen, Prof H Ageta (Showa College of Pharmacy, Tokyo) for a sample of ferna-7,9(11)-diene and Prof H Kakisawa (Tokyo Kyoiku University, Tokyo) for its IR spectrum This work was performed within the Programme of Chemistry 1971 supported by the Foundation "Juan March"