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LIMONOIDS FROM *TURRAEA HOLSTII* AND *TURRAEA FLORIBUNDA*

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Key Word Index—*Turraea holstii*; Meliaceae; limonoids; 1,3-diacetylvilasinin; 11-*epi*-toonacilin; 11β,12α-diacetoxycedrelone; 12-*O*-methylnimbolinin B; 12α-acetoxy-neotrichilenone; 12α-acetoxy-7-acetyl-1,2-dihydroneotrichilenone; 12α-acetoxy-1,2-dihydroneotrichilenone; 11β-acetoxy-7-acetyl-12α-hydroxy-1,2-dihydroneotrichilenone; *Turraea floribunda*; turraflorins.

Abstract—Investigations of the stem and root bark of *Turraea holstii* have yielded the known 1,3-diacetylvilasinin and seven novel limonoids: 11-*epi*-toonacilin, 11β,12α-diacetoxycedrelone, 12-*O*-methylnimbolinin B, 12α-acetoxyneotrichilenone, 12α-acetoxy-7-acetyl-1,2-dihydroneotrichilenone, 12α-acetoxy-1,2-dihydroneotrichilenone and 11β-acetoxy-7-acetyl-12α-hydroxy-1,2-dihydroneotrichilenone. The stereochemistry at C-11 in turraflorins A–C from *Turraea floribunda* has been revised. © 1998 Elsevier Science Ltd. All rights reserved

INTRODUCTION

The genus *Turraea* comprises some 60–70 species of shrubs and small trees widely distributed in eastern Africa and the islands of the Indian Ocean. Species of the genus have previously been shown to afford a variety of both protolimonoids and limonoids, included among which are: simple A–D ring-intact limonoids from the bark of *T. floribunda* [1] and the rootbark of *T. nilotica* [2] and *T. robusta* [3]; ring B-opened turraflorins from the seed of *T. floribunda* [4]; the ring C-opened limonoid, nimbolinin B, from *T. robusta* [3]; and complex prieurianin-type limonoids from the seed of *T. obtusifolia* [5] and *T. mombasana* [6]. In a continuation of our investigations into members of this genus, the stem and root bark of the East African species *T. holstii* have now been examined.

RESULTS AND DISCUSSION

Eight limonoids were isolated in this investigation from the methanol extract of the stem and root bark of *T. holstii*. The isolation of the triterpenoids, holstinone A and B from this species has been reported previously [7]. Compounds **1**, **2**, **3**, **4**, **6** and **7** were isolated from the stembark and compounds **2**, **3**, **5** and **8** from the root bark. Compounds **2**–**8** have not been described previously. Compound **1** was found to be 1,3-diacetylvilasinin, which has been isolated previously from the seed oil of *Azadirachta indica* [8]. Compound **2** was identified as 11-*epi*-toonacilin. HRMS of **2** gave a molecular ion at *m/z* 554.2500 indicating a molecular formula $C_{31}H_{38}O_9$. Peaks at *m/z* 494 $[M\text{-}CH_3COOH]^-$ and 434 $[M\text{-}2CH_3COOH]^+$ indicated the presence of two acetate groups in the molecule. The limonoid β-substituted furan ring proton resonances occurred at δ 7.26, 7.09 and 6.12. The presence of an α,β-unsaturated ketone in ring A was indicated by a pair of doublets at δ 7.41 and 6.13 (J = 10.5 Hz) in the ^{1}H NMR spectrum and resonances at δ 152.3, 125.7 and 203.9, ascribable to C-1, C-2 and C-3, respectively, in the ^{13}C NMR spectrum. A carbomethoxy group three-proton singlet resonance at δ 3.64 and exocyclic methylene group proton resonances at δ 5.18 and 5.25 indicated an open ring B. A proton resonance at δ 3.85 which corresponded to a methine carbon resonance at δ 59.6 in the HETCOR spectrum confirmed the presence of a 14,15-epoxide as in toonacilin. The two acetate groups were placed at C-11 and C-12. The

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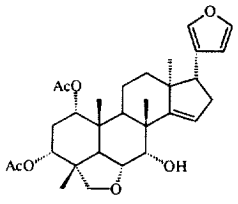

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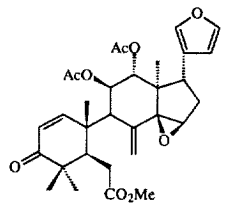

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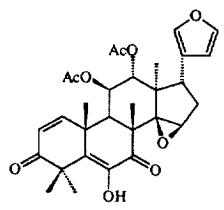

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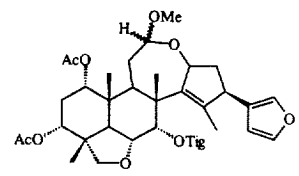

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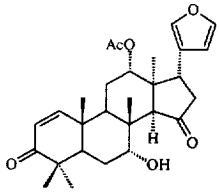

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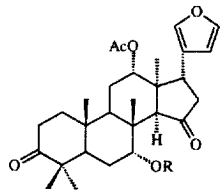

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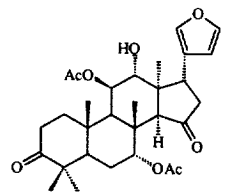

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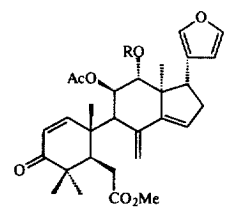

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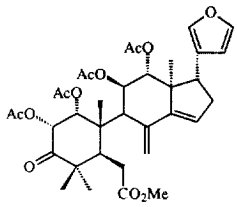

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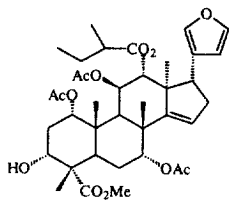

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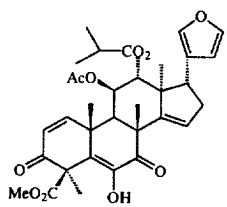

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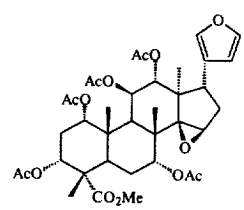

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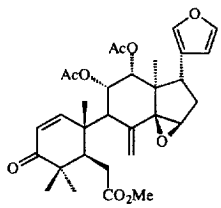

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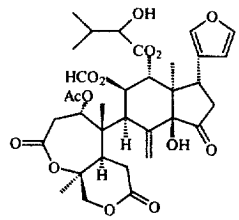

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H-9 resonance occurred as a doublet at δ 2.97 (J = 7.2 Hz) and was coupled to the H-11 double doublet at δ 5.50 which was, in turn, coupled to the H-12 doublet at δ 5.68 (J = 10.8 Hz). The two acetate methyl group proton singlets occurred at δ 1.67 and 1.87. In ring B-opened limonoids, the 12α-acetate group proton resonance is shielded [9]. Thus the resonance at δ 1.67 was assigned to the methyl group proton resonance of a 12α-acetate group. In toonacilin, H-12 occurs as a doublet ($J_{11,12}$ = 4.3 Hz), H-11 also occurs as a doublet ($J_{11,12}$ = 4.3 Hz) and H-9 appears as a broad singlet [10]. In **2**, $J_{11,12\alpha}$ is 10.8 Hz and $J_{9,11}$ is 7.2 Hz. Thus **2** is 11-*epi*-toonacilin.

Compound **3**, $C_{30}H_{34}O_9$ was identified as 11β,12α-diacetoxycedrelone. Rings A, C and D were the same as **2**, but ring B was not opened. The COSY spectrum indicated coupling between H-9α(δ2.92, *bs*), H-11α(δ5.36, *bs*) and H-12β(δ5.19, *bs*). This difference between $J_{9,11}$ and $J_{11,12}$ in compounds **2** and **3** is discussed later. A singlet at δ 6.45 disappeared on deuteration suggesting the presence of a diosphenol as in hirtin [11]. Fully substituted carbon resonances at δ 134.1, 140.9 and 196.9 could be ascribed to C-5, C-6 and C-7, respectively, in **3**; these are found to occur at δ 135.0, 140.2 and 195.8 in the ^{13}C NMR of hirtin [11].

Compound **4**, $C_{36}H_{48}O_{10}$, was identified as the ring C-oxidized 12-*O*-methylnimbolinin B. Nimbolinin B has been isolated previously from *T. robusta* [3] and it is possible that methylation could have occurred during the extraction process.

Compounds **5–8** were all limonoids with rings A–D intact and a keto-group at C-15 indicating that the 14,15-epoxide had been opened as in the neotrichilinones which were formed from limonoids from *Trichilia havanensis* on treatment with MeOH–HCl [12]. The C-14 methine carbon resonance occurred in the δ 58–60 region and the C-15 keto-group carbon resonance occurred between δ 217 and 220 in the ^{13}C NMR spectrum of these compounds. Compound **5**, $C_{28}H_{36}O_6$, was identified as 12α-acetoxyneotrichilinone. An α,β-unsaturated ring A ketone was present as in **2**. ^1H,^{13}C NMR and MS data indicated the presence of a secondary hydroxy group and an acetate group in **5**. NOE experiments indicated that the acetate group was present at C-12α. Positive NOEs were found between H-12β, H-17β and H-22. H-12β occurred as a triplet at δ 5.18 (J = 3.4 Hz). The hydroxy group was placed at C-7α. H-14 has been shown to occur at about δ 2.8 when a hydroxy group is present at C-7α but occurs at δ 2.5 when an acetate group is present at this position [12, 13]. In **5**, H-14 occurred at δ 2.9 confirming the presence of the hydroxy group at C-7α.

Compound **6**, $C_{30}H_{40}O_7$, was found to be the 1,2-dihydro-7-acetyl derivative of **5**. H-7 occurred at δ 4.33 and H-14 occurred at δ 2.52 as expected when an acetate group is present at C-7α. Compound **7** was obtained in very small quantities and only a ^1H NMR spectrum could be obtained. It was found to be the 1,2-dihydro derivative of **5**. Acetylation of **7** yielded **6**.

Compound **8**, $C_{32}H_{42}O_9$, was identified as 1,2-dihydro-11β-acetoxy-12α-hydroxy-7α-acetylneotrichilinone. Mass and ^1H NMR spectroscopy indicated the compound was a diacetate. H-9 occurred as a broad singlet at δ 1.92 and was coupled to a C*H*OAc methine proton resonance at δ 5.45 ascribable to H-11, which was in turn coupled to a methine proton resonance at δ 3.83 ascribable to H-12. H-12 shifted downfield on acetylation to δ 5.19. The stereochemistry was ascertained from the very small coupling constant $J_{9,11} = J_{11,12} \sim 0$ Hz. A model showed that H-9α:H-11α and H-11α:H-12β dihedral angles are close to 90° thus the acetate group was placed at C-11β and the hydroxy group at C-12α in **8**. H-7β occurred at δ 4.90 and H-14 at δ 2.57.

The stereochemistry of 11,12-disubstituted limonoids from *Turraea* species has invariably been found to be 11β,12α, with the single exception of the ring B-open turraflorins A–C isolated from *T. floribunda* seeds [5]. These were assigned as 11α,12α on the basis of $J_{9,11}$ and $J_{11,12}$ coupling constants of 11 and 6 Hz, which differed widely from the corresponding values of 3–5 Hz and 3–5 Hz, respectively, of those of the ring B intact limonoids from *T. floribunda* bark [1]; coupling constants for the only known ring B-open 11α,12α-disubstituted compound, the 14,15-epoxy analogue toonacilin from *Toona ciliata* [14], were not originally recorded, rendering direct comparison impossible. Their significant difference (H-9, *br s*; $J_{11,12}$ = 4.3 Hz) from expected values, on subsequent discovery in a second publication [10], prompted a literature investigation to examine the effects of structural features at C-8 and C-14 on the coupling constants $J_{9,11}$ and $J_{11,12}$. These results are summarized in Table 1, from which it can readily be seen that when ring B is open, the 11β,12α-substitution pattern is indicated by large coupling constants, with 11α,12α-substitution affording smaller values. Conversely, when ring B is closed, small coupling constants indicate the 11β,12α-substitution pattern; while ring-B intact 11α,12α-disubstituted compounds are not known, they presumably would exhibit larger values. Examination of molecular models reveals that while ring C can be chair-like in ring B-cleaved compounds, giving rise to dihedral angles of ~45° and ~180° for H-9/H-11α and H-11α/H-12β, respectively, it can only be boat-like if ring B is intact, with the corresponding angles both very close to 90°. Remarkably, the conformations adopted are independent of the C-14,C-15 substitution pattern and/or the hybridisation state of C-14 in particular, hence the similarity between the coupling constants for compounds **2**, **9** and **16** on one hand and **12** and **14** on the other. Thus the stereochemistry of the substituents at C-11 in the turraflorins is reassigned as β, giving revised structures **9**, **10** and **11** for turraflorins A, B and C, respectively.

EXPERIMENTAL

Stem bark (296 g) and root bark (360 g) of *Turraea holstii* were collected in Wesu area, Taita Javeta District, Coast Province, Kenya, and identified by Mr G. Mwachala of the National Museum of Kenya Herbarium, where a voucher specimen is retained. The plant material was air dried, finely ground, and left to stand in MeOH at room temp. for one week. The MeOH was then decanted and concentrated and the resulting extracts sent to Durban, South Africa for analysis.

Separation of components was achieved by means of silica gel (Merck 9385) CC, using the solvent system EtOAc–CH_2Cl_2 (9:1). Compounds **1**, **2**, **3**, **4**, **6** and **7** were isolated from the rootbark extract and compounds **2**, **3**, **5** and **8** from the stembark extract. NMR spectra were run in $CDCl_3$ on a Varian Gemini 300 spectrometer. ^{13}C NMR data are given in Table 2.

Table 1. Variation in $J_{9,11}$ and $J_{11,12}$ in relation to nature of C-8 and C-14

Compound type			H-9α	H-11	H-12β
Ring B intact					
A	H-11α	**12**	2.89*d* (4.4)	5.04*m*	5.13*d* (3.3)
		13	2.97*d* (5.1)	5.73*dd* (5.1, 4.7)	5.36*d* (4.7)
	H-11β	–	–	–	–
B	H-11α	**14**	3.38*d* (3)	5.20*m*	4.88*d* (3)
		3	2.92*brs*	5.36*brs*	5.19*brs*
	H-11β	–	–	–	–
C	H-11α	**8**	+	5.46*m* (3,3)	5.19*d* (3)
	H-11β	–	–	–	–
Ring B open, $\Delta^{8(30)}$					
E	H-11α	**9**	2.84*d* (6)	5.45*dd* (6,11)	5.82*d*(11)
	H-11β	–	–	–	–
F	H-11α	**2**	2.95*d* (7.2)	5.50*dd* (7.2, 10.8)	5.68*d* (10.8)
	H-11β	**15**	2.58*brs*	5.34*d* (4.3)	5.36*d* (4.3)
G	H-11α	**16**	3.76*d* (7)	5.45*dd* (7,12)	6.13*d* (12)
	H-11β	–	–	–	–

In all examples given, compounds are 11,12-diacetates except where indicated. Chemical shifts and coupling constants (in brackets) are listed.

A: Δ^{14}, H-11α: **12** [15], H-11α, ring B diosphenol, 12α-isobutyrate: **13** [16].

B: 14,15-epoxide, H-11α: **14**: *T. floribunda* A acetate [1], H-11α, ring B diosphenol: **3**.

C: 14-αH,15-one, H-11α: **8**.

E: Δ^{14}, H-11α: **9**.

F: 14,15-epoxide, H-11α: **2**, H-11β: Toonacilin, **15** [10].

G: 14-βOH,15-one, H-11α: Rohitukin: **16** [17], 12α-2′-hydroxy-3′-methylbutyrate.

–Unknown (search based on compounds in Dictionary of Natural Products).

+Peak obscured.

Table 2. ^{13}C NMR Data of **1**, **2**, **3**, **4**, **5**, **6** and **8** (75 MHz, $CDCl_3$)

Carbon	**1**	**2**	**3**	**4**	**5**	**6**	**8**
1	72.2 *d*	152.3 *d*	150.1 *d*	71.6 *d*	157.1 *d*	38.6 *t*	38.7 *t*
2	27.2 *t*	125.7 *d*	127.8 *d*	27.5 *t*	126.1 *d*	33.7 *t*	33.5 *t*
3	71.7 *d*	203.9 *s*	202.9 *s*	70.9 *d*	204.8 *s*	216.4 *s*	216.2 *s*
4	42.3 *s*	46.2 *s*	53.4 *s*[a]	42.4 *s*	45.6 *s*	36.4 *s*[a]	39.3 *s*[a]
5	39.6 *d*	45.1 *d*	134.1 *s*	40.1 *d*	38.8 *d*	46.8 *d*	47.1 *d*
6	72.8 *d*	31.3 *t*	140.9 *s*	72.1 *d*	25.4 *t*	22.7 *t*[b]	22.9 *t*
7	74.0 *d*	174.2 *s*	196.9 *s*	75.0 *d*	69.8 *d*	73.3 *d*	74.4 *d*
8	45.8 *s*	136.8 *s*	45.5 *s*[a]	45.1 *s*	39.0 *s*[a]	45.4 *s*[a]	45.2 *s*[a]
9	33.6 *d*	52.9 *d*	42.3 *d*[b]	35.8 *d*	43.8 *d*	44.0 *d*	44.5 *d*
10	39.2 *s*	45.2 *s*	48.4 *s*[a]	40.7 *s*	44.2 *s*[a]	45.4 *s*[a]	37.2 *s*[a]
11	15.2 *t*	71.3 *d*	72.5 *d*	38.1 *t*	23.5 *t*	23.3 *t*[b]	73.8 *d*
12	32.9 *t*	75.2 *d*	78.7 *d*	98.0 *d*	72.4 *d*	72.2 *d*	68.9 *d*
13	47.4 *t*	42.0 *s*	40.0 *s*[a]	140.6 *s*	42.2 *s*[a]	46.7 *s*[a]	46.4 *s*[a]
14	159.9 *s*	77.3 *s*	77.2 *s*	142.9 *s*	60.5 *d*	59.5 *d*	58.1 *d*
15	120.7 *d*	59.6 *d*	15.1 *d*	76.5 *d*	219.7 *s*	217.7 *s*	217.9 *s*
16	34.3 *t*	33.5 *t*	32.0 *t*	31.4 *t*	43.0 *t*	42.8 *t*	42.5 *t*
17	51.5 *d*	37.8 *d*	41.6 *d*[b]	46.6 *d*	38.2 *d*	37.9 *d*	37.0 *d*
20	124.5 *s*	122.2 *s*	121.7 *s*	129.3 *s*	122.4 *s*	122.4 *s*	122.8 *s*
21	139.7 *d*	140.3 *d*	140.4 *d*	138.9 *d*	140.3 *d*	140.3 *d*	139.9 *d*
22	111.1 *d*	111.2 *d*	111.0 *d*	110.4 *d*	110.6 *d*	110.6 *d*	110.6 *d*
23	142.6 *d*	142.5 *d*	142.8 *d*	142.8 *d*	143.3 *d*	143.4 *d*	143.4 *d*
CH_2O (28)	77.9 *t*	–	–	78.0 *t*	–	–	–
30	–	120.8 *t*	–	–	–	–	–
CH_3	26.2 *q*	23.0 *q*	26.8 *q*	20.6 *q*	27.4 *q*	26.0 *q*	33.5 *q*
	21.2 *q*	22.7 *q*	24.7 *q*	19.3 *q*	21.4 *q*	21.6 *q*	26.5 *q*
	19.5 *q*	21.3 *q*	22.6 *q*	16.1 *q*	21.3 *q*	20.8 *q*	21.9 *q*
	15.4 *q*	13.6 *q*	21.1 *q*	15.9 *q*	19.1 *q*	17.6 *q*	19.6*q*
	–	–	15.6 *q*	–	18.6 *q*	15.9 *q*	17.7 *q*
$OCOCH_3$	170.3 *s*	170.1 *s*	169.3 *s*	166.4 *s*[a]	170.3 *s*	170.1 *s*	170.0 *s*
$OCOCH_3$	170.0 *s*	169.7 *s*	168.9 *s*	169.3 *s*[a]	–	169.4 *s*	169.4 *s*
$OCOCH_3$	21.1 *q*	20.6 *q*	20.9 *q*	20.8 *q*	21.2 *q*	21.3 *q*	21.3 *q*
$OCOCH_3$	21.2 *q*	20.6 *q*	21.2 *q*	20.7 *q*	–	21.2 *q*	20.9 *q*
$COOCH_3$	–	52.1 *q*	–	–	–	–	–
OCH_3	–	–	–	54.0 *q*	–	–	–
1′	–	–	–	169.9 *s*[a]	–	–	–
2′	–	–	–	128.3 *s*	–	–	–
3′	–	–	–	136.5 *d*	–	–	–
4′	–	–	–	14.2 *q*	–	–	–
5′	–	–	–	11.8 *q*	–	–	–

[a,b]Values in a vertical column may be interchanged.

1,3-*Diacetylvilasinin* (**1**)

84.3 mg, identified by comparison with literature data [8].

11-*epi-Toonacilin* (**2**)

75 mg, EIMS *m/z* 554.2500 ($C_{31}H_{38}O_9$ req. 554.2514), 494 $[M\text{-}CH_3COOH]^+$, 434 $[M\text{-}2CH_3COOH]^+$, mp 119–121°. ^1H NMR: δ 7.41 (*d*, J = 10.5 Hz, H-1), 7.26 (*d*, J = 1.8 Hz, H-23), 7.09 (*s*, H-21), 6.13 (*d*, J = 10.5 Hz, H-2), 6.12 (*d*, J = 1.8 Hz, H-22), 5.68 (*d*, $J_{11,12}$ = 10.8 Hz, H-12β), 5.50 (dd, $J_{9,11}$ = 7.2 Hz, $J_{11,12}$ = 10.8 Hz, H-11α), 5.28 (*br s*, H-30a), 5.18 (*br s*, H-30b), 3.85 (*br s*, H-15), 3.64 (3H, *s*, $COOCH_3$), 3.02 (*dd*, J = 7.0 Hz, 10.7 Hz, H-17), 2.97 (*d*, $J_{9,11}$ = 7.2 Hz, H-9), 1.87, 1.67 (each 3H, *s*, $OCOCH_3$), 1.06, 0.95, 0.94, 0.88 (ea 3H, *s*, CH_3). IR γ_{max} (NaCl) cm^{-1}: 2935, 1748, 1679, 1237. $[\alpha]_D$ = + 68.5° (*c* 0.897, $CHCl_3$).

11β,12α-*Diacetoxycedrelone* (**3**)

83 mg, EIMS *m/z* 538.2207 ($C_{30}H_{34}O_9$ req. 538.2202), 478 $[M\text{-}CH_3COOH]^+$, mp 137–139°. ^1H NMR: δ 7.29 (*d*, J = 1.7 Hz, H-23), 7.10 (*s*, H-21), 6.91 (*d*, J = 10.0 Hz, H-1), 6.45 (*s*, OH, disappears in D_2O), 6.13 (*d*, J = 10.0 Hz, H-2), 5.36 (*br s*, H-11α), 5.19 (*br s*, H-12β), 3.89 (*br s*, H-15), 2.92 (*s*, H-9), 2.90 (*dd*, J = 7.0 Hz, 11.3 Hz, H-17), 2.29 (*dd*, J = 7.0 Hz, 13.5 Hz, H-16b), 1.97 (*dd*, J = 11.3 Hz, 13.5 Hz, H-16a), 2.15, 1.94 (ea 3H, s, $OCOCH_3$), 1.55, 1.48, 1.35, 1.27, 0.77 (ea 3H, s, CH_3). IR γ_{max} (NaCl) cm^{-1}: 3408, 1749, 1685, 1628, 1367, 1240, 1034, 756.

12-*O-Methylnimbolinin B* (**4**)

97 mg, EIMS *m/z* 640.3233 ($C_{36}H_{48}O_{10}$ requires 640.3244), mp 121–123°. ^1H NMR: δ 7.26 (*d*, J = 1.5 Hz, H-23), 7.22 (*s*, H-21), 6.97 (qq, J = 1.5 Hz, 7.2 Hz, H-3'), 6.35 (*d*, J = 1.5 Hz, H-22), 5.70 (*d*, J = 2.8 Hz, H-7β), 4.92 (*t*, J = 2.6 Hz, H-3β), 4.88 (*d*, J = 7.8 Hz, H-15), 4.71 (*t*, J = 2.6 Hz, H-1β), 4.58 (*br m*, H-12), 4.05 (*dd* J = 2.8 Hz, 12.8 Hz, H-6β), 3.47 (2H, *d*, J = 8.9 Hz, 2H-28), 3.30 (*d*, J = 8.3 Hz, H-17), 3.15 (*br d*, J = 9.8 Hz, H-9), 3.04 (3H, *s*, OMe), 2.77 (*d*, J = 12.8 Hz, H-5), 2.35 (m, H-16α), 2.16–2.19 (2H, *m*, 2H-2), 1.98, 1.98 (ea 3H, *s*, 3H-5', $OCOCH_3$), 1.88 (3H, *s*, $OCOCH_3$), 1.81 (3H, *d*, J = 7.2 Hz, 3H-4'), 1.71 (3H, *s*, 3H-18), 1.69 (*m*, H-11β), 1.61 (*m*, H-11α), 1.57 (*m*, H-16β), 1.40 (3H, *s*, 3H-30), 1.15 (3H, *s*, 3H-29), 0.96 (3H, *s*, 3H-19). IR γ_{max} (NaCl) cm^{-1}: 1747, 1736, 1658, 1265, 1241, 1060, 756. $[\alpha]_D$ = − 62.5° (*c* 0.28, $CHCl_3$).

12α-*Acetoxyneotrichilenone* (**5**)

79 mg, EIMS *m/z* 468.2518 ($C_{28}H_{36}O_6$ req. 468.2512), 408 $[M\text{-}CH_3COOH]^+$, mp 126–128°. ^1H NMR: δ 7.39 (*d*, J = 1.6 Hz, H-23), 7.34 (*s*, H-21), 6.89 (*d*, J = 10.1 Hz, H-1), 6.30 (d, J = 1.6 Hz, H-22), 5.83 (d, J = 10.1 Hz, H-2), 5.18 (*t*, J = 3.4 Hz, H-12β), 3.90 (*br s*, $W_{1/2}$ = 7.6 Hz, H-7β), 3.46 (*t*, J = 10.0 Hz, H-17), 2.90 (*s*, H-14), 2.53 (2H, *br d*, J = 10.0 Hz, 2H-16), 2.00 (3H, *s*, $OCOCH_3$), 1.13, 1.07, 1.07, 1.07, 0.79 (ea 3H, *s*, CH_3). IR γ_{max} (NaCl) cm^{-1}: 3468, 2969, 1728, 1666, 1249. $[\alpha]_D$ = + 37.3° (*c* 0.134, $CHCl_3$).

12α-*Acetoxy-7-acetyl*-1,2-*dihydroneotrichilenone* (**6**)

55 mg, EIMS *m/z* 512.2784 ($C_{30}H_{40}O_7$ req. 512.2772), 452 $[M\text{-}CH_3COOH]^+$, 392 $[M\text{-}2CH_3COOH]^+$, mp 107–109°. ^1H NMR: δ 7.38 (*d*, J = 1.8 Hz, H-23), 7.29 (*s*, H-21), 6.28 (*d*, J = 1.8 Hz, H-22), 5.12 (*t*, J = 3.2 Hz, H-12β), 4.93 (*m*, $W_{1/2}$ = 5.8 Hz, H-7β), 3.42 (*t*, J = 10.0 Hz, H-17), 2.52 (*s*, H-14), 2.4–2.6 (4H, *m*, 2H-16, H-9, H-5), 2.11, 2.03 (ea 3H, *s*, $OCOCH_3$), 1.11, 0.99, 0.99, 0.99, 0.76 (ea 3H, *s*, CH_3). IR γ_{max} (NaCl) cm^{-1}: 2966, 1743, 1738, 1251. $[\alpha]_D$ = + 21.6° (*c* 0.12, $CHCl_3$).

12α-*Acetoxy*-1,2-*dihydroneotrichilenone* (**7**)

11.5 mg. ^1H NMR: δ 7.38 (*d*, J = 1.7 Hz, H-23), 7.29 (*s*, H-21), 6.29 (*d*, J = 1.7 Hz, H-22), 5.13 (*t*, J = 3.4 Hz, H-12β), 3.87 (*m*, $W_{1/2}$ = 7.6 Hz, H-7β), 3.45 (*t*, J = 10.0 Hz, H-17), 2.87 (*s*, H-14), 2.52 (2H, br *d*, J = 10.0 Hz, 2H-16), 1.99 (3H, *s*, $OCOCH_3$), 1.09, 1.04, 0.94, 0.78 (ea 3H, *s*, CH_3).

11β-*Acetoxy-7-acetyl*-12α-*hydroxy*-1,2-*dihydroneotrichilenone* (**8**)

53 mg, EIMS *m/z* 528 ($C_{30}H_{40}O_8$), mp 131–133°. ^1H NMR: δ 7.38 (*d*, J = 1.7 Hz, H-23), 7.11 (*s*, H-21), 6.15 (*d*, J = 1.7 Hz, H-22), 5.45 (*br m*, H-11α), 4.90 (*br m*, H-7β), 3.88 (*t*, J = 10.0 Hz, H-17), 3.83 (*br s*, H-12β), 2.57 (*s*, H-14), 2.51 (4H, *m*, 2H-16, 2H-2), 2.18, 2.09 (ea 3H, *s*, $OCOCH_3$), 1.92 (*br s*, H-9), 1.39, 1.12, 1.01, 0.98, 0.83 (ea 3H, *s*, CH_3).

Acetylation of **8**

Acetylation of **8** with pyridine–Ac_2O at room temp. yielded *11*β,*12*α-*diacetoxy-7-acetyl-1,2-dihydroneotrichilenone*. ^1H NMR: δ 7.39 (*d*, J = 1.7 Hz, H-23), 7.20 (*s*, H-21), 6.23 (*d*, J = 1.7 Hz, H-22), 5.46 (*br m*, H-11α), 5.19 (*d*, J = 3.3 Hz, H-12β), 4.92 (*br m*, H-7β), 3.94 (*t*, J = 10.0 Hz, H-17), 2.57 (*s*, H-14), 2.17, 2.10, 2.06 (ea 3H, *s*, $OCOCH_3$), 1.41, 1.13, 1.02, 0.99, 0.72 (ea 3H, *s*, CH_3).

UNLINKED REFERENCES

[15, 17]

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REFERENCES

1. Akinniyi, J. A., Connolly, J. D., Rycroft, D. S. and Taylor, D. A. H., *Phytochemistry*, 1986, **25,** 2187.
2. Bentley, M. D., Adul, G. O., Alford, A. R., Huang, F., Gelbaum, L. and Hassanali, A., *J. Nat. Prod.*, 1995, **58,** 748.
3. Bentley, M. D., Gaul, F. and Rajab, M. S., *J. Nat. Prod.*, 1992, **55,** 84.
4. Fraser, L. A., Mulholland, D. A. and Nair, J. J., *Phytochemistry*, 1994, **35,** 433.
5. Fraser, L. A., Mulholland, D. A. and Taylor, D. A. H., *S. Afr. J. Bot.*, 1995, **61,** 281.
6. Adul, G. O., Bentley, M. D., Benson, B. W., Huang, F., Gelbaum, L. and Hassanali, A., *J. Nat. Prod.*, 1993, **56,** 1414.
7. Monkhe, T. V., Ph.D. Thesis, University of Natal, 1997.
8. Kraus, W. and Cramer, R., *Liebigs Ann. Chem.*, 1981, 181.
9. Connolly, J. D., Okorie, D. A. and Taylor, D. A. H., *J. Chem. Soc. Perkin Trans. I*, 1972, 1488.
10. Kraus, W. and Grimminger, W., *Nouv. J. Chim.*, 1980, **4,** 651.
11. Chan, W. R. and Taylor, D. R., *J. Chem. Soc. Chem. Comm.*, 1966, 206.
12. Chan, W. R., Gibbs, J. A. and Taylor, D. R., *J. Chem. Soc. Chem. Comm.*, 1967, 720.
13. Kraus, W., Grimminger, W. and Sawitzki, G., *Phytochemistry*, 1981, **20,** 117.
14. Kraus, W., Grimminger, W. and Sawitzki, G., *Angew. Chem. Int. Ed. Engl.*, 1978, **17,** 452.
15. Torto, B., Bentley, M. D., Cole, B. J. W., Hassanali, A., Huang, F., Gelbaum, L. and Vanderveer, D. G., *Phytochemistry*, 1995, **40,** 239.
16. Cortez, D. A. G., Vieira, P. C., Fernandes, J. B., Da Silva, M. F. G. F. and Ferreira, A. G., *Phytochemistry*, 1992, **31,** 625.
17. Akinniyi, J. A., Connolly, J. D., Rycroft, D. S., Sondengam, B. L. and Ifeadike, N. P., *Can. J. Chem.*, 1980, **58,** 1865.