(3). Pale yellow oil (238 mg). R_f 0.54 (silica gel, petrol–EtOAc, 17:3). ([M]$^+$ found: 356.1629. $C_{21}H_{24}O_5$ requires 356.1624.) ν_{max}^{film} cm^{-1}: 1670 (C=O stretch). UV λ_{max}^{MeOH} nm (ε): 274 (12 500), 228 (20 319); $\lambda_{max}^{MeOH+NaOH}$ nm (ε): 274 (12 500), 228 (20 319). MS *m/z* (rel. int.) 356 (7), 194 (100), 165 (27), 135 (16.9), 77 (10), 28 (11). ^{1}H NMR (60 MHz, $CDCl_3$) δ 7.32 (*m*, H-2, H-6), 6.85 (*br s*, H-5), 6.65 (*br s*, H-2′, H-5′, H-6′), 5.88 (*s*, O_2CH_2), 3.90 (*s*, OMe-3), 3.85 (*s*, OMe-4), 2.0–3.7 (*m*, H-7, H-7′, H-8, H-8′), 1.15 (*d*, J = 6.5 Hz, Me-9), 0.85 (*d*, J = 6.5 Hz, Me-9′); ^{1}H NMR (220 MHz, $CDCl_3$) δ 7.45 (*br s*, H-2), 7.37 (*dd*, J = 9.5, 1.5 Hz, H-6), 6.84 (*d*, J = 9.5 Hz, H-5), 6.70 (*m*, H-2′, H-5′, H-6′). 5.94 (*s*, O_2CH_2), 3.95 (*s*, OMe-3), 3.90 (*s*, OMe-4), 3.38 (*dq*, J = 7.0, H-8), 2.58 (*dd*, J = 14.4, 7.8 Hz, H-7′), 2.43 (*dd*, J = 14.4, 7.8, H-7′), 2.25 (*dddq*, J = 7.8, 7, 7 and 7, H-8′), 1.15 (*d*, J = 7.0, Me-9), 0.85 (*d*, J = 7.0, Me-9′). ^{13}C NMR (100 MHz, $CDCl_3$) δ 129.7 (C-1), 110.5 (C-2), 148.9 (C-3), 152.9 (C-4), 109.9 (C-5), 122.4 (C-6), 202.4 (C-7), 42.8 (C-8), 14.8 (C-9), 55.7 (3-OMe), 55.8 (4-OMe), 134.5 (C-1′), 108.0 (C-2′), 147.4 (C-3′), 145.6 (C-4′), 109.4 (C-5′), 121.9 (C-6′), 37.4 (C-7′), 41.2 (C-8′), 11.2 (C-9′), 100.5 (3′-O_2CH_2, 4′-O_2CH_2).

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FLAVONOIDS FROM *WYETHIA GLABRA*

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Key Word Index—*Wyethia glabra*; Compositae; Heliantheae; prenylated flavanones; isoflavones; flavanones; chalcone.

Abstract—Ten flavonoid compounds, including three new natural products, were isolated from a dichloromethane extract of *Wyethia glabra*. The known compounds are: orobol 7-methyl ether, orobol 3′-methyl ether, naringenin 7-methyl ether, eriodictyol, 8-*C*-prenyleriodictyol, 6-*C*-prenyleriodictyol and 8-*C*-prenylnaringenin. Eriodictyol 7-methyl ether, 2′,4′,6′-trihydroxy-4-methoxychalcone and 6-*C*-prenylnaringenin are new natural products. An additional prenylated flavanone was isolated and partially characterized.

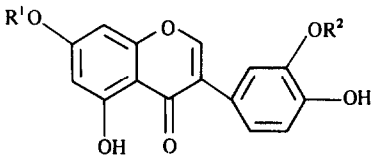
INTRODUCTION

As part of a chemical and morphological study on the related genera *Wyethia* and *Balsamorhiza* (tribe Heliantheae, subtribe Helianthinae), the leaf-surface flavonoids of *Wyethia glabra* Gray were examined. *Wyethia helenioides*, which is in the same section as *W. glabra*, produces 8-*C*-prenyleriodictyol, 6-*C*-prenyleriodictyol, 8-*C*-prenylnaringenin, orobol 7-methyl ether and orobol 3′-methyl ether [1]. From *W. glabra* besides these five compounds, 6-*C*-prenylnaringenin, eriodictyol, eriodictyol 7-methyl ether, naringenin 4′-methyl ether, 2′,4′,6′-trihydroxy-4-methoxychalcone and an additional 8-*C*-prenylflavanone have been found. Similar prenylated flavanones have been isolated from *Flourensia* [2], *Marshallia* [3] and *Helichrysum* [4].

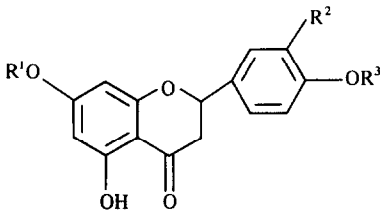
RESULTS AND DISCUSSION

A dichloromethane leaf wash of *W. glabra* afforded orobol 7-methyl ether (10 mg) (**1**) [5], orobol 3′-methyl ether (10 mg) (**2**) [6], eriodictyol (10 mg) (**3**) [7], naringenin 4′-methyl ether (20 mg) (**4**) [8], 8-*C*-prenyleriodictyol (180 mg) (**5**) [1], 6-*C*-prenyleriodictyol (300 mg) (**6**) [1], 8-*C*-prenylnaringenin (50 mg) (**7**) [3], 6-*C*-prenylnaringenin (150 mg) (**8**), eriodictyol 7-methyl ether (5 mg) (**9**), 2′,4′,6′-trihydroxy-4-methoxychalcone (5 mg) (**10**) and a 8-*C*-prenyltrihydroxymonomethoxyflavanone (5 mg) (**11**).

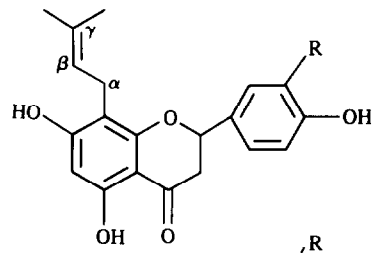
The UV spectrum of **8** exhibited a major *A* of 295 nm which shifted to 325 nm after the addition of sodium methoxide. This is typical of a flavanone with a 5,7-hydroxylation pattern in the A-ring. The mass spectrum of



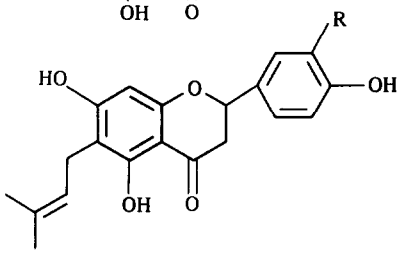
	R^1	R^2
1	Me	H
2	H	Me



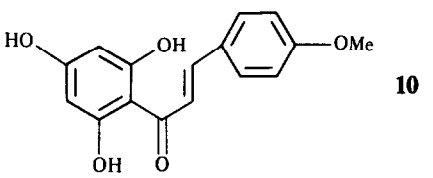
	R^1	R^2	R^3
3	H	OH	H
4	H	H	Me
9	CH	OH	H



	R
5	OH
7	H



	R
6	OH
8	H



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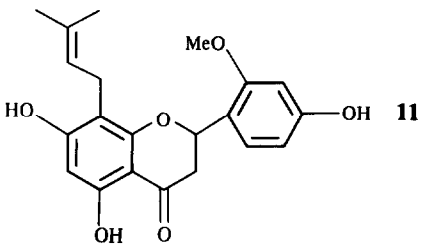

11

8 exhibited a molecular ion at *m/z* 340 consistent with a flavanone with three hydroxyl groups and one prenyl group. Losses of 15, 43 and 55 mass units from both the molecular ion and the A_1 fragment were consistent with the presence of a *C*-prenyl group [9]. The absence of a bathochromic shift in the UV spectrum after the addition of aluminium chloride suggested that the prenyl group was *ortho* to the 5-hydroxyl group [10]. The A-ring proton in the ^{1}H NMR spectrum appeared at δ6.03 and was assigned to the 8-position. Two two-proton doublets at δ7.25 and 6.76 supported a naringenin B-ring. From these data **8** was identified as 6-*C*-prenylnaringenin. The spectral data of **8** also correspond to those reported for synthetic 6-*C*-prenylnaringenin [11].

The UV spectrum of **9** exhibited a major *A* at 286 nm which shifted only 1 nm after the addition of sodium methoxide suggesting that **9** was a flavanone with a substituted 7-position. A bathochromic shift of 10 nm after the addition of aluminum chloride suggested that there was a hydroxyl group present at the 5-position. The mass spectrum exhibited a molecular ion at *m/z* 302 consistent with a flavanone with three hydroxyl groups and one methoxyl group. The presence of $[B_3]^+$ and $[B_4]^+$ fragments at *m/z* 136 and 123, respectively, confirmed a B-ring with two hydroxyl groups. An $[A_1+1]^+$ fragment at *m/z* 167 was consistent with an A-ring with one hydroxyl group and one methoxyl group. Compound **9** was, therefore, identified as eriodictyol 7-methyl ether. This compound has been isolated as an 8-*C*-prenyl derivative from *Flourensia heterolepis* [2].

The UV spectrum of **10** recorded in methanol exhibited a major *A* at 360 nm with a shoulder at 298 nm typical of a chalcone. A bathochromic shift of 26 nm after the addition of aluminum chloride suggested that there was a 2'-hydroxyl group. A shift of 30 nm with a decrease in intensity after the addition of sodium methoxide suggested that the 4-position was substituted. The ^{1}H NMR spectrum of **10** confirmed that it was a chalcone. Doublets with a large coupling constant at δ8.15 and 7.80 were assigned to the α- and β-protons, respectively, and doublets at δ7.4 and 6.95 were consistent with a monosubstituted B-ring. The remaining signals were a two-proton singlet at δ5.96 and a three-proton singlet at δ3.87. The mass spectrum of **10** exhibited a molecular ion at *m/z* 286 consistent with a chalcone with three hydroxyl groups and one methoxyl group. Since the UV data indicated the presence of a 2'-hydroxyl group, flavanone fragmentation was expected [12]. The appearance of $[B_3]^+$ and $[B_4]^+$ fragments at *m/z* 134 and 121, respectively, indicated that the B-ring had one methoxyl group. An $[A_1]^+$ fragment appeared at *m/z* 152 consistent with an A-ring with three hydroxyl groups. Since the A-ring protons appeared as a singlet, the hydroxyl groups were assigned to the 2'-, 4'- and 6'-positions. The observation that **10** over time converts to naringenin 4'-methyl ether (**4**) also supported the assignment of **10** as 4-methoxy-2',4',6'-trihydroxychalcone.

The UV spectrum of **11** in methanol exhibited major *A* at 289 and 271 nm. The addition of sodium methoxide and sodium acetate caused bathochromic shifts of 41 and 29 nm, respectively, consistent with a flavanone with a 5,7-hydroxylation pattern in the A-ring. A shift of 21 nm after the addition of aluminium chloride suggested that there was no prenyl substituent *ortho* to the 5-hydroxyl group. The mass spectrum exhibited a molecular ion at *m/z* 370 consistent with a flavanone with three hydroxyls, one methoxyl and one prenyl. Losses of 15, 43 and 55 mass units from the molecular ion confirmed the presence of a *C*-linked prenyl group. The appearance of an $[A_1-1]^+$ fragment at *m/z* 219 was consistent with an A-ring with two hydroxyl groups and one *C*-prenyl group. The presence of $[B_3]^+$ and $[B_4]^+$ fragments at *m/z* 150 and 137 and a $[B_3-Me]^+$ fragment at *m/z* 135 indicated that the B-ring had one methoxyl and one hydroxyl group. The presence of a large $[M-31]^+$ fragment suggested that the methoxyl was at the

2′-position [13]. Interpretation of the UV spectra does not give significant information about the B-ring of flavanones. Insufficient material was available for ^{1}H NMR analysis.

EXPERIMENTAL

Plant material. Leaves of *Wyethia glabra* were collected on 16 March 1984 in Solano Co., California (voucher No. 3223, M. Warnock, S. McCormick, deposited in UBC herbarium).

Extractions and separation. Air-dried leaves (30 g) were extracted overnight with CH_2Cl_2. The extract was taken to dryness and chromatographed over a Polyclar AT column using CH_2Cl_2–MeOH (3:1) and gradually increasing amounts of MeOH. Fractions from this column were further separated on Sephadex LH-20 (MeOH) columns and on polyamide TLC using: (1) ethyl formate–cyclohexane–*n*-BuOAc–HCO_2H (55.25.23:2); (2) toluene–petrol (80–100)–MeCOEt–MeOH (60:30:10·5); or (3) toluene–MeCOEt–MeOH (60 25:15). Isolated compounds were cleaned over Sephadex LH-20 columns prior to spectral analysis. Individual compounds were identified on the basis of UV, ^{1}H NMR and MS.

6-C-*Prenylnaringenin* (**8**) UV λ_{max}^{MeOH} nm. 350 sh, 295, + NaOMe 325, 255, + $AlCl_3$ 380 sh, 308, + $AlCl_3$–HCl 380 sh, 305, + NaOAc 324, 290 sh, + NaOAc–H_3BO_3 337 sh, 288 ^{1}H NMR (90 MHz, TMS ether, CCl_4): δ 7.25 (2H, *d*, $J_{2',3',5',6'}$ = 9 Hz, H-2′, H-6′), 6.76 (2H, *d*, $J_{2',3',5',6}$ = 9 Hz, H-3′, H-5′), 6.06 (1H, *s*, H-8), 5.15 (1H, *dd*, $J_{2,3b}$ = 3 5 Hz, $J_{2,3a}$ = 13 Hz, H-2), 5.05 (1H, *t*, *J* = 9 Hz, H-β), 3.15 (2H, d, *J* = 9 Hz, H-α), 2.80 (1H, *dd*, $J_{3a,3b}$ = 17 Hz, $J_{2,3a}$ = 12 5 Hz, H-3a) 2.53 (1H, *dd*, $J_{3a,3b}$ = 17 Hz, $J_{2,3b}$ = 3.5 Hz, H-3b) 1.65 (6H, *br s*, Me-2γ). MS (probe, 70 eV): 340 $[M]^+$ (62), 325 $[M-Me]^+$ (24), 297 $[M-C_3H_7]^+$ (43), 285 $[M-C_4H_7]^+$ (50), 220 $[A_1]^+$ (42), 205 $[A_1-Me]^+$ (77), 192 $[A_1-CO]^+$ (58), 177 $[A_1-C_3H_7]^+$ (65), 165 $[A_1-C_4H_7]^+$ (88), 120 $[B_3]^+$ (67), 107 $[B_4]^+$ (51)

Eriodictyol 7-methyl ether (**9**). UV λ_{max}^{MeOH} nm: 328 sh, 286, + NaOMe 287, 350 sh, + $AlCl_3$ 307, + $AlCl_3$–HCl 305, 370 sh. MS (probe, 70 eV): 302 $[M]^+$ (84), 193 $[M-B\text{-ring}]^+$ (82), 167 $[A_1]^+$ (100), 136 $[B_3]^+$ (94) 123 $[B_4]^+$ (64).

2′,4′,6′-*trihydroxy-4-methoxychalcone* (**10**). UV λ_{max}^{MeOH} nm: 360, 296 sh, + NaOMe 390, 320, + $AlCl_3$ 395, 310, + $AlCl_3$–HCl 386, 308. MS (probe, 70 eV): 286 $[M]^+$ (45). ^{1}H NMR (90 MHz, Me_2CO-d_6): δ 8.15 (1H, *d*, $J_{\alpha,\beta}$ = 15 Hz, H-α), 7.75 (1H, *d*, $J_{\alpha,\beta}$ = 15 Hz, H-β), 7.63 (2H, *d*, $J_{2',3',5',6}$ = 9 Hz, H-2′, H-6′), 6.97 (2H, *d*, $J_{2',3',5',6}$ = 9 Hz, H-3′, H-5′), 3.87 (3H, *s*, OMe) MS (probe, 70 eV): 286 $[M]^+$ (45), 179 $[M-B\text{-ring}]^+$ (17), 134 $[B_3]^+$ (99), 121 $[B_4]^+$ (91), 152 $[A_1]^+$ (37).

8-C-*Prenyltrihydroxymonomethoxyflavanone* (**11**). UV λ_{max}^{MeOH} nm: 289, 271, + NaOMe 330, 285 sh, 247, + $AlCl_3$ 310, 271, + $AlCl_3$–HCl 310, 271, + NaOAc 328, 271. MS (probe, 70 eV): 370 $[M]^+$ (21), 355 $[M-Me]^+$ (8), 339 $[M-CH_3O]^+$ (26), 327 $[M-C_3H_7]^+$ (6), 315 $[M-C_4H_7]^+$ (10), 219 $[A_1-1]^+$ (12), 205 $[A_1-Me]^+$ (41), 177 $[A_1-C_3H_7]^+$ (47), 165 $[A_1-C_4H_7]^+$ (60), 150 $[B_3]^+$ (28), $[B_4]^+$ (28), $[B_3-Me]^+$ (45).

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