

TERPENOIDS OF *HELIANTHUS NUTTALLII*

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In conjunction with our continuing study of the terpenoid chemistry of *Helianthus* (Asteraceae), we report here the results of our investigation of *Helianthus nuttallii* T. & G. ssp. *nuttallii*. A large number of sesquiterpene lactones and diterpenes have been isolated previously from species of *Helianthus* (1-6, and references cited therein). *H. nuttallii* is a diploid perennial native to southern Canada and the Rocky Mountain region of the United States (7) and is classified in section *Divaricati* series *Corona-Solis* in the most recent taxonomic revision of the genus (8). Based on morphological data and the results of crossing studies, *H. nuttallii* is considered to be most closely related to *Helianthus grosseserratus* Martens and *Helianthus giganteus* L. (7,9,10). Systematically, these three species form a taxonomic complex that, according to Heiser (7), could be treated as a highly variable single species, although he has maintained them as separate entities.

Three diterpene carboxylic acids and two sesquiterpene lactones were isolated from a CH_2Cl_2 extract of the aerial parts of *H. nuttallii* ssp. *nuttallii*: 15 α -OH-*ent*-kaur-16(17)-en-19-oic acid (*grandifloric* acid), **1** (2,11); 17-OH-*ent*-isokaur-15(16)-en-19-oic acid, **3**(12); 7 α -OH-*ent*-trachyloban-19-oic acid (*ciliaric* acid), **5**(13); angeloyloxyatripliciolide, **6**(14,15); and 1 α -OH-2 β -OH-dihydro-pinnatifidin, **9**(16). Comparison of our results with those obtained earlier from *H. grosseserratus* (16) supports the proposed close relationships between *H. nuttallii* and *H. grosseserratus*. Compounds **1**, **3**, **5**, **7**, **8**, **9**, **10**, and **11** were reported from *H. grosseserratus* by Herz and co-workers (16); we also isolated five of these, namely **1**, **3**, **5**, **7**, and **9**, from this same species (17). Both taxa, *H. nuttallii* and *H. grosseserratus*, contain

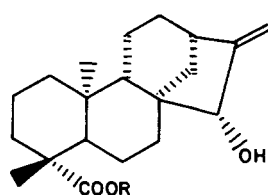
furano-heliangolides, 12,8-*cis*-lactonized eudesmanolides, and the same three diterpene carboxylic acids. The unusual 12,8-*cis*-lactonized eudesmanolide **9** provides strong chemical evidence for the proposed close relationship of these species. Compounds **9**, **10**, and **11** are the first eudesmanolides and the first *cis*-lactonized sesquiterpene lactones isolated from this genus.

In contrast, our chemical studies do not support a close relationship between *H. nuttallii* and *H. giganteus*. *H. giganteus* yielded two 1,2-secogermacranolides (18). An earlier examination of the latter species (19) reported only the sesquiterpene germacrene D from the aerial parts and kaurane diterpenes from the roots.

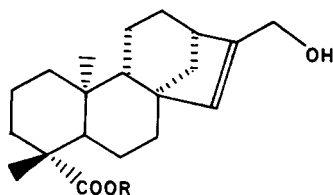
EXPERIMENTAL

PLANT MATERIAL.—Leaves of *H. nuttallii* ssp. *nuttallii* were collected at the U. S. Department of Agriculture research station at Bushland, Texas, on August 11, 1979, and August 2, 1980, from plants growing from rootstocks transplanted from Colorado (8.5 miles north of Louviers on Hwy 85, Douglas Co., August 22, 1977, C.E. Rogers and T.E. Thompson #734) and Utah (junction of interstate Hwy 15 and state Hwy 115 near Payson, Utah Co., August 24, 1977, C.E. Rogers and T.E. Thompson #750). Voucher specimens, J.G. #84 and #85, respectively, are deposited in the Herbarium of the University of Texas at Austin.

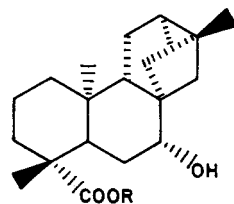
EXTRACTION AND FRACTIONATION.—Tlc profiles of leaf wash extracts of the two collections were very similar. Therefore, all of the plant material (1.9 kg) was combined and washed with CH_2Cl_2 for 5 min at room temperature. Intact rather than ground leaves were extracted, since in many species of *Helianthus* sesquiterpene lactones are localized in surface glands (20) and a rapid surface wash has been shown to give a greater absolute yield of sesquiterpene lactones and reduced amounts of other plant constituents than does an extraction of ground material. Qualitative differences in terpenoid constituents are not found between leaf wash and ground whole-leaf extracts. The wash was concentrated in vacuo and was pre-



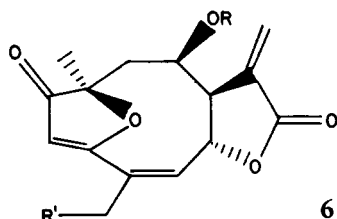
1 R=H
2 R=CH₃



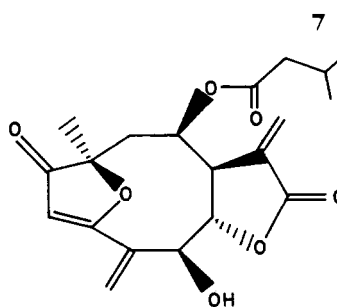
3 R=H
4 R=CH₃



5 R=H

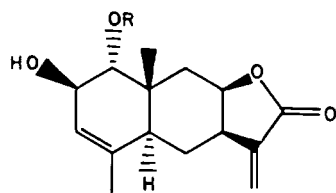


6 R = R' = H

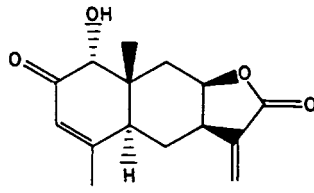


7 R = R' = OH

8



9 R=H
10 R=Ac



11

pared for column chromatography by standard procedures (21) to yield 20.7 g of yellow syrup. The syrup was chromatographed over a silica gel column (1 kg) packed in CH₂Cl₂. The column was eluted with a CH₂Cl₂-iPrOH gradient. Fifty fractions of one liter each were collected.

Crystals formed in fractions 17-20 (1.5% iso-PrOH), which upon recrystallization from isopropyl ether-EtOAc, gave 85 mg of **6**, mp 134° [lit 132-134° (14,15)]. In fractions 22 and 23 (2% iPrOH) a precipitate formed which, after washing in cold MeOH, gave 10 mg of **5**. A precipitate from fractions 27 and 28 (5% iPrOH) was washed in cold MeOH to give 7 mg of a 1:1

mixture of **1** and **3** (5% iPrOH). Because the quantity of this material was limited, an additional 30 mg of the same mixture (identity established by nmr and tlc) was obtained from *H. grosseserratus* (17). Methylation with CH₂N₂ and separation of the reaction products by preparative tlc (silica gel, 1 mm, CHCl₃-MeOH, 15:1) gave 7 mg of **2** and 7 mg of **4**. Crystals of **9** (385 mg), mp 218° [lit 222-224° (16)], were obtained from fractions 30 and 31 (5% iPrOH) after recrystallization from hot EtOAc. All compounds were identified by comparison of their spectral data with those in the literature [**1**(2, 11), **2**(2), **4**(12), **5**(13), **6**(14, 15), and **9**(16)]. Compounds **2**, **4**,

and **9** were also identified by co-tlc with authentic samples isolated from other species of *Helianthus* (2,3,17).

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