SHORT REPORT

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records of natural products

Chemical Constituents Isolated from *Lycium shawii* and their Chemotaxonomic Significance

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Abstract: Phytochemical investigation of *Lycium shawii* Roem. & Schult provided fourteen compounds, including lyciumate (**1**), dehydrocostus lactone (**2**), costunolide (**3**), catechin (**4**), lyciumaside (**5**), emodin (**6**), emodin-8-*O*-*β*-D-glucoside (**7**), aloe-emodin (**8**), aloe-emodin-8-*O*-*β*-D-glucoside (**9**), aloe emodin-11-*O*-rhamnoside (**10**), chrysophanol-8-*O*-*β*-D-glucoside (**11**), nonacosane-10-ol (**12**), betulinic acid (**13**) and *β*-sitosterol glucopyranoside (**14**). The compounds may be classified as three sesquiterpene lactones (**1-3**), two phenolic compounds (**4** and **5**), six anthraquinones (**6-11**), one long chain alcohol (**12**), one lupane-type triterpenoid (**13**) and a steroid (**14**). Compounds **2**, **3**, **7** and **9-12** are reported here for the first time as isolated from any species of *Lycium* as well as from the Solanaceae family while compounds **8**, **13** and **14** are reported to be found for the first time in the genus *Lycium*. All structural assignments were made by comparing the NMR spectral data of the pure isolates with that published in the quoted literature.

Keywords: *Lycium shawii*; Solanaceae; anthraquinone; sesquiterpene.

1. Plant source

Lycium (Solanaceae) comprises of ca. 90 species of thorny shrubs distributed throughout the tropical regions of the world. *L. shawii* Roem & Schult is a thorny shrub which is locally known as "Ghasad" and is found in the Sultanate of Oman. The stem bark, *L. shawii*, was purchased from Nizwa Souq (May, 2015) and identified through a plant taxonomist (Department of Biological Sciences and Chemistry, University of Nizwa, the Sultanate of Oman), where a voucher specimen (BSHR-05/2015) is deposited.

2. Previous studies

A previous report by Baghdadi *et al*. described the presence of rutin, diosgenin, and *β*-sitosterol [1], while the current author described the presence of one diacylglycoside and one sesquiterpene lactone from *L. shawii* [2].

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3. Present Study

Due to the increasing importance in the use of active agents in plants for medicinal purposes, a more comprehensive phytochemical investigation of *L. shawii* was of paramount importance. The air-dried powder material (640 g) of the stem bark (*L. shawii*) was extracted with methanol for a couple of weeks. The obtained methanol extract (304 g) was suspended in water and successively partitioned to provide the following fractions viz., *n*-hexane (26 g), CH_2Cl_2 (11 g), EtOAc (25 g), *n*-BuOH (26 g) and aqueous (44.5 g). The *n*-hexane fraction was loaded on silica gel column chromatography (CC) and eluted with *n*-hexane, followed by increasing concentrations of EtOAc in *n*-hexane (10, 20, 30, and 100%) to give four fractions H_{A-D}. Fraction H_B (0.5 g) was further purified by CC using *n*-hexane:EtOAc (80:20 to 60:40) to provide lyciumate (**1**, 5 mg) [2], dehydrocostus lactone (**2**, 60 mg) and costunolide (**3**, 45 mg) [3], while fraction H_A (0.3 g) on further CC purification with *n*-hexane:EtOAc (90:10) as eluent provided nonacosane-10-ol (**12**, 12 mg) [4].

Similarly, the EtOAc fraction (25 g) was loaded over CC and eluted with a solvent system of increasing polarity, viz., *n*-hexane–EtOAc, EtOAc, EtOAc–MeOH and pure MeOH to obtained four fractions (E_{A-D}). Fraction E_B was further subjected to CC purification using the eluent system of *n*-hexane:EtOAc (80:20 to 40:60) and afforded catechin (**4**, 85 mg) [5], emodin (**6**, 16 mg) [6], aloe-emodin (**8**, 60 mg) [7], and aloe-emodin-11-*O*-rhamnoside (**10**, 25 mg) [8], chrysophanol-8-*O*-*β*-D-glucoside *(***11**, 9 mg) [9], betulinic acid (**13**, 30 mg) [10] and *β*-sitosterol glucopyranoside (**14**, 30 mg) [11]. Similarly fraction E_C was further subjected to silica gel CC eluting with MeOH:EtOAc (10:90) to afford lyciumaside (**5**, 12 mg) [2] while fraction E_D was loaded directly onto a recycling HPLC system using MeOH:EtOAc (50:50) at a flow rate of 4 mL/min and using a UV detector to indicate the active compounds, provided emodin-8-*O*-β-D-glucoside (**7**, 12 mg) [7] and aloe-emodin-8-*O*-*β*-D-glucoside (**9**, 9 mg).

4. Chemotaxonomic Significance

More than 200 natural products have been reported to be present in the genus *Lycium*, including the alkaloids viz., cyclopentapyrrolidine, imidazole, piperidine, nortropane, tropane, pyrrole, spermine, in addition to peptides, flavonoids, ceramides, anthraquinones, coumarins, steroids, terpenoids (monoterpenes, diterpenes and triterpenes), organic acids, polysaccharides, carotenoids, cinnamic acid amides, lignans, neo-lignanamides, and lignanamides [12]. In the current investigation, a total of fourteen compounds viz., three sesquiterpene lactones [(lyciumate (**1**), dehydrocostus lactone (**2**) and costunolide (**3**)], two phenolic compounds [(catechin (**4**) and lyciumaside (**5**], six anthraquinones/anthraquinone glycosides [(emodin (**6**), emodin-8-*O*-*β*-D-glucoside (**7**), aloe-emodin (**8**), aloe-emodin-8-*O*-*β*-D-glucoside (**9**), aloe-emodin-11-*O*-rhamnoside (**10**), chrysophanol-8-*O*-*β*-D-glucoside (**11**)], one long chain alcohol (nonacosane-10-ol, **12**), one lupane-type triterpenoid (betulinic acid, **13**), and the steroid (*β*-sitosterol glucopyranoside, **14**) have been isolated and identified (Figure 1). Moreover lyciumate (**1**) and lyciumaside (**5**) have earlier been identified in *L. shawii* while compounds **2-4**, and **6-14** are reported here for the first time as being isolated from the title plant.

Although the sesquiterpene lactone viz., lyciumate (**1**) has been identified in the extract of the title plant [2], the sesquiterpene lactones viz., dehydrocostus lactone (**2**) and costunolide (**3**) are reported here for the first time to be identified from any species of *Lycium* as well as from the Solanaceae family. Moreover, no sesquiterpene lactone, to our best knowledge, has been reported from genus *Lycium.* Our search of the literature revealed that only four sesquiterpenes were reported from *L. chinense* and *L. halimifolium* [12]. It is well known that sesquiterpene lactones are common in families' viz., Euphorbiaceae, Cactaceae, Solanaceae and Araceae as well as being quite prevalent in the Asteraceae [13]. A further interesting feature of plants of the Solanaceae family is that they produce a distinctive collection of sesquiterpenes described as the phytoalexins [14]. Previously dehydrocostus lactone (**2**) and costunolide (**3**) were reported to be isolated from *Saussurea lappa* Clarke (Compositae) [15], *Cichorium intybus* L. (Asteraceae) [16]. On the other hand the occurrence of catechin (**4**) in the title plant is in agreement with similar types of compounds previously reported from other *Lycium* species i.e from *L. chinens* [17]. Importantly, compound **4** is now reported for the first time as being isolated from the genus *Lycium* while it has previously been reported to be present in various plants of Solanaceae viz., potato (*Solanum tuberosum*) [18], *Amanaga capsicum, Lycopersicon esculentum* Mill, *Capsicum annuum* [19], and *Alchemilla barbatiflora* Juz [20]. The diester lyciumaside (**5**) has previously been reported from the title plant [2].

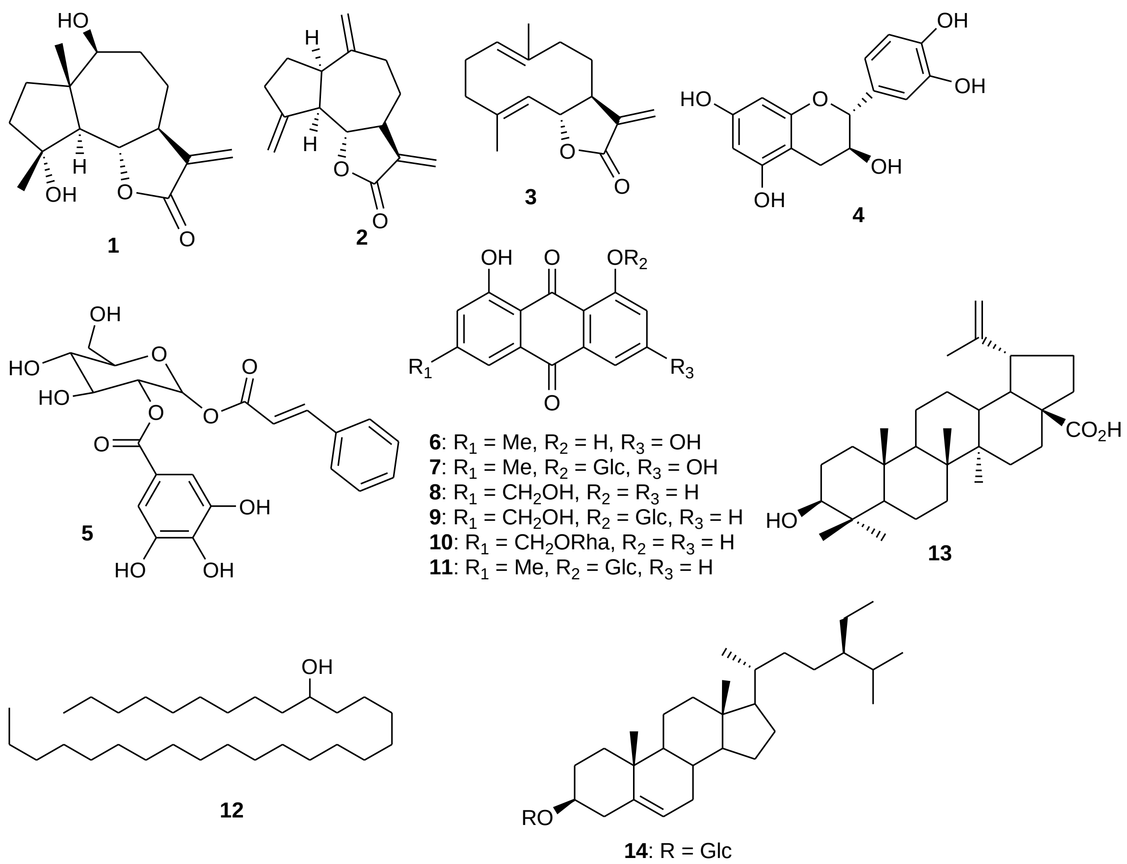

Figure 1. Compounds **1-14** isolated from *L. shawii*

Emodin (**6**) has to the best of our knowledge been reported to be present in only one species of the genus *Lycium* viz., root bark *L. chinense* [12]. However, the presence of emodin (**6**) has been found in numerous other plant families; Actinidiaceae, Amaranthaceae, Asteraceae, Bignoniaceae, Clusiaceae, Cupressaceae, Fabaceae, Liliaceae, Myrsinaceae, Plantaginaceae, Poaceae, Polygonaceae, Rhamnaceae, Rosaceae, Saxifragaceae, Simaroubaceae and Vitaceae [21]. Furthermore, the presence of the anthraquinones emodin-8-*O*-*β*-D-glucoside (**7**), aloe-emodin (**8**), aloe-emodin-8-*O*-*β*-D-glucoside (**9**), emodin-11-*O*-rhamnoside (**10**) and chrysophanol-8-*O*-*β*-D-glucoside (**11**) were reported, for the first time, from the genus *Lycium* and family Solanaceae except aloe-emodin (**8**) which was previously reported from Solanaceae [22]. Interestingly, aloe-emodin (**8**) has been found to be present in various *Cassia species* (family Fabaceae) viz., *C. absus*, *C. alata*, *C. angustifolia*, C. *didymobotrya*, *C. fistula*, *C. grandis*, *C. italica*, *C. javanica* and *C. obtusifolia* [23]. Four additional anthraquinones (other than **6-11**) have previously been reported from only one species of the genus *Lycium* viz., *L. chinense* [12]. The substitution patterns in anthraquinones isolated from *L. shawii* and *L. chinense* have some common structural feature viz., most of the anthraquinones are 1, 3-oxygenated with a methyl group at the C-2 position. Finally, the presence of nonacosane-10-ol (**12**), betulinic acid (**13**) and *β*-sitosterol glucopyranoside (**14**) is reported here for the first time being isolated from *L. shawii*. The authors have noted that the latter compound (**14**) has previously been reported from *L. chinense* and *L. barbarum* [12] and *Embelia schimperi* [24]. Moreover, a number of triterpenoids have been reported as being isolated from the genus *Lycium* [12]. However, only one lupane-type triterpenoid (lupeol) has been reported from the said genus [12] and betulinic acid (**13**) represents a second example of a lupane-type triterpenoid from the genus *Lycium* and *Calophyllum* [25].

The current investigation has shown that the main secondary metabolites identified in *L. shawii* were anthraquinones and sesquiterpenoids, in addition to one flavanol, triterpene and steroid. Interestingly, anthraquinones, sesquiterpenoids, flavanols and steroids, as a collective group have only been reported from one species of *Lycium* i.e. *L. chinense* [12]. Of further interest to the authors is the fact that only four additional anthraquinones (other than **6-11**) have previously been reported from only one species of the genus *Lycium* viz., *L. chinense* [12] and that six anthraquinones **6-11** (major class of compound) have been isolated in the current investigation from *L. shawii*. The authors are of the opinion that isolation of anthraquinones sesquiterpenoids, flavanols and steroids in the current study strongly suggests that *L. shawii* has a similar inherent biosynthetic system to and shares a close genetic relationship with *L. chinense* which might have a collective chemotaxonomic value.

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Supporting Information

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