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Jay F. Bolin

Darach Lupton

Lytton John Musselman  
Old Dominion University, [lmusselm@odu.edu](mailto:lmusselm@odu.edu)

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## *Hydnora arabica* (Aristolochiaceae), a new species from the Arabian Peninsula and a key to *Hydnora*

JAY F. BOLIN<sup>1</sup>\*, DARACH LUPTON<sup>2</sup> & LYTTON JOHN MUSSELMAN<sup>3</sup>

<sup>1</sup> Department of Biology, Catawba College, Salisbury NC USA

<sup>2</sup> Oman Botanic Garden, Muscat, Oman

<sup>3</sup> Department of Biological Sciences, Old Dominion University, Norfolk VA USA

\*Author for correspondence: [jfbolin@catawba.edu](mailto:jfbolin@catawba.edu)

### Abstract

The plant parasite *Hydnora arabica* (Aristolochiaceae) is described from the Arabian Peninsula. This species was previously identified as *Hydnora africana* in Oman. It can be separated from other *Hydnora* taxa primarily by its terete rhizome, red to orange inner perianth tube color, and tepal lobe margins entirely covered with dense strigose setae. In Oman, *Hydnora arabica* is known to parasitize two leguminous trees: *Acacia tortilis* and the introduced *Pithecellobium dulce*, but may parasitize additional Fabaceae. At least eleven synonyms or subspecific varieties of *H. abyssinica* are described in the literature, all from east or southern Africa. These synonyms are discussed in light of new observations of morphology including tepal margin ornamentation. A new key for *Hydnora* is proposed.

**Key words:** parasitic plant, Hydnoraceae

### Introduction

The two genera of obligate root holoparasites, *Prosopanche* and *Hydnora*, previously in the Hydnoraceae, are now placed in the Aristolochiaceae (APG IV 2016) based on molecular work (Nickrent *et al.* 2002, Naumann *et al.* 2013) and aligning with the earliest placement by Meyer (1833) and Ballion (1886). In the old-world genus *Hydnora*, seven species are recognized and two major lineages have been identified (Bolin *et al.* 2011), aligning with the subgeneric sections delineated in the monograph by Harms (1935), based on their host preference and several major synapomorphies. The *Euphorbia*-parasitizing *Hydnora* species are distributed in southern Africa (sections *Euhydnora* Decaisne and *Tricephalohydnium* Harms), including *Hydnora africana* Thunberg (1775: 69–75), *H. longicollis* Welwitsch (1869: 66), *Hydnora triceps* Drège & Meyer (1833: 779), and *H. visseri* Bolin, Maass, & Musselman (2011: 255–260). The Fabaceae-Burseraceae parasitizing *Hydnora* lineage ranges from South Africa to Ethiopia, the Arabian Peninsula and Madagascar (sections *Neohydnora* Harms and *Dorhyna* Decaisne) and comprise *Hydnora abyssinica* Braun (1867: 217), *Hydnora esculenta* Jumell & Perrier (1912: 327), and *Hydnora sinandevu* Beentje & Luke (2002: 1–7). The best morphological character that delineates the *Euphorbia*-parasitizing lineage and the Fabaceae-Burseraceae-parasitizing one is that the former lineage has osmophores recessed near the midpoint of the tepals while the latter all have apically positioned osmophores.

There are very few historical collections of *Hydnora* from the Arabian Peninsula. The earliest collections are by the inveterate British explorer and naturalist Wilfred Thesiger, from his several crossings by camel of the Rub al Khali, or Empty Quarter, in the mid to late 1940s, though *Hydnora* was not expressly mentioned in his published account (Thesiger 1959). Thesiger's earliest collection of *Hydnora* is from 8 November 1945 from the southeast Rub al Khali near Wadi Haluf in Oman (vouchered at BM). Thesiger's only notes on his herbarium material are that the Arab vernacular name is *Dhanuna* and that "Arabs eat it". Four Thesiger vouchers of *Hydnora* from southern Oman are in the BM. There are two collections of *Hydnora abyssinica* (= *H. johannis*) from extreme south western Saudi Arabia near Jebel Manfah by Sheila Collenette from 1985 at K and RGBE (no. 5119), and a 1981 collection by Anthony Miller from Oman (RBGE). While Thesiger made only cursory notes and identifications of the *Hydnora* material, both Collenette and Miller provided detailed notes and descriptions of the *Hydnora* on the Arabian Peninsula. The Miller

material from Oman was identified as *H. africana*, likely due to the bright red color of the inner tepal surfaces. Miller provides detailed ethnobotanical notes for the Dhofar region about the edibility of the fruit and flower and ethnobotanical applications of the powdered and dry *Hydnora* rhizome for tanning leather, a dye, and a preservative for cotton fishing nets (Miller and Morris 1988). The Saudi Arabian material was identified as *Hydnora johannis* Beccari (1871: 5–6), a synonym of *H. abyssinica*, and was described as very rare, appearing only after rains, parasitic on *Acacia* and with pale orange inner flower surfaces (Collenette 1999). Recent *Hydnora* photos, part of an ethnobotanical account and phytochemical analysis of *Hydnora* (identified as *H. abyssinica*) from Yemen were published, demonstrating antibacterial and fungal properties of *Hydnora* extracts (Al-Fatimi *et al.* 2016).

Based on the concept that the subgeneric section *Dorhyna* is defined by terete rhizomes and osmophores positioned on tepal apices (Decaisne 1873, Vaccaneo 1934, Harms 1935), it currently comprises only two species, *H. abyssinica* and *H. sinandevu*. Following the taxonomy of Beentje and Luke (2002) and Musselman and Visser (2002) there are at least nine synonyms of *H. abyssinica* and two subspecific taxa described primarily from East Africa during the “Scramble for Africa” and colonial periods (late 1800’s-early 1900s) by Italian, German, and French botanists. Some recent literature uses the commonly applied synonym *H. johannis* (e.g. Collenette 1999) in lieu of *H. abyssinica*. The monographic work of Vaccaneo (1934) recognizes 5 species and two subspecific forms in the section *Dorhyna* primarily based on the size of the osmophore relative to the tepal lobe size, lobe shape, and lobe margin setae. Harms’ (1935) monograph follows Vaccaneo but cautions that the variation between species within *Dorhyna* is slight and may represent one species, *H. johannis* (= *H. abyssinica*). The apparent synonymy rife in this subgenus has much to do with the under collection of this largely subterranean plant and the poor condition of the *Hydnora* herbarium material as discussed in Musselman and Visser (1989) and Bolin *et. al.* (2011). Further fieldwork, closer examination of fresh material, and molecular work is likely to eventually elevate some of the submerged taxa. In this manuscript we endeavor to summarize the taxonomy of this enigmatic genus on the Arabian Peninsula.

## Material and Methods

We conducted fieldwork in Southern Oman in December 2014 with the assistance of the Oman Botanic Garden with the goal of relocating and describing *Hydnora* in Oman. No vouchers of *Hydnora* were available in any herbaria in the Sultanate of Oman, thus we focused on locations described by Thesiger during his expeditions across Oman in the 1940s. We made collections of *Hydnora* at four locations in the Dhofar region of Oman including relatively fresh flowers and describe a new *Hydnora* species previously identified as *H. africana* or *H. abyssinica*. Herbarium material was studied with a Zeiss Discovery V8 Stereoscope, photographed with an integrated AxioCam camera and AxioVision software. In the field GPS positional data was collected with a Garmin Etrex 20 handheld GPS receiver.

## Taxonomic Treatment

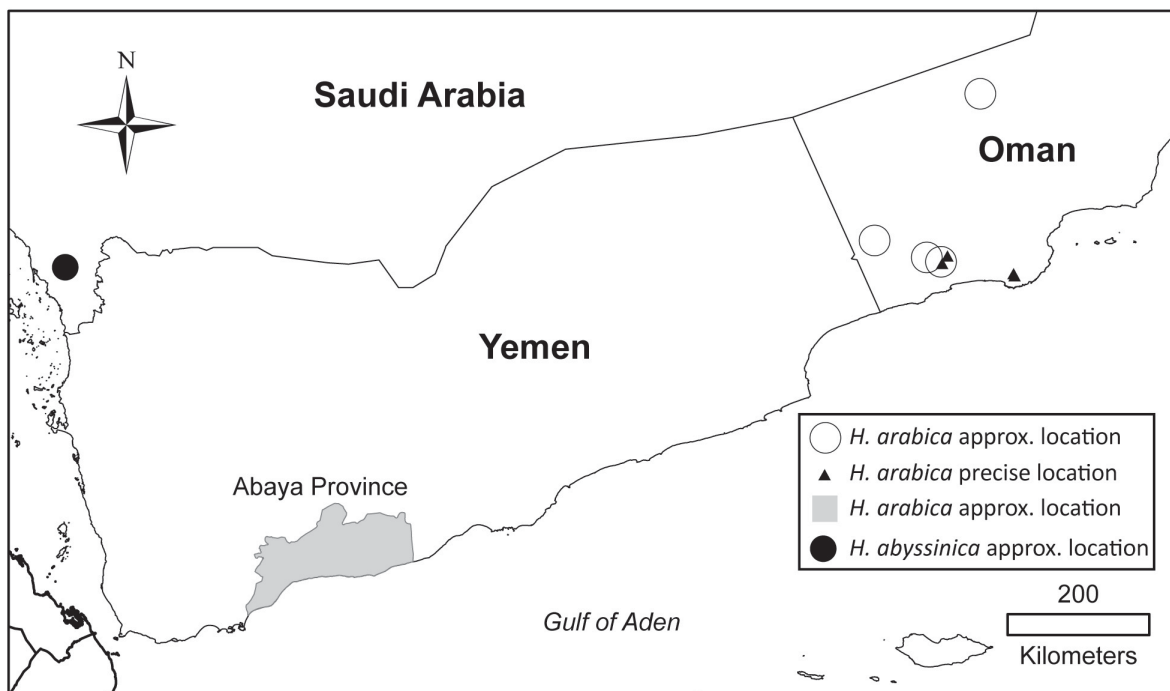
*Hydnora arabica* Bolin & Musselman, *sp. nov.* (Figs. 1–4)

**Diagnosis:**—*Hydnora arabica* is similar to *Hydnora abyssinica*, but can be distinguished by having red to orange inner perianth tube color and tepal lobe margins entirely covered with dense strigose setae.

**Type:**—SULTANATE OF OMAN. Dhofar region: Ayn Ayuoon. 0.66 km SE of the spring. Flowers emerging from deep alluvial sand, on margin of main wadi bed, parasitizing *Acacia tortilis*, other dominant vegetation *Salvadora persica*, *Lycium shawii*, and *Ziziphus spina-christi*, 660 m, 17°14’28.66”N, 53°53’29.92”E, 16 December 2014 J. Bolin, S. Al Rahbi, L. Musselman JFB2014OM3 (holotype OBG!, isotype US!).

Herbaceous perennial root holoparasite. Rhizome terete, subterete, or compressed (1–5 cm wide, may be much larger on mature specimens, but not seen), rhizome surface coriaceous, dark brown to light tan, lighter colored (when fresh) near growth tip, rhizome spreads laterally and may bifurcate or branch irregularly, rhizome ornamented with numerous lateral tuberculate appendages that can form haustoria, branches of the rhizome, or flower buds, numerous flowers and flower buds on single rhizomes, rhizome swollen and irregular at haustorial interface with host root and rhizome fleshy, pink to red internal tissue when broken, lighter colors at growing tip (in life). Merosity usually 4, though 3 and 5 observed. Flower emerges only partially from soil. External perianth tissues brown to reddish brown and scaly (in life), perianth tissues fleshy, internal perianth tube and tepal lobe tissues red to orange (in life), darkening

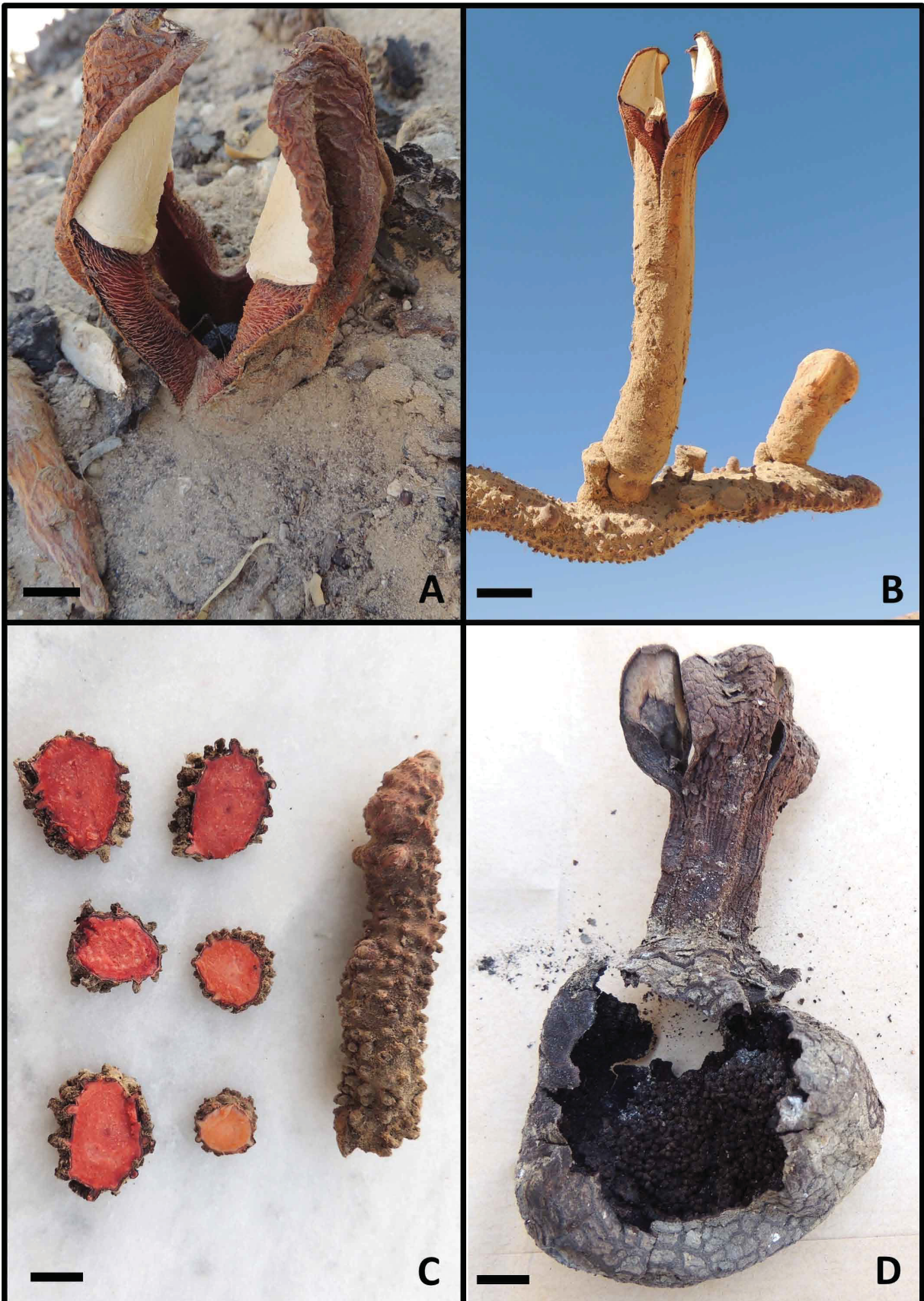
to brick red-brown, perianth tubular 10–28 cm long (total length) × 1.9–3.6 cm wide (tubular portion), tepal lobe length measured from apex to point of connation with adjacent tepal 4.0–8.5 cm, tepal lobe width measured at midpoint 1.9–3.5 cm (on 4–merous flowers, wider on 3–merous and narrower on 5–merous flowers), tepal lobes clavate to elongate-linear and typically curved, not fused at apex, and dense strigose setae on margins of tepal lobes (max. 3.3 mm) covering entire tepal lobe margin from ventral to dorsal edge. Two floral chambers, an androecial chamber subtended by a gynoecial chamber, inner surfaces of chambers glabrous, perianth chambers joined by antheral ring with a central orifice, formed by connate anther lobes. Osmophores oriented on the ventral surface of the tepal apices, osmophore spongy and white (in life) generating fetid odor, and osmophore darkens to tan when dried. Ovary inferior unilocular with numerous ovules, ovary 25–45 mm wide, lobed and cushion-like stigma on the floor of the gynoecial chamber, and stigma width 19–22 mm. Only one fruit observed, globose, (7 cm in diameter). Subterranean fruit contained thousands of spherical black-brown seeds, diameter 0.7–1.2 mm. Parasitic on the roots of *Acacia tortilis* Forssk. (1775: 150) Hayne (1825: 10: pl. 31) and *Pithocellobium dulce* Bentham (1844: 199) Roxburgh (1798: 67).



**FIGURE 1:** Distribution of *Hydnora arabica* and *Hydnora abyssinica* in the Arabian Peninsula. A single collection of *Hydnora abyssinica* (Collenette 5119, K, RGBE), represented by a black circle (●) is reported from southwestern Saudi Arabia, approximate location. For *Hydnora arabica* open circles (○) are approximate locations from the literature and from herbarium labels without precise locality information. Black triangles (▲) represent collections conducted by the authors during Dec. 2014 based on GPS coordinate information. The recent *Hydnora arabica* collections with color photographs have been reported from Abaya Province, Yemen, grey shaded area (Al-Fatimi *et al.* 2015).

**Distribution:**—Known from southern Oman (Dhofar region) and Yemen. Collected from an elevation of 200 to 680 m (Fig. 1).

**Habitat and Ecology:**—*Hydnora arabica* is an obligate root parasite of Fabaceae that is visible above the soil surface only when flowering (Fig. 2). Most of our collections in Oman occurred on *Acacia tortilis* and the same host was reported from Yemen (Al-Fatimi 2015). Interestingly, in a small Dhofar settlement approximately 16 km NE of Mirbat, adjacent to Ayn Ayuoon south of Jebel Samhan, we were directed to a robust *H. arabica* population associated with and below the non-native *Pithocellobium dulce* (5 m high) in the settlement courtyard and goat yard. No other potential host trees were within 50 meters, thus *P. dulce* was likely the host plant. The villagers mentioned that the goats fed in the nearby wadi where *H. arabica* was abundant and were the likely vector of *Hydnora* seeds into the settlement. Interestingly, in Madagascar, the same introduced host *P. dulce* was a common host of *H. esculenta* (Bolin and Musselman 2013).



**FIGURE 2.** A) *Hydnora arabica* flower emerging from soil. White osmophores apparent on tepal apices; B) Excavated mature *H. arabica* flower, flower bud, and growth tip of rhizome; C) Cross section of terete rhizomes and growth tip of rhizome covered in numerous tubercle-like lateral appendages (Fig 1A–1C: *J. Bolin, S. Al Rahbi, L. Musselman, JFB2014OM3*); D) Dried berry and flower from previous season, numerous dark spherical seeds inside broken fruit (from *J. Bolin, D. Lupton, L. Musselman, S. Al Rahbi, JFB2014OM1*). Scale bars A) = 1 cm; B) 4 cm; C) 2 cm; D) 1 cm.

The apparent primary host *Acacia tortilis* is abundant in northern Oman and present across much of the Middle East; however, the parasite *H. arabica* is apparently restricted to the southern portion of the Arabian Peninsula. In Oman, the gravel plains separate the Northern and Southern mountains (Patzelt, 2015) and are a phytogeographic barrier to dispersal. The plains are hyper-arid without natural springs, or temporary or permanent water bodies. Rainfall is sporadic from year to year, often with several years between rainfall resulting in a sparsely vegetated landscape with low levels of species diversity (Ghazanfar, 2004). The general geology and soils of the type locality, Ayn Ayuoon, were mountainous with strongly dissected rocky plateaus and loamy-skeletal to sandy-skeletal shallow soils underlain by formations of the Tertiary, Hadhramaut group - beige bioclastic, calcarenitic and micritic limestone with abundant fossilized mollusks (Platel *et al.* 1992).

We observed *H. arabica* in southern Oman flowering in December but local villagers reported that flowering also occurs in other months. At some sites flowering was reported in July and at others in May; the apparent sporadic flowering may be dependent on adequate rainfall. Fruits of other *Hydnora* species are slow developing, only maturing 2–4 months after anthesis (Bolin *et al.* 2009).

**Etymology:**—The specific epithet refers to the distribution of *H. arabica* on the Arabian Peninsula.

**Vernacular Name:**—Thesiger reported the vernacular name as *dhanuna* on herbarium material from the 1940s. Miller and Morris (1998) give the Jibbali name *xamleg* and the Dhofari Arabic names *khamlayyeh* and *khumla 'ah*. We can confirm that Jibbali settlers in Dhofar that knew the plant well as a potential food item in fruit used the name *xamleg*. From Yemen in the districts of Lawdar and Dathina that use the plant the Arabic local names of *nabeekh*, *fateekh*, and *tarateef* (Al-Fatimi *et al.* 2015) are used.

**Conservation Status:**—In the Dhofar region of Oman, dried rhizomes of *H. arabica* were common in most wadi beds with an abundance of its common host *Acacia tortilis*, though fresh flowering material was difficult to locate due to its infrequent flowering and primarily hypogeous habit. Based on our observations, the conservation status of *H. arabica* in southern Oman is secure. However, *H. abyssinica* is reported as rare in Saudi Arabia (Collenette 1999) and we have little basis to comment on *H. arabica* abundance in Yemen.

**Additional specimens examined: *Hydnora arabica* sp. nov.** OMAN. Dhofar region: SE of the Empty Quarter Dhofar: (Rub el-Khali) near Wadi Haluf, 8 November 1945, *W. Thesiger* s.n. (BM); Oman Um Shedid, 31 October 1946, *W. Thesiger* s.n. (BM); Mughsin El Ain, no date, *W. Thesiger* s.n. (BM), Wadi Masila, 14 April 1947, *W. Thesiger* s.n. (BM); Zufar, 50km west of Mudhai, 13 September 1985, *A. Miller* 7619 (RGBE, ODU); Approx 17 km NE of Mirbat, Wadi Ayn south of Jebel Samhan, 310 m, 17° 7'2.64"N 54°47'53.21"E, 15 December 2014, *J. Bolin*, *D. Lupton*, *L. Musselman*, *S. Al Rahbi* JFB2014OM1 (OBG); Approximately 2 km south of the village of Haluf, Wadi Haluf, 680 m, 17°20'3.56"N 53°57'35.82"E, 16 December 2014, *J. Bolin*, *S. Al Rahbi*, *L. Musselman* JFB2014OM2 (OBG); Approximately 16 km NE of Mirbat. In small settlement adjacent to Wadi Ayn south of Jebel Samhan, 200m, 17° 5'40.62"N 54°48'35.53"E, 17 December 2014, *J. Bolin*, *S. Al Rahbi*, *A. Rahman*, *L. Musselman* JFB2014OM4 (OBG).

## Discussion

### Comparison to other *Hydnora* spp.

The Oman *Hydnora* material has been previously identified as *H. africana* (Miller and Morris 1988), probably due to its bright red-orange internal tepal (Fig. 3) and perianth tube coloration that is characteristic of *H. africana* and other *Euphorbia*-parasitizing *Hydnora* species in the subgeneric sections *Euhydnora* and *Tricephalohydnium*. However, the terete rhizomes reported for all of the Oman *Hydnora* material indicate placement in the section *Dorhyna* that contain Fabaceae and Burseraceae- parasitizing *Hydnora* species. Yemen and Oman *Hydnora* are all reported to parasitize Fabaceae hosts (*A. tortilis* and the introduced *P. dulce*). The color of inner tepal surfaces and the perianth tube is diagnostic. *Hydnora abyssinica* coloration for inner tepal can vary from white to light pink to red-orange though the inner surface of the androecial chamber portion of the perianth tube is white or light pink. All observations of *H. arabica* indicate orange to red inner tepal surfaces, as well as orange to red coloration of the inner surface of the androecial chamber (upper chamber) of the perianth tube. Perianth color, particularly of the androecial chamber is diagnostic with fresh material, unfortunately *Hydnora* herbarium material dries to a dark black or tawny color. Hence, when collecting *Hydnora* in the field photos and notes of the ventral tepal surfaces and inner perianth chamber should be recorded.



**FIGURE 3:** A) Photo of a *H. abyssinica* fresh open flower and open buds showing habit and bright red internal perianth coloration (Bar=4.0 cm) B) Close-up of apical osmophore (white) and dense strigose tepal margin setae. (Bar=0.5cm) both photographs taken by Anthony Miller, Sept. 1985 (Miller 7619, RBGE, ODU).

The ornamentation of the tepal lobe margins, meaning the surface of a tepal that touches the next tepal when in bud, has diagnostic value with herbarium material. Taxa in the section *Euhydnora*, *H. africana*, *H. longicollis*, and *H. visseri*, have longer bristles on the dorsal edge of the tepal lobe margin and consistently small setae. The section *Tricephalohydnium* represented only by *H. triceps* lack longer bristles on the tepal lobe margin and are ornamented with tiny setulae. The section *Neohydnora* that includes only *H. esculenta* has distinct ribbing on the tepal margins in addition to setae. In the section *Dorhyna*, *H. sinandevu* has glabrous tepal margins (Beentje & Luke 2002). Critically, *H. arabica* differs from *H. abyssinica* from East and Southern Africa by having very dense strigose setae (maximum 3.3 mm) that cover the entire tepal margin from ventral to dorsal edges, whereas setae from *H. abyssinica* typically have longer (maximum 7–11 mm) and more diffuse setae with remote setae apices (Fig. 4). When dense strigose setae are observed on some collections of *H. abyssinica* from East Africa they do not cover the entire sepal margin.

The eleven synonyms of *H. abyssinica* were described on the basis of tepal lobe shape, size and merosity, and include some variation in tepal margin ornamentation. All synonyms of *H. abyssinica* include some form of setae on tepal margins but can range from short fleshy setae (e.g. *Hydnora hanningtonii* Rendle (1896: 55)) to longer filiform setae (e.g. *Hydnora ruspolii* (1917: 57)) and setae coverage of the tepal margin can vary leaving ventral (e.g. *Hydnora cornii* (Vaccaneo 1932: 414–427)) or dorsal portions of the tepal margin glabrous (e.g. *Hydnora bogosenis* (Beccari 1871: 5–7)). No synonyms of *H. abyssinica* (*H. johannis*) have the tepal margin setae described for *H. arabica*, dense strigose setae on the entire margin of the tepal lobe. Drawings and photographs of tepal margin setae form, density, and location for several currently synonymized taxa in Vaccaneo (1932) are particularly helpful and Beentje and Luke (2002) show the tepal margin setae differences clearly for *H. sinandevu* and *H. abyssinica* when compared with *H. arabica*, lacking tepal margin setae and with diffuse setae with remote apices, respectively.

After reviewing tepal margin ornamentation on much of the *H. abyssinica* material from southern and east Africa, *H. abyssinica* may constitute a wide ranging and somewhat variable taxon in the sense of Musselman and Visser (1987), Musselman (1997), and Beentje and Luke (2002) or may be further segregated in the future, using careful observations of tepal lobe margin morphology and ornamentation, flower color, and collection of molecular data. When evaluating *Hydnora* species boundaries, synonymized taxa should be considered closely (Table 1). Notably, on the available herbarium material some variation in tepal margin ornamentation was observed in species of the section *Dorhyna*. It is not clear if these taxa represent variation in *H. abyssinica* or discrete taxa, perhaps previously described, but they warrant further investigation. The basic challenge in *Hydnora* taxonomy continues to be a lack of useful voucher specimens, due to the furtive nature of the plant, and the current political instability in the Horn of Africa and Yemen.

Photos of *H. abyssinica* in extreme southwestern Saudi Arabia (Collenette 1999) from her collections (Collenette 5119, K, RGBE) show pale inner tepal surface coloration and a glabrous surface at least on the dorsal portions of the tepal margin. These characteristics indicate that this plant was correctly identified as *H. abyssinica* (*H. johannis*),

agree with the treatment of *Hydnora* for Saudi Arabia (Musselman 2001), and are strikingly different than *H. arabica*. Hence, two species of *Hydnora* are now recorded from the Arabian Peninsula, *H. abyssinica* and *H. arabica*.

The species key to *Hydnora* in Vaccaneo (1934), original species diagnoses, and type material should be consulted closely when new segregate *Hydnora* species are proposed. The section *Dorhyna* Decaisne primarily defined by terete rhizomes and osmophores on tepal apices was monographed by Vaccaneo (1934) and Harms (1935). In the section *Dorhyna*, Vaccaneo recognized *H. cornii*, *H. ruspolii*, *H. bogosensis*, *H. hanningtoni*, and *H. johannis*, all taxa from Ethiopia and the Horn of Africa region. Moreover, Vaccaneo established that *H. abyssinica* Braun (1867: 217) var. *quinquefida* (Engler 1901: 386) and *H. gigantea* (Chiovenda 1916: 156–157) were forms of *H. johannis* (= *H. abyssinica*). The following taxa were considered doubtful by Vaccaneo based on insufficient descriptions or material, *H. aethiopica* (Decaisne 1873: 77), *H. angloensis* (Decaisne, 1873: 75) and *H. solmsiana* (Dinter 1909: 57–58). As detailed by Beentje and Luke (2002), *H. johannis* is a synonym of *H. abyssinica* based on the priority of the very brief but valid treatment by Braun (1867). The monograph of Harms (1935) largely followed that of Vaccaneo (1934) but cautioned that the differences among the species in section *Dorhyna* treated by Vaccaneo (including *H. solmsiana*), were slight and may represent variation in *H. johannis* (= *H. abyssinica*). A summary of the species level taxonomic boundaries of the section *Dorhyna* is presented in Table 1. A new key to the species of the genus *Hydnora* is presented below.



**FIGURE 4.** Comparison of tepal margin setae of *H. arabica* and *H. abyssinica*. **A)** Dense strigose tepal margin setae from *H. arabica* (J. Bolin, S. Al Rahbi, L. Musselman, JFB2014OM3); the next panels show *H. abyssinica* with some variation in the tepal margin setae considered diffuse with with remote apices, **B)** *H. abyssinica* (BolinJB\_09\_8, WIND) **C)** *H. abyssinica*. (Musselman 6279a, US **D)** *H. abyssinica* (Luke 7182, US). (Size Bars = 1 mm)



TABLE 1. Historical and taxonomic summary of the *Hydnora* section *Dorhyna*. *Hydnora arabica* sp. nov. is also in section *Dorhyna*.

| Names in the Section<br><i>Dorhyna</i>                            | Year<br>Described | Type Locality | Collector and Types*   | Vaccaneo<br>(1934) | Harms (1935) | Musselman<br>(1993) | Musselman (1997) | Beentje and<br>Luke (2002) |
|---|-------------------|---------------|--|--------------------|--------------|---------------------|------------------|----------------------------|
| <b>Accepted Taxa</b>  |                   |               |  |                    |              |                     |                  |                            |
| <i>Hydnora abyssinica</i> A. Braun                                | 1867              | Ethiopia      | Schimper 963 (holotype, B, isotype, P, W)                                    |                    |              | X                   |                  | X                          |
| <i>Hydnora sinandevi</i> Beentje & Q. Luke                        | 2002              | Kenya         | Luke 3033a (holotype EA, isotype, K, MO, US)                                 |                    |              |                     |                  | X                          |
| <b>Synonymized Taxa of</b>  |                   |               |  |                    |              |                     |                  |                            |
| <b><i>Hydnora abyssinica</i></b>                                  |                   |               |  |                    |              |                     |                  |                            |
| <i>Hydnora abyssinica</i> A. Braun var. <i>quinquefida</i> Engler | 1900              | Tanzania      | Goetze 487 (holotype, B)   | +                  | +            |                     |                  |                            |
| <i>Hydnora angolensis</i> Decne.                                  | 1873              | Angola        | n.d.   |                    |              |                     |                  |                            |
| <i>Hydnora bogosensis</i> Becc.                                   | 1886              | Eritrea       | Beccaris. s.n. (holotype, FT)  | X                  | X            |                     |                  |                            |
| <i>Hydnora cornii</i> Vaccaneo                                    | 1932              | Somalia       | Cornis. s.n. (holotype TOM)  | X                  | X            |                     |                  |                            |
| <i>Hydnora gigantea</i> Chiov.                                    | 1916              | Somalia       | Paoli 980 & 1035 (holotype, FT, not found)                                   | +                  | X            |                     |                  |                            |
| <i>Hydnora gigantea</i> Chiov. var. <i>trimera</i> Chiov.         | 1916              | Somalia       | n.d.   | +                  |              |                     |                  |                            |
| <i>Hydnora hanningtonii</i> Rendle                                | 1896              | Tanzania      | Hannington. n. Donaldson Smith   | X                  | X            |                     |                  |                            |
| <i>Hydnora johannis</i> Becc.                                     | 1871              | Eritrea       | s.n. (holotype, BM)<br>Beccari 417, 423, 424, 3685, 3687, 3690 (syntype, FT) | X                  | X            |                     | X                |                            |
| <i>Hydnora michaelis</i> Peter                                    | 1932              | Tanzania      | Peter 32690 (holotype, B)  |                    |              |                     |                  |                            |
| <i>Hydnora ruspolii</i> Chiov.                                    | 1917              | Ethiopia      | Riva & Ruspoli 1091 (holotype, FT)   | X                  | X            |                     |                  |                            |
| <i>Hydnora solmsiana</i> Dinter                                   | 1909              | Namibia       | Holotype, B, likely destroyed (Musselman and Visser 1989)                    |                    | X            |                     |                  |                            |

X recognized in treatments. \*Data from Beentje & Luke (2002); + recognized as a subspecies of *H. johannis* (= *H. abyssinica*)

## Key to to the species of *Hydnora*:

1. Mature rhizomes angular in cross section .....2.
2. Tepal margin ornamentation ribbed and with setae, root parasite of Fabaceae, spongy osmophore on ventral surface of tepal apex, root parasite of Fabaceae including *Alatsylodendron decaryum*, *Albizia tulearensis*, *Pithocellobium dulce* (Section *Neohydnora*) ..... *H. esculenta*
2. Tepals margins not ribbed, spongy osmophore recessed in ventral surface of tepal, not a root parasite of Fabaceae .....3.
3. Tepals fused forming a hood, flowers 3-merous, root parasite of *Euphorbia dregeana* (Section *Tricephalohydnium*) ..... *H. triceps*
3. Tepals free at apex not fused and forming a hood, flowers 3- or 4-merous (rarely 5), not root parasite of *Euphorbia dregeana* (Section *Euhydnora*) .....4.
4. Tepal lobes less than 2.2 cm, generally less than 1/5 of flower length protruding above ground, commonly root parasite of *Euphorbia damarana*, only known from NW Namibia and SW Angola ..... *H. longicollis*
4. Tepal lobes more than 2.2 cm, generally more than 1/5 of flower length protruding above ground, not a root parasite of *E. damarana* .....5.
5. Tepal lobes between 2.2 cm and 4.5 cm, root parasite of *Euphorbia mauritanica*, *E. chersina*, *E. caput-medusae*, *E. decussata*, *E. grandidens*, *E. lignosa*, and *E. trigona* ..... *H. africana*
5. Tepal lobes greater than 4.5 cm, root parasite of *Euphorbia gregaria* and *E. gummifera* ..... *H. visseri*
1. Mature rhizomes terete to sub-terete in cross section (Section *Dorhyna*) .....6.
6. Tepal lobe margins not setose, root parasite on *Commiphora africana* ..... *H. sinandevu*
6. Tepal lobe margins with well-developed setae, strigose to diffuse at setae apices, root parasite on *Acacia* spp .....7.
7. Androecial chamber inner surfaces white to light pink, tepal margins white to light pink, occasionally red to orange, tepal lobe margins partially covered with strigose setae or partially to entirely covered with diffuse setae, setae apices often remote ..... *H. abyssinica*
7. Androecial chamber inner surfaces red to orange, tepal margins and internal surfaces red to orange, tepal lobe margins entirely covered with dense strigose setae, setae apices not remote ..... *H. arabica*

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## References

- Al-Fatimi, M., Ali, N.A.A., Kilian, N., Franke, K., Arnold, N., Kuhnt, C., Schmidt, J. & Lindequist, U. (2015) Ethnobotany, chemical constituents and biological activities of the flowers of *Hydnora abyssinica* A. Br. (Hydnoraceae). *Die Pharmazie-An International Journal of Pharmaceutical Sciences* 71: 222–226.
- APG IV (2016) *Botanical Journal of the Linnaean Society* 181: 1–20.  
<https://doi.org/10.1111/boj.12385>
- Ballion, H.E. (1886) *Hydnoraceae trib. Aristolochiacearum*, Librairie Hachette, Paris, France.
- Beccari, O. (1871) Descrizione di due nuove specie d'*Hydnora* d'Abissinia. *Nuovo Giornale Botanico Italiano* 3: 5–7.
- Beentje, H. & Luke, Q. (2002) Hydnoraceae. In: Beentje, H. & Luke, Q. (Eds.) *Flora of Tropical East Africa*. A.A. Balkema Publishers, Rotterdam.
- Bentham, G. (1844) *London Journal of Botany* 3: 199.
- Bolin, J.F., Maass, E., Tennakoon, K.U. & Musselman, L.J. (2009) Host-specific germination of the root holoparasite *Hydnora triceps* (Hydnoraceae). *Botany* 87: 1250–1254.  
<https://doi.org/10.1139/B09-078>
- Bolin, J.F., Maass, E. & Musselman, L.J. (2011) A new species of *Hydnora* (Hydnoraceae) from Southern Africa. *Systematic Botany* 36: 255–260.  
<https://doi.org/10.1600/036364411X569453>
- Bolin, J.F. & Musselman, L.J. (2013) Epitypification and ecological notes for the Malagasy holoparasite *Hydnora esculenta* (Hydnoraceae). *Nordic Journal of Botany* 31: 286–290.  
<https://doi.org/10.1111/j.1756-1051.2012.00731.x>
- Braun, A.K.H. (1867) *Hydnora abyssinica*. *Schweinfurth Beitrage zur Flora Aethiopiens* 28: 217.

- Chiovenda, E. (1916) *Hydnora gigantea*. *Resulti Scientifica della missione Stefanini-Paoli nella Somalia Italiana* 1: 156–157.
- Chiovenda, E. (1917) Plantae novae vel minus notae e regione Aethiopica. *Bullettino Della Societa Botanica Italiana* 6: 57.
- Collenette, S. (1999) *Wildflowers of Saudi Arabia*. National Commission for Wildlife Conservation and Development, 435 pp.
- Decaisne, J. (1873) Note sur trois espèces d'*Hydnora*. *Bulletin de la Société Botanique de France* 20: 75–77.  
<https://doi.org/10.1080/00378941.1873.10827697>
- Dinter, M.K. (1909) *Deutsch-Sudwest Afrika, Flora, Forst, und Landwirtschaftliche Fragmente*: 57–58.
- Drège, J.F. & Meyer, E.H.F. (1833) *Nova Acta Physico-medica Academiae Caesareae Leopoldino Carolinae Naturae Curiosorum* 16: 779.
- Engler, A. (1901) *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 28: 386.
- Forsskål, P. (1775) *Flora Aegyptiaco-Arabica* 176.
- Ghazanfar, S.A. (2004) Biology of the Central Desert of Oman. *Turkish Journal of Botany* 28: 65–71.
- Harms, H. (1935) Hydnoraceae. In: Engler, A. & Prantl, K. (Eds.) *Die Natürlichen Pflanzenfamilien. Zweite Auflage. Band 16b*, Leipzig: Wilhelm Engelmann, pp. 282–295.
- Hayne, F. (1825) *Getreue Darstellung und Beschreibung der in der Arzneykunde gebräuchlichen Gewächse* 10: pl. 31.
- Jumell, H.H. & Perrier, H. (1912) Quelques phanérogrammes parasites de Madagascar. *Revue Générale de Botanique* 24: 321–328.
- Meyer, E.H.F. (1833) De *Hydnora*. *Nova Acta Physico-medica Academiae Caesareae Leopoldino Carolinae Naturae Curiosorum* 16: 765.
- Miller, A.G. & Morris, M. (1988) *Plants of Dhofar, The Southern Region of Oman, Traditional, Economic, and Medicinal Uses*. Office of the Adviser for Conservation of the Environment, Diwan of Royal Court, Sultanate of Oman, 148 pp.
- Musselman, L.J. (1993) Hydnoraceae. In: Thulin, M. (Ed.) *Flora of Somalia* Vol. 1. Royal Botanic Gardens, Kew, pp. 30–31.
- Musselman, L.J. (1997) Hydnoraceae. In: Pope, G.V. (Ed.) *Flora Zambesiaca* Vol. 9 Part 2. Royal Botanic Gardens, Kew, pp. 16–18.
- Musselman, L.J. & Visser, J.H. (1987) *Hydnora johannis* in Southern Africa. *Dinteria* 19: 77–82.
- Musselman, L.J. & Visser, J.H. (1989) Taxonomy and natural history of *Hydnora*. *Aliso* 12: 317–326.  
<https://doi.org/10.5642/aliso.19891202.09>
- Musselman, L.J. (2001) Hydnoraceae. In: Chaudhary, S.A. (Ed.) *Flora of the Kingdom of Saudi Arabia Illustrated vol. II (Part I)*. National Herbarium of Saudi Arabia, Ministry of Agriculture and Water, Riyadh, Saudi Arabia, pp. 268–270.
- Naumann, J., Salomo, K., Der, J.P., Wafula, E.K., Bolin, J.F., Maass, E., Frenzke, L., Samain, M.-S., Neinhuis, C., de Pamphilis, C.W. & Wanke, S. (2013) Single-copy nuclear genes place haustorial Hydnoraceae within Piperales and reveal a Cretaceous origin of multiple parasitic angiosperm lineages. *PLoS ONE* 8: e79204.  
<https://doi.org/10.1371/journal.pone.0079204>
- Nickrent, D.L., Blarer, A., Qui, Y.-L., Soltis, D.E., Soltis, P.S. & Zanis, M. (2002) Molecular data place Hydnoraceae with Aristolochiaceae. *American Journal of Botany* 89: 1809–1817.  
<https://doi.org/10.3732/ajb.89.11.1809>
- Patzelt, A. (2015) Synopsis of the flora and vegetation of Oman, with special emphasis on patterns of plant endemism. *Jahrbuch 2014 der Braunschweigischen Wissenschaftlichen Gesellschaft*: 282–317.
- Platel, J.P., Berthiaux, A. & Chevrel, S. (1992) Geological Map of Habarut, Sheet NE 39–12. Ministry of Petroleum and Minerals, Directorate General of Minerals, Muscat, Sultanate of Oman.
- Rendle, A.B. (1896) *Hydnora hanningtonii*. *Journal of Botany, British and Foreign* 34: 55.
- Roxburgh, W. (1798) *Plants of the Coast of Coromandel* 1: 67.
- Thesiger, W. (1959) *Arabian Sands*. Longmans, London, pp. 330.
- Thunberg, C.P. (1775) Beskrifning på en ganska besynnerlig och obekant svamp, *Hydnora africana*. *Kongalia Vetenskaps Akademiens Handlingar* 36: 69–75.
- Vaccaneo, R. (1932) Una nuova *Hydnora* della Somalia Italiana. *Nuovo Giornale Botanico* 39: 304–308.  
<https://doi.org/10.1080/11263503209440420>
- Vaccaneo, R. (1934) Hydnoraceae Africae. *Memorie Della R. Accademia Nazionale Dei Lincei-Classa Di Scienze Fisiche, Matematiche e Naturali* 5: 413–456.
- Welwitsch, F.M.J. (1869) Sertum Angloense. *Transactions of the Linnean Society of London* 27: 66.