

## STUDIES IN THE FLORA OF ARABIA XX: The genus *Striga* in Arabia

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**ABSTRACT.** Six species of *Striga* (Scrophulariaceae) are found in the Arabian Peninsula. Most widespread is *S. gesnerioides*, usually parasitizing fleshy *Euphorbia* species. *S. asiatica* and *S. hermonthica* are serious pathogens of sorghum and millet in some areas of Yemen, Saudia Arabia, and Oman. *S. densiflora*, an Indian species, has been collected once in Oman as a parasite of sorghum; *S. angustifolia* is known from two collections from Dhofar Region of Oman. *S. yemenica* from North Yemen and Ethiopia is here described for the first time.

### INTRODUCTION

The genus *Striga* reaches its greatest diversity in the Sudano-Zambesian Region (terminology according to Brenan, 1978) of Africa where approximately 24 of the 30 or so species occur (Musselman, 1987). Another centre of apparent diversity is India where *S. asiatica*, *S. gesnerioides*, *S. angustifolia*, *S. densiflora*, *S. masuria*, and the endemic *S. sulphurea* occur. Because of its phytogeographical importance as a bridge between two phytochoria (Mandaville, 1984), the southern part of the Arabian peninsula is of especial interest in considering the relationship between the Indian and African taxa of *Striga*. Indeed, in this South Arabian domain (Brenan, 1978) is the only area where strictly Indian and African elements are found together. Furthermore, *S. angustifolia*, a species common in India but only scattered in East Africa, is also found in this domain. We describe here *S. yemenica*, a distinct new species in Yemen and Ethiopia. This discovery emphasizes the importance of this region in the phytogeography of the genus.

In this paper, we present a taxonomic treatment of the genus in Arabia with descriptions of the species and notes on distribution, agronomic importance and species biology.

***Striga* Lour., Fl. Cochinch. 22 (1790).**

Annual, rarely perennial, hirsute or scabrous root parasitic herbs. Root system greatly condensed, adventitious roots often arising from beneath subterranean scales, fine lateral roots terminated by small (1-2mm diam.) haustoria; in some species a large (to 5cm) single haustorium forms the single connection with the host. Stems stiffly erect, green or grey, usually square, often ridged. Leaves opposite, sessile or subsessile; lower leaves near the base of the stem reduced to small scales in most species. Inflorescence a spike, flowers in axils of leaves (bracts) or in dense heads. Bracts leaf-like or reduced, bracteoles 2. Calyx tubular, 5-lobed, with 5 (rarely 4) teeth, in some species intracostal veins occur. Corolla with a narrow tube and expanded 2-lipped limb. Orifice of tube small, less than

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1mm diam. with hairs at orifice. Upper lobes fused, lower lobes 3, spreading. Stamens 4, didynamous, inserted in the tube below the orifice. Anthers unilocular, basifixed on short filaments. Pollen sparse, often sticky. Pistil tubular with numerous minute ovules. Style terete, elongate, stigma bifid. Nectary present at base of ovary. Capsule elongate or subovoid, style usually persistent. Dehiscence loculicidal. Seeds minute ('dust seeds') with prominent encircling ridges. Embryo small. Germination hypogeal and cryptocotylar. Seedlings achlorophyllous, squamate.

#### KEY TO ARABIAN SPECIES OF STRIGA

1. Calyx with 10 or more ribs (sect. *Polypleurae* Engler) . . . . . 2
- + Calyx with 4 or 5 ribs (sect. *Pentapleurae* Engler) . . . . . 3
2. Plants densely hispid; flowers white, yellow, or scarlet; leaves 0.3–2mm wide . . . . . 1. *S. asiatica*
- + Plants not densely hispid; flowers white; leaves 1–3mm wide . . . . . 2. *S. angustifolia*
3. Leaves reduced to scales; stems usually succulent; large single haustorium often present . . . . . 3. *S. gesnerioides*
- + Leaves not reduced to scales; stems not succulent; many small haustoria present . . . . . 4
4. Bracts lanceolate c.2mm broad, about as long as the calyx, much shorter than cauline leaves, with prominent fringe of hairs on margin; corolla large and showy pink . . . . . 4. *S. hermonthica*
- + Bracts linear c.1mm broad, lower ones longer than cauline leaves, decreasing in size, hispid and pubescent all over . . . . . 5
5. Flowers dull red or mauve, lower corolla lobes less than 1mm long; stem with dense hairs . . . . . 6. *S. yemenica*
- + Flowers white, lower corolla lobes to 3mm long; stem with scattered hairs . . . . . 5. *S. densiflora*

#### SECTION POLYPLEURAE

1. *Striga asiatica* (L.) Kuntze, Rev. Gen. Pl. 2:466 (1891).

Type: Comoro Is., St Joanna, *Toreen* s.n. (LINN).

Syn.: *S. lutea* Lour., Fl. Cochinch. 22 (1790); Schwartz, Fl. Trop. Arab. 247 (1939).

Sparsely branched, or, if branched, then from above the middle, 15–20cm tall, densely hispid, stems square. Leaves ascending, 8–16 × 0.3–2mm. Bracts longer than the calyx (9–12mm long). Bracteoles 2mm or less long. Flowers opposite or subopposite, only 2 open at a time per inflorescence branch. Calyx 6 (including 2mm-long teeth) × 2.5mm. Corolla white, yellow or scarlet, tube 6–9mm long, bent near limb; upper lobe emarginate, 1–1.5mm long, lower lobes spreading, 4 × 1.5mm, whole limb positioned at right angles to the tube. Style persistent, usually with white pollen mass remaining on stigma. Capsule 7 × 2mm. Seeds 0.1mm, brown.

YEMEN ARAB REPUBLIC. Misrah, *Wood* 1413 (K); Tha'bad, *Radcliffe-Smith* 4943 (K, E, BM); Ibb, *Wood* 1832 (K); Bait Al Bashari, *Miller* 277 (flowers red) (E); Al Khawkhan, *Miller* 3084 (flowers white) (E); Tha'bad, Tur, *King* 190, 191 (flowers white) (E); Wadi Hayle, *King* 174 (flowers white) (E); Saana, *Zuccarini* 33 (K).

SAUDI ARABIA. Banirazan, *Colleenette* 1386 (K); Giar Abyan, *Hearn* 15 (flowers white) (BM); Beni Rezam, *Nasher* (P45) (flowers red) (BM).

OMAN. Dhofar, *Bent* 237 (K).

*S. asiatica* is found throughout much of the Old World tropics and subtropics and has been introduced into the U.S.A.

Two forms are found in Arabia. The first, and apparently the more common, is the much-branched, white-flowered form similar to that most frequently seen in India. The second has brilliant crimson flowers, is less branched and also is less pubescent. The red form resembles plants found in Africa (e.g. Ethiopia and Sudan).

**2. *Striga angustifolia*** (D. Don) Saldanha in Bull. Bot. Surv. India. 5:70 (1963); Hepper in Taxon 35:390 (1986).

Type: Nepal, *Wallich* s.n. (K).

Syn.: *S. euphrasioides* sensu Benth. in Hooker's Comp. Bot. Mag. 1:364 (1936); Skan in Fl. Trop. Afr. 4, 2:412 (1906).

*Buchnera angustifolia* D. Don, Prodr. Fl. Nepal 91 (1825).

Green or grey-green, 15–50cm tall, sparsely branched; stem ridged when dry. Leaves few (less than 10 pairs), opposite,  $25 \times 1\text{--}3\text{mm}$ . Bracts leaf-like, alternate, similar in size to largest leaves, scabrous. Calyx  $4 \times 2\text{mm}$  with 12 ribs, the acute teeth as long as the tube. Corolla white, tube  $10 \times 0.75\text{mm}$ ; upper lobe  $0.5 \times 1\text{mm}$ , lateral and lower lobes  $1 \times 3\text{mm}$ . Style persistent; pollen mass usually present on stigma. Capsule  $3 \times 4\text{mm}$ ; valves reflexed at maturity. Seeds  $0.75\text{mm}$  long, black.

OMAN. Dhofar, *Radcliffe-Smith* 5208 (K); Dhofar, above Ain Jarses waterhole, wet woodland with *Anogeissus dhofarica*, *Blepharisperrum hirtum*, *Croton confertus* etc., 80m, 7 ix 1985, *A. G. Miller* 7500 (E).

*S. angustifolia* is common in India where it grades imperceptibly into *S. masuria* (Musselman, 1987) but is also found at scattered locations in East Africa (Hepper, 1984). The persistent pollen mass on the stigma suggests that this species is autogamous.

Recently, Hepper (1986) has recommended that the earlier name *Buchnera euphrasioides* Vahl be rejected on the basis that it is a *nomen confusum* and that the name *Striga angustifolia* (D. Don) Saldanha be used for this plant.

#### SECTION PENTAPLEURAE

**3. *Striga gesnerioides*** (Willd.) Vatke in Oesterr. Bot. Zeitschr. 25:11 (1875).

Type: India, *Koenig* s.n. (B-WILLD. 11573).

Syn.: *Buchnera gesnerioides* Willd., Sp. Pl. 3:338 (1801).

*Striga orobanchoides* (R. Br.) Benth. in Hooker's Comp. Bot. Mag. 1:361 (1836); Schwartz, Fl. trop. Arab. 247 (1939).

*Buchnera orobanchoides* R. Br. in Endl. Bot. Zeit. 2:388, t.2 (1831).

Greenish yellow, often succulent, 11–25cm tall. A single large primary haustorium to 5cm diam. is often present on each plant. Adventitious roots abundant from beneath subterranean scales. Stem square but only obtusely angled. Leaves scale-like, appressed to the stem, 5–10 × 2–3mm. Leaves and stems minutely puberulent with upward pointing hairs, or almost glabrous. Bracts usually same length and width as calyx, acuminate. Bracteoles minute,  $\frac{3}{4}$  length of calyx. Flowers opposite or alternate, usually 2, rarely 3, per node, not fragrant. Calyx 4–6 (with linear teeth) × 2mm. Corolla light blue or dark purple; tube 8–11mm long, bent just below limb; upper lobes 2–2.5mm long, sharply recurved, lower lobes 2–3.2mm long. Capsules 1–2 × 3mm. Pollen mass usually persistent on stigma.

YEMEN ARAB REPUBLIC. Hodidah, *Popov* s.n. (BM); Jiblah, *Hepper* 6113 (K); Qaideh, *Radcliffe-Smith & Henchie* 4412 (K); Wasab al-Aly, *Miller* 74 (E); Taiz, *Hepper & Wood* 5833 (K); Taiz, *Chaudhary* 5686 (RAWRC); Hateeb, *Chaudhary* 5687 (RAWRC); Salfiyah, *Gillespie* 18 (K); Dhi Sufal, *Wood* 1350 (K); Huth, *Radcliffe-Smith & Henchie* 4769 (K); Abdullah, *Gillespie* 17 (K).

SOUTH YEMEN. Jebel Jihaf, *Grozovsky* 63 (BM); Audhali, *Radcliffe-Smith & Lavranos* 885 (K); Socotra, *Bent* s.n. (E).

SAUDI ARABIA. Mahayl, *Collenette* 1976 (E, K); Jebel Fayfa, *Collenette* 3581 (K); Taif, *Collenette* 666 (K).

OMAN. Dhofar, *Miller* 2391 (E); Dhofar, *Miller* 2430 (E); Dhofar, *Radcliffe-Smith* 5237 (K).

*S. gesnerioides* is widespread in tropical Africa and Asia. In Arabia it is apparently limited in its parasitism to the succulent arborescent *Euphorbia abyssinica* apart from the following collection—Saudi Arabia: Farasan Island, N of Farasan village, sand pans in fossil coral, in shady places, host plant always *Cissus quadrangularis*, 3 ii 1985, *I. S. Collenette* 5020' (E). The morphology of these plants is similar to that of *S. gesnerioides* parasitizing succulent *Euphorbia* in Sudan (Musselman & Hepper, 1986). By contrast, parasites on weedy Convolvulaceae or on Fabaceae are characteristically much branched.

**4. *Striga hermonthica* (Del.) Benth.** in Hooker's Comp. Bot. Mag. 1:365 (1836); Schwartz, Fl. trop. Arab. 247 (1939).

Type: Egypt, *Delile* s.n. (P).

Syn.: *Buchnera hermonthica* Del., Fl. Egypte: 245, t. 34 fig. 3 (1813).

Stiffly erect, dark green, much branched, 20–50cm tall. Stem 4-angled with a groove on each face, scabrous. Leaves rather thick, 6–9 × 1.1–1.5cm, both surfaces scabrous, margins with hispid hairs at regular intervals. Bracts almost as long as the calyx with prominent fringe of hairs on the margin, tip curved away from stem. Bracteoles half the length of the calyx. Flowers opposite or subopposite, 8–10 open at same time per inflorescence branch, variable in size, faint sweet fragrance in early morning. Calyx 10–12 × 2.5mm intracostal portion whitish and translucent, teeth subulate at apex. Corolla bright pink (rarely white), tube 10–20mm long, usually bent just above the calyx teeth, outside with very scattered hairs; upper lobe emarginate, erect, 2–4mm long, lower lobes 10–13 × 8–10mm. Capsule 12–15 × 2–2.5mm.

SAUDI ARABIA. Giar Abyen, *Hearn* 13, 14 (BM); Marroua (?), *Schweinfurth* 161 (K); Ad-Daob, *Collenette* 2026 (K); (?), *Ehrenberg* (K); (?), *Wahab* (E); Bani 'abs, *Hewitt* 17 (BM); Jebel Faifa, *Vesey-Fitzgerald* 16186/2 (BM); Abu-Arish, *Chaudhary* 6975 (RAWRC).

YEMEN ARAB REPUBLIC. Ta'izz, *Scott & Britton* 298 (BM); Dahil, *Lavranos & Newton* 15995 (E); Wadi Ayen, *Muller-Hohenstein & Deil* 132 (E); Taiz, *Miller* 27 (BM, E); Taiz, *Hepper & Wood* 5832 (K); Wadi Rima, *Acres* 17 (K); Bayt al Faqih, *Hepper & Wood* 6080 (K); Wadi Rima, *Pratt* 70, 102 (K); Zabid, *Watt* 818 (K); Surdud, *Chaudhary* 5685 (RAWRC).

SOUTH YEMEN. Hajej, *Grierson* 101 (BM, E).

Stewart & Harris (1983) are among several authors to document the seriousness of this species in yield reduction of subsistence grain crops. It is known as a pathogen in many areas of the semi-arid tropics (Ramaiah *et al.*, 1983).

**5. *Striga densiflora* (Benth.) Benth. in Hooker's Comp. Bot. Mag. 1:363 (1836).**

Syn.: *Buchnera densiflora* Benth., *Scroph. Ind.* 41 (1835).

Syntypes: India, *Heyne & Wight* in *Wallich* 3873 (K); *Royle* s.n. (K).

Green, to 17cm tall, sparsely branched. Stem  $\pm$  glabrous. Leaves linear, 2–16  $\times$  1–2mm. Bracts leaf-like, recurving, 10–36  $\times$  2mm, scabrous. Flowers in dense elongated inflorescences. Corolla white, tube 7–9mm long, lobes 2–5mm long. Capsule 2  $\times$  3mm.

OMAN. Nizwa, *Parker* 0-36 (BM).

*S. densiflora* is known from the Arabian Peninsula only by the single collection cited above. It has perhaps been introduced to this region from India where it is well-known as a parasite in grain crops (Ramaiah *et al.*, 1983) and sugar-cane.

**6. *Striga yemenica* Musselman & Hepper, sp. nov.**

Affinis *S. densiflorae* sed corolla minor, indumento magis denso differt.

Herba annua erecta (5–)10–29cm alta, simplex vel 2-ramosa, sordide viridis; radices basi caulis adventitiae; indumentum hispidum pilis base crasso in sicco albo. Caulis quadrangularis, in sicco sulcati, pilis reflexis. Folia opposita, usque 6-geminata; base caulis squamiformia, patentia, 8–24  $\times$  2–5mm, pilis adscendentibus. Bractae inferiorae foliiformes, superiores calycis breviores. Calyx 4  $\times$  1mm, 5-costatus, glaber, juventute costis  $\pm$  villosis; dentes erecti, 0–5mm longi, acutae. Corolla 7mm longa, rubra ad lilacina; tubus perangustus abrupte angulatus; lobus superiore 0–25mm reflexus, lobus inferiore 0–75mm longus, lobi laterali 0–5mm long. Stylus caducus. Capsula 3  $\times$  1mm. Semina leviter reticulata cristis tuberculatis.

Type: Yemen Arab Republic, Jiblah, *Miller* 546 (holo. E, iso. K).

Stiffly erect dull green annual (5–)10–29cm tall, usually unbranched, branches never more than 2. Indumentum of stiff hairs with swollen bases which dry white. Stems 4-sided, grooved (when dry) with downward pointing hairs. Lowermost leaves scale-like; adventitious roots present at base of stem. Leaves usually few (never more than 6 pairs), opposite, ascending, 8–24  $\times$  2–5mm with ascending hairs. Lower floral bracts leaf-like, erect or reflexed at tip; lower bracts shorter than leaves, uppermost shorter than calyx. Calyx 4  $\times$  1mm, glabrous except for the 5 ribs which may be villous when young, teeth of calyx erect, 0–5mm long, acute. Corolla dull red to mauve, tube 7mm long, very narrow, abruptly angled

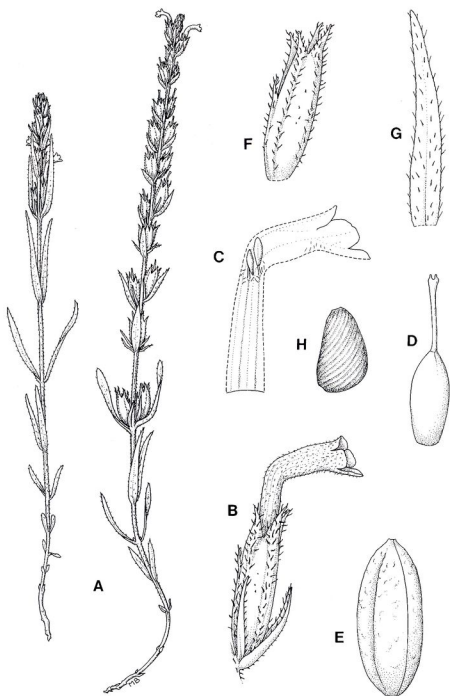


FIG. 1. *Striga yemenica*: A, habit  $\times 1\frac{1}{2}$ ; B, flower with bract  $\times 8$ ; C, corolla in LS  $\times 10$ ; D, pistil  $\times 10$ ; E, capsule  $\times 8$ ; F, calyx  $\times 8$ ; G, leaf  $\times 4$ ; H, seed  $\times 500$  (from Miller 546).

at top of calyx; upper lobe reflexed, 0.25 mm long; lower lobe 0.75 mm long, lateral lobes 0.5 mm long. Style not persistent. Capsule  $3 \times 1$  mm. Seeds with reduced ornamentation, crests of ridges with short protuberances.

YEMEN ARAB REPUBLIC. Ibb to Udayn, Wood 1260 (K); Jiblah, Hepper 6122 (K); Mudhakira, Wood 526 (K).

Miller 546 was found growing at c. 2600 m, in short grass on an exposed ridge in association with *Felicia dentata* (A. Rich.) Dandy, *Cyanotis barbata* D. Don, *Swertia polynectaria* (Forssk.) Aschers., *Linum strictum* L. etc. All the gatherings come from the Ibb Region of N Yemen, an area with one of the highest rainfalls in the Arabian Peninsula. Two collections have recently been recognized from continental Africa across the Red Sea: ETHIOPIA. Harar Prov., Mt Hakim,  $9^{\circ}17'N$   $42^{\circ}06'E$ , De Wilde 5486 & 7223 (MO).

This taxon has been annotated as *S. aspera* but is distinct from that African species in several ways: (1) the corolla of *S. yemenica* is very small, only a fraction of the size of typical *S. aspera*; (2) the indumentum of *S. aspera* is different, the corolla is glandular-pubescent and the bracts are not densely villous when young; (3) the Yemen plant lacks persistent styles, a common feature of *S. aspera*; (4) the Yemen collections are diminutive plants with the largest being 29 cm tall while *S. aspera* is a more robust and more branched plant up to 60 cm in height. No data are available on the hosts or floral biology of *S. yemenica*.

*Striga yemenica* appears to be related to *S. densiflora*, a widespread species in India. Generally, *S. densiflora* is a much larger plant than *S. yemenica*, although diminutive specimens of *S. densiflora* (e.g. Musselman 7084, K, ODU) superficially resemble *S. yemenica*. Important differences between the two can be summarized as follows. *S. densiflora*: stem with sparse pubescence, hairs with swollen bases; corolla white, to 6 mm long, lobes broadly spreading. *S. yemenica*: stem densely hairy, hairs with only slightly swollen bases; corolla dull red to mauve to 2.5 mm long, lobes not spreading.

While *S. densiflora* appears to be autogamous as many plants have persistent pollen masses on the stigma, no such masses have been seen on *S. yemenica*.

At present we know very little about relationships within the genus *Striga* and it would be premature to assign *S. yemenica* to any alignment within the genus although it does belong to section *Pentapleurae*. Again, we know little of the taxonomic value of these sections which depend on the number of calyx ribs, a feature which shows considerable variation (Musselman, unpublished).

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