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HAMID MOAZZENI

SHAHIN ZARRE

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On the Circumscription of *Isatis tinctoria* L. (*Brassicaceae*) in Iran

Hamid MOAZZENI, Shahin ZARRE*

Research Centre of Plant Sciences, School of Biology, University College of Science, Tehran University, PO Box: 14155-6455,
Tehran - IRAN

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Abstract: In the course of preparing a revision of *Isatis* L. and its allies in Iran, we verified *Isatis tinctoria* L. among the material studied. Although it has been previously recorded for Iran, we give a more extensive description and a map of its distribution in Iran. A key to distinguishing this species from its allies and a discussion of the affinities in this group are provided.

Key Words: Brassicaceae, *Isatis tinctoria*, Iran

Introduction

Isatis L., with about 50 species (Appel & Al-Shehbaz, 2003), is an extremely difficult genus of *Brassicaceae* (*Cruciferae*), which is distributed primarily in the northern hemisphere and has an Irano-Turanian distribution pattern (Davis, 1965). According to Hedge (1968) and additions made by Sajedi et al. (2004), Iran, with 19 species, is one of the important diversification centres of the genus. Extractions of *I. tinctoria* L. are widely used as the Old World blue dye, woad, which became the dominant blue dye in Europe, especially in western Europe. In some parts of the world, it is a noxious weed, and nowadays it is rarely cultivated.

Isatis tinctoria L. (woad) is distributed in south-west Asia, Uzbekistan, Russia, Tajikistan, Mongolia, Pakistan, Korea, Kazakhstan, Japan (Shu, 2001), and Europe (Tan, 2002), and is naturalised elsewhere (e.g., North America). In the recently published *Flora Hellenica*, 2 subspecies have been considered for *I. tinctoria* (Tan, 2002), while in the *Flora of Turkey and the East Aegean Islands*, the species is composed of 4 subspecies (Davis, 1965).

There are 2 references recording *Isatis tinctoria* from Iran. Parsa (1951) recorded this species from Kermanshah province in western Iran based on a

specimen collected near Tagh-e Bostan by Cowan and Darlington. Although this specimen was not seen by us, all other specimens identified by Parsa as *I. tinctoria* and deposited in the herbarium of the Pharmacological Faculty of Tehran University were actually *I. kotschyana* Boiss. Another specimen verified and published recently as *I. tinctoria* by Sajedi et al. (2004) from northern Tehran and deposited in IRAN herbarium, is only a form of *I. gaubae*. Therefore, the presence of *I. tinctoria* in Iran seemed to be doubtful; however, while preparing a revision of *Isatis* for the *Flora of Iran*, we found several specimens, distributed mainly in eastern Iran, which are indeed *I. tinctoria*.

Materials and Methods

This study was primarily based on material deposited in the main herbaria of Iran, i.e. FUMH (Ferdowsi University of Mashhad Herbarium), IRAN, TUH, the local herbarium of Kerman University, and the Natural History Museum of Vienna (W). Several field studies were also conducted in north-east Iran. The specimens were compared with the material deposited in W and identified as *I. tinctoria* by Davis and Hedge (Edinburgh). It is described below and a distribution map for Iranian specimens is provided (Figure 1).

* E-mail: zarre@khayam.ut.ac.ir

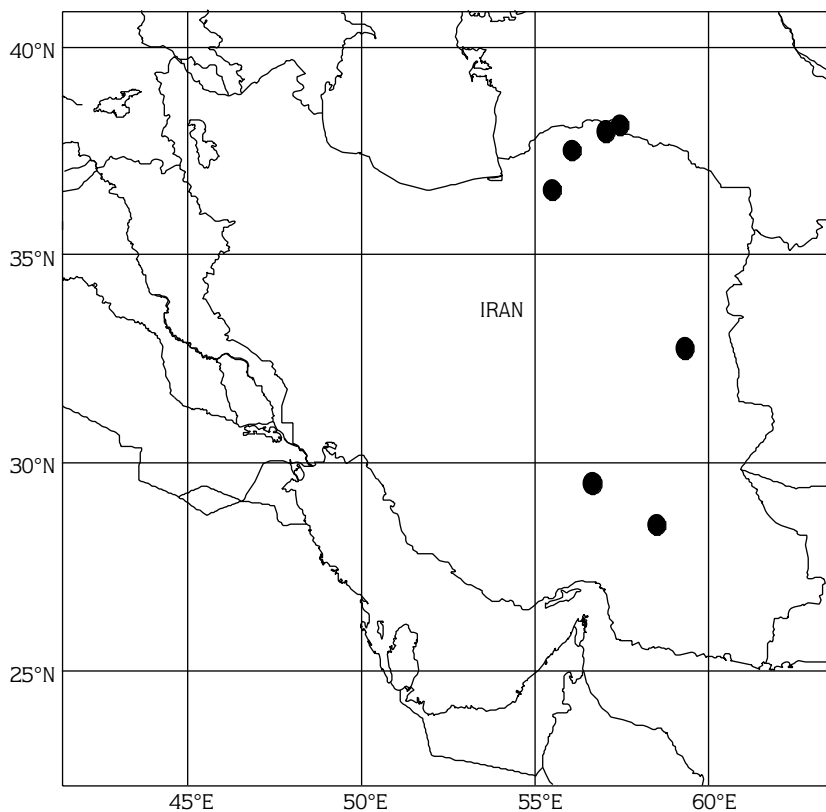


Figure 1. Map of the distribution *Isatis tinctoria* in Iran.

Results and Discussion

Taxonomic account

Isatis tinctoria L., Sp. Pl. 2: 670. 1753. Type: "Hab. ad littora maris Balthici et oceani Europae", Hb. Linn. 848/1 (microfiche!). Common names: woad, dyers woad.

Short-lived perennial (according to Davis, 1965; Hedge, 1968; Tan, 2002), biennial, or rarely, annual herbs, glaucous, glabrous, or pubescent below. Stems (30-)40-100(-150) cm, erect, often paniculately branched above middle. Basal leaves rosulate, petiole 0.5-5.5 cm; leaf blade oblong or oblanceolate, (2.5-)5-15(-20) × (0.5-)1.5-3.5(-5) cm, base attenuate, margin entire, repand, or dentate, apex obtuse; cauline leaves sessile; leaf blade oblong or lanceolate, rarely linear-oblong, base sagittate or auriculate, margin entire, apex acute. Fruiting pedicels slender, considerably thickened, and subclavate at apex, 5-10 mm. Sepals oblong, 1.5-2.8 × 1-1.5 mm, glabrous or sparsely pubescent; petals yellow, oblanceolate, 2.5-4 × 0.9-1.5 mm, base

attenuate, apex obtuse; filaments 1-2.5 mm; anthers oblong, 0.5-0.7 mm. Fruits black or dark brown, oblong-ob lanceolate, elliptic-obovate, or rarely oblong, (0.8)1.1-2(-2.7) cm × 3-7 mm, often broad above middle, glabrous or pubescent, winged all around, base cuneate, margin sometimes slightly constricted, apex subacute, rounded, or rarely subemarginate; loculus with a distinct mid vein and inconspicuous lateral vein; apical wing 3.5-5(-7) mm wide. Seeds light brown, narrowly oblong, 2.3-3.5(-4.5) × 0.8-1 mm. $2n = 14, 28$.

Flowering: April-June. Habitat: Roadsides, field pastures, hillsides, prairies, railroad embankments, waste places, 300-2200 m; south-west Asia, Europe; naturalised in North and South America.

Specimens examined (Figure 1):

Prov. Kerman: Kerman, 24.6.1976, *M. Mousavi & B. Tehrani* 15441 (IRANI!); NE Jebale Barez, Jebale Barez, 29.3.2005, *M. Mirtajedini* 35785 (TUH!); Kerman, Laleh Zar maountain, 26.4.1997, *M. Mirtajedini* 35827

(TUH!). Prov. Khorassan: NE Bojnourd, Darband to Gifan, 1050 m, 1.5.2005, *H. Moazzeni* 35803 (TUH!); NE Bojnourd, Tang-e Turkaman, 988 m, 3.4.2005, *H. Moazzeni* & *A. Ghorbani* 35779 (TUH!). Prov. Gorgan: Golestan national park, pass between Robat-e Gharabil and Solgerd, 5.6.1987, *A. Ghahreman* & *V. Mozaffarian* 5884 (TUH!); Birjand, Tannak to Esfazar, 2000 m, *M. Faghihnia* & *H. Zangoie* 30268 (FUMH!); Prov. Golestan: Shahpasand to Bojnord, Almehr road, 1300-1500 m, 7.6.1975, *F. Termeh* 15649 (IRANI).

Note:

Isatis gaubae and *I. pachycarpa* are most closely related to *I. tinctoria*. Both of these species are endemic to Iran. From the former, *I. tinctoria* can be distinguished by its obovate fruits with the wider part at the upper third of the fruit, while the fruits in *I. gaubae* are more or less linear-oblong. Moreover, in the middle of the fruits, the locules are wider than the wings in *I. gaubae*, but the fruit wings are distinctly wider than the locules in *I. tinctoria*. *Isatis pachycarpa*, known from southern Iran (Jebal-e Barez mountain range), differs from *I. tinctoria* in that it has distinctly hairy leaves and velutinous hairy fruits. Furthermore, the fruits of *I. pachycarpa* are distinctly carinate at the locules. Table 1 shows some characteristic features useful in separating the species in this group.

Based on the map presented in Figure 1, *Isatis tinctoria* covers a much wider area in Iran than previously reported. The specimen reported by Sajedi et al. (2004) is distinctly perennial¹, with fruit that are wide in the middle and fruit locules are wider than the wings (appropriate with *I. gaubae*). This specimen collected

from central Alborz in northern Tehran in an area adjacent to Dizin is only a form of *I. gaubae*. According to our concept, *I. tinctoria* is distributed in eastern Iran and has a wide distribution throughout the rest of Iran. Most probably, the species penetrates Iran from neighbouring countries to the east, i.e. Afghanistan and Pakistan. *Isatis tinctoria* has also been recorded from Turkey, most eastern up to C9 Hakkari (Davis, 1965), doubtfully from Iraq (Hedge & Lamond, 1980), Caucasus and Central Asia (Vasil'chenko, 1939), Afghanistan (as *I. koelzii* by Rechinger, 1958; Hedge, 1968), and west of Pakistan (Jafri, 1973). Therefore, its occurrence in Iran is not unexpected. We think that this species is widely distributed in eastern Iran and in adjacent neighbouring countries, i.e. Afghanistan and Pakistan, but based on the map presented in Figure 1 it seems that there are disjunctions in distribution of this species in eastern Iran. The species is recorded from eastern Afghanistan and the Swat/Chitral area in Pakistan, but not from areas adjacent to Iran. However, the borders between Iran, Afghanistan, and Pakistan have been extremely dangerous for long time, making it difficult for botanists to work. More intensive collection in the future may fill the gaps in the distribution of *I. tinctoria* in this area.

Isatis tinctoria is one of the most polymorphic species of the genus and has been cultivated since ancient times as a source of blue dye (woad), which is obtained by fermenting the ground leaves and lower portions of the plant. Yıldırım (1988) reported that *I. tinctoria* had a global dispersion, except for southern Asia, and Central and southern Africa. He also stated that up to 20 species of *Isatis* could be reviewed under the *I. tinctoria* complex. Several subspecies and varieties have been recognised in

Table 1. Diagnostic characters useful in distinguishing *Isatis tinctoria* from its closest relatives in Iran.

Taxon → Character ↓	<i>Isatis gaubae</i>	<i>Isatis pachycarpa</i>	<i>I. tinctoria</i>
Shape of the fruit	oblong-linear	obovate-elliptic	obovate to elliptic, rarely oblong
Carinate fruit locule	absent	present	absent
Width of the fruit locule	2-3 mm	3 mm	1.5-2 mm
Width of the wings at the middle of the fruit	1-1.5 mm	2.5 mm	2-3 mm

¹ We did not observe any perennial specimens of *Isatis tinctoria*, but according to Hedge (1968), Davis (1965), and Tan (2002) this species can also be a short-lived perennial.

it. Davis (1965) recognised 3 subspecies under this species for Turkey. Hedge (1968) considered *I. koelzii* as a species separate from *I. tinctoria* restricted to east Afghanistan and Pakistan, on the basis of its short (ca. 15 mm long) oblong fruits, which are rounded at both ends. However, these characters show considerable variation among specimens of *I. tinctoria* and cannot be considered diagnostic for separation of taxa at a specific level. For these reasons Jafri (1973) considered it as *I. tinctoria* subsp. *koelzii* (Rech.f.) Jafri. Based on some overlapping characters, Tan (2002) also considered 2 subspecies for *I. tinctoria* in the area covered by *Flora Hellenica*: subsp. *tinctoria* and the localised subsp. *athoa* (Boiss.) Papan. None of the above-named treatments provide an exact definition for the different subspecies. Based on Iranian samples of *I. tinctoria*, we were not able to recognise subspecies. For example, in one population we observed some individuals matching the type of *I. tinctoria* subsp. *tinctoria* and some in accordance with *I. tinctoria* subsp. *koelzii*. Even in one specimen, different sizes and shapes

were observed. We were also unable to use the concept applied in the recent volume of the *Flora of Turkey* (Güner et al., 2001) for delimitation of the 4 subspecies of the Iranian material known in that area. Therefore, it seems that the subspecific concept in *I. tinctoria* should be re-assessed and more precisely defined. A more detailed biosystematic study in the future may clarify the final systematic position of this species along with other taxa related to it.

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