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ADDITIONS TO THE KNOWLEDGE OF *SYMPETRUM SINAITICUM* DUMONT (ODONATA: LIBELLULIDAE)

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Abstract

New information shows that *S. sinaiticum* is not divided into subspecies, as hitherto supposed. The subspecific name *tarraconense* Jödicke, 1994 must be regarded as a junior synonym of *sinaiticum*. In contrast, the name *arenicolor* Jödicke, 1994 denotes a taxon at full species rank, characterized by its larval and ligula morphology. This species is taxonomically identical to *S. s. deserti* Jödicke, 1994. Since the latter name has been established in the same work, we determine the precedence of *arenicolor* as the valid name for the Asiatic species. Range, seasonality, and habitat selection of *S. sinaiticum* are outlined.

Introduction

The taxon *sinaiticum* has been erected by Dumont (1977) as a subspecies of *Sympetrum decoloratum* (Sélys, 1884). Jödicke (1994) demonstrated that the name *decoloratum* originally denoted an Asiatic subspecies of *S. vulgatum* (Linnaeus, 1758) which had hitherto been addressed under its junior synonym *S. vulgatum flavum* Bartenef, 1915. In consequence, the valid name of the species, erroneously deemed to be *S. decoloratum*, is *S. sinaiticum*. The populations of this species, which extend over north Africa, the Iberian Peninsula, Asia Minor, and Central Asia, have been split, on the basis of structural differences in the male accessory genitalia, into four subspecies: the nominotypical ssp., ssp. *tarraconense*, ssp. *deserti*, and ssp. *arenicolor* respectively (Jödicke 1994).

This subspecific concept came into swaying when larval characters were considered: Haritonov & Borisov (1991) described the larva of *S. s. arenicolor* (sub *S. decoloratum*) as bearing dorsal spines on the abdomen, similar to *Sympetrum vulgatum*, *S. striolatum*, and *S. meridionale*. In contrast, the larva of *S. s. tarraconense* has no dorsal spines (Jödicke 1995).

Because material for the subspecific divison of *S. sinaiticum* was restricted to single specimens, the authors arranged a meeting in Karasuk Station, Novosibirsk District, Siberia, on 19 August 1998. We analysed series from Spain and Central Asia, and

discussed the relationship between *tarraconense* and *arenicolor*. Additionally, the first author made several collecting trips to Tunisia. Further important material from south-western Jordan and from various localities in Syria was provided by Wolfgang Schneider. On the basis of these series an improved taxonomic concept of *S. sinaiticum* and its Asian relatives can be presented.

Larval and imaginal description of the north African population

Material: At Tozeur oasis,Tunisia, the first author collected a single F-1 larva and teneral adults on 6 May 1999. On 10-12 October 1999 he took mature adults at Tozeur and at Tamerza. Further fully mature adults were collected by him on 27 January 2000 and on 8 March 2000 at Tozeur. Altogether, this African series consists of 25 males and 14 females. Further material: 2 males and 6 females from Petra, Jordan, collected by W. Schneider and F. Krupp and deposited in coll. Schneider (Hessisches Landesmuseum Darmstadt). The Spanish series of *S. s. tarraconense*, which has been used for comparison, is described in Jödicke (1994).

The larva has remained undescribed until now. A lack of mid-dorsal spines and the short lateral spines of S8 are its most striking characters (Fig. 1). There is no indication that the larval morphology differs from that of *S. s. tarraconense*. On the other hand, there is no similarity with the larva of *S. s. arenicolor*. Due to shrinking of the material in acetone, we conducted the analysis without meristic data.

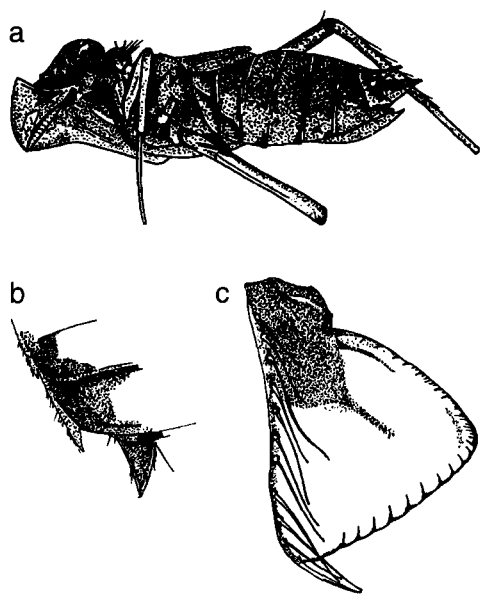

Figure 1. Larval characters of *Sympetrum sinaiticum* from northern Africa, coll. 6 v 1998 at Tozeur, Tunisia: (a) general appearance of the F-1 larva; (b) abdominal tip in ventral view; and (c) labial palp with its setae. Drawn by H. von Hagen.

Several imaginal characters of the material taken in Libya, Sinai, Tunisia, and Algeria had been thoroughly described (Ris 1911a; le Roi 1915; Dumont 1977, 1978, 1991; Jödicke 1994). However, nothing has been said on ligula morphology. The conspicuous cornua at the tip of the ligula are long and rather thick (Fig. 2a). They are clearly visible in a ventral view of the accessory genitalia, where they are situated below the inner hamules and are bent in a cranial direction. The tips of the cornua usually reach to the base of the outer hamules (Fig. 3a). This situation is markedly different in *S. s. deserti* and *S. s. arenicolor* (see below), but identical in *S. s. tarraconense*.

Concerning the position of the inner hamules, an important correction must be introduced: the inner hamules are completely covered by the outer ones in lateral view, and are thus invisible. This contrasts with the figures in Dumont (1977, 1991) and Jödicke (1994). Indeed, the holotype from Tozeur shows the tips of the inner hamules in lateral view, but this is certainly not typical and may be an individual anomaly. All 27 males analysed in the present paper agree in having a hidden inner hamulus. This trait has been the main argument for dividing the Spanish and African populations into distinct subspecies. Thus the only remaining difference between the nominotypical subspecies and ssp. *tarraconense* is coloration. A comparison of colour photographs with fully mature males from Spain and Tunisia demonstrates more extension of black markings on thorax, legs and abomen in Spanish specimens, and this also applies to females. The figures in Dumont (1977, 1991) and Jödicke (1994) clearly reflect this difference. In mature males from Tunisia the black markings are not conspicuous, and the abdomen is dominated by the bright red on the dorsal parts, while the ventral parts are yellow. In all Tunisian females the abdominal red is confined to a small line along the dorsum of S2-7 which is continued by a black line along S8-9. Due to the overall coloration, African *S. s. sinaiticum* can easily be mistaken for *S. meridionale* (Sélys, 1841) in the field.

The vulvar scales of females from Spain and Tunisia are identical. In all cases their shape is tapering and somewhat bilobed in ventral view, and only moderately projecting in lateral view. In both populations there is some variation concerning the shape of the vulvar scale. The females from Petra/Jordan generally have the largest and widest scales. This can best be seen in lateral view.

Measurements (in mm; arithmetic mean ± standard deviation followed by range in parentheses)
Males from Tunisia (n = 25): abdomen 23.6 ± 0.9 (21.5-25.5); hindwing 26.4 ± 1.0 (24.5-29.0). Females from Tunisia (n = 14): abdomen 23.9 ± 0.9 (23.0-25.0); hindwing 26.3 ± 1.0 (24.5-28.0).
Males from Petra (n = 2): abdomen 23.0 ± 0.0; hindwing 26.5 ± 0.7. Females from Petra (n = 6): abdomen 23.2 ± 1.5 (21.5-26.0); hindwing 26.1 ± 1.0 (25.0-28.0).

Description of the populations from Asia Minor and Central Asia

Material: Long series of *Sympetrum sinaiticum arenicolor* from various localities in Turkmenistan, Uzbekistan, Kirghistan, and Tajikistan are deposited in the Novosibirsk

collection. Out of this material, a random selection of 20 males and 15 females, taken by the second author and now in coll. Jödicke, has been analysed for the present paper. Further material: 1 male collected by M. Nuß in Kirghistan (coll. Jödicke) and the types from Turkmenistan (Rijksmuseum van Natuurlijke Historie, Leiden). *S. s. deserti* is represented by the types from Iran (also Leiden) and a series of 7 males and 15 females from various localities in northeast Syria, collected by F. Krupp, D. Kock, and G. Eppler and deposited in coll. Schneider (Hessisches Landesmuseum Darmstadt).

S. s. deserti and *S. s. arenicolor* had been erected as distinct subspecies based on male characters: the size of the lobes and the shape of the outer hamules (Jödicke 1994). The series analysed in this paper demonstrates that there is some variablity in these traits which seems to be independent of an individual's origin. Another interesting feature is the variable extension of black markings: the holotypes of ssp. *deserti* and ssp. *arenicolor* figured in Jödicke (1994) represent the palest extreme. This light pattern is also shown by specimens from Buchara/Uzbekistan and Tajikistan. The maximum black resembles the pattern of *S. s. sinaiticum* from Tunisia or Jordan, and is represented by specimens from the foothills of Kopet Dagh Mts in Turkmenistan, Buchara in Uzbekistan again, and Dzalal-Abad in Kirghistan. Intermediate patterns occur in other series from Syria to Tajikistan. The amount of thoracic black seems to be age-independent, i.e. black markings can already be seen in tenerals. On the other hand, in mature specimens the black may be covered by whitish pruinosity as occurs also in mature specimens of the relatives in Spain and Africa.

Both *deserti* and *arenicolor* agree in morphology of the ligula. In ventral view, its head is situated between the inner hamules. The chitinous structures along the ventral side of the penis head are elongated into two roundish lobes which distally bear a thin, short filament (Fig. 2b). These are not longer than 0.006-0.010 mm and sideways bent towards the outer hamules (Fig. 3b). This is in clear contrast to the ligula morphology in the Spanish and African populations and can normally be seen without dissecting the specimen.

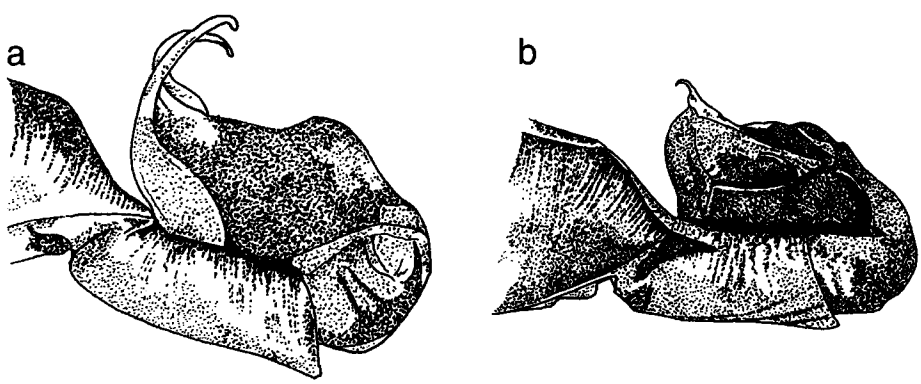

Figure 2. Ligula in (a) *Sympetrum sinaiticum*, C. Bonet leg. viii 1992 near Valencia, Spain, and (b) *S. arenicolor*, leg. 02 x 1988 at Bukhara, Uzbekistan, lateral view. *S. sinaiticum* has two long cornua at the tip; *S. arenicolor* has two short filaments. Drawn by H. von Hagen after microphotographs by R. Seidenbusch.

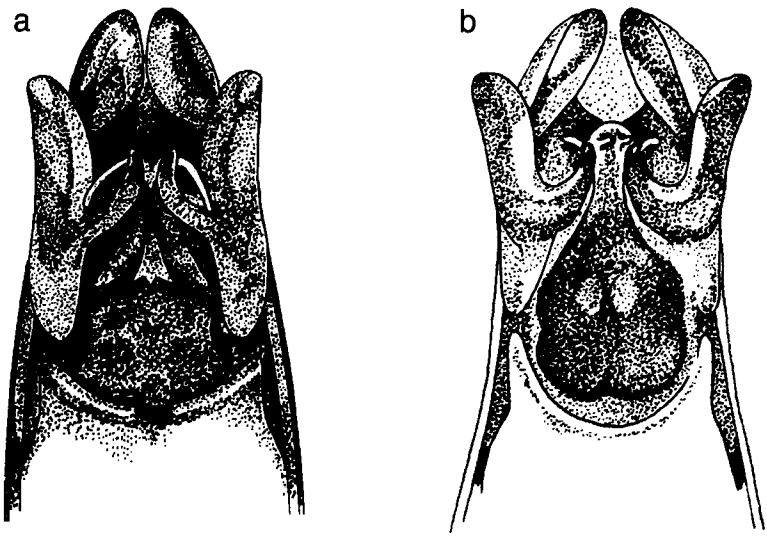

Figure 3. Male accessory genitalia in (a) *Sympetrum sinaiticum*, coll. 11 x 1998 at Tozeur, Tunisia, and (b) *S. arenicolor*, coll. 10 x 1979 at Tigrovaja Balka, Tajikistan, ventral view. Note the tip of the ligula situated below the inner hamules: in *S. sinaiticum* the tip is elongated into two long cornua; in *S. arenicolor* the tip has two short filaments. Drawn by H. von Hagen.

The rear of the head is pale in all specimens of *S. s. deserti* and *S. s. arenicolor*, without any blackish stripes and spots (Fig. 4b). This is also so in those specimens which have striking thoracic markings. On the contrary, all specimens of the nominotypical subspecies and ssp. *tarraconense* exhibit a contrasting pattern of the rear of the head (Fig. 4a).

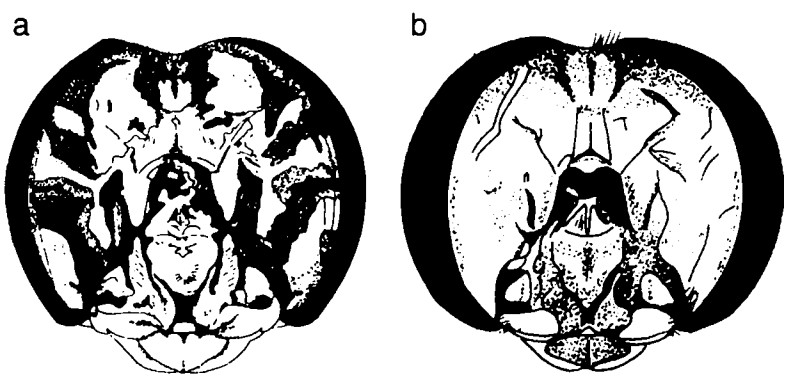

Figure 4. Coloration pattern of the rear of the head in (a) *Sympetrum sinaiticum*, coll. 11 x 1998 at Tozeur, Tunisia, and (b) *S. arenicolor*, coll. 10 x 1979 at Tigrovaja Balka, Tajikistan. *S. sinaiticum* has brown to blackish stripes, whereas *S. arenicolor* is almost without markings. Drawn by H. von Hagen.

The vulvar scale of the Asian relatives is similar to Spanish and north African females. On average, in ventral view the shape is broader without any tendency of tapering. All tips of the scale are distinctly to slightly bilobed. However, there are single specimens with a tapering scale, and these are similar to African or Spanish females.

Measurements
Males (n = 30): abdomen 22.6 ± 0.7 (21.5-24.0); hindwing 26.4 ± 0.8 (25.0-28.5).
Females (n = 32): abdomen 23.1 ± 1.6 (17.5-25.5); hindwing 26.4 ± 1.3 (22.0-28.0).

Taxonomic consequences

The present system of one species — *Sympetrum sinaiticum* — with four subspecies — *sinaiticum, tarraconense, deserti* and *arenicolor* — cannot hold in light of the latest findings.

The morphological differences between *tarraconense* and the nominotypical subspecies cannot be confirmed. Especially the ligula morphology demonstrates a perfect agreement in both groups. The differences in coloration constitute an insufficient argument for a taxonomic separation on a subspecific level: *tarraconense* and *sinaiticum* must be treated as the same taxon. Therefore, the name *tarraconense* is a junior synonym of *sinaiticum.*

In addition, the morphological differences between ssp. *deserti* and ssp. *arenicolor* have not proven reliable. The accessory genitalia in males as well as the vulvar scales in females or the thoracic pattern in both sexes showed some individual variation within the material investigated. Concerning ligula morphology, ssp. *deserti* and ssp. *arenicolor* totally agree in having short and fine filaments in contrast to the long cornua of the African and Spanish relatives. Therefore both Asiatic taxa are considered to be taxonomically identical, and the names *deserti* and *arenicolor* are synonyms. Since both names have been published on the same date, we arbitrarily choose the name *arenicolor* as the valid one. This precedence will best serve stability due to the recent acceptance of this name to denote the populations of Central Asia.

Although the taxa *sinaiticum* and *arenicolor* are similar, the differences in their larval and penis morphology provide a strong argument for separating them at a species level. We therefore regard them as two distinct species without subspecific division (for synonymy see Jödicke 1994): *Sympetrum sinaiticum* Dumont, 1977, and *Sympetrum arenicolor* Jödicke, 1994.

The range of *Sympetrum sinaiticum*

The range of the Spanish population was recently outlined by Jödicke (1997). A list of all known records in northern Africa and northwestern Arabia is here provided in chronological order.

Algeria
Ouargla; Amgid; Oued Agelil; Ideles — 1914 leg. F. Geyr von Schweppenburg (le Roi 1915)
Touggourt, 1922 leg. J. Surcouf (Lacroix 1924)
Guelta Imelaouaene; Guelta Affilâl; Guelta Issakarasène; Guelta Edjif Mellène; Guelta Emeghra (Oued 'n Tazzait) — all Ahaggar, leg. 5/6 ix 1976 (Dumont 1978)
Guelta on plateau of Assekrem/Ahaggar, leg. 25 iii 1977 (coll. Dumont)
Tassili-n-Ajjer/Iherir canyon, leg. 7 vi 1978 (coll. Dumont)
Mount Ilaman/Ahaggar, 29 viii 1994 leg. (Samraoui & Menaï 1999, and in litt.)

Tunisia
Tozeur, leg. 10 v 1913 A. v. Schulthess (Ris 1919)
Tozeur, leg. 5 vi 1976 (Dumont 1977, with fixation of the date in litt.)
Gabès, leg. 1 vi 1976 (coll. Dumont)
Tozeur, leg. 6 v 1998, 10/11 x 1998 (Jödicke et al. 2000)
Tamerza, leg. 12 x 1998 (Jödicke et al. 2000)
Oued el Hattab 15 km NW Kasserine, obs. 13 x 1998 (Jödicke et al. 2000)
Natural Park de Jebil, 50 km S Douz, leg. 11/15 X 1999 H. Pohl (Jödicke et al. 2000)
Oued Ahmadi nr Tamezret, leg. 16/17 x 1999 H. Pohl (Jödicke et al. 2000)
Tozeur, obs. 5 xi 1999 B. Kunz (Jödicke et al. 2000)
Spring 40 km N Remada, obs. 3 xi 1999 B. Kunz (Jödicke et al. 2000)
Oued el Hamma nr El Hamma, obs. 30 i 2000 (Jödicke unpubl.)
Tozeur, leg. 27 i 2000 and 8/11 iii 2000 (Jödicke unpubl.)

Libya
Gherran 13/14 vii 1906; Endschila 23 vii 1906; Dschebel T'kut 18 ix 1906, leg. B. Klaptocz (Ris 1911a)

Egypt
Suez (Fraser 1936)
Mt Katherina/Sinai 13 vii 1974; El-Arbain/Sinai 14 vii 1974 (Dumont 1977, with correction of date in litt.)
Oir raba/Sinai, leg. 7 vii 1974 L. Kinarty (coll. Tel Aviv)
Mt Katharina/Sinai, leg. 25 ix 1977 A. Freidberg (coll. Tel Aviv)
Wadi Baraber/Sinai, leg. 13 xi 1974 L. Kinarty (coll. Tel Aviv)
Wadi Jebal, leg. 26 ix 1974 L. Kinarty (coll. Tel Aviv)
Wadi Shag, leg. 7 vii 1974 F. Hizkiahoo (coll. Tel Aviv)

Jordan
Wadi Musa/Petra, leg. 16 ix 1980 W. Schneider & F. Krupp (Schneider 1986)

Saudi Arabia
Jabal Lauz/Wadi Muharraq, leg. 26 iii 1990 (Schneider & Krupp 1993)

We suppose that all records belong to *S. sinaiticum*, although this is not certain. An overview of all localities shows three different areas of distribution:

— the Mediterranean parts of the Iberian Peninsula
— northern Africa from the Ahaggar Mts. over northeastern Algeria and southern Tunisia to northwestern Libya
— the Sinai and adjacent regions of northwestern Arabia.

It remains unclear whether these areas are disjunct or not. Further information from the gaps in western Morocco/western Algeria (min. distance 800 km) and eastern Libya/Egypt (min. distance 2 000 km) would be needed to answer this question.

S. sinaiticum and *S. arenicolor* appear to be allopatric species. The nearest known findings of *S. arenicolor* are located in the floodplains of the Euphrates and Tigris and their tributaries: in northeastern Syria (Schneider & Krupp 1996, sub *S. s. deserti*), Malatya in Turkey (Ris 1911b), and several localities in Iraq (Morton 1919, 1920a, 1920b, 1921; Sage 1960; Asahina 1973). The distance from Petra — the northeasternmost record of *S. sinaiticum* — to the steppe 10 km ENE of Tall Sheik Hamad in Syria — the southwestern most record of *S. arenicolor* — amounts to about 770 km. This broad corridor is dominated by desert and steppe. But since there are several wadis in that region, the possibility cannot be excluded that one or the other species exists there, outside its currently known limits. In this respect the identity of the specimens under the name *S. decoloratum* in the collection of "Beth Gordon" (Dumont 1991) needs confirmation. They were caught in the north of Israel (Dumont in litt.) and were identified by Erich Schmidt.

Ecological notes on *Sympetrum sinaiticum*

The larva from Tozeur was caught in a complex of several temporary pools within a swamp with *Juncus*, *Salicornia* and *Salix* shrubs, some 100 m outside of the palm gardens. This area was flanked by a ditch with the surplus water from the oasis irrigation. Near the pools we took several teneral adults, but all exuviae collected here belonged to *Sympetrum fonscolombii* (Sélys 1840) which was also emerging. In October at the same place, we observed both sexes of *S. sinaiticum* in the low *Juncus* and *Salicornia* vegetation during the morning and evening. The pools were almost dry at that time. About 3 h after sunrise the males started to perch at the remaining water bodies. About 3:45 h after sunrise we observed the earliest tandem formation, and 15 min later the earliest oviposition. All ovipositions took place in the ditch with running water. About 3 h before sunset the males left the mating place and entered the vegetation of the dry hinterland again. Although the Tozeur oasis has a dense net of ditches, we found the species only at that single locality. Oviposition in running water was also noticed 1 km SW of Tamersa where the road to Chbika crosses a mountain stream.

No individuals of *S. sinaiticum* were present at the Tunisian breeding sites during September. The earliest date of oviposition was observed on 11 October. The reproductive season in Tozeur continued through November to January and at least to March. We observed oviposition still on 8 March. In January and March we collected egg clutches for rearing experiments.

In Spain *S. sinaiticum* uses running as well as stagnant water for reproduction (Jödicke 1995). Although there is little information on the larval habitat in northern Africa and northwestern Arabia, it can be expected that a broad spectrum of habitats is utilized. Schneider & Krupp (1993) observed oviposition in pools of a deeply carved wadi with an intermittent flow regime. The lack of further information seems to be related to the seasonal peculiarity of the species. This is characterized by an unusually long adult life span, probably associated with delayed reproductive maturation as in *S. meridionale* and *S. striolatum* (Charpentier, 1840) from the Algerian Maghreb (Samraoui et al. 1998).

Our observation of emergence already on 6 May is confirmed by A. von Schulthess who took tenerals on 10 May at Tozeur (Ris 1919). The emergence period seems to be very long, since Ris (1911a) mentioned a young male collected on 23 July. After emergence the insects settle for several months in steppic habitats with sparse vegetation (Dumont 1978), far away from any water body (Samraoui in litt.). Also the record from the Natural Park de Jebil in south Tunisia confirms this habitat selection: the insects occurred far from water, in sand dunes, until mid October. Return to the water for reproduction has not been reported to happen before October (this paper). The species is on the wing throughout the winter season, and there are several records until late March (le Roi 1915; Dumont in litt). Schneider & Krupp (1993) reported oviposition still occurring on 26 March. The lifespan of the Spanish population is shorter: emergence has not been seen before early June (Jödicke 1995), and oviposition lasts at least from September to early November (Jödicke 1997). This can be interpreted as an adaptation to the less hot and dry summer in Spain.

Acknowledgements

Richard Seidenbusch was the first to point out structural differences in the ligula of *Sympetrum sinaiticum* and *S. arenicolor*. He also helped by providing photographs of several imaginal characters. Herbert von Hagen provided all drawings. Wolfgang Schneider made a loan of his material from Syria and Jordan, and supplied information about specimens in the collection of the University of Tel Aviv. Henri Dumont and Boudjema Samraoui gave information about their field experience and collections. Jörg Arlt, Rolf Busse, Bernd Kunz, Wolfgang Lopau and Sabine and Joachim Werzinger were companions on the field trips to Tunisia. Jan van Tol gave the opportunity for a new investigation of the types of *arenicolor* and *deserti*. Günther Peters let us have one male of *S. arenicolor* from his collection. We are indebted to them all.

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