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Coenagrion scitulum in Central Asia: a biogeographical analysis and rectification (Odonata: Coenagrionidae)

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Abstract

This study provides information on the occurrence of *Coenagrion scitulum* in Central Asia, in English for the first time. Based on critical evaluation of published and previously unpublished data, a schedule of records and an up-to-date distribution map is presented. With reference to occurrence of *C. scitulum* in Europe, specific chorological and ecological characteristics of Central Asian *C. scitulum* are discussed and by means of the example of a Kyrgyz population a regional habitat of *C. scitulum* is described. *Coenagrion scitulum* is among those dragonfly species being widely distributed in Europe and whose eastern limit of distribution runs through Central Asia. Due to language barriers and insufficient communication, a considerable lack of knowledge of the proper distribution range of such species amongst European odonatologists seems to persist. This article addresses the knowledge gap and aims to rectify erroneous statements and establish the correct eastern limit of distribution of *C. scitulum* in European non-Russian-language odonatological literature.

Zusammenfassung

Coenagrion scitulum in Zentralasien: Eine biogeographische Analyse und Richtigstellung (Odonata: Coenagrionidae) – Die vorliegende Arbeit präsentiert die erste englischsprachige Übersicht über das Vorkommen von *C. scitulum* in Zentralasien. Dafür wurden alle verfügbaren publizierten und unpublizierten Information ausgewertet und die geographischen und faunistischen Basisdaten in Form einer Tabelle sowie einer aktuellen Verbreitungskarte dargestellt. Mit Bezug auf die aus Europa bekannten Fakten zur Ökologie von *C. scitulum* werden die Besonderheiten des zentralasiatischen Areals der Art sowie am Beispiel einer kirgisischen Population die regionalen ökologischen Spezifika diskutiert. *Coenagrion scitulum* gehört zu einer Reihe in Europa weit verbreiteter Arten, deren östliche Verbreitungsgrenzen in Zentralasien liegen und deren Vorkommen in diesem Raum u.a. aus Gründen sprachlicher Hürden in der europäischen odonatologischen Literatur bisher weitgehend übersehen wurde. Der Artikel wendet sich daher gezielt an nicht-russischsprachige Odonatologen und bemüht sich um die Richtigstellung und Korrektur des Areals von *C. scitulum* in der europäischen Literatur.

Introduction

Coenagrion scitulum (Rambur, 1842) has a primarily Mediterranean distribution and occurs most frequently in the west of the region (Dijkstra 2006; Boudot et al. 2009). It is considered local throughout (Dijkstra 2006) but in recent decades in Europe showed a considerable tendency to expand to the north (Vanderhaeghe 1998; Boudot & Jacquemin 2002; Proess 2006; Bouwman et al. 2008; Brook & Brook 2010; Hunger 2011; Lingenfelder 2011).

It is distributed in a patchy belt from Morocco and Spain in the west (Jacquemin & Boudot 1999) to Turkey, where *C. scitulum* is fairly common in the west (Kalkman 2006). Further towards the east, however, the species generally seems to become increasingly rare, and scattered records are known only from Armenia (Tailly et al. 2004), Georgia (Shengelia 1975), Azerbaijan and Nakhichevan (Kasymov 1972; Dumont 2004), and Iran, where a single record from «Astrabad» (today's Gorgan) on the foothills of the Alborz range, at the southeastern edge of the Caspian Sea, was reported by Bartenev (1916; cf. Schmidt 1954). East of the Caspian Sea and separated by a gap of ca. 2,000 km, *C. scitulum* has been recorded within the territories of today's Republics of Tajikistan, Kazakhstan and Kyrgyzstan. Thus, with the exception of Usbekistan and Turkmenistan, the species has been encountered in all Central Asian successor states of the former Soviet Union so far (Borisov & Haritonov 2007; Schröter 2010a, this paper).

This study aims to provide a review of the distribution of *C. scitulum* in Central Asia and establish the correct status of the species. Another objective is to outline basic information on the ecology from the eastern edge of the species' distribution. Based on the most recent regional record from Kyrgyzstan, a model habitat of *C. scitulum* is described in detail.

Studied regions

Tajik data referred to the southwestern provinces Nohijahoi tobei Dschumhurij (Ноҳияҳои тобеи ҷумҳурӣ) and Chatlon (Хатлон) in the region of the Kofarnihon (Кофарниҳон) and Vakhsh (Вахш) river valleys south of the Gissar range (Гиссарский хребет). The Kazakh record originated from the southeastern province Almaty (Алматы облысы) at the middle flow of the Ili (Іле) river. Detailed information on the dragonfly fauna of both countries including national checklists was given by Borisov & Haritonov (2007, 2008). For additional data of Tajik dragonflies we direct attention to Borisov (1985, 1989a), Borisov & Haritonov (1986), and Belyshev et al. (1989).

The habitat described in detail was situated in southern Kyrgyzstan near the town of Arslanbob (Арсланбоб; Жалалабат областы/Jalalabad province) in the walnut forest area at the southern foothills of the Baubash Ata (Баубаш-Ата) mountain range. This particular habitat was situated in the immediate vicinity of "locality 1" as presented in Schröter (2011: 205 ff.). Thus, for any further information on climate, geology and vegetation structure of the country and the study region we refer to the latter study and an annotated checklist of the Odonata of Kyrgyzstan (Schröter 2010a).

Material and methods

The majority of data have been collected during extensive fieldwork of SNB in the 1980s in Tajikistan and are identical to those mentioned in a general manner by Borisov & Haritonov (2007), but are presented here in more detail. The same applies to a more recent record from Kazakhstan. An additional record from Tajikistan referred to a male specimen recognised in the collection of the Institute of Zoology and Parasitology at the Academy of Sciences of the Republic Tajikistan, Dushanbe. Kyrgyz data have been obtained during an extended visit from May to September 2009 by AS (Schröter 2010a, 2011, 2012). Data from literature without further geographical specification that could not be tracked down to a defined locality has been ignored (Krylova 1972). Climate data from the period 1950-2000 at the Kyrgyz habitat (41°19'43N, 72°59'37E) and at Ifrane (Morocco) (33°32'40N, 05°05'44W) was taken from Hijmans et al. (2005) at a spatial resolution of 2.5 arcmin.

Results

List of sampled localities

Table 1 provides faunistical basis data on all nine records of *C. scitulum* from Central Asia. The numbering of the scheduled records refers to the localities shown in the detailed map of Central Asia (Fig. 1).

Thirty-five males and 24 females from Tajikistan and Kazakhstan are deposited in coll. Institute of Systematics and Ecology of Animals, Russian Academy of Sciences, Siberian Branch, Novosibirsk, and three males from Kyrgyzstan are deposited in coll. AS.

Portrait of locality 9: a habitat of *Coenagrion scitulum* in Kyrgyzstan

In the following the habitat of an autochthonous population of *C. scitulum* from Kyrgyzstan is described in detail (Tab. 1). The species was encountered at a shallow perennial pool of ca. 12 m of diameter situated in an open park-like area within the transition zone between the lower walnut forest belt and thermophilic scrub vegetation at about 1,500 m a.s.l. (as to the terminus walnut forest see Schröter 2011a: 205). The area was southerly oriented and the northern edge surrounded by mature walnut forest and thus wind-sheltered. The pool had clear water, up to ca. 50 cm deep and fed by a limnocrene spring, resulting in a small outflow seeping away after a few meters at the southeastern edge. Except for a central section with Characeae on open loess soil, the pool was densely overgrown with aquatic vegetation, notably *Potamogeton lucens*, *Hippuris vulgaris, Utricularia vulgaris*, *Polygonum amphibium* and *Ranunculus aquatilis* agg. Riverine vegetation consisted mainly of *Eleocharis palustris* agg., *Juncus inflexus* and smaller stands of *Phragmites australis* and *Schoenoplectus lacustris.* The area was used for haymaking and mowing, and was fenced to keep away cattle. The meadow was patchily interspersed with single fruit tree species like *Malus sieversii*, *Prunus sogdiana* and *Crataegus turkestanica* and bushes like *Lonicera altmannii*, *Cotoneaster melanocarpus* and *Rosa corymbifera*. The grassy and herbaceous vegetation was characterised by *Dactylis glomerata, Festuca arundinacea, Bromus inermis, Poa pratensis, Aegilops triuncialis, Trifolium pratense, Elaeosticta ferganensis, Echium vulgare,*

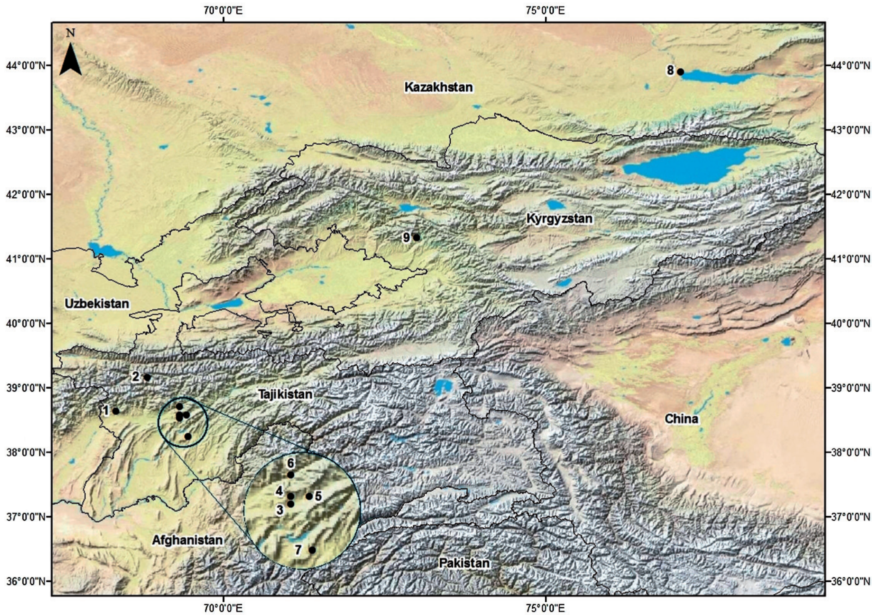

Figure 1. Detailed map of Central Asia, with the situation of known records of *Coenagrion scitulum* in Tajikistan, Kyrgyzstan and Kazakhstan. The numbering corresponds to the localities in Table 1. – Abbildung 1: Ausschnittskarte von Zentralasien mit Lage der bisher bekannten Nachweise von *Coenagrion scitulum* in Tadschikistan, Kirgisistan und Kasachstan. Die Nummerierung der Fundorte entspricht Tabelle 1.

Table 1. Hitherto known records of *Coenagrion scitulum* in Central Asia. The numbering corresponds to the localities as depicted in Figure 1. – Tabelle 1: Bisher bekannte Funde von *Coenagrion scitulum* aus Zentralasien. Die Nummerierung der Fundorte entspricht den Nachweispunkten in Abbildung 1. **Repr.** reproduction confirmed, Reproduktionsnachweis; **Abun.** maximum abundance, maximale Abundanz.

Site	Date	Coordinates; altitude [m a.s.l.]	Repr.	Abun.	Source
Tajikistan/Tadschikistan					
1	05-vi-1983	38°39'N, 68°20'E; 1,120	X	common	SNB
2	04-vii-1958	39°10'N, 68°49'E; 2,300	–	1♂ [1]	IZiP AS TJ [2]
3	23-vi-1988 04-vii-1988 18-v-1989 01-vi-1989	38°32'N, 69°19'E; 1,100	X	mass emergence	SNB
4	28-vi-1988	38°35'N, 69°19'E; 1,450	X	59♂ 19♀	SNB
5	25-v-1988	38°35'N, 69°26'E; 1,150	X	mass emergence	SNB
6	19-vii-1979 27-vi-1981	38°43'N, 69°19'E; 1,190	X	18♂ 6♀	SNB
7	18-vi-1983	38°15'N, 69°27'E; 1,270	–	1♂	SNB
Kazakhstan/Kasachstan					
8	25-vi-2006	43°54'45N, 77°05'34E; 485	–	1♂ 1♀	SNB
Kyrgyzstan/Kirgisistan					
9	11-29-vi-2009	41°19'43N, 72°59'37E; 1,500	X	15♂ 3♀	AS

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Achillea millefolium, Conioselinum tataricum, *Rumex paulsenianus*, *Geranium collinum*, *Carex polyphylla*, *Rubus caesius* and *Ranunculus polyanthemos.* Moreover, several ornamental plants, typical of such utilisation of half-open walnut forest, like *Eremurus robustus* and *Dictamnus angustifolius,* were present. Abundance of *C. scitulum* was low. First observations date from 11-vi-2009, when three freshly emerged males and one female were found. The last observation was on 29-vi--2009. Individuals have been observed only in the immediate vicinity of the pool, mainly perching on vertical helophytes at the water's edge. Two tandems were observed ovipositing on a dense lawn of *Utricularia, Hippuris* and *Potamogeton*.

Odonate community at locality 9

Twenty-two species of Odonata were observed syntopically at locality 9, of which 15 showed evidence of reproduction (Tab. 2).

Table 2. Species of Odonata recorded syntopically with *Coenagrion scitulum* in 2009 at locality 9 in Kyrgyzstan. – Tabelle 2: Übersicht der 2009 an Fundort 9 in Kirgisistan syntop mit *Coenagrion scitulum* beobachteten Arten.

Species	Reproduction	Abundance
Lestes barbarus		3 ♂
Lestes virens [1]	X	moderate
Sympecma fusca	X	moderate
Sympecma gobica	X	low
Sympecma paedisca	X	low
Ischnura forcipata		2 ♂
Ischnura pumilio		1 ♂, 1 ♀
Aeshna affinis		high [3]
Aeshna isoceles [2]	X	low
Aeshna mixta	X	low
Anax imperator	X	low
Anax parthenope	X	low
Ophiogomphus reductus		1 ♀
Cordulegaster coronata		2 ♂
Crocothemis servilia	X	high
Libellula depressa		1 ♂
Libellula quadrimaculata	X	low
Orthetrum albistylum	X	medium
Sympetrum arenicolor	X	low
Sympetrum flaveolum	X	low
Sympetrum meridionale	X	medium
Sympetrum sanguineum	X	medium

[1] The status of Central Asian populations within the taxa complex of *L. virens* is still unclear, as well as the nature of several further populations and taxa allied to this species (Jödicke 1997; Samraoui et al. 2003)

[2] Kyrgyz *A. isoceles* phenotypically corresponded to the ssp. *antehumeralis* Schmidt, 1950

[3] After mass emergence of the species in the near vicinity (cf. Schröter 2011)

Discussion

History of the discovery of *Coenagrion scitulum* in Central Asia and recognition in Europe

The occurrence of *Coenagrion scitulum* in Central Asia was reported for the first time by Krylova (1972) and repeatedly since (Borisov & Haritonov 1986, 2001, 2007; Borisov 1989b, 2002, 2006a, 2009; Haritonov & Borisov 1989; Belyshev et al. 1989; Haritonov et al. 2007). Neither these publications nor the comprehensive review of the Odonata of the five Central Asian successor states of the former Soviet republics by Borisov & Haritonov (2007, 2008) provided further details of the exact locations; however the latter publication provided a rough distribution map with dots. In addition, none of the papers in Russian mentioned above has been given attention by European odonatologists. For this reason, the occurrence of *C. scitulum* in the region seemed to be unclear to a large extent and data on a rather general level provided an ambivalent idea of its distribution. Hence, a considerable uncertainty on the proper eastern distribution of *C. scitulum* seemed to prevail widely amongst European authors. This situation was reflected by numerous vague or erroneous statements in recent European publications, applying to both journal articles and standard guides (e.g., Steinmann 1997; Sternberg 1999; Heitz 2002; Askew 2004; Monnerat & Schmidt 2005; Dijkstra 2006; Glitz 2006; Grebe et al. 2006; Grand & Boudot 2006; Raab et al. 2006).

Status and distribution of *Coenagrion scitulum* in Central Asia

Hitherto, from the entire area of Central Asia only nine sites of *C. scitulum* are known (Tab. 1) and the status of the species in the region remains puzzling and not easily interpreted. Nevertheless, in the following an attempt will be made to relate and discuss available data on the occurrence of *C. scitulum* in Central Asia, with consideration of the knowledge about the species' distribution and ecology in Europe.

Historic-causal considerations

The only record from Iran (Bartenev 1916), which appeared to be highly isolated, has also been cited frequently in non-Russian European literature. Moreover, it has widely been considered erroneously to represent the most eastern record of *C. scitulum* and used to define the species' eastern range limit. However, between this single Iranian record at the eastern edge of the Caspian Sea and records from Central Asia (Fig. 1) lies the vast desert belt of Karakum and Kyzylkum, representing one of the largest expanses of sand in the world. Thus, with regard to the main distribution area around the Mediterranean, Central Asian populations of *C. scitulum* give the impression of a highly isolated eastern outpost (Borisov & Haritonov 2007: 349). Supposing that Central Asian *C. scitulum* in fact represent a disjunct, isolated regional eastern population, separated from the western area of coherent distribution by a broad desert belt, questions about the zoogeographical history of this isolated population arise. In the case of the Sahara desert, isolated relict populations of afrotropical dragonfly species situated north of their present continuous ranges are usually considered as remnants of the early Holocene pluvial period 8,000-10,000 years BP (Dumont 1975, 1977, 1982; Samraoui et al. 1993; Dijkstra & Boudot 2010).

In contrast, the deserts of the Turan Depression seem to have a considerably different palaeoclimatic history as compared to the Sahara. According to Berg (1959: 108), the occurrence of typical regional desert plants of the genera *Haloxylon*, *Calligonum* and *Eremosparton* could have been traced back in Karakum by palynological analysis to at least the lower Pliocene. Therefore the deserts of the Turan Depression probably existed almost continuously during the whole Quaternary Period, and a former continuous occurrence of *C. scitulum* from the eastern edge of the species' European area of distribution to Central Asia, including the current gap of over 2,000 km, appears to be highly questionable.

A similar scenario has been discussed for the closely related species pair *Ischnura forcipata* and *I. intermedia* by Dumont & Borisov (1995). Both species are separated by a stretch of deserts ranging from the Karakum in the north and the Kavier and Lut across Iran towards the south. However, in the case of the two *Ischnura* species the fluctuating barrier of the deserts during the Pleistocene divided the ancestral form of both and subsequently led to differentiation of the two taxa, whereas Central Asian *C. scitulum* do not deviate from European individuals in measurement and coloration. Thus, considering the low level of odonatological exploration of adjacent Afghanistan, a patchy belt of interconnected populations in a sweeping arc from the mountains of eastern Iran to the south across the Hindu Kush to Tajikistan appears possible. Only additional faunistical research and an analysis of the palaeoclimatic history in detail could clarify if such a connection between Central Asian and European populations still exists or has ever existed. For the time being, the question about history and nature of Central Asian *C. scitulum* remains entirely open.

Methodological considerations

One major issue in interpreting Central Asian data of *C. scitulum* is the low number of researchers there, and the remoteness of the entire area. Vast parts of Central Asia still remain completely roadless and therefore difficult to access, which makes an even odonatological survey almost impossible, because certain areas can't be accessed. In consequence, data obtained might be highly biased. For example, Tajik records appear to be centred conspicuously on Dushanbe, a former focus area of research of SNB (Fig. 1). Thus, the clustering of records there was probably due to the extensive fieldwork of SNB in the region rather than an actual distribution centre of *C. scitulum*. A similar interpretation of records has been outlined recently by Deubelius & Jödicke (2010: 8) for *Leucorrhinia caudalis* in western Siberia.

In the reverse case, however, at least on a regional-scale evidence suggests that *C. scitulum* is actually scarce. The population at locality 9 (Tab. 1) was situated in an area thoroughly explored during 2008 and 2009 (Schröter 2010a, 2011). Over a radius of ca. 10 km, several other spring-fed pools of the same type have been scrutinised without success, indicating the species' actual scarceness in the entire region. All facts considered, *C. scitulum* might well be much more widespread in Central Asia, but is evidently uncommon region-wide.

In this context it has to be taken into account that large parts of Central Asia remain at a very low level of faunistic exploration. Especially, Uzbekistan and Turkmenistan, within which territories the deserts Karakum and Kyzylkum are situated, justifiably could be considered an odonatological *terra incognita* and in this regard both even surpassing Kyrgyzstan (Schröter 2010a, 2011, 2012). It therefore could be assumed that current poor data is probably due to the very low level of faunistic exploration rather than reflecting the true status of *C. scitulum*. Mountain ranges towards the western and eastern border of the region covered by the map in Figure 1 especially, like the western spurs of the Hissar range at Usbek territory, Kopet Dag or Uly Balkan in Turkmenistan or Dzungar Alatau and Tarbagatai in Kazakhstan might well host more populations of *C. scitulum.*

On the other hand, the overall picture of the occurrence in very low density with populations spread patchily all over the area seems to be in accordance with the occurrence east of Turkey and the Caucasus. Although the Caucasus region also remains on a very poor level of odonatological exploration (Schröter 2010b), from Turkey, which is comparatively well explored (Kalkman 2006), only two records from the eastern half of the country are known so far (Kalkman 2006). Thus, the obvious decreasing density of occurrence east of the Mediterranean and very few records hitherto known from Caucasia might well reflect a characteristic of the species by showing a continuous thinning-out of population density towards the east.

Adaption to desert environments

Even though, according to our current data from Central Asia, populations conspicuously seem to be confined to the foothills zone (Tab. 1), a scattered distribution in lowlands along the remaining floodplains ("Tugai") of the endorheic main rivers irrigating the Turan Depression, like Amu-Darya, Morghab, Zeravshan, Syr Darya, Chu and Ili, appears at least to be possible. Irrigation for agricultural purposes has a long history in the region, and according to Herodotus (book three; Haussig 1971), sophisticated irrigation networks along the Central Asian Akes river (Morghab), whose water was used to grow millet and sesame, existed at least since the beginning of the 7th century BC. According to Masson et al. (1982), earliest artificial oases in Central Asia can even be dated back to the early Chalcolithic Age, i.e., the beginning of the 5th millennium BP. Large irrigation systems similar to the recent ones, however, appeared only at the beginning of the Common Era (Shishkina et al. 1985). Irrigation massively increased in Soviet times (Berg 1959: 142) and, in consequence, several regional dragonfly species previously restricted to the mountains, like *Sympetrum arenicolor* and *Ophiogomphus reductus*, took advantage of the presence of numerous artificial waterbodies like reservoirs and channels to spread deeply into the desert (Borisov 2005, 2006b, 2008, 2009). The record of a male and a female of *C. scitulum* from the western edge of the large Kapchagai reservoir at 485 m a.s.l. (Tab. 1: loc. 8) at the middle flow of the Ili river might be understood as an indication of such assumptions.

Moreover, records from south of 31° latitude in Jordan and Morocco (Schneider 1986; Jacquemin & Boudot 1999) point to a certain ability of the species to adapt to (semi-) desert environments. However, as virtually no data from these vast areas along the lower courses of the regional major rivers are available, the question if and to what extent *C. scitulum* might penetrate into the desert has to be left open.

Life cycle

Central Asia in general and the considered mountainous region in particular is subject to a very continental climate. Not surprisingly, over large areas the number of lentic species exhibiting a life cycle with egg diapause, like lestids and *Sympetrum* spp., clearly prevail (Borisov & Haritonov 2007, 2008; Schröter 2010a).

In consequence, members of the genus *Coenagrion*, which to current knowledge obligatorily hibernate in the larval stage and do not undergo delayed embryonic development (Corbet 1999: 3.1.3), are comparatively scarce. They are mainly confined to perennial habitats and specific favourable hydrological conditions, even though locally occurring in very high abundances. Regional *Coenagrion* species appear to be restricted to either bigger and deeper water bodies and/or spring-fed habitats, providing protection against freezing and drought.

On the example of Kyrgyzstan, which is dominated by mountains, all four representatives of the genus *Coenagrion* found during a two-year survey appeared to be conspiciously rare (Schröter 2010a). The only other *Coenagrion* species that was found in the study region in the immediate vicinity of the habitat of *C. scitulum* (loc. 9) was *C. pulchellum*. The same applied to the genus *Ischnura*. The only other member of the family occurring in significant numbers, *Enallagma risi,* however, was confined to larger perennial spring-fed fens and mountain lakes at higher altitudes, providing sufficiently deep areas for larvae to avoid freezing. The same goes for the only known Kyrgyz population of *C. armatum* (habitat picture in Schröter 2010a). According to Grand & Boudot (2006: 258), larvae of French *C. scitulum* hatched six to seven weeks after oviposition. Provided that Central Asian *C. scitulum* also show this genus-typical life cycle, the scarceness and patchy distribution of *C. scitulum* might well be explained by the dependence on thinly spread favourable perennial habitats, which could enable larvae to survive the fierce continental winter, either by minimum depth and/or the supply of spring water. Sternberg (1999) considered larvae of *C. scitulum* to have high warmth requirement, which might support these considerations. Again, only further specific research will probably confirm such tentative reflections.

According to the data compiled in Table 1, there is evidence of a trend allowing at least cautious interpretation to locate the main flight period of *C. scitulum* in the region to June, which matches with phenological data from Turkey (Kalkman & van Pelt 2006), France (Grand & Boudot 2006: 259) and southwestern Germany (Lingenfelder 2011). Unfortunately no observation data covering the entire flight period of a single population is available yet and therefore the actual length of the flight period in the region is still uncertain. Notably, at locality 3 on 01-vi-1989 oviposition and mass emergence has been observed simultaneously. This phenomenon of synchronous presence of all stages of age of *C. scitulum* has also been reported by Schneider (1986) from the Levant.

Altitude and climate

According to our current data from Central Asia, autochthonous populations of *C. scitulum* are confined to altitudes beyond 1,000 m a.s.l. This appears to be significantly different to the situation in Europe, where *C. scitulum* is considered as a typical lowland species with Mediterranean river floodplains as primary habitat (Sternberg 1999), whereas its occurrence at higher altitudes is rather unusual and confined to the southern part of its range. According to Grand & Boudot (2006: 258), *C. scitulum* in southern France exceptionally reaches altitudes up to 1,300 m a.s.l., which also applies to the Rif Mountains in Morocco (Jacquemin 1994). Further south in the Middle Atlas, *C. scitulum* has been found reproducing even up to 2,000 m a.s.l. (Jacquemin & Boudot 1999). However, a direct comparison of basic climate data between locality 9 from Kyrgyzstan and this Mediterranean habitat at corresponding altitude reveals remarkable differences in climatic parameters (Tab. 3). Climate data from Ifrane, situated in the Middle Atlas, Morocco, refer to one of several strong populations of *C. scitulum* at one of the reservoirs around the city (Jacquemin & Boudot 1999; J. Arlt pers. comm.). The Moroccan site shows a clearly higher precipitation rate and a higher mean annual temperature. The most striking difference, however, refers to significantly wider temperature variation at locality 9, which in this case in particular means a considerably colder winter typical of a continental climate. Thus, in contrast to Mediterranean populations at all alitudes, Central Asian *C. scitulum* appear to be exposed to a much more severe climate with very cold winters. Such results, however, call the overall picture of an *a priori* 'thermophilous' species (e.g., Stark 1976) seriously into question. Probably due to the lack of deeper understanding of habitat selection and preferences in general, as well as the puzzling nature of the northern limit of distribution which escaped a simple explanation, *C. scitulum* has been frequently associated with such doubtful attributes.

In the past, due to insufficient knowledge of the occurrence in continental climate of Asia on the one hand and a fragmentary point of view focused on Europe alone on the other hand, several other species with a similar distribution pattern as *C. scitulum* have been regarded similarly. Even though already pointed out correctly by Peters (1987: 31), *Aeshna affinis* for instance has hastily been regarded as 'thermophilous', erroneously implying cold winter temperatures as a crucial restricting factor. Only recently, this general opinion has changed and the actual role of wet Atlantic summers receives more attention (Drees et al. 1996;

Table 3. Comparison of altitude and climatic key data of the presented Central Asian habitat of *Coenagrion scitulum* with a Mediterranean habitat: Arslanbob (Kyrgyzstan) and Ifrane (Middle Atlas, Morocco). – Tabelle 3: Vergleich von Höhe und klimatischer Basisdaten des präsentierten zentralasiatischen Fundortes bei Arslanbob (Kirgisistan) mit jenen eines mediterranen Vorkommens bei Ifrane (Mittlerer Atlas, Marokko). **Alt** altitude a.s.l., Höhe ü.NN; **P** annual mean precipitation, mittlerer Jahresniederschlag; **T** annual mean temperature, mittlere Jahrestemperatur; $\mathbf{T_{min}}$ mean temperature minimum of the coldest month, mittleres Temperaturminimum des kältesten Monats; $\mathbf{T_{max}}$ mean temperature maximum of the warmest month, mittleres Temperaturmaximum des wärmsten Monats.

Site/ Coordinates	Alt [m]	P [mm]	T [°C]	T_{min} [°C]	T_{max} [°C]
Arslanbob 41°19’41N, 72°59’38E	1,520	547	8.4	-11.6	29.0
Ifrane 33°32’40N, 05°05’44W	1,595	812	11.7	-3.5	31.0

Brauner 2005; Bönsel & Frank 2011; Schröter 2011). Even though, due to a different life cycle, *C. scitulum* might not be that robust and resistant to cold as *A. affinis*, and the examined habitat provides ice-free spring water, climate data from locality 9 clearly suggest that for *C. scitulum* also in Middle Europe mean summer temperatures might rather be the crucial factor than cold temperatures in winter. This line of argument has been followed by Lingenfelder (2011), who emphasised that two subsequent hard winters from 2008 to 2010 obviously had no negative effect on a recent northward expansion of *C. scitulum* in Germany and several new individual-rich populations have been discovered afterwards. In consequence, he also assumes that increasing mean summer temperatures might rather be of relevance for the species.

This issue impressively demonstrates the importance of the knowledge of the chorology for a proper understanding of the ecology of a species. Considerations that do not cover the entire area of distribution of a species almost inevitably will lead on the wrong track.

Locality 9 and threats

As far as morphology and surroundings are concerned, locality 9 strikingly resembled German habitats depicted in Lingenfelder (2011) and Grebe et al. (2006). In this respect it is notable that actually all Central Asian sites (Tab. 1) can be characterised as small to medium-sized shallow lakes or pools in rather open landscape with rich aquatic vegetation like *Myriophyllum*, *Potamogeton* or *Utricularia*.

This seems to be in line with habitat preferences reported from all over Europe and North Africa (e.g., Schneider 1986; Schorr 1990; Kotarac 1997; Jödicke et al. 2000; Grand & Boudot 2006: 258; Dijkstra 2006: 112; Boudot et al. 2009; Höttinger 2010) and hence justifiably could be considered an ecological common denominator throughout. Remarkably, at least six of the other eight sites in Table 1 referred to water bodies fed from ground or spring water. This fact supports the considerations above on the species' regional stenotopy and close connection to specific favourable hydrological conditions.

For the surprising fact that locality 9 was the only Kyrgyz site for *C. scitulum* found during a two-years' study, further reasons are conceivable. In post-Soviet times the local population increasingly became subject to economic pressure. Due to a shortage of financial and transportation resources and limited pasture mobility, livestock numbers increasingly concentrated in the direct vicinity of permanent settlements. This led to uncontrolled exploitation of the walnut forest, which nowadays entirely serves as grazing ground for numerous cattle (Schröter 2011: 205). All other sampled pools, which had been considered to be generally appropriate for *C. scitulum*, had either not been situated in fenced areas and/or had clearly been affected by cattle. Thus, these pools showed degraded aquatic and riparian vegetation and therefore probably no longer met the species' ecological demands. However, this issue can be generalized to large parts of Central Asia. Even more than Kyrgyzstan, in post-Soviet times Tajikistan became exposed to economic constraints due to socio-economic ruptures and a civil war. Today, land degradation due to unorganised pasture management and uncontrolled livestock breeding occurs almost everywhere in the region (Samimi et al. 2011; Vanselow 2011). Except for one locality, all other eight habitats of *C. scitulum* presented in Table 1 were protected against cattle damage, emphasising the extremely strong negative impact of cattle on larval habitats of *C. scitulum*.

Measurements and colouration

Individuals of *C. scitulum* from Central Asia showed a considerable variation in colour pattern, but in this respect could readily be applied to the range of variation shown by the species in European populations, for instance from France, Italy and Greece (Gardner 1952; Sternberg 1999: 297; AS). The total length of all 62 available specimens from Tajikistan, Kazakhstan and Kyrgyzstan corresponds largely with measurements stated for Europe by Dijkstra (2006) and Grand & Boudot (2009): males varied between 28-35 mm (n = 38), mainly 31-32 mm; females between 27-32 mm (n = 24), mainly 30-31 mm.

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