SYMPETRUM DEPRESSIUSCULUM (SELYS), A SOUTHERN CONTINENTAL DRAGONFLY DEPENDING ON ARTIFICIAL HABITATS IN ATLANTIC NORTHWESTERN GERMANY (STATE OF NORTHRHINE-WESTPHALIA) (ANISOPTERA: LIBELLULIDAE)

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Dedicated to my dear colleague and friend since 4 decades, Boštjan K i a u t a, on his 70th birthday in honour of his unsurpassed commitment to dragonflies and the world odonatological community.

Abstract – In the atlantic northwest of central Europe, *S. depressiusculum* is confined to shallow artificial ponds with a particular aquatic vegetation, clear water, rich food supply (zooplancton, zoobenthos) for the larvae, and – due to drying up during winter – with reduced

negative impact by fish. Essentially, water temperature has to rise above the average level typical for this region. Carp breeding ponds offer these conditions, favouring *S. depressiusculum* outside of its original area. The artficial carp breeding ponds provide invaluable chances for species conservation in this geographical region, furthering the state's official nature conservation management. Some lead water ponds near the Dutch-Belgian border (in the vicinity of Lommel) seem to provide similar habitat conditions. It is assumed, though still an open question, that *S. depressiusculum* is relying on the same ecological conditions in fish ponds in more continental areas of central Europe (e.g. the Lausitz district near the Oder; the Fränkisches Weihergebiet in the hilly zone of northern Bavaria). This paper should promote the verification of this assumption.

Introduction

The geographical range of dragonflies is mainly limited by climatic factors (ASAHINA, 1961; BELYSHEV, 1973; CORBET, 1999; d'AGUILAR & DOMMANGET, 1998; ILLIES, 1978; SCHMIDT, 2004). In the plains of north central Europe the northward temperature gradient from warm mediterranean to cooler atlantic climate mingles with a westward gradient from cool continental to maritime climate. In mountainous regions of south central Europe and even more so in the Alps, these two gradients are obliterated by a third one, namely along the altitude.

In the northern plains the geographical range of more or less continental species (*Coenagrion armatum*, *Aeshna viridis*, *A. subarctica*, *Sympetrum vulgatum*, *Leucorrhinia rubicunda*) has its western border, while their range covers Siberia (but not Japan) in the East. The northern plains are also crossed by the western border of the range of more or less southern continental species (*Sympecma paedisca*, *Sympetrum depressiusculum*, *S. pedemontanum*), the range of which includes Japan in the East. The west-mediterranean species *Gomphus pulchellus* and *Oxygastra curtisii* have their eastern borders in the northern plains, and the southern species, like *Chalcolestes viridis*, *Erythromma viridulum*, *Aeshna affinis*, *Anax parthenope*, and *Crocothemis erythraea* find their northern limits here. Continental species do not suffer directly from winter cold, but they demand strong, longlasting sunshine. High air temperature under a persistently and densely clouded sky has little effect on water temperature, while direct insolation warms up a water body and its organisms even on cold days, especially in shallow ponds and among floating vegetation. Larvae of continental species need rather high temperature for quick development, and only full sunshine allows full flight activity of the imagines. However, atlantic climate means a more often clouded sky and less insolation, but, on the other hand, mild nights and winters. Consequently, at the western border of their range the continental species show an altered or more specified microhabitat preference (CORBET, 1999; TISCHLER, 1993). Here *Aeshna subarctica* is confined to floating mats of *Sphagnum*, and *A. viridis* is restricted to *Stratiotes* mats. *Sphagnum* bogs, inhabited by *A. subarctica*, are well known islands of continental microclimate in an atlantically affected zone, where *Coenagrion armatum* and *Leucorrhinia rubicunda* also prefer boggy microhabitats with low and sparse vegetation (e.g. small *Carex* species like *C. rostrata*, often combined with *Sphagnum* as far as *L. rubicunda* is concerned). In the West, *Sympetrum pedemontanum* prefers open banks of shallow water bodies, especially those in an initial stage of vegetation development. In northwestern Germany the southern and western species are momentarily favoured, while continental species become rare or even extinct (SCHMIDT, 2004; WOLFF-STRAUB & WASNER, 1999).

The present paper discusses the importance of artificial ponds, which are warmed up by a particular management, for *S. depressiusculum* in northwestern Germany. An analysis of factors constituting the ecological niche of this species in the spacious fish pond regions in more continental parts of Germany, e.g. the Lausitz district and Franken/Northern Bavaria, is urgently requested.

Material and methods

The own field work was performed according to the principles of a "representative spectrum of Odonata species" (longtime recording of the

imagines by binoculars, photodocumentation, some collecting of exuviae; SCHMIDT, 1985, 1989). *S. depressiusculum* was observed at the Dnjepr River in Kiew City (30-IX/2-X-1988), and occasionally at several places in the alpine region, including one of the very few records (18-IX-1976) at the southern Upper Rhine near Kaiserstuhl volcano (STERNBERG & BUCHWALD, 2000, p. 535). Intensive longtime observations were made at the Dülmen fish pond farm (SCHMIDT, 1993, 2006): 45 days with records of the species during 1991-1999; 57 days 2000-2006 (records already in June: 30-VI-1993, 25-VI-2001, 30-VI-2004; and still in the second half of October: 28-X-1995,17-X-1999,21-X-2004, 16/26-X-2006).

Natural breeding habitats of *S. depressiusculum* in central Europe

In central Europe the main natural breeding areas are the lower parts of the Alps and the valleys of rivers having their spring in the Alps (HUNGER et al., 2006; KUHN & BURBACH, 1998; STERNBERG & BUCHWALD, 2000). Here the nival water regime seems to be a key factor of the ecological niche of the species. Typical features of the water regime are: low level during winter; the banks of lakes, ponds and rivers usually drying up already in late summer/autumn; the banks are flooded again in spring (melting water from the Alps) with maximum level in early summer (at Lake Bodnan in July). In this region the climate is much more continental than in northwestern Germany, providing more sunny days, but occasionally heavy downpour in summer.

In the East, the species is common at the rivers of the steppe belt (BELYSHEV, 1973 combined with WALTER, 1970). In Japan *S. depressiusculum* is only a guest, while its subspecies, *frequens* is common and frequent at paddy fields (HAMADA & INOUE, 1985). These eastern regions also have a nival water regime with prolonged very cold winter, open water bodies being covered with thick ice. There the eggs of *S. depressiusculum* overwinter on dry, snowcovered ground. An accelerated larval development takes place in shallow water bodies which are quickly warmed already in spring and dry out in summer. These water bodies are bordered by reeds of the Magnocaricion-type, where the dragonflies feed, rest, roost and in the morning form tandems.

Figs 1-2. Carp breeding ponds through the seasons: (1) Carp spawning ponds remain dry through most of the year; dragonflies are not able to breed here, *S. depressiusculum* use the grassy area for hunting and resting (18 Dec. 2005); – (2) Warming up of the pond water: the upper pond has been flooded, its shallow water is warmed up by unrestricted insolation; the lower pond will be flooded later with the water from the upper pond (8 May 1993; all photos from Dülmen fish farm).

Due to their high water level from autumn to early spring, water bodies in the plains of northwestern Germany obviously do not comply with the ecological requirements of the species, and therefore this region is not regarded as part of the natural range of *S. depressiusculum* (DIJKSTRA et al., 2002; SCHMIDT, 2006). Nevertheless, several records were reported from that region during the last century, prevailing from artificial habitats (GRIES & OONK, 1975; KIKILLUS & WEITZEL, 1981).

Permanent breeding habitat near Dülmen city in Northrhine-Westfalia

In the atlantically affected plains of Northrhine-Westfalia only one persistent colony of *S. depressiusculum* remained, namely at the fish pond farm in Dülmen, Westphalia. This colony is well known since at least forty years. The fish pond farm holds several ponds with varying type of management, depending on fish species, age and season (GRIES & OONK, 1975; SCHMIDT, 1993, 2006; carp: STEFFENS, 1962). It could be shown that larval development is confined to carp breeding ponds. Carp is a subtropical fish needing at least about 20°C for egg production, spawning and for development of the spawn. Spawning occurs during a sunny period of a week or 10 days in May/beginning of June, and takes place in special "spawning ponds", which are in fact flooded meadows surrounded by shallow ditches (Fig. 1). The water level in these meadows is kept so low that the carp's back project above the surface. This shallow water bodies are easily warmed by insolation, and their grassy bottom provides shelter for the spawn and the fish larvae. Having consumed their yolk supply the young carp are transferred to the "breeding ponds". These ponds are kept dry from autumn until May when they are flooded with water that has already been warmed for some weeks in other shallow ponds (Fig. 2). During the dry period winter cereals (rye, barley) had been sown on half of the bottom area of each breeding pond (Fig. 3). When flooded, the rotting green matter of the cereal plants provides the nutritional basis for developing ciliates and daphnids as prey for the young carp. The marginal fertilization produced by the young fish is immediately absorbed by submerse vegetation, thus preventing mass development of planctontic algae which would suppress the macrophytic vegetation. Filamentous algae are reduced by the fish which, being too small, do not act as competitors or predators of dragonfly larvae. The larvae of such species which are not impeded by the long dry phase during win-

Figs 3-4. Carp breeding ponds through the seasons: (3) Flooding of the pond with its field of young cereals (26 May 1992); – (4) The pond in summer, containing sparse vegetation (12 September 2006); here *S. depressiusculum* oviposits.

ter benefit from the typical conditions at these breeding ponds, viz. raised water temperature, adequately structured vegetation, rich food supply, procured by the specific management of the breeding ponds (Fig. 4). Other common species at these ponds in Dülmen are *Sympecma fusca*, *Chalcolestes viridis*, *Lestes sponsa*, *Aeshna mixta*, *Sympetrum striolatum*, *S. vulgatum*, *S. sanguineum*, often also *Sympetrum (Tarnetrum) fonscolombii*, while *Orthetrum cancellatum* is emerging only exceptionally. There are a few records of the mediterranean species *Crocothemis erythraea*, *Sympetrum meridionale* and *Anax parthenope*. The adult *S. depressiusculum* depend on Magnocaricion reeds from mid summer to early autumn. At the Dülmen fish pond farm an elaborate management of the vegetation on the dams of the ponds ideally meets this requirement.

Verification of the key factors by wrong management

The fish pond farm is part of a spacious nature reserve. Until about 1990 the ponds were managed professionally by the owner to whom the state payed compensation for fish predation by cormorant (*Phalacrocorax carbo*), heron (*Ardea cinerea*), grebe (*Podiceps cristatus*, *Tachybaptus ruficollis*) and kingfisher (*Alcedo atthis*). When this was regarded too expensive, the ponds were leased by the governmental nature conservancy office. They were declared bird sanctuaries and their specific management as carp breeding ponds was terminated. Throughout the year a constant water level was kept, although the adverse effect upon *S. depressiusculum* could have been foreseen. Mud accumulated in the ponds and *S. depressiusculum* as well as rare plant species (e.g. *Elatine*) vanished soon. Other dragonfly species, including the spring species *Anax imperator*, *Enallagma cyathigerum* and *Erythromma viridulum*, could now breed there.

Some *S. depressiusculum* individuals survived at another pond where the owner had newly started carp breeding. In 2002 traditional management was restarted at those breeding ponds that had been transformed to bird sanctuaries. Some of these were again used for carp breeding while others were kept at distinctly low water level but without fish, meant as a reserve for rare plant species (*Elatine*, *Potamogeton gramineus*, *Eleocharis acaulis*). *S. depressiusculum* populations immediately reestablished at both types of ponds, the more flourishing populations, however, at those with carp breeding. In sunny springs the species was among the first to emerge. Cloudy springs caused an extensive delay of emergence and also a significant loss in abundance. The demand of *S. depressiusculum* for raised water temperature in early spring again became evident when the very cloudy springs of the years 2004-2006 heavily affected the species which still appears endangered at the Dülmen fish farm.

Comparison with other regions

In the Upper Rhine valley the species at present is rare (HUNGER et al., 2006). This seems to be due to habitat destruction by the excavation of a canal along the French bank of the Rhine. An exceptionally flourishing colony existed in the Camargue, the delta of the alpine river Rhone, where paddy fields were colonized (MILLER et al., 1984). However, information on the colony's recent status is lacking. At the fish breeding farm, Ahlhorner Teiche, southwest of Bremen, the ecological conditions were very similar to those in Dülmen (EWERS, 1999), as they were at a breeding farm in the well known heath area around Lüneburg, South of Hamburg (CLAUSNITZER, 1983; pers. comm.). A huge colony exists in the vicinity of Lommel city near the Dutch-Belgian border (DIJKSTRA et al., 2002; VERBEEK, 1999), where lead water ponds offer conditions probably similar to those at the Dülmen fish farm, though detailed information is lacking.

Carp breeding and distribution of *S. depressiusculum* in the past and in the future

Carp was much in demand in former times, especially in monasteries and at aristocratic courts. Since long distance transportation of carp was impossible at that time, carp breeding facilities were numerous and widespread throughout Central Europe. Accordingly, there were quite a few records of *S. depressiusculum*, at least in Northrhine-Westphalia. Since about 50 years facilities for long distance transportation of young carp had noticeably improved.

As a consequence, carp breeding was more and more restricted to a few localities only, reducing the records of *S. depressiusculum*. During that phase, fish farms made best bargains with carp in their first autumn, mainly sold for release in sport fishing ponds and for fattening through another 2-3 years for the table. Carp breeding ponds were still flooded long enough to ensure dragonfly development. However, nowadays sport fishermen and retailers preferably buy carp in their second year from the fish farms because they are not that much subject to avian predators which became abundant in the last decades. In their first summer these carps are kept in the breeding ponds only until July and are then transferred to deeper ponds for overwintering until they are sold by the farm in their second summer. So, on the one hand, the shallow breeding ponds dry up too early, on the other hand the ponds for overwintering do not match the requirements of *S. depressiusculum*. Since nowadays carp breeding is undertaken at extremely low cost in Hungary and other eastern states, commercial fish farming in northwestern Germany does appear to be ill-fated and so does *S. depressiusculum*.

Conclusion

At the northwestern border of its range *S. depressiusculum* exhibits an evident change of habitat preference. Here the species prefers artificial ponds, mainly carp breeding ponds (as in Dülmen) but also lead water ponds (as in Lommel). This is a fundamental change compared with the mere restriction in ecological factors exhibited in central Europe by *Aeshna subarctica* (confined to *Sphagnum*), *Aeshna viridis* (confined to *Stratiotes*), and *Somatochlora alpestris* as well as *S. arctica* (in the plains confined to bogs).

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