

***Onychogomphus costae* in Andalusia, southern Spain – mapping an overlooked species (Odonata: Gomphidae)**

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Abstract. *Onychogomphus costae* is an Ibero-Maghrebian endemic, which is rare in the Iberian Peninsula. This study updates its distribution in Andalusia, southern Spain, based on a targeted survey carried out in 2015–2017 and the compilation of all available records. The species appears to be more widespread than previously documented, with a core distribution along the river Guadalquivir and its tributaries in the province of Córdoba. The altitudinal distribution of *Onychogomphus costae* reflects its general preferences for permanent, seasonally flooding, lowland rivers. The period of most observations of adults stretches over two months from mid-May to mid-July. Factors likely to explain why the species has been overlooked in past decades are discussed. These include recording effort, habitat features, adult behaviour, larval ecology and general water quality.

Further key words. Dragonfly, Anisoptera, Iberian Peninsula, survey, European distribution

On the nature and distribution of *Sympetrum tibiale*, a rare Central Asian species spilling over into Europe (Odonata: Libellulidae)

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Abstract. Literature data, museum collections as well as fieldwork were used to produce an up-to-date distribution map and a list of records of *Sympetrum tibiale*, a species restricted to the semi-deserts of Russia, Kazakhstan, Uzbekistan, Mongolia and western China. The type locality is in Xinjiang province, China, and the type specimens are preserved in the Zoological Museum of Hamburg, Germany (ZMUH). Language barriers, publication in obscure journals and poor data exchange meant *S. tibiale* was little-known to non-Russian speaking odonatologists for a long time. Yet, it has been confirmed to breed in the steppes of the Kuma–Manych Depression on the western shore of the Caspian Sea, situated in the southern part of European Russia, making the species a genuine member of the European fauna. This article addresses these European sites, hitherto neglected in non-Russian language literature, and establishes the correct westernmost limit of the species' range. In addition, all currently certified records are mapped. Available knowledge on the species' ecology – a summer species with a larval preference for brackish water – is summarized. Identification characters of adults and larvae are provided; its closest relative is identified as *Sympetrum depressiusculum*.

Further key words. Dragonfly, Anisoptera, European species, ecology, larva, brackish water

TSOI – a new index based on Odonata populations to assess the conservation relevance of watercourses in Tunisia

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Abstract. Global ecological conditions existing in the streams of northern Tunisia are very unequal. In consideration of their appropriate management and restoration requirements, breeding populations of 28 Odonata species were studied over an annual cycle in twenty-eight watercourses (22 permanent, 6 intermittent). In total, 7 363 larvae and 337 exuviae were collected. We developed a new indicator, the Tunisian Stream Odonatological Index (TSOI), to assess conservation aspects of Odonata biodiversity in African Mediterranean streams by analysing dragonfly communities. The TSOI operates at the species level. Taxonomic richness, voltinism, endemism, relative taxonomic distinctiveness, and regional conservation status (IUCN) are elements taken into account to design this index. Accordingly, presence of both Maghreb endemic and semivoltine species (*Calopteryx exul*, *Platycnemis subdilatata*, *Aeshna cyanea*, *Boyeria irene*, *Gomphus lucasii*, *Onychogomphus costae*, *O. forcipatus*, and *O. uncatus*) may provide useful information about the refuge quality of each habitat type for species with different biological features, and their interest level from a conservation point of view. The results of a first application of this approach are presented in the paper as well. As far as we know, a biodiversity conservation index based on benthic invertebrates in the African Mediterranean area has never before been proposed nor used.

Further key words. Dragonfly, agricultural environments, forest environments, Maghreb, North Africa, Mediterranean area, biological index

Odonata assemblages along an anthropogenic disturbance gradient in Ghana's Eastern Region

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Abstract. We assessed the effects of different levels of anthropogenic disturbance on Odonata species richness and assemblage composition in four different habitats in Ghana: mining sites, agricultural fields, human settlements, and primary forest habitat. A total of 992 individual adult Odonata representing 51 species (20 Zygoptera, 31 Anisoptera) in six families were recorded from 16 sites across these habitats. A majority of species (75 %) recorded across all sites were previously classified as habitat generalists, while 20 % represented specialists. The human settlement habitat exhibited the overall highest Odonata abundance (302 individuals), whereas the greatest species diversity was observed in the mining sites ($D=4.59$). Agricultural fields had lowest abundance ($n=196$ individuals), while primary forest sites exhibited the lowest diversity ($D=2.75$), although these differences were not statistically significant. There was also no significant difference in adult Odonata richness D ($F_{3,59,72}=2.48$, $p=0.07$) among habitats. However, species composition differed significantly among the various habitats (ANOSIM: global $R=0.73$, $p=0.001$). A canonical correspondence analysis revealed that river flow rate, percentage of canopy cover and channel width were the key factors influencing Odonata assemblages. Generalist and heliophilic dragonflies dominated in human-altered habitats, while the matured forest habitat included more specialists and stenotopic damselflies. The results suggest that specialist dragonflies can be used as freshwater habitat quality indicators, and their habitat requirements also support the need to maintain the remnant primary forest in the East Akim District.

Further key words. Dragonfly, species richness, species composition, canonical correspondence analysis, multidimensional scaling, habitat types

***Coenagrion hastulatum* and *C. lunulatum* – their responses to the liming of acidified lakes and the release of fish (Odonata: Coenagrionidae)**

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Abstract. The rare and acidification-tolerant *Coenagrion lunulatum* became extinct in Romundstadjern, a small acidic lake in southern Norway, at some time between 1950 and 1980. The reason was suspected to be liming of the lake to raise the pH level before releasing fish (trout). To substantiate the hypothesis, in 1998–2001 we experimentally limed two other small acidic lakes, Øynaheia A (pH 4.6) and B (pH 4.8), which were also inhabited by *C. lunulatum*. Instead of being made extinct by the liming and the rise of the pH to 7.0, the *C. lunulatum* population at Øynaheia grew strongly during the experimental period. However, when fish (perch) were released later, before 2011, the invertebrate fauna became tremendously impoverished, and *C. lunulatum* was not observed there in 2012, 2014 or 2016. Therefore, liming of lakes does not seem to be a threat to *C. lunulatum*, but the release of fish may probably lead to its extinction. A coexisting population of *C. hastulatum* also grew during the years of liming, but not as much as *C. lunulatum*. However, it survived the introduction of fish, although in low numbers.

Further key words. Dragonfly, damselfly, Zygoptera, pH, acidic precipitation, fish predation, Norway, Scandinavia

Sexual ornamentation triggers rival aggressiveness in the Neotropical damselfly *Hetaerina longipes* (Odonata: Calopterygidae)

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Abstract. Coloration is associated with male quality in various animal species. These secondary sexual characters are a result of selective pressures that favor males able to cope with the physiological costs of production and maintenance of the ornament. Males of the Neotropical damselfly *Hetaerina longipes* exhibit red wing pigmentation, which is considered a sexual ornament. We tested the hypothesis that territorial males assess the quality of sexual ornamentation of rival males and respond with aggressive or neutral behaviors according to the quality of the opponent. Since wing pigmentation is an indicator of male quality, influencing contest outcome and territory acquisition, we expected that territorial males would decrease their aggressiveness when facing opponents with experimentally enhanced wing pigmentation, assuming that males should avoid conflicts with stronger males. The results suggest that territorial males are in fact more aggressive against rivals with increased pigmentation, contrary to our initial hypothesis. We discuss the cognitive ability of odonates in the assessment of opponents and suggest three hypotheses to explain the observed patterns.

Further key words. Dragonfly, Zygoptera, Brazil, decision making, territoriality, sexual selection, honest signals

Egg chorion of *Paragomphus lineatus* (Odonata: Gomphidae)

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Abstract. The egg chorion of the exophytic dragonfly *Paragomphus lineatus* was examined using light and scanning electron microscopy. The egg is sub-spherical and possesses a very large conical but flat-top micropylar apparatus. The outer surface of the chorion is uniformly sculptured with strong hexagonal reticulations formed by the fusion of tiny low nodules on the chorion (3–4 µm). The area lying inside the hexagonal reticulation is filled with 7–10 nodules. The chorion is formed of a uniformly thin endochorion and a multi-layered exochorion. The micropylar apparatus is composed of a central, tubular micropylar projection which terminates as a flat circular disc. This plate bears a central elevated knob around which 6–7 micropylar orifices are arranged in a circle. The micropylar projection is surrounded by a thick mass of sticky jelly. Development of the micropylar apparatus takes place during the late vitellogenic and choriogenic stages of egg maturation. The jelly mass is exochorionic in origin and is deposited by the follicular epithelial cells of the oocyte. The micropylar projection is formed by the evagination and morphogenetic movement of the endochorion. The egg chorionic architecture of *P. lineatus* is discussed with respect to phylogeny and oviposition behaviour of the female.

Further key words. Dragonfly, Anisoptera, exochorion, endochorion, vitelline membrane, micropylar apparatus, oviposition

Chromosome observations based on C-banding, Ag-NOR and sequence-specific staining in two *Anax* species from India (Odonata: Aeshnidae)

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Abstract. The previously known male karyotypes ($2n=27$, m ; $n=14$, m ; X0 sex determination) of *Anax immaculifrons* and *A. nigrofasciatus nigrolineatus* from Himachal Pradesh are re-described, based on conventional staining and are described for the first time using three other staining techniques. In the two species, C-bands occur on chiasmatic/non-chiasmatic bivalent ends, there is a C-positive X, while the m bivalent is C-negative in *A. immaculifrons* and C-positive in *A. nigrofasciatus*. The other details are given in the text and micrographs are provided.

Further key words. Dragonfly, Anisoptera, chromosome complement, sex determination, meiosis, constitutive heterochromatin, NOR regions

Grass and water preference during oviposition by *Sympetrum pedemontanum elatum* in Japan (Odonata: Libellulidae)

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Abstract. *Sympetrum pedemontanum* is regionally endangered or extinct in several countries despite having a wide distribution across the Eurasian continent and its neighboring islands. Its subspecies *S. p. elatum* in Japan has been decreasing rapidly with the loss of larval habitat in rural areas since the 1970s. Previous studies have detailed habitat use by larvae and mature adults, but information on grass and water preferences during oviposition is still lacking. In this study, we tracked adults as they performed reproductive behaviors and documented the grass height and water conditions preferred for oviposition in a lowland, mid-slope river in Japan. Our results showed that females dipped their abdomens significantly more into stagnant than into flowing water for oviposition and that short surrounding grass and shallow water enhanced oviposition behavior. These findings emphasize the importance of riparian grass management and water flow regulation for the conservation of *S. p. elatum*.

Further key words. Dragonfly, Anisoptera, conservation, microhabitat use, semi-natural grasslands, reproductive behavior, tandem formation