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First data on the reproduction of the Vagrant Emperor *Anax ephippiger* in North-Eastern Italy, Friuli-Venezia Giulia Region
(Odonata Aeshnidae)

Riassunto: *Primi dati sulla riproduzione di Imperatore Migrante* Anax ephippiger *in Friuli-Venzia Giulia*, *Nord-Est d'Italia.*
Anax ephippiger (Burmeister, 1839) è una libellula migratrice che proviene dall'Africa e dal Medio Oriente e di cui in Europa sono conosciute solo generazioni estive e non vi sono evidenze di larve svernanti. Durante l'agosto 2010 in Friuli-Venezia Giulia, Italia nord-orientale, è stato trovato un sito riproduttivo per questa specie, prima prova di riproduzione per la specie in Nord-Est d'Italia. Nello stagno in cui è stata accertata la riproduzione, con lo scopo di incrementare le conoscenze ecologiche sulla specie e delinearne l'habitat di riproduzione, sono stati rilevati: la comunità a odonati (adulti ed esuvie), la vegetazione e i parametri chimico-fisici dell'acqua (compresa la salinità dell'acqua, essendo lo stagno in comunicazione con il mare e non essendo disponibili informazioni dettagliate rispetto alla tolleranza delle larve a tale parametro). Questo nuovo ritrovamento faunistico, corredato da dati ecologici, si inserisce all'interno di una più vasta rete di avvistamenti per la specie, rappresentando la prova dell'ampliamento verso Nord dell'areale di *A. ephippiger* e avvalorando la tesi della sensibilità degli odonati al riscaldamento globale.

Abstract: The Vagrant Emperor, *Anax ephippiger* (Burmeister, 1839), is a migrant dragonfly species from Africa and Middle East; in Europe only summer generation are known, without evidence of overwintering larvae. In August 2010 a reproductive breeding site for this species was found in the in Friuli-Venezia Giulia Region (north-eastern Italy). This discovery represents the first proof of reproduction for the species in north-eastern Italy. With the aim of increasing the knowledge on the species requirements, a study to delineate the emerging habitat was conducted: dragonfly community (adult and exuviae), vegetation, chemical and physical water parameters were sampled. This yielded data about larval tolerance toward salinity. This new data proves a northward move for the species, which may also have been facilitated by global warming.

Key words: Odonata, Aeshnidae, *Anax ephippiger*, Monfalcone, brackish water, global warming.

Introduction

Anax ephippiger (Burmeister, 1839) is a species with strong migrational tendencies (Müller, 1974; Corbet, 1999; Silsby, 2001; Dijkstra & Lewington, 2006; Lambret & Boudot, 2013), that can often be seen in large numbers (Boudot *et al*., 2009). It is typical of arid parts of Africa, the Middle East and South-West Asia wandering to and from to breed after the rains, and it also breeds sporadically in southern Europe (Askew, 2004). However, localities with regular reproduction are strongly limited to regions with a hot climate in northern Africa and some European areas directly bordering the Mediterranean Sea, although a summer generation may also emerge in Central Europe during favourable years. The species has turned up various places in Europe, especially in the Mediterranean region but also in England (*e.g*. Cambridge and Leeds) (Askew, 2004) and even in Iceland (representing the only dragonfly ever recorded on Iceland) and the Faroe Islands (Jensen & Nielsen, 2012). The species is not uncommon in the East Mediterranean (*e.g*. Kos), Turkey, Iraq and along the East coast of the Black Sea (Askew, 2004). The timing of the species' occurrence in Europe is related to the life-cycle at the breeding ground in Africa: in May, after the wet season starts, eggs are laid in temporary pools and lakes. Larvae develop rapidly (60-90 days) and mass emergence occurs from September to November. Then the adults locally disperse and spend the winter as adults. The species flies following the rain-developing systems (monsoon) for several hundred kilometers until arriving in Europe. There they feed, mate, and lay eggs in newly filled water bodies (Edelaar *et al*., 1996; Resh & Cardé, 2009). Such long-distance migrations are accompanied

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by successful local breeding and appear to be mostly passive, largely due to strong winds blowing in the same direction for several days (Lambret & Boudot, 2013). Although far from the Mediterranean coast the species is usually seen only in autumn, emerging individuals and exuviae can be found during the summer period and not during the spring (Grand, 2009), with the exception of a female captured in Devonport (England) on 24th February (Mclachlan, 1903) and two exuviae and many fresh individuals found on 29th April in Camargue (Faton, 2003). In July 1983 several individuals were observed hawking along cliff tops near Novorossiysk on the Black Sea coast and in April specimens were seen flying over coastal dunes, arable land and heavily-grazed inland valleys on the island of Kos (Askew, 2004). In Iceland, the species was found in late September and at the beginning of October. After these records the species was found again in Iceland on October 29th and November 5th (Norling, 1967; Ólafsson, 1975). Even though winter deposition, starting in December, has been reported from northern Morocco, there is practically no evidence for development of a larval generation in the Mediterranean region during winter (Boudot *et al*., 2009). *A. ephippiger* breeds in small, shallow, warm (more than 35°C during summer) (Wildermuth *et al*., 2005) standing water bodies, sometimes of a temporary nature and sometimes brackish, in part sparsely overgrown (Gerken & Sternberg, 1999; Günther & Muersberger, 1999; Askew, 2004; Dijkstra *et al*., 2006) with abundant presence of vegetation, especially *Phragmites australis* and different species belonging to the following genus: *Juncus, Eleocharis, Carex, Schoenoplectus* (Bedjanic, 1999; Wildermuth *et al*., 2005). The water surface has to be partially covered by vegetation. Usually the dragonfly community living together with *A. ephippiger* is composed by 20-30 different dragonfly species (Wildermuth *et al*., 2005). Feeding occurs on emerged vegetation during the evening, when individuals form aggregations; in the same places males patrol and look for females (Günther & Muersberger, 1999). Oviposition occurs in tandem as in *Anax parthenope* (Selys, 1839) and in *Aeshna affinis* Vander Linden, 1820 (Askew, 2004) and eggs are laid down on leaves, dead or alive, or on the wet pond bank (Wildermuth *et al*., 2005).

The primary aim of this note is to describe the main ecological parameters of the first reproductive site of *A. ephippiger* in north-eastern Italy, in order to delineate the requirements for the species in Europe. The pond, despite its recent formation, is well naturalized and constitutes a unique habitat along the north-eastern Italian coastal system. The vegetation analysis and the water chemical and physical parameters allow to describe in detail the habitat and define how much tolerance toward salinity larvae show during their development.

Materials and Methods

Study area. The breeding site of *A. ephippiger* belongs to the brackish biotope "Zona del Lisert", an area that lies between the coastal region of Dalmatia, characterized by high mountains and rocky environments, and the Isonzo's river mouth, characterized by low altitude and sandy environments (Poldini, 2009). In the "Zona del Lisert" and in the neighboring areas the first human modifications date back to 1948-1950 (Michelutti *et al*., 2006), while the most recent one occurred in 2006, when an empty artificial area was created, filled with the extra material resulting from the port expansion and the drainage of the ship canals. After many years of work, a stop to this activity induced a spontaneous naturalization of the area, with the creation of many wet habitats. Despite the numerous modifications, nowadays the area displays a large biodiversity, with an interesting coastal habitat characterized by autochthonous flora and fauna species.

Sampling design. Chemical and physical parameters of the water [pH, Temperature (°C), Dissolved Oxygen (ppm), Conductivity (mS/cm)] were measured every two weeks from 14th May 2010 to 23th April 2011 between 12 am and 2 pm, without rain and with low tides, necessary condition to have access to the area. Hanna Instruments Probes were used: pH and Temperature were measured with instrument HI 9025 (pH ±0.01 and temperature ±0.5°C); Conductivity was measured with instrument HI 8633 (±1% end to the scale); Dissolved Oxygen was measured with instrument HI 9143 (±1.5% end to the scale). Since the pond is situated in proximity to the sea, chemical analyses of the water were conducted to correlate the high values of conductivity with salinity (presence of chloride ions); after that the conductivity value was converted to Practical Salinity Units (PSU), according to the international convention (U.N.E.S.C.O., 1985) that uses the practical salinity scale PSS-1978. Samplings on Odonata were conducted twice-monthly

from 14th May 2010 to 29th September 2010 and from 15th March to 23th April 2011: adults were checked from 10 am to 6 pm during sunshine days when temperatures were higher than 20°C and with low wind speed (Buchwald, 1994); they were caught with an entomological net, photographed and then released. The vegetation in and around the pond was checked for exuviae, determined reaching the species rank (Gerken *et al*., 1999; Askew, 2004). Adults and exuviae were counted in three patches of 10 m^2 around the pond bank and classes of abundance were used to compare the data (Buchwald, 1990): 1: 1-4 specimens (or exuvie); 2: 5-10 specimens (or exuvie); 3: 11-20 specimens (or exuvie); 4: 21-40 specimens (or exuvie); 5: >40 specimens (or exuvie). For data interpretation, 1=very few individuals; 2=poor population; 3=medium population; 4=dense population; 5=very big population, mass population (Buchwald, 1990). Furthermore, a phytosociological analysis on helophytic and hydrophytic plants in and around the pond was carried out, with particular attention to the perilacual vegetation. Each plant specimen was measured in height and the mean was annotated. The vegetation analysis was performed using the Braun-Blanquet method (1964); see also Reichelt and Wilmanns (1973), integrated with Pignatti (1953).

Results

A. ephippiger's exuvia was found on 1th August 2010. Thirteen species of Odonata (eleven of them confirmed by the presence of exuviae) were found in the pond together with *Anax ephippiger*: *Sympecma fusca* (Vander Linden, 1820), *Ischnura elegans* (Vander Linden, 1820), *Erythromma viridulum* (Charpentier, 1840), *Aeshna mixta* Latreille, 1805, *Aeshna affinis* Vander Linden, 1820, *Brachytron pratense* (Muller, 1764), *Orthetrum cancellatum* (Linnaeus, 1758), *Crocothemis erythraea* (Brullé, 1832), *Sympetrum fonscolombii* (Selys, 1840), *Sympetrum meridionale* (Selys, 1841), *Chalcolestes parvidens* (Artobolevski, 1929), *Anax imperator* Leach, 1815, *Lindenia tetraphylla* (Vander Linden, 1825). The most common species are: *Aeshna mixta, Crocothemis erythraea, Sympetrum fonscolombii, Sympetrum meridionale* (Fig. 1) The pond is subject to strong water fluctuations during the year with a maximum water level ranging from 60 cm to 74 cm; watering is pluvial and tidal due to the sea tidal waves. The phytosociological attribute of the helophytic vegetation was *Puccinellio festuciformis-Phragmitetum australis* (Pignatti 1953) Poldini and Vidali 2002 (Poldini *et al*., 1999) and consists of peripheral reed beds of *Phragmites australis s.l.* (200 cm height) with a brackish connotation and a massive presence of *Bolboschoenus maritimus*. The lakeside vegetation is *Puccinellio festuciformis-Scirpetum compacti* (Pignatti 1953) Gehu *et al*. 1984, while the phytosociological attribute of the hydrophytic vegetation is *Chaetomorpho-Ruppietum* Br.-Bl. 1952. The sporadic presence of *Tamarix africana* suggests the ephemeral nature of many basin zones. To better describe the characteristics of the pond, we obtained

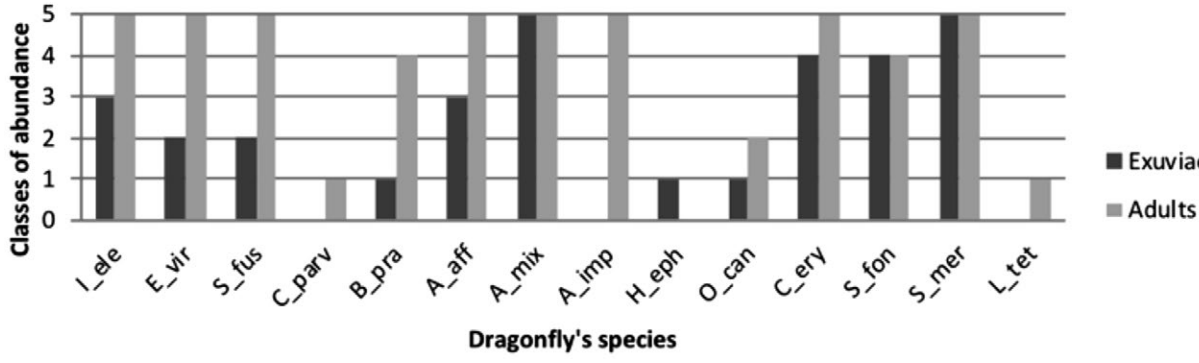

Fig. 1. Classes of abundance (adults and exuviae) found in the transect B of the pond. Species are abbreviated like follow: I_ele=*Ischnura elegans*; E_vir=*Erythromma viridulum*; S_fus=*Sympecma fusca*; C_par=*Chalcolestes parvidens*; B_par=*Brachytron pratense*; A_aff=*Aeshna affinis*; A_mix=*Aeshna mixta*; A_imp=*Anax imperator*; H_eph=*Anax ephippiger*; O_can=*Orthetrum cancellatum*; C_ery=*Crocothemis erythraea*; S_fon=*Sympetrum fonscolombei*; S_mer=*Sympetrum meridionale*.

the following water chemical-physical parameters: pH average value was 8.65, T (°C) average value was 19.14°C; the Conductivity (mS) average value was 3.20 mS; the Oxygen Dyssolved (ppm) average value was 14.51 ppm; the PSU average value was 1.88 PSU.

Discussion and Conclusions

The first Italian record of *A. ephippiger* goes back to 18th July 1867 when at around 7 pm Federico Craveri collected three individuals (sub *Anax mediterraneus* De Selys) flying in endless numbers over his garden in Bra (TO, Piedmont) (Ghiliani, 1867); on the 8th August a large number of specimens reached La Mandria (Venaria Reale, Torino) (Ghiliani, 1867) and at this place exactly a year later, a young female was collected, as first evidence of the reproduction in Europe (Ghiliani, 1869). Actually, in Piedmont less is known about breeding populations of the species (Boano *et al.*, 2007). One larva was found in Pieve (Macerata) and many oviposition were observed in Trapani (Sicily) (Utzeri *et al.,* 1987). In Sardinia two fresh and many adult specimens were observed in 1986, 1988 and 1989 (Leo, 1990). The data about the distribution of the species in Italy are reported in Riservato *et al*. (2014).

Considering the two countries bordering Friuli Venezia Giulia, the first record of *A. ephippiger* in Slovenia refers to 1995, when larvae and exuviae of this species were found at Proseniško, east of Celje (Pirnat, 1997). The species was later confirmed in 1998 near the city of Maribor (North-eastern Slovenia) with exuviae found in two intensive fish-ponds characterized by sparse emergent vegetation and shallow, warm and eutrophic water (Bedjanic, 1999). A few years later, 30 kilometers from the Italian border, in Secovlje Salina and Skocjan inlet (Koper), *A. ephippiger* individuals were observed many times during spring 2000, but proof of reproduction was not found. The habitat in Secovlje Salina is characterized by salt-pan channels and saltmarshes, and in Skocjan inlet by mudflats and abandoned places covered in rubble and overgrown with reeds (Geister, 2002). In Austria, the exuviae of the species were found in 1990 in a site situated nine kilometers north of the city of Salzburg, characterized by *Phalaris arundinacea* (where the exuviae were found) (Laister, 1991).

In Friuli Venezia Giulia, only scattered records of *A. ephippiger* exist: the first in Gorizia in September 1988 (Bognolo & Pecile 1995), then in Trieste in August 2007 (Uboni *et al*., 2008), at the Natural Reserve "Isonzo's river mouth" in 2008 (Boudot *et al*., 2009), in the town of Spilimbergo (PN) on 12th August 2017 (C. Uboni and L. Dorigo obs.).

The exuvia found on August 2010 at "Lisert" represents a first in north Italy for the species. The habitat, when investigated closely, resembles the prototypical habitat described for the species in the literature (Bedjanic, 1999; Gerken *et al*., 1999; (Günther & Muersberger, 1999; Askew, 2004; Wildermuth *et al*., 2005; Dijkstra *et al*., 2006): shallow ponds characterized by high temperature (more than 30°C during summer), weakly brackish water (3.41 as the maximum value of PSU) and the massive presence of emerged and submerged vegetation (*Puccinellio festuciformis-Phragmitetum australi*s, *Puccinellio festuciformis-Scirpetum compacti, Chaetomorpho-Ruppietum)*, and a species-rich odonata community living together with *A. ephippiger* (thirteen species in total). It is important to underline the observation of *Lindenia tetraphylla*, since this species is included in the annexes II and IV of the Directive 43/92 EEC and this finding represents the first data for the species at least in north-east Italy.

In conclusion, the new increasing data emerging from this study indicates that *A. ephippiger* is becoming more and more present in the north-eastern part of the Adriatic Sea, proving the trend of many African species moving to Europe probably due to climate changes and global warming (Walther *et al*., 2001; Ott, 2010; Grand, 2009).

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