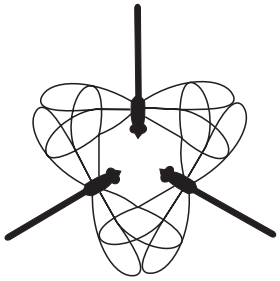

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THERMOREGULATION AND MICROHABITAT CHOICE IN *ERYTHRODIPLAX LATIMACULATA* RIS MALES (ANISOPTERA: LIBELLULIDAE)

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It was assessed whether solar incidence affects the spatial distribution, microhabitat choice, territorial defense, time spent in behavioural categories, activity patterns, and abundance of *E. latimaculata*. The study was conducted in a semi-lotic area in the Cerrado in Aparecida de Goiânia, Goiás, Brazil, using the scan procedure with a fixed area, sampling 3 environments, viz. shade, partial shade, and an area with constant solar incidence. There was a higher abundance and activity concentration of this sp. in areas with higher solar incidence than in other areas ($H = 19.180$; $P < 0.001$). This can be explained by the ecophysiological requirements of *E. latimaculata*, in which individuals need to be exposed to solar radiation to warm their bodies, allowing the beginning of their activities. Diurnal variation did not affect the behavioural pattern, indicating that individuals are ectothermic and need direct solar incidence on their bodies ($H = 12.193$; $P = 0.160$). They spend most of the time perching with wings dropped (41.448 ± 21.781; mean ± SD) and displaying a territorial behaviour, making defense flights around the perch. In lenthic water bodies ♀♀ seem only to mate and oviposit (exophytic, directly into the water).

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INTRODUCTION

The distribution of odonate species in a given landscape is determined by their ability to thermoregulate, which may be influenced by climate, body size, behaviour, and microhabitat choice (MAY, 1976; CORBET, 1962). CORBET (1962) classified anisopterans as fliers or perchers and considered differences in their thermoregulation and behaviour. Fliers tend to have larger body size and can produce endogenous heat, controlling their inner temperature, flying most of the time and regulating their body temperature by controlling haemolymph flow (MAY, 1976; CORBET & MAY, 2008; CORBET, 1999). On the other hand, perchers have smaller body sizes, remaining perched most of the time and are classified as thermal conformers or heliotherms. Thermal conformers have a higher surface: volume ratio and are thus more susceptible to thermoregulation by convection (DE MARCO & RESENDE, 2002). As they have high conductance, they can quickly gain or lose heat to the environment. Consequently, they can start their activities as ambient temperature increases. However, this restricts their activities to a certain period of the day (CORBET & MAY, 2008). Because of their lower conductance, heliothermics need direct sunlight to warm their bodies and start their activities, i.e. they are influenced by the solar irradiation on their bodies (CORBET & MAY, 2008; MAY, 1976). Perchers remain resting, close to sites visited by females for oviposition, usually defending spots against conspecifics, displaying territorial behaviour (CORBET, 1999).

According to SAMWAYS (2006), dragonflies are sensitive to habitat quality and ambient light. This is in agreement with the results of SILVA et al. (2010), suggesting that dragonfly communities are more sensitive to landscape changes (e.g., deforestation, grazing, loss of habitat integrity) than to the physicochemical parameters of water. Environmental disturbance can cause serious problems to species with strict ecological requirements, which can be replaced by those that are more generalist. FERREIRA-PERUQUETI & DE MARCO (2002) found that species living in areas with some kind of environmental change can invade pristine areas, but not the contrary. This suggests that anthropogenic changes homogenize the environment, and consequently decrease resource availability and oviposition sites (PAULSON, 2006; FERREIRA-PERUQUETTI & FONSECA-GESSNER, 2003).

The environment in which behavioural interactions occur is wider than the range of environmental conditions that may affect an odonate species. This environment also includes other species that can compete for perches, forcing individuals to occupy sub-optimal habitats. For example, DE MARCO & RESENDE (2004) showed that, when *Planiplax phoenicura* Ris is present, males of *Orthemis discolor* (Burm.) tend to use lower perches due to competition for high perches. Thus, behavioural studies of single species can benefit from information about the biotic environment in which the species occurs, fostering the interpretation

of mechanisms responsible for patterns of microhabitat use and other associated behaviours.

Erythrodiplax latimaculata Ris belongs to the intrageneric group *famula* (Libellulidae). Species of this group are widely distributed in South America (BORROR, 1942; HECKMAN, 2006). In general, males of *E. latimaculata* remain perched most of the day, defending breeding areas in lakes. This activity pattern is consistent with that of percher's species (RESENDE, 2010; CORBET & MAY, 2008). Considering the thermoregulation constraints (DE MARCO et al., 2005; CORBET, 1999) and the competition between males in territory defense, we analyzed the ethological patterns of males of *E. latimaculata*, to test the hypothesis that the spatial pattern of distribution, microhabitat choice, territorial defense and activity patterns of *E. latimaculata* are directly affected by the solar incidence and temperature fluctuations throughout the day. We also analyzed the species composition in areas where males of *E. latimaculata* defended territories.

METHODS

STUDY AREA – The study was conducted between April and June 2009 in Aparecida de Goiânia, Goiás, Brazil (16º49'54.6" S; 49º15'10.3" W). The region is covered by a typical Cerrado vegetation, and has two distinct seasons: a rainy (October-March) and a dry (April-September) season (KLINK & MACHADO, 2005).

The study site was a 97 m long farm dam. We divided it into three sections. Section 1 was 22 m long, with dense vegetation that shaded the sampling area throughout the day. Section 2 was 28 m long in a pasture area, with grasses (*Brachiaria* sp.) that covered up to the edge of the dam; this area received constant solar irradiance during the day. Section 3 was 48 m long, it was located between the other two and had intermediate characteristics. Some parts of section 3 were predominantly covered by grasses; in the morning (up to 10:00 h), the pond margins remained shaded but, later in the day, they received some sun.

SAMPLING – We made ten days of field observations, once a week from 10:00 h to 14:00 h. Air temperature was recorded hourly in each shaded place. A scan procedure within a fixed area was used to estimate species abundance (FERREIRA-PERUQUETTI & DE MARCO, 2002; FERREIRA-PERUQUETTI & FONSECA-GESSNER, 2003). In sections 1 and 2, 22 sticks were placed per section, at 3 m intervals. In section 3 we put 25 sticks spaced 1 m apart because of the higher dragonfly density. Thus, in total 69 stretches were marked.

Entomology nets were used for sampling. Specimens were identified with keys (BORROR, 1942; GARRISON et al., 2006) and by comparison with museum specimens. They were deposited in the collection of the Laboratory of Theoretical Ecology and Synthesis of the Federal University of Goiás.

ANALYSIS OF THE BEHAVIOUR – The focal animal method was used in behavioural observations (DE MARCO & VITAL, 2008; DE MARCO & RESENDE, 2002; ALTMANN, 1974). The observations were limited to one minute and a half. The classification of activities was based on CORBET (1962) and further subdivided according to DE MARCO (1998) and DE MARCO et al. (2005). The following types of behaviour were observed: copulation (CO), – oviposition (OV), – transition flight (TRA), patrolling (PAT), – open wings posture (OWP), – obelisk perching (OP), – dropped-wings perching (DP), – wings in different positions (WDP), and – flying (FL).

STATISTICAL ANALYSIS – Species richness was estimated using the first order jackknife method, which allows the correction of bias and calculates a confidence interval to compare different

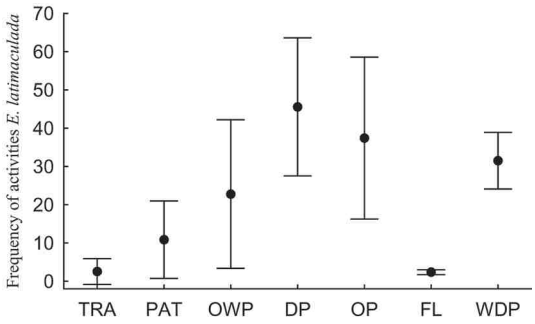

Fig. 1. *Erythrodiplax latimaculata*: frequency of activities in relation to the period of observation. – [Bars represent 95% CI] – TRA: transition flight; – PAT: patrolling; – OWP: open wings posture; – DP: dropping-wings perching; – OP: obelisk perching; – FL: flying; – WDP: wings in different positions.

treatments. This analysis and the rarefaction curve were implemented using the program EstimateS (COLWELL & CODDINGTON, 1994).

To test if time of day influenced the behaviour of individuals, we first tested the assumptions of normality and homoscedasticity (Levene test). If the assumptions were met, a one-way ANOVA (ZAR, 1999) was used, associated with a Tukey test, to identify which treatments had significantly different means. When they were not met, we used the nonparametric Kruskal-Wallis test (ZAR, 1999). The same routine was used to test if the three sections had differences in species abundance.

RESULTS

ETHOLOGICAL CATEGORIES AND TEMPORAL BUDGET

E. latimaculata remains in a dropping-wings posture while perching (DP) most of the time (41.448 ± 21.781; mean ± SD), followed by open wings posture (OWP) (7.107 ± 15.1571), transition flight (TRA) (0.535 ± 1.888), patrolling (PAT) (2.905 ± 7.296) and obelisk (OB) (2.23 ± 10.296; Figs 1, 2).

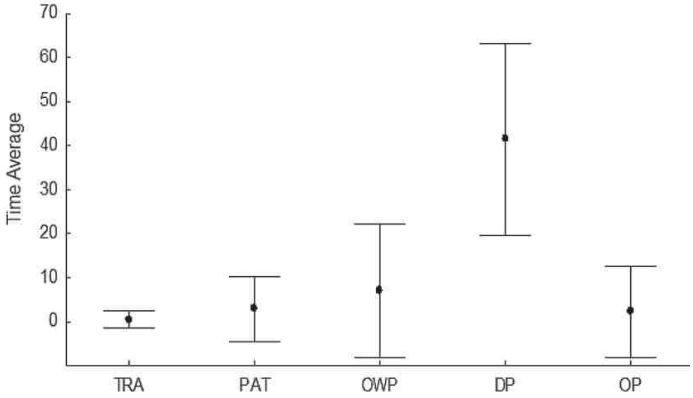

Fig. 2. *Erythrodiplax latimaculata*: mean proportion of time spent in each behavioural activity. – [Bars represent 95% CI] – TRA: transition flight; – PAT patrolling; – OWP: open wings posture; – DP: dropping-wings perching; – OP: obelisk perching.

During our observations, we found that *E. latimaculata* displayed two predominant flight types: the transition flight, associated with a change of perch usually last for 1 s, while the defense or patrolling flight around the territory lasted 4 to 10 s. These flights included agonistic interactions with direct contact and chasing when there was an intruder. However, this species spent most of the time in dropping-wings perching (DP; Fig. 2).

BREEDING BEHAVIOUR

Males displayed territorial behaviour in perches located in the vegetation extending towards the stream bank. When the male found a receptive female, he quickly held her in a tandem position. Generally, they remain perched after copulation for about two to three minutes, and then the female started ovipositing into the water. The male displayed guard behaviour, without physical contact. Immediately after oviposition, females perched on the vegetation while the male kept patrolling. Eventually the female moved away slowly while the male remained in his territory.

EFFECT OF DAYTIME ON ABUNDANCE

The abundance of *E. latimaculata* did not vary with the time of day (Kruskal-Wallis =12.193; DF=4; N= 26; P =0.160; Fig. 3).

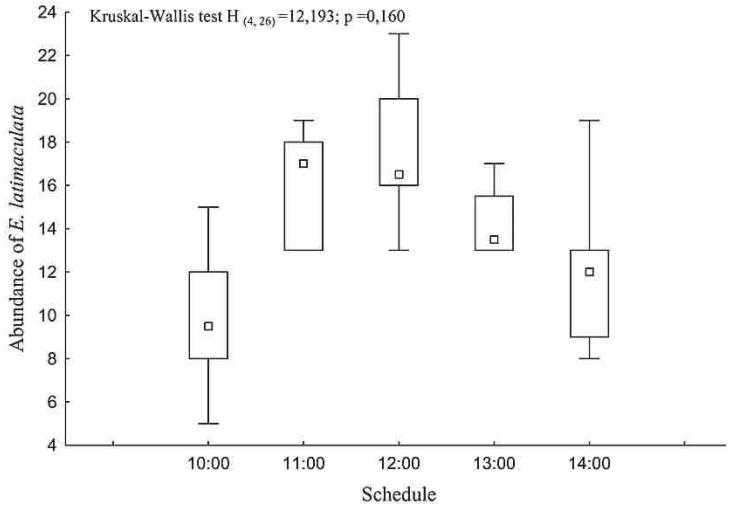

Fig. 3. *Erythrodiplax.latimaculata*: effect of daytime on the abundance. – [Bars represent the total ranges; – boxes represent 25 and 75% quartiles; – points represent the medians of the observed abundances].

ABUNDANCE PER AREA

E. latimaculata abundance was influenced by direct sunlight on their bodies. As a consequence, a higher abundance was found in open areas (Fig. 4), than in areas with dense vegetation (H = 19.231: df = 2; N = 40; P <0.001). Accordingly, a higher density of males defending territories was recorded in sunny areas. Dragonflies avoid shaded areas because it prevented heat gain to increase body temperature and hence the start of their activities. This influenced the distribution and abundance patterns of this species. For example, there was an increase in the abundance during periods of increased solar irradiation, possibly because they require direct sunlight on their bodies to become active.

ADULT ODONATA COMMUNITY

The following species were recorded at the farm dam, Aparecida de Goiânia (Goiás): *Acanthagrion lancea* Sel., *Neoneura sylvatica* Hag., *Telebasis limoncocha* Bick & Bick, *Phyllogomphoides* sp., *Erythrodiplax basalis* (Kirby), *E. fusca* (Ramb.), *E. juliana* Ris, *E. latimaculata* Ris, *Erythrodiplax* sp., *Micrathyria artemis* Ris, *M. ocellata* Martin, *Orthemis discolor* (Burm.) and *Perithemis lais* (Perty).

Our sampling effort was adequate for determining the species richness in the area since the rarefaction curve and the estimated richness by the jackknife method reached an asymptote (Fig. 5).

A higher odonate richness was recorded in areas with higher sunlight but there

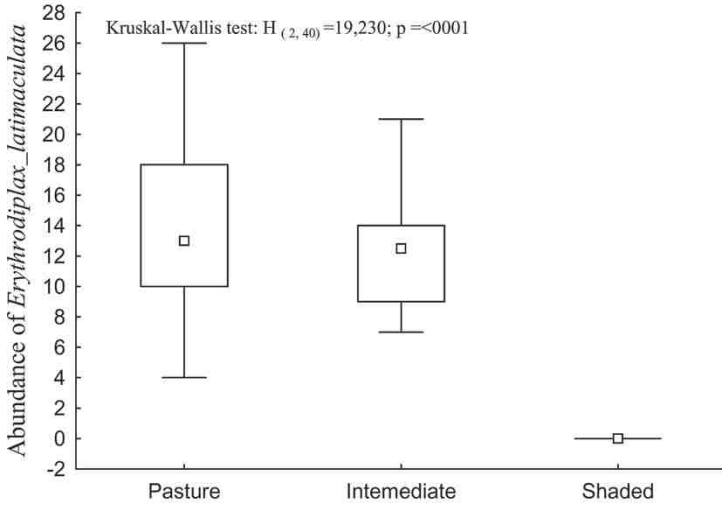

Fig. 4. *Erythrodiplax. latimaculata*: abundance in stream transects. – [Bars represent total range; – boxes represent 25 and 75% quartiles; – points represent the medians of the observed abundances].

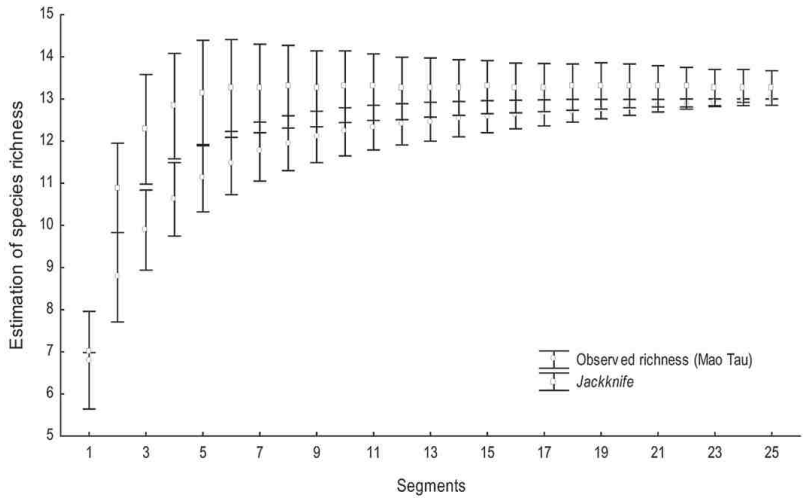

Fig. 5. Rarefaction curve of odonate species and richness estimate using the jackknife method.

was no difference between the pasture (14 ± 1.41, mean ± confidence interval) and the intermediate area (13 ± 1.00). The more shaded area showed the lowest richness, i.e. six species (7 ± 1.00) in mean (Fig. 6).

The larger proportion of large-bodied anisopteran species may be due to the availability of oviposition sites with constant sunlight, which may be related to their ecophysiological needs.

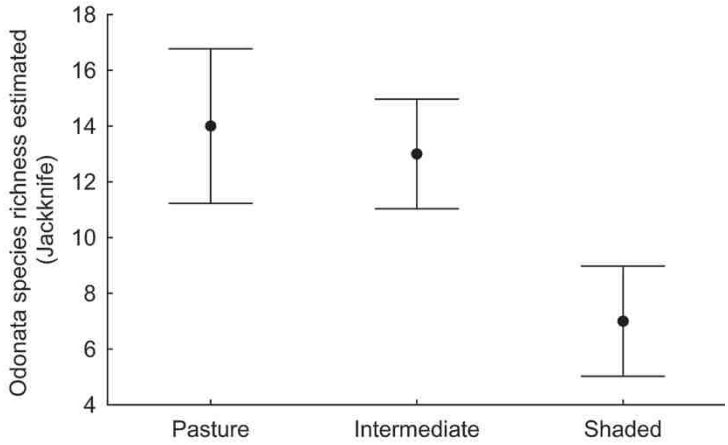

Fig. 6. Estimated richness of odonate species (jackknife) found in areas with different shade intensities. – [Bars represent 95% CI].

DISCUSSION

BEHAVIOUR

Individuals of *Erythrodiplax latimaculata* can be classified as heliothermic perchers, since they need direct sunlight incidence on their bodies to increase their body temperature and start their activities (CORBET & MAY, 2008; MAY, 1976; RESENDE, 2010). Males occur more frequently than females at the breeding site and defend territories on perches near water. On the other hand, females visit these sites only to mate and oviposit, selecting males that defend the best territories (e.g. MILLER, 1995; RESENDE, 2010; CORBET, 1999). In *E. latimaculata* the pattern of spatial distribution, habitat choice, territorial defense and time spent in activity were directly affected by direct solar incidence on their bodies and they concentrated most of their activity in periods of strong sunlight (RESENDE, 2010) as a consequence of their ecophysiological constraints.

Taken together, the above observations suggest temporal restriction in the activities of this species that could also influence its spatial distribution. *E. latimaculata* seems to be restricted to open areas near water bodies, due to its dependence on direct sunlight, which influences choice of microhabitats. A prediction that can be put forward is that it may benefit from the disturbance of natural areas, due to its behavioural and eco-physiological aspects, as is the case in other species with heliothermal behaviour (FERREIRA-PERUQUETTI & DE MARCO, 2002; SILVA et al., 2010). This suggests that the geographical range of species such as *E. latimaculata* may be expanded as a consequence of current environmental changes, provided the availability of suitable aquatic environments.

CORBET (1999) pointed out that the behaviour of adult dragonflies is sensitive to several factors such as age, time of day and temperature. Ectothermic thermoregulation affects microhabitat selection and posture. Some body postures minimize the solar incidence, such as obelisk perching, with the body parallel to the sun, or maximize sun exposure, such as holding the wings raised and the abdomen horizontal while perching to increase or decrease body temperature. The dropping-wings perching may be related to balance in high winds. These dragonflies hold the wings open, preventing wing rotation. Possibly with dropping-wings perching, they decrease the contact surface. After the high winds, these species return to the initial dropping-wings position and remain on their perches (pers. obs.).

When clouds blocked the sun, we observed more individuals with dropped wings, probably to increase the body surface exposed to sunlight and thermoregulate. On other occasions, when an insect flew over *E. latimaculata*, it immediately opened its wings, showing the stains.

For a more intense defense, *E. latimaculata* males frequently displayed an agonistic defense, in which they flew in a spiral with physical contact, disputing perch-

es or females (CORBET, 1999). These behavioural interactions directly influence the distribution of these animals (OSBORN & SAMWAYS, 1996). Many dragonflies defend territories attractive to females and can become involved in conflicts, chasings, expulsions and injuries. According to RESENDE (2010), males of *Erythrodiplax* species, such as *E. famula*, *E. media* and *E. fusca*, spend more time in territorial disputes than *E. latimaculata.* However, all species display an interspecific territorial dispute, i.e. agonistic behaviour. We recorded one of these disputes for a perch between *E. latimaculata, E. fusca* and *Acanthagrion lancea* males. *E. latimaculata* expelled *A. lancea* by physical contact in order to become the resident male. It is common to find *E. fusca* males perched on the same spots as *E. latimaculata.* This could have been influenced by *E. latimaculata* being larger than the others, since body size may determine the winner of a contest.

BREEDING BEHAVIOUR

The choice of the perch to be defended by a male is related to the arrangement of the vegetation and the availability of suitable sites for reproduction, particularly where females of *E. latimaculata* occur (RESENDE, 2010). Unlike *E. fusca* and *E. media* (DE MARCO & RESENDE, 2002), the frequency of females interacting with males in males' territories was very low. However, it is not clear whether this is a feature of this species, possibly related to the frequency females return to oviposition sites, or an environmental characteristic affecting the density of these insects.

After copulation, females of *E. latimaculata* lay eggs directly in the water while males remain nearby, protecting females against other males (CORBET, 1999; RESENDE, 2010). This guarding behaviour in mating is common in dragonflies, and happen in two ways: with or without physical contact. These behaviours are frequent in territorial species of the family Libellulidae (SILSBY, 2001).

During oviposition, *E. latimaculata* males guarded females by flying above them, without contact, preventing other males from approaching the female and extract the sperm, as occurs in some species of Odonata (CORBET, 1999). Since chasings between males are intense, it was common for the female to remain alone when ovipositing after copulation. This increases the chance of mating of other males with the female, similar to what was observed in *Libellula pulchella* (McMILLAN, 2000).

Where the density of females is high, it is expected that guarding behaviour without physical contact would occur after copulation (KNOX & SCOTT, 2005). This brings the advantage for males that they can continue to defend their territories and copulate with other females (ALCOCK, 1994). In this study, guarding behaviour without physical contact when there was a low female density suggests that there is a strong genetic component restricting behavioural plasticity. However, guarding a female without contact, even when there is a high male density,

may be associated with energy saving, which increases longevity and fitness and reduces predation risk, as shown for *Tramea* (ALCOCK, 1994). Although air temperature is high in the tropics, factors such as higher wind velocity and increased detectability by predators in places without riparian vegetation are more pronounced, affecting survival and behavioural strategies.

We also observed that *E. latimaculata* males simulated oviposition, i.e., touched the water with the abdomen. This behaviour was interpreted as a test of oviposition sites against attacks by amphibians on females or mating pairs, as in *Erythemis plebeja* (DE MARCO et al., 2002), providing more chances for offspring survival.

HABITAT

Most odonate species display some kind of habitat selection (DE MARCO & RESENDE, 2004; CORDERO-RIVERA, 2006). According to ASSIS et al. (2004), the genus *Erythrodiplax* is typically associated with lentic environments with organic substrates, but can also invade lotic areas (FERREIRA-PERUQUETTI & DE MARCO, 2002). Microhabitat choice is related to ecophysiological requirements, such as maintenance of body temperature that requires places with high solar irradiation (MAY, 1976; DE MARCO, 1998). Our results corroborate these predictions, since we found that the abundance of *E. latimaculata* was directly influenced by the availability of sunlight (RESENDE, 2010).

RELATIONSHIP OF *ERYTHRODIPLAX LATIMACULATA* WITH OTHER ODONATE SPECIES

SAHLÉN (2006) points out that, in general, forest-dwelling species are specialists, while those found in open areas are generalists. Our results corroborate this assertion, since the majority of species recorded in this study belong to genera that are common and widely distributed in Brazil, such as *Erythrodiplax* and *Micrathyria* (COSTA et al., 2002). This suggests that environmental disturbances such as deforestation and dam construction may favour the establishment of populations of generalist species, at the expense of specialist ones (DE MARCO & VITAL, 2008; FERREIRA-PERUQUETTI & DE MARCO, 2002).

According to CORDERO-RIVERA (2006), habitat quality is a major factor dictating the success of colonization and establishment of biological communities. In this study, we found species that avoided open areas, more prone to environmental disturbances (DE MARCO & RESENDE, 2004; FULAN & HENRY, 2007), such as *Perithemis lais*, *Telebasis limoncocha* and *Acanthagrion lancea*.

Although *E. latimaculata* is a territorial species, it is common to find males on perches along with other odonate species, mainly *E. fusca*, which are more engaged in territorial contests than *E. latimaculata* (RESENDE, 2010). *Erythro-*

diplax fusca, *Micrathyria hesperis*, and *Orthemis discolor* are species with similar activity periods to *E. latimaculata*, suggesting that these species are also affected by sunlight (DE MARCO, 1998; DE MARCO & RESENDE, 2002).

CONCLUSION

Erythrodiplax latimaculata prefers environments with high solar irradiation. It can be classified as a heliothermal percher. Thus, the ability to maintain body temperature is influenced by climate and behaviour. Most of the time, individuals were found perched with dropped wings. The higher abundance in areas with constant solar incidence shows that shadow impairs thermoregulation in this species, preventing it from increasing the body temperature to start its activities or to keep it constant throughout the day. Males choose perches and defend them aggressively in suitable breeding sites, where encounters with females are more common. Although receptive females are not found generally in these sites, defending an oviposition site can increase a male's chances to be chosen by a female, thus increasing the probability of copulation.

REFERENCES

ALCOCK, J., 1994. Post insemination associations between males and females in insects: the Mate-Guarding hypothesis. *Annu. Rev. Ent.* 39: 1-21.

ALTMANN, J., 1974. Observational study of behaviour: sampling methods. *Behaviour* 49: 227-267.

ASSIS, J.C.F., A.L. CARVALHO & J.L. NESSIMIAN, 2004. Composição e preferência por microhábitat de imaturos de Odonata (Insecta) em um trecho de baixada do Rio Ubatiba, Maricá-RJ, Brasil. *Revta brasil. Ent*. 48: 273-282.

BORROR, D.J., 1942. *A revision of the Libellulinae genus Erythrodiplax (Odonata)*. Ohio St. Univ., Columbus.

COLWELL, R.K. & J.A. CODDINGTON, 1994. Estimating terrestrial biodiversity through extrapolation. *Phil. Trans. R. Soc. Lond.* 345: 101-118.

CORBET, P.S., 1962. *A biology of dragonlies*. Witherby, London.

CORBET, P.S., 1999. *Dragonflies: behaviour and ecology of Odonata*, Harley, Colchester.

CORBET, P.S. & M.L. MAY, 2008. Fliers and perchers among Odonata: dichotomy or multidimensional continuum? A provisional reappraisal. *Int. J. Odonatol.* 11: 155-171.

CORDERO-RIVERA, A., [Ed.], 2006. *Forests and dragonflies*. Pensoft Sofia-Moscow.

COSTA, J.M., A.N. LOURENÇO & L.P. VIEIRA, 2002. Chave de identificação para imagos dos gêneros de Libellulidae citados para o Brasil: comentários sobre os gêneros (Odonata: Anisoptera). *Ent. Vect.* 9: 477-504.

DE MARCO, P., 1998. The Amazonian Campina dragonfly assemblage: patterns in microhabitat use and behaviour in a foraging habitat (Anisoptera). *Odanotologica* 27: 239-248.

DE MARCO, P., A.O. LATINI & D.C. RESENDE, 2005. Thermoregulatory constraints on behaviour: patterns in a neotropical dragonfly assemblage. *Neotrop. Ent.* 34: 155-162.

DE MARCO, P., A.O. LATINI & P.H.E. RIBEIRO, 2002. Behavioural ecology of Erythemis plebeja (Burmeister) at a small pond in southeastern Brazil (Anisoptera: Libellulidae). *Odonatologica* 31: 305-312.

DE MARCO, P. & D.C. RESENDE, 2002. Activity patterns and thermoregulation in a tropical dragonfly assemblage. *Odonatologica* 31: 129-138.

DE MARCO, P. & D. RESENDE, 2004. Cues for territory choice in two tropical dragonflies. *Neotrop. Ent.* 33: 397-401.

DE MARCO, P. & M.V.C. VITAL, 2008. Ecology of Tigriagrion aurantinigrum Calvert in response to variations in environmental conditions (Zygoptera: Coenagrionidae). *Odonatologica* 37: 1-11.

FERREIRA-PERUQUETTI, P. & P. DE MARCO, 2002. Efeito da alteração ambiental sobre comunidades de Odonata em riachos de Mata Atlântica de Minas Gerais, Brasil. *Revta brasil. Zool.* 19: 317-327.

FERREIRA-PERUQUETTI, P.S. & A.A. FONSECA-GESSNER, 2003. Comunidade de Odonata (Insecta) em áreas naturais de Cerrado e monocultura no nordeste do Estado de São Paulo, Brasil: relação entre o uso do solo e a riqueza faunística. *Revta brasil. Zool.* 20: 219-224.

FULAN, J.A. & R. HENRY, 2007. Distribuição temporal de imaturos de Odonata (Insecta) associados a Eichhornia azurea (Kunth) na Lagoa do Camargo, Rio Paranapanema, São Paulo. *Revta brasil. Ent.* 51: 224-227.

GARRISON, R.W., N. VON ELLENRIEDER & J.A. LOUTON, 2006. *Dragonfly genera of the New World. An illustrated and annotated key to the Anisoptera*, Johns Hopkins Univ. Press, Baltimore.

HECKMAN, C.W., 2006. *Encyclopedia of South American aquatic insects: Odonata -Anisoptera. Illustrated keys to known families, genera, and species*. Springer, Dordrecht.

KLINK, C.A. & R.B. MACHADO, 2005. A conservação do Cerrado brasileiro. *Megadiversidade* 1: 1-9.

KNOX, T.T. & M.P. SCOTT, 2005. Size, operational sex ratio, and mate-guarding success of the carrion beetle, Necrophila americana. *Behav. Ecol.* 17: 88-96.

MAY, M.L., 1976. Thermoregulation and adaptation to temperatures in dragonflies (Odonata: Anisoptera). *Ecol. Monogr.* 46: 1-32.

McMILLAN, V.E., 2000. Postcopulatory behaviour in Libellula pulchella Drury (Odonata: Libellulidae) and females tactics for avoiding male interference with oviposition. *J. Insect Behav.* 13: 583-207.

MILLER, P.L., 1995. Visually controlled head movements in perched anisopteran dragonflies. *Odonatologica* 24: 269-382.

OSBORN, R. & M.J. SAMWAYS, 1996. Determinants of adult dragonfly assemblage patterns at new ponds in South Africa. *Odonatologica* 25: 49-58.

PAULSON, D., 2006. The importance of forests to neotropical dragonflies. *In*: A. Cordero-Rivera, [Ed.], *Forests and dragonflies*, pp. 79-101, Pensoft, Sofia-Moscow.

RESENDE, D.C., 2010. Residence advantage in heterospecific territorial disputes of Erythrodiplax Brauer species (Odonata, Libellulidae). *Revta brasil. Ent.* 54: 110-114.

SAHLÉN, G., 2006. Specialists vs generalists among dragonflies: the importance of forest environments in the formation of diverse species pools. *In*: A. Cordero-Rivera, [Ed.], *Forests and dragonflies*, pp. 153-179, Pensoft, Sofia-Moscow.

SAMWAYS, M.J., 2006. Threat levels to odonate assemblages from invasive alien tree canopies. *In*: A. Cordero-Rivera [Ed.], *Forests and dragonflies*, pp. 209-224, Pensoft, Sofia-Moscow.

SILSBY, J., 2001. *Dragonflies of the world*. Smithsonian Institution Press, Washington, DC.

SILVA, D.P., P. DE MARCO & D.C. RESENDE, 2010. Adult odonate abundance and community assemblage measures as indicators of stream ecological integrity: a case study. *Ecol. Indic*. 10: 744-752.

ZAR, J.H., 1999. *Biostatistical analysis*. Prentice-Hall, Englewood Cliffs, New Jersey.

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REVIEW OF THE ODONATA OF BOSNIA AND HERZEGOVINA

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The current knowledge on the Odonata fauna of Bosnia and Herzegovina is summarized based on museum and private collections, literature and new unpublished data of the authors. In all, 63 spp. are known, including first reports of *Platycnemis pennipes nitidula*, *Anax parthenope, Gomphus flavipes, G. schneiderii, Cordulegaster heros* and *Selysiothemis nigra* for the country. *Caliaeschna microstigma* is rediscovered after more than 100 yr. The first reliable data on the occurrence of *Somatochlora metallica* is reported. More than 1,400 new records were collected and a national odonatol. database has been created. Annotations to the new spp. and to some other faunistically interesting species are given. Possible future additions to the fauna of Bosnia and Herzegovina are discussed.

INTRODUCTION

Bosnia and Herzegovina is located in the western part of the Balkan Peninsula (Fig. 1), between 42º26' and 45º15' N, and 15º45' and 19º41'E. The northern and central part is called Bosnia, while Herzegovina is situated in the south. The climate is moderate-continental in the northern part, sub-mountainous and mountainous in the central part and Mediterranean in the south, resulting in three distinct biogeographical regions and in a high diversity of habitats and species (REDŽIĆ et al., 2008). The most important habitats can be found in the karstic Dinaric Alps, which cover more than half of the country. The major part of them remains largely unexplored. To the north of the karst region lies the lowland region of Posavina, with the lower reaches of several large rivers and the Sava river that forms the natural border with Croatia. Locally, especially in the poljes or flat

fields, these ecosystems are threatened by increasing human exploitation, especially for agriculture practices and energy production (KULIJER, 2012).

Most historical data is based on voucher specimens found in the collections of the National Museum in Sarajevo. This collection comprises more than 660 specimens from Bosnia and Herzegovina and was collected between 1888 and 1932. First reports on the dragonfly fauna date from the end of 19th century. After Bosnia and Herzegovina became part of the Austrian-Hungarian Empire in 1878, the country became more accessible to foreign researchers and several papers were published on the dragonfly fauna (PETROVIĆ et al., 1891; PUSCHING, 1896; KLAPALEK, 1898; McLACHLAN, 1898). Various field surveys carried out mostly during the 20th century resulted in new data on dragonflies. As a result, many papers were published but most of them only give anecdotal information on dragonflies or concentrate on small region (i.e. MORTON, 1908; ADAMOVIĆ, 1949, 1967; MIKŠIĆ, 1953; GEORGIJEVIĆ & LUTERŠEK, 1966; GEORGIJEVIĆ, 1976; DUMONT, 1977; DELIRY & LOOSE, 1987; LOHMANN, 1992; KIAUTA & KOTARAC, 1995; BEDJANIČ, 2011). Based on material from the collection of the National Museum, the first comprehensive list of Odonata was published by ADAMOVIĆ (1948) and includes data on 45 species. Recently a review of all literature data was summarized by JOVIĆ et al. (2010a) and it also included some new records.

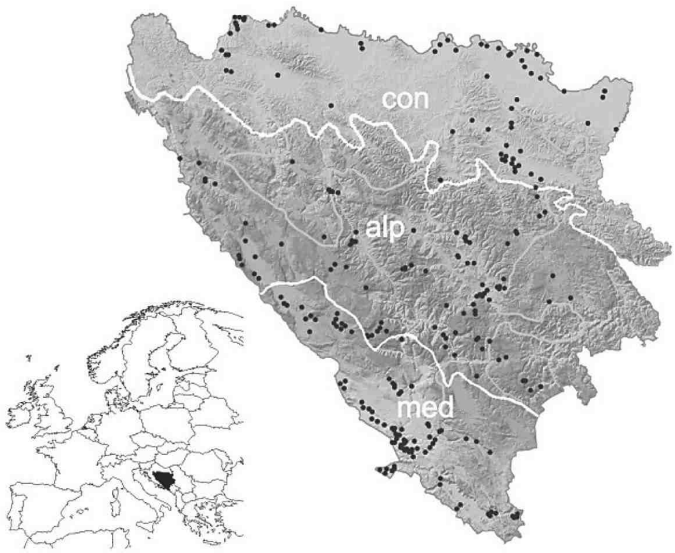

Fig. 1. Geographical position of Bosnia and Herzegovina in Europe, showing the localities from which new records were gathered (black dots). White lines indicate the border between the biogeographical regions, based on the European Environmental Agency (EEA), 2005.

In this paper we critically review existing data on the Odonata of Bosnia and Herzegovina and include many new, unpublished records, including five newly recorded species and one subspecies for Bosnia and Herzegovina. This contribution will serve as a baseline for future research and conservation.

MATERIAL AND METHODS

The checklist we present here is based on specimens found in the collections of the National Museum of Bosnia and Herzegovina in Sarajevo and the Croatian Natural History Museum in Zagreb and all published records known to the authors. Additionally more than 1,400 new records have been collected by the authors from 251 localities (Fig. 1). Most of these observations were made in the period 2009-2011. Specimens from the collection of the National Museum in Sarajevo, previously published by ADAMOVIĆ (1948), were re-examined and several corrections were made. Furthermore, many previously unknown specimens were found in this collection. Voucher specimens of all species are deposited at the National Museum in Sarajevo. Some of the collected specimens are deposited at the Croatian Natural History Museum and in the personal collections of the second and third authors.

All former and recent observations were georeferenced and included into one database. This database is stored at the National Museum in Sarajevo and managed by the first author. It is the intention that this database becomes the national database of dragonflies for Bosnia and Herzegovina and that it will serve as a valuable source of information for nature conservation and the protection of dragonflies and their habitats.

RESULTS

Alltogether 63 species have been found in Bosnia and Herzegovina (Tab. I). In recent years, more than 1,400 new records belonging to 59 species were collected. Five species, *Anax parthenope, Gomphus flavipes, G. schneiderii, Cordulegaster heros* and *Selysiothemis nigra* and one subspecies, *Platycnemis pennipes nitidula*, are reported here for the first time for Bosnia and Herzegovina. Our investigations resulted in the rediscovery of *Caliaeschna microstigma* after more than 100 years. *Somatochlora metallica* was previously reported by ADAMOVIĆ (1948) but re-examination of the collected specimens showed them to be all *Somatochlora meridionalis*. Our new record from Zelengora mountain is presently the only reliable record of the occurrence of *S. metallica* in Bosnia and Herzegovina. Of particular importance was the discovery of populations of several threatened European species such as *Coenagrion ornatum, Gomphus flavipes, Lindenia tetraphylla* and *Cordulegaster heros*.

Although most of the dragonfly specimens from the collection of the National Museum of Bosnia and Herzegovina are very old, they remain still an important source of information for the Balkan Peninsula (KULIJER & MARINOV, 2010). The knowledge of the dragonfly fauna of the country was mostly based on this collection, which was previously reviewed and resulted in the publication of ADAMOVIĆ (1948). Our revision of the collection in 2010 revealed the presence of additional specimens of some species previously not mentioned by

Table I

Checklist of the Odonata of Bosnia and Herzegovina and the total number of records for the country. – [med = Mediterranean; – alp = Alpine; – con = Continental; – nd = new data; – new species for the country are given in bold]. – Taxonomy follows DIJKSTRA & LEWINGTON (2006) and GYULAVARI et al. (2011) for *Chalcolestes*. For key to the bibliographic references, see footnote

Species	Biogeographical region			Total No. of records
	med	alp	con	
CALOPTERYGIDAE				
Calopteryx splendens (Harris, 1782)	1, 4, 6, 7, 11, 13, 15, 20, 27, nd	1, 11, 12, 13, 30, 35, nd	1, 13, 15, 23, nd	117
Calopteryx virgo (Linnaeus, 1758)	1, 6, 7, 13, 15, 22, 35, nd	1, 12, 13, 14, 19, 25, 35, nd	1, 13, 15, 17, nd	108
LESTIDAE				
Lestes sponsa (Hansemann, 1823)	15	1, 15, nd	15, 26, nd	26
Lestes dryas Kirby, 1890	nd	1, 15, nd	-	43
Lestes barbarus (Fabricius, 1798)	6, 7, 15, 19, nd	1, 19, nd	1, 15	53
Lestes virens (Charpentier, 1825)	nd	nd	1, 15, nd	22
Lestes macrostigma (Eversmann, 1836)	15	-	-	1
Chalcolestes viridis (Vander Linden, 1825)	1*, 6, 7, 15	nd	nd	4
Chalcolestes parvidens (Artobolevskii, 1929)	15, nd	15	nd	11
Sympecma fusca (Vander Linden, 1820)	1, 6, 7, 15, 19, nd	1, 15, nd	1, nd	40
COENAGRIONIDAE				
Ischnura elegans (Vander Linden, 1820)	1, 2, 3, 5, 6, 7, 9, 15, nd	1, 5, 15, 34, nd	15, nd	159
Ischnura pumilio (Charpentier, 1825)	1, 5, 15, nd	1, 5, nd	1,1 5, nd	49
Enallagma cyathigerum Charpentier, 1840	15, nd	1, 5, 15, nd	nd	50
Coenagrion pulchellum (Vander Linden, 1825)	1, 15, nd	1, 15, nd	1, nd	19
Coenagrion puella (Linnaeus, 1758)	5, 15, nd	1, 15, 23, 25, nd	1, nd	90
Coenagrion ornatum (Selys, 1850)	nd	1	1	5
Coenagrion scitulum (Rambur, 1842)	nd	1, nd	-	8
Coenagrion hastulatum (Charpentier, 1825)	-	5	-	2
Erythromma najas (Hansemann, 1823)	15, 19	-	nd	7
Erythromma viridulum (Charpentier, 1840)	15, nd	15, nd	15, nd	26
Erythromma lindenii (Selys, 1840)	2, 6, 7, 15, 19, nd	-	-	33
Pyrrhosoma nymphula (Sulzer, 1776)	5, 15, nd	1, 5, 35, nd	-	29
Ceriagrion tenellum (de Villers, 1789)	15, nd	1, nd	-	8
PLATYCNEMIDIDAE				
Platycnemis pennipes (Pallas, 1771)	1, 5, 6, 7, 9, 15, 19, nd	1, 14, 30, nd	1, 15, nd	138
AESHNIDAE				
Aeshna mixta Latreille, 1805	1, 13, 15, 19, nd	1, nd	26, nd	33
Aeshna affinis Vander Linden, 1820	1, 15, nd	15, 25, nd	15, nd	28
Aeshna isoceles (Müller, 1767)	1, 5, nd	1, nd	1, nd	35
Aeshna grandis (Linnaeus, 1758)	-	5, 13, 15, 24, 28, 29, nd	-	11
Aeshna cyanea (Müller, 1764)	13, 15, nd	1, 5, 13, 15, 25, 26, nd	1, nd	58
Aeshna juncea (Linnaeus, 1758)	-	1, 5, 15, nd	-	21
Anax imperator Leach, 1815	5, 9, 13, 15, 18, 23, nd	1, 24, nd	1, nd	72
***Anax parthenope* (Selys, 1839)**	nd	nd	nd	17
Anax ephippiger (Burmeister, 1839)	1, nd	nd	-	4
Brachytron pratense (Müller, 1764)	1, nd	nd	1, 26, nd	16
Caliaeschna microstigma (Schneider, 1845)	1, nd	-	-	5

Table I, continued

Species	Biogeographical region med	alp	con	Total No. of records
GOMPHIDAE				
Gomphus vulgatissimus (Linnaeus,1758)	1, 13, 15, 21, 22, 25, nd	nd	1, 13, nd	34
***Gomphus flavipes* (Charpentier, 1825)**	-	-	nd	3
***Gomphus schneiderii* Selys, 1850**	nd	-	-	1
Onychogomphus forcipatus (Linnaeus,1758)	1, 9, 15, 25, nd	25, nd	1, 16, 17, nd	54
Lindenia tetraphylla (Vander Linden, 1825)	15, nd	-	-	3
CORDULEGASTERIDAE				
***Cordulegaster heros* Theischinger,1979**	nd	nd	nd	13
Cordulegaster bidentata Selys, 1843	1, 25, nd	1, 5, 19, nd	nd	33
CORDULIIDAE				
Cordulia aenea (Linnaeus, 1758)	nd	5, 15, nd	1, nd	16
Somatochlora metallica (Vander Linden, 1825)	-	nd	1**	1
Somatochlora meridionalis Nielsen, 1935	9, 15, nd	nd	nd	16
Somatochlora flavomaculata (Vander Linden, 1825)	15, nd	nd	-	7
Epitheca bimaculata (Charpentier, 1825)	-	-	1	1
LIBELLULIDAE				
Libellula quadrimaculata Linnaeus, 1758	5, nd	1, 5, 15, nd	nd	31
Libellula depressa Linnaeus, 1758	5, 9, 13, 15, nd	1, 12, 13, 15, 19, nd	1, nd	67
Libellula fulva (Müller, 1764)	1, 5, 6, 7, 15, nd	nd	nd	35
Orthetrum cancellatum (Linnaeus, 1758)	2, 5, 6, 7, 9, 15, 23, nd	15, nd	nd	61
Orthetrum albistylum (Selys, 1848)	nd	1, nd	1, 15, nd	32
Orthetrum coerulescens (Fabricius, 1798)	15, 35, nd	1, 15, 23, 25, 32, nd	1, nd	42
Orthetrum brunneum (Fonscolombe, 1837)	5, 9, 15, 19, nd	1, 23, 32	nd	29
Leucorrhinia pectoralis (Charpentier, 1825)	-	-	1, 10	1
Sympetrum sanguineum (Müller, 1764)	1, 2, 8, 9, 15, 23, 33, nd	1, 15, 30, nd	1, 15, nd	113
Sympetrum flaveolum (Linnaeus, 1758)	5, 15, 19, nd	1, 15, 23, 24, 25, 33, 35, nd	-	54
Sympetrum fonscolombii (Selys, 1840)	1, 2, 9, 15, nd	15, nd	nd	36
Sympetrum striolatum (Charpentier, 1840)	1, 6, 7, 15, nd	1, 19, 25, nd	nd	49
Sympetrum vulgatum (Linnaeus, 1758)	-	nd	31, nd	3
Sympetrum meridionale (Selys, 1841)	9, 15, 19, 25, nd	15, 19, nd	nd	37
Crocothemis erythraea (Brullé, 1832)	1, 2, 5, 9, 13, 15, nd	15, nd	nd	71
***Selysiothemis nigra* (Vander Linden, 1825)**	nd	-	-	27
Total number of species	55	53	46	2216

* reported species is *Lestes parvidens*; – ** reported species is *Somatochlora meridionalis*; – key to bibliographic references: 1: ADAMOVIĆ (1948; includes most material from the Victor Apfelbeck collection, 1888-193, in Natn. Mus. Sarajevo); – 2: ADAMOVIĆ (1949); – 3: ADAMOVIĆ (1967); – 4: ADAMOVIĆ & VIJATOV (1996); – 5: BEDJANIČ (2011); – 6: BOGDANOVIĆ ET AL. (2008; records from Bukvić, 1998); – 7: BUCKVIĆ (1998); – 8: DELIRY & LOOSE (1987); – 9: DUMONT (1977); – 10: FRANKOVIĆ (1991; records from Adamović, 1948); – 11: FUDAKOWSKI (1930); – 12: GEORGIJEVIĆ & LUTERŠEK (1966); – 13: GEORGIJEVIĆ (1976); – 14: JOVIĆ & MIHAJLOVA (2009); – 15: JOVIĆ et al. (2010a); – 16: KEROVEC (2005a); – 17: KEROVEC (2005b); – 18: KIAUTA & KOTARAC (1995); – 19: KLAPALEK (1898); – 20: LOHMANN (1992); – 21: MATONOČKIN & PAVLETIĆ (1960); – 22: MATONIČKIN & PAVLETIĆ (1963); – 23 McLACHLAN

(1898); – 24: MIKŠIĆ (1953); – 25: MORTON (1908); – 26: PETROV (1891); – 27: PONGRAC (2000); – 28: PROTIĆ (1925); – 29: PROTIĆ (1927); – 30: PUSCHNIG (1896); – 31: RADEVIC et al. (2002); – 32: RIS (1909-1910); record published previously by McLachlan, 1898); – 33: RIS (1911-1912; record published previously by McLachlan, 1898); – 34: ŠENK (1956); – 35: VUKIĆ (1992)

Adamović and in the examination of the specimens collected after his review. Additional corrections were made for several species as a result of new taxonomic viewpoints. More details are given in the annotations to species.

ANNOTATIONS TO SOME SPECIES

The taxonomic status and distribution of the different subspecies of ***Calopteryx splendens*** in the Balkans has been discussed by many researchers, e.g. FUDAKOWSKI (1930), DUMONT (1977), ADAMOVIĆ & VIJATOV (1996), OLIAS & SERBEDIJA (1998) and PONGRAC (2000), but the status of the populations in Bosnia and Herzegovina is still insufficiently known. Three taxa of this variable species have been reported from Bosnia and Herzegovina. *Calopteryx splendens ancilla* was reported by ADAMOVIĆ & VIJATOV (1996) and PONGRAC (2000), while FUDAKOWSKI (1930) described *Calopteryx splendens balcanica* based on specimens from southern Herzegovina and Dalmatia (Croatia). The latter subspecies was later reported from southern Herzegovina and Dalmatia by several other researchers, e.g. ADAMOVIĆ (1967), DUMONT (1977), ADAMOVIĆ & VIJATOV (1996), BELANČIĆ et al. (2008) and JOVIĆ et al. (2010a). Based on our data *Calopteryx splendens balcanica* is confined to the Mediterranean part of the country (Trebinje, Stolac, Hutovo Blato, Ljubuški). The type subspecies *Calopteryx splendens splendens* was reported by FUDAKOWSKI (1930) from a single locality in central Bosnia. In regard to the wing spot size and pigmentation of the wings, specimens found in most parts of Bosnia and Herzegovina resemble ssp. *ancilla*.

In Europe, ***Lestes macrostigma*** is largely confined to brackish waters, both coastal and inland, and is mainly found in the Mediterranean region (BOUDOT et al., 2009). Recently, the species was observed at some ponds at Seline, near the Bilečko lake, close to the border with Montenegro (JOVIĆ et al., 2010a). An unconfirmed record exists from some ponds northeast and southeast of Trebinje (B. Gligorović, pers. comm.). It is unclear if local populations are present or if these refer to vagrant individuals.

The distribution ranges of the closely related species ***Chalcolestes viridis*** and ***C. parvidens*** overlap widely in the Balkans (OLIAS et al., 2007; BOUDOT et al., 2009). Historical records from Stolac and Domanovići were reported by ADAMOVIĆ (1948) as *C. viridis* but, after re-examination of the specimens, it turned out to be *C. parvidens.* Our data demonstrate that both species are present in all three regions of Bosnia and Herzegovina. At the moment, more records of

C. parvidens are known. Both species co-exist at Modrac lake in north-western Bosnia. The precise sympatric zone of both species and if hybridization occurs and at what level is insufficient known.

Coenagrion ornatum is Near Threatened species in Europe (KALKMAN et al., 2010) which was previously only known from two localities (ADAMOVIĆ, 1948). A specific field survey conducted in 2011 revealed that the species inhabits several karst poljes in Herzegovina (KULIJER, 2012; unpublished data). Karst poljes (or karst fields) are one of the specific habitats present in the Dinaric Alps and are flooded during winter months. The majority of karst fields of southeastern Europe are found in Bosnia and Herzegovina. They occur in the Mediterranean and in the Alpine region from 80 up to 1200 m a.s.l. As most of them are still poorly investigated, we expect that more local populations of *C. ornatum* will be found here in the future.

Erythromma najas was first mentioned by KLAPALEK (1898) from three localities in the region of Mostar. More than a century later new records were collected from several localities near the artificial Bilećko lake in eastern Herzegovina (JOVIĆ et al., 2010a) and by DK in 2011 at one pond close to Modrac lake in northern Bosnia. Compared to its congener *E. viridulum* (26 records), *E. najas* (7 records) is much scarcer. Although it is more common in central and northern Europe than in the Mediterranean part (BOUDOT et al., 2009), most records from Bosnia and Herzegovina come from the south. This is probably due to a better knowledge of this area.

Ceriagrion tenellum is a mainly western Mediterranean species that in the Balkans is confined to a narrow belt along the Adriatic coast and to some Greek islands (KALKMAN, 2005; BOUDOT et al., 2009). Our research in 2010 confirmed an old record from Boračko lake previously reported by ADAMOVIĆ (1948). The species was also found at several localities at Hutovo Blato Nature Park. Boračko lake is located in the northern part of Herzegovina, away from the coastal belt but still influenced by the warm Mediterranean climate through the Neretva river valley. Furthermore JOVIĆ et al. (2010a) reported the species from one locality near Trebinje. It is likely that more populations could be found in the southern part of the country.

Two subspecies of ***Platycnemis pennipes*** are present in Bosnia and Herzegovina. The nominal subspecies *pennipes* occurs in the major part of the country. The subspecies *nitidula* is restricted to the extreme southern part and was only discovered in 2009 at Hutovo Blato Nature Park and in 2011 at Jazina (Trebinje), both by GDK. The morphology and distribution of *P. p. nitidula* in the Balkans is discussed by ADAMOVIĆ & VIJATOV (1997). They considered Skadar lake in Montenegro as the most western location. This range has been extended by the findings of JOVIĆ et al. (2008) and DE KNIJF et al. (2013) in the Mediterranean part of Montenegro, where the species is common. Our findings in the southern part of Bosnia and Herzegovina extend the range of this subspecies

further to the west.

A field campaign carried out in 2009 at Zelengora mountain in the eastern part of Herzegovina resulted in the discovery of populations of ***Aeshna grandis*** at three mountain lakes (JOVIĆ et al., 2010a; this paper). Although JOVIĆ et al. (2010a) considered the records as the first for Bosnia and Herzegovina, the species was already known for the country. PROTIĆ (1925, 1927) found larvae while collecting zooplankton at several lakes. As the identification was only based on larvae that were not preserved, his records should be taken with reservation. Later *A. grandis* was found at Treskavica mountain by MIKŠIĆ (1953) and by GEORGIJEVIĆ (1976) from several localities. It is currently only known from mountain lakes in the central part of the country. The record from Drina river in Serbia (JOVIĆ et al., 2010b) at the border with Bosnia and Herzegovina suggests that the species might also be present in the northern lowland area.

Although known from all neighbouring countries, ***Anax parthenope*** had never been observed in Bosnia and Herzegovina. Field surveys in 2009, 2010 and 2011 resulted in the discovery of the species at several localities. At some localities, such as Hutovo Blato, Boračko and Modrac lake, the species was very abundant.
Most observations of ***Anax ephippiger*** from Bosnia and Herzegovina date from early spring and originate from the Mediterranean part. In July 2009 one teneral specimen was collected at Haljinići ponds in the central part of the country. This was the first proof of reproduction of this migrant species in the country.

Before our study, ***Caliaeschna microstigma*** was only known from a male collected in Mostar and found in the collection of the National Museum. A specific search for this species in 2011 resulted in the discovery of several new localities in the river valleys of Trebižat and Tihaljina, in the southern part of the country. At those localities exuviae, tenerals and adults were observed. These new localities in the southern part of Bosnia and Herzegovina are, together with the localities along the Dalmatian coast in Croatia, the most western populations of this species in Europe.

Another new species for Bosnia and Herzegovina is ***Gomphus flavipes***, which was found in June and July of 2011. Exuviae were collected at three localities along the river Sava in northern Bosnia, on the border with Croatia. Its presence was expected as *G. flavipes* is a common species along the Sava and Danube river in Croatia and Serbia (ADAMOVIĆ, 1948, 1949; FRANKOVIĆ & VILENICA, 2009; VILENICA et al., 2011). The species has also been recorded from the region of Skadar lake in Montenegro (GLIGOROVIĆ & PEŠIĆ, 2007).

The distinction between ***Gomphus schneiderii*** and *G. vulgatissimus* was, until very recently, mainly based on the coloration of the eyes and on the geographical separation, whereby the blue-eyed *G. schneiderii* is restricted to Turkey and southern Greece (DIJKSTRA & LEWINGTON, 2006; BOUDOT et al., 2009). A small zone of co-occurrence is known from northern Greece (LOPAU, 2010). Recently, several populations of *G. schneiderii*, which lack the clear blue eyes, were

discovered in Montenegro (DE KNIJF et al., 2013). They differ of *G. vulgatissimus* in that the superior appendages are curved upwards and have a widening tip, and the vulvar scale is short, blunt and has a clear rounded tip. The underside of the thorax, behind the third pair of the legs is clearly yellow (DE KNIJF et al., 2013). Our finding in the most southeastern part of the country extends the presence of *G. schneiderii* a little further west. We expect the species to be found at some other localities but limited to the warmest part of the country.

Many records of ***Lindenia tetraphylla*** in the Mediterranean probably refer to temporary populations or wandering specimens (SCHORR et al., 1998; BOUDOT et al., 2009). Several strong populations are known from countries along the eastern Adriatic coast. Probably the most important population is found at Skadar lake in Montenegro (DE KNIJF et al., 2013). More close by, a population occurs in the delta of the Neretva river, a wetland area shared between Croatia and Bosnia and Herzegovina. *L. tetraphylla* was first mentioned for Bosnia and Herzegovina at Hutovo Blato Nature Park by BEDJANIĆ & BOGDANOVIĆ (2006) but without any further details. While visiting this site, we observed single individuals. Additionally, JOVIĆ et al. (2010a) reported two males from Trebinje in the southeast of Herzegovina. We have no indication if a local population occurs in Bosnia and Herzegovina. It is possible that all observed individuals are just wandering from nearby populations such as from the Neretva river delta in Croatia (BELANČIĆ et al., 2008; BOGDANOVIĆ et al., 2008) or from Skadar lake in Montenegro (DE KNIJF et al., 2013). We presume that at least temporary populations exist in Bosnia and Herzegovina, which probably act as sink populations from wandering individuals from Croatia and Montenegro.

Cordulegaster heros is another new species for Bosnia and Herzegovina. It was found for the first time in 2007 at the spring of the river Tihaljina, soon followed by more observations at several other streams and small rivers in the southern part of the country. In 2011 it was also found in the northern part of Bosnia at several small tributaries of the river Una. It was expected there, as several populations occur in nearby Croatia (FRANKOVIĆ & VILENICA, 2009). *C. bidentata* is the common species in the central part of the country, which is dominated by high mountains and numerous small streams. Nevertheless, many streams and small rivers in the lower part of the valleys look to be very promising habitats for *C. heros*. ADAMOVIĆ (1967) mentions also the presence of *C. boltonii* (cited as *Cordulegaster annulatus*) from Bosnia but without giving further details. He refers to an older paper by himself on the collection of Sarajevo Museum (ADAMOVIĆ, 1948), where this species is mentioned from a single locality in eastern Serbia. Later ADAMOVIĆ et al. (1992) refers to the two specimens from eastern Serbia as *C. heros*. KULIJER & BOUDOT (2013) reviewed these specimens from Serbia and concluded that they belong to *C. insignis*. Other specimens of *C. boltonii*, *C. heros* or *C. insignis* were not found in the collection of the National Museum in Sarajevo.

Somatochlora metallica is a rather rare species in southeast Europe (BOUDOT et al., 2009) where it is mostly restricted to high altitudes (DE KNIJF et al., 2013). ADAMOVIĆ (1948) mentions the species as being found in the area of Derventa in the northern lowland area. His findings were based on several specimens present in the collection of the National Museum in Sarajevo. These specimens were checked and turned out to be all *S. meridionalis*. It was only in 2009 that *S. metallica* was for the first time discovered in Bosnia and Herzegovina. A male was collected by DK at Donje Bare lake, Zelengora mountain, in eastern Herzegovina and remains the only observation for the country. More research in the Dinaric Alps may yield more observations, as suitable habitats are present at more localities. When *S. metallica* and *S. meridionalis* co-occure in the same region, the former tends to be found at lakes and bogs at high altitudes, the latter at lowland streams (MARINOV, 2001; DIJKSTRA & KALKMAN, 2012; MILL, 2012).

Orthetrum coerulescens is a widespread species in Bosnia and Herzegovina. Both subspecies, *O. c. coerulescens* and *O. c. anceps* have been previously reported for the country. The status and the distribution of these taxa in Europe were discussed in details by MAUERSBERGER (1994). Both ssp. overlap in a large part of the Balkan, where often intermediate forms can be found. ADAMOVIĆ (1948) reported both ssp. from Bosnia based on specimens present in the collection in the Museum of Sarajevo. We reviewed these specimens and concluded that they belong to the ssp. *anceps* or to an intermediate phenotypes. McLACHLAN (1898) presented one record of *O. c. anceps* from Sarajevo (reported as *O. ramburii*). MAUERSBERGER (1994) mentioned pure *O. anceps* and hybrids of both taxa from Croatia, Montenegro and Serbia. Our observations confirm the presence of *O. c. anceps* and hybrids in Bosnia and Herzegovina. Most of the observed individuals belong to intermediate phenotypes that are closer to the ssp. *anceps*. Individuals with fully pruinose abdomen and thorax are also found, especially in the southern part.

Sympetrum vulgatum is the rarest of the six *Sympetrum* species occurring in Bosnia and Herzegovina and is only known from three localities. It was for the first time mentioned for Bosnia and Herzegovina by RADEVIĆ et al. (2002) from Bardača fishponds in the north of Bosnia. This observation could unfortunately not be checked. In 2009, DK found the species at Haljinići ponds and at Plivska lakes in the central part. The species is probably more common, especially in the north.

Selysiothemis nigra has a very scattered distribution in the Mediterranean (BOUDOT et al., 2009). Our records are the first for Bosnia and Herzegovina. Its presence was expected in the southern part of the country considering the number of observations in neighbouring coastal areas of Croatia and Montenegro (BELANČIĆ et al., 2008; DE KNIJF et al., 2013). *S. nigra* has been found to be locally very common in the south of Herzegovina, even very abundant such as in Hutovo Blato in 2009 and 2010.

DISCUSSION

For the compilation of the list of dragonfly species from Bosnia and Herzegovina, we used all specimens contained in the collection of the Museums of Sarajevo and Zagreb, records published by several authors and many new data collected by the authors. The collections of the National Museum of Sarajevo were criticaly checked and, if necessary, corrected. All this resulted in more than 2200 records of 63 species of Odonata being found in Bosnia and Herzegovina. All these data are now stored in an odonatological database which is managed by the first author. Although many records were collected within the last few years, the total number of records remains quite low. This can be explained by the nearly complete lack of old data, especially from the last 50 years. Many areas are still under investigated, partly due to recent war activities and numerous minefields that are still present.

More than 100 records are available of five species (Tab. I). The species which has been observed most is *Ischnura elegans* (159 records), followed by *Platycnemis pennipes* (138), *Calopteryx splendens* (117), *Sympetrum sanguineum* (113) and *Calopteryx virgo* (108). At the other end of the list are five species which are only known from a single record. These are *Lestes macrostigma, Gomphus schneiderii, Epitheca bimaculata, Somatochlora metallica and Leucorrhinia pectoralis.* No recent records of *E. bimaculata* and of *L. pectoralis* are available. As could be expected, the Mediterranean region of Bosnia and Herzegovina with 55 species present (Tab. I) has the highest diversity. The Alpine region hosts 53 species despite its less favourable climate for dragonflies. Only 46 species were observed in the Continental region. The regional diversity probably reflects more research intensity in the different regions rather than real differences in species richness.

The topography and the climate are the main factors that influence the diversity and distribution of dragonflies in Bosnia and Herzegovina. The Dinaric Alpine mountain system extends in a northwest-southeast direction and forms a barrier for many species. South of it, lays the Mediterranean part of the country, which holds populations of *Caliaeschna microstigma, Gomphus schneiderii, Lindenia tetraphylla* and *Selysiothemis nigra*. Several mountain lakes, ponds and bogs are found in the Alpine region. They are home to species with a more central and northern distribution in Europe. Populations of *Coenagrion hastulatum*, *Aeshna grandis*, *A. juncea*, and *Somatochlora metallica* are confined to those specific habitats in Bosnia and Herzegovina and are here at their edge of their ranges (DIJKSTRA & LEWINGTON, 2006; BOUDOT et al., 2009; BEDJANIĆ, 2011; DE KNIJF et al., 2013). The northern part of Bosnia belongs to the Continental region and is characterised by several large rivers and numerous oxbows along the Sava river. This is the region where *Gomphus flavipes*, *Epitheca bimaculata* and *Leucorrhinia pectoralis* have been seen. The presence of *E. bimaculata* and

L. pectoralis requires confirmation, as only single observations from more than 100 years ago exist.

Dragonflies are not protected at all in Bosnia and Herzegovina and no Red List is available. Six species of European concern are found in Bosnia and Herzegovina. *Coenagrion ornatum, Lindenia tetraphylla, Cordulegaster heros, Gomphus flavipes* and *Leucorrhinia pectoralis* are all listed in the Annexes II and/or IV of the Habitats Directive. *L. tetraphylla, G. flavipes* and *L. pectoralis* are also mentioned in Annex II of the Bern convention. Two species, *Lestes macrostigma* and *Lindenia tetraphylla* were assessed as Vulnerable, and *Coenagrion ornatum* and *Cordulegaster heros* were classified as Near threatened in the European Red List (KALKMAN et al., 2010). Based on the present data and on our expert judgement we consider 13 species as rare and potentially threatened. *Lestes macrostigma Ceriagrion tenellum*, *Caliaeschna microstigma*, *Gomphus schneiderii, Lindenia tetraphylla* and *Selysiothemis nigra* are all confined to the Mediterranean region whereas *Coenagrion hastulatum, Aeshna grandis* and *Somatochlora metallica* are restricted to lakes and ponds at higher altitudes in the mountain region. Four species, *Erythromma najas*, *Epitheca bimaculata, Leucorrhinia pectoralis* and *Sympetrum vulgatum* are very rare in the country.

Although several new species have been discovered during the last few years, we expect that the list of species will be augmented in the near future. Several species are present in neighbouring parts of Croatia, Serbia or Montenegro and suitable habitats seems to be present in Bosnia and Herzegovina. *Ophiogomphus cecilia* is a common species along large rivers in the adjacent lowland area in Croatia (BELANČIĆ et al., 2008) and the presence of populations along Sava river and its larger tributaries seems very likely. Another species which can be expected to occur in this part of Bosnia and Herzegovina is *Leucorrhinia caudalis.* A population exists in Lonjsko polje area in Croatia (BELANČIĆ et al., 2008) close to the border. Numerous mountain lakes and small fragmented *Sphagnum* bogs occurs at an altitude from 1,400 to 1,800 m a.s.l. in Bosnia and Herzegovina. This is the area where it would be useful to search for *Somatochlora arctica* or *Leucorrhinia dubia*. Populations of *L. dubia* can be found in nearby mountain ranges in Serbia and Montenegro (JOVIĆ et al., 2010a; DE KNIJF et al., 2013). *Trithemis annulata* has expanded its range during the last few decades in Europe, especially in the western Mediterranean (BOUDOT et al., 2009). Nevertheless, the species remains very rare in southeastern Europe and is only found in Greece (BOUDOT et al., 2009). In the last few years, some populations were discovered in Montenegro (DE KNIJF et al., 2013).

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REFERENCES

ADAMOVIĆ, Ž.R., 1948. La liste de la collection des odonates du Musée d'Etat à Sarajevo. *Godišnjak biol. Inst. Saraj.* 1: 79-84. – [Serbian, with Fr. s.]

ADAMOVIĆ, Ž.R., 1949. La liste des odonates du Muséum d'Histoire Naturelle du Pays Serbe. *Glas. prir. Muz. srp. Zeml.* (B) 1/2: 275-293. – [Serbian, with Fr. s.]

ADAMOVIĆ, Ž.R., 1967. Odonata collected in Dubrovnik district, Jugoslavia. *Dt. ent. Z.* (N.F.) 14(3/4): 285-302.

ADAMOVIĆ, Ž.R., LJ. ANDJUS & A. MLADENOVIĆ, 1992. Cordulegaster heros Theischinger, 1979 in Serbia and Macedonia (Odonata: Cordulegastridae). *Opusc. zool. flumin.*101: 1-11.

ADAMOVIĆ, Ž.R. & S.T. VIJATOV, 1996. Morphometric examination of Calopteryx balcanica Fudakowski, 1930 and C. splendens ancilla Selys, 1853 (Zygoptera: Calopterygidae). *Odonatologica* 25(2): 109-118.

ADAMOVIĆ, Ž.R. & S.T. VIJATOV, 1997. Morphometric distinction of Platycnemis pennipes nitidula Brullé, 1832 from P. p. pennipes Pallas, 1771 (Odonata: Platycnemididae). *Acta ent. serb*. 2(1/2): 61-75.

BEDJANIĆ, M., 2011. Coenagrion hastulatum (Charpentier, 1825), new for the dragonfly fauna of Bosnia and Herzegovina (Odonata: Coenagrionidae). *Natura Sloveniae* 1(2): 31-36.

BEDJANIĆ, M. & T. BOGDANOVIĆ, 2006. Regional guide to dragonflies: other states of former Yugoslavia. *In*: K.-D.B., Dijkstra & R. Lewington, *Field guide to the dragonflies of Britain and Europe*, p. 57, British Wildlife Publishing, Dorset.

BELANČIĆ, A., T. BOGDANOVIĆ, M. FRANKOVIĆ, M. LJUŠTINA, N. MIHOKOVIĆ & B. VITAS, 2008. *Red data book of dragonflies of Croatia*. St. Inst. Nature Prot., Zagreb. – [Croat., with Engl. s.]

BOGDANOVIĆ, T., E. MERDIĆ & J. MIKUSKA, 2008. Data to the dragonfly fauna of Lower Neretva river. *Ent. Croat.* 12(2): 51-65.

BOUDOT, J.-P., V.J. KALKMAN, M. AZPILICUETA AMORÍN, T. BOGDANOVIĆ, A. CORDERO RIVERA, G. DEGABRIELE, J.-L. DOMMANGET, S. FERREIRA, B. GARRIGÓS, M. JOVIĆ, M. KOTARAC, W. LOPAU, M. MARINOV, N. MIHOKOVIĆ, E. RISERVATO, B. SAMRAOUI & W. SCHNEIDER, 2009. Atlas of the Odonata of the Mediterranean and North Africa. *Libellula* (Suppl.) 9: 1-256.

BUKVIĆ, V., 1998. *Fauna of dragonflies (Odonata, Insecta) of the Neretva Delta*. Dipl. thesis, Univ. Zagreb, Zagreb. – [Croat.]

DE KNIJF, G., C. VANAPPELGHEM & H. DEMOLDER, 2013. Odonata from Montenegro, with notes on taxonomy, regional diversity and conservation. *Odonatologica* 42(1): 1-29.

DELIRY, C. & D. LOOSE, 1987. Notes odonatologiques de Grèce et de Yougoslavie. *Sympetrum* 1: 3-22.

DIJKSTRA, K.-D.B. & V.J. KALKMAN, 2012. Phylogeny, classification and taxonomy of European dragonflies and damselflies (Odonata): a review. *Org. Divers. Evol*. 12(3): 209-227.

DIJKSTRA, K.-D.B. & R. LEWINGTON, [Eds], *Field guide to the dragonflies of Britain and Europe*. British Wildlife Publishing, Gillingham.

DUMONT, H.J., 1977. Sur une collection d'odonates de Yougoslavie, avec notes sur la faune des territoires adjacents de Roumanie et de Bulgarie. *Bull. Ann. Soc. roy. Belge Ent.* 113: 187-209.

EUROPEAN ENVIRONMENTAL AGENCY [EEA], 2005. *Biogeographical regions of Europe.* http://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-2005

FRANKOVIĆ, M., 1991. Review of Leucorrhinia records in Croatia and other successor states of the former Yugoslavia (Anisoptera: Libellulidae). *Notul. odonatol.* 3(8): 118-119.

FRANKOVIĆ, M. & M. VILENICA, 2009. *Studija inventarizacije vretenaca (Odonata) donjeg dijela rijeke Une i priobalnog pojasa*. St. Inst. Nature Prot., Zagreb. – [Croat.]

FUDAKOWSKI, J., 1930. Über die Formen von Calopteryx splendens Harr. aus Dalmatien und

Herzegovina (Odonata). *Annls Mus. zool. pol.* 9(6): 57-63.
GEORGIJEVIĆ, E., [Ed.], 1976. Prilog poznavanju entomofaune Šuma Bosne i Hercegovine. *Šumarski fakultet i Institut za sumarstvo u Sarajevu, posebno izdanje br.* 10: 51-53. − [Bosnian, with Engl. s.]
GEORGIJEVIĆ, E. & D. LUTERŠEK, 1966. Prilog poznavanju entomofaune Šuma BiH. *Rad. šum. Fak. Inst. Šum. Saraj.* 11(5): 19. − [Bosnian, with Germ. s.]
GLIGOROVIĆ, B. & V. PEŠIĆ, 2007. A contribution to knowledge of the dragonflies (Odonata) from the Skadar lake drainage basin (Montenegro). *Acta ent. serb.* 12(2): 11-16.
GYULAVARI, H. A., T. FELFOLDI, T. BENKEN, L.J. SZABO, M. MISKOLCZI, C. CSERHATI, V. HORVAI, K. MAÍRIALIGETI & G. DÉVAI, G. 2011. Morphometric and molecular studies on the populations of the damselflies Chalcolestes viridis and C. parvidens (Odonata, Lestidae). *Int. J. Odonatol.*14: 329-339.
JOVIĆ, M., LJ. ANDJUS, M. BEDJANIĆ & S. SANTOVAC, 2008. Review of the Odonata fauna of Montenegro. *Opusc. zool. flumin.* 224: 1-27.
JOVIĆ, M., B. GLIGOROVIĆ & M. STANKOVIĆ, 2010a. Review of faunistical data on Odonata in Bosnia and Herzegovina. *Acta ent. serb.* 15(1): 7-27
JOVIĆ, M. & B. MIHAJLOVA, 2009. Catalogue of the Odonata collection in the Macedonian Museum of Natural History. *Acta ent. serb.* 14(2): 133-146.
JOVIĆ, M., M. STANKOVIĆ & LJ. ANĐUS, 2010b. Aeshna grandis (Linnaeus 1758) – A new species in Serbian fauna (Odonata: Aeshnidae). *Bull. nat. Hist. Mus.*, Belgrade 3: 137-140.
KALKMAN, V. J., 2005. On the distribution of the genus Ceriagrion in the Balkans, including C. georgifreyi, a species newfor the European fauna (Odonata: Coenagrionidae). *Libellula* (Suppl.) 6: 25-32.
KALKMAN, V.J., J.-P. BOUDOT, R. BERNARD, K.-J. CONZE, G. DE KNIJF, E. DYATLOVA, S. FERREIRA, M. JOVIĆ, J. OTT, E. RISERVATO & G. SAHLEN, 2010. *European Red List of dragonflies*. Publs Off. Europ. Un., Luxembourg.
KEROVEC, M., 2005a. *Biomonitoring sliva rijeke Une - ocjena kakvoće temeljem analize makrozoobentosa*. Univ. Bihać, Bihać. − [Croat.]
KEROVEC, M., 2005b. *Biomonitoring sliva rijeke Une - ocjena kakvoće temeljem analize makrozoobentosa*. Univ. Bihać, Bihać. − [Croat.]
KIAUTA, B. & M. KOTARAC, 1995. Two dragonfly records from karst caves in Bosnia-Herzegovina and Slovenia (Anisoptera: Aeshnidae, Corduliidae). *Notul. odonatol.* 4(6): 106-107.
KLAPALEK, F., 1898. Zprava o neuropterach a pseudoneuropterach sbiranih v Bosne a Hercegovine. *Vest. čzeske Akad. Cis. Františka Josefa* 7(2): 126-134.
KULIJER, D., 2012. Odonata species and habitats at Livanjsko polje karst wetland area. *Int. Dragonfly Fund Rep.* 48: 1-38.
KULIJER, D. & J.-P. BOUDOT, 2013. First evidence of the occurrence of Cordulegaster insignis Schneider, 1845 in Serbia (Anisoptera: Cordulegastridae). *Odonatologica* 42(1): 55-62.
KULIJER, D. & M. MARINOV, 2010. Odonata from Bulgaria in the collection of National Museum of Bosnia and Herzegovina. *Acta ent. serb.* 15(2): 161-169.
LOHMANN, H., 1992. Amphiadriatic faunal elements in genera Calopteryx Leach and Cordulegaster Leach in southern Italy (Zygoptera: Calopterygidae; Anisoptera: Cordulegasteridae). *Notul. odonatol*. 3(9): 152-153.
LOPAU, W., 2010. Verbreitungsatlas der Libellen in Griechenland (Odonata). *Libellula* (Suppl.) 10: 5-153.
MARINOV, M., 2001. The genus Somatochlora Selys in Bulgaria. *Int. Dragonfly Fund Rep.* 3(1/2): 46-53.
MATONIČKIN, I. & Z. PAVLETIĆ, 1960. The participation of the single animals and plants groups in building of the life communities on the travertine and erosive falls in Bosnia and Herzegowina. *Godišnjak biol. Inst. Saraj.* 13(1/2): 41-62. − [Croat., with Engl. s.]

MATONIČKIN, I. & Z. PAVLETIĆ, 1963. Biocenological relations of the Kravica fall on the river Trebižat in Herzegovina. *Acta biol.* 32: 15-53. – [Croat., with Engl. s.]

MAUERSBERGER, R., 1994. Zur wirklichen Verbreitung von Orthetrum coerulescens (Fabricius) und O. ramburi (Selys) = O. anceps (Schneider) in Europa und die Konsequenzen für deren taxonomischen Rang (Odonata, Libellulidae). *Dt. ent. Z.* (N.F.) 41: 235-256.

McLACHLAN, R., 1898. On Neuroptera collected by Mr. Malcolm Burr in Wallachia, Bosnia, Herzegovina, & c., in July and August, 1898. *Ent. mon. Mag.* (II) 34: 248-249.

MIKŠIĆ, S., 1953. Prilog poznavanju entomozajednica planinskih pašnjaka Treskavice. *Godišnjak biol. Inst. Saraj.* 6(1/2): 43-47. – [Bosnian, with Germ. s.]

MILL, P.J., 2012. The Brilliant Emerald Somatochlora metallica (Vander Linden) and its close relative the Balkan Emerald S. meridionalis Nielson. *J. Br. Dragonfly Soc.* 28: 75-91.

MORTON, K., 1908. Odonata collected by Miss Fountaine in Bosnia and Hercegovina. *Ent mon. Mag.* (II) 44: 37.

OLIAS, M. & M. SERBEDIJA, 1998. *Zur Faunistik und Ökologie der Libellen der Kvarner-Insel Krk (Kroatien)*. Dipl. thesis, Fachhochschule Eberswalde.

OLIAS, M., F. WEIHRAUCH, M. BEDJANIĆ, N. HACET, M. MARINOV & A. ŠALAMUN, 2007. Lestes parvidens and L. viridis in southeastern Europe: a chorological analysis (Odonata: Lestidae). *Libellula* 26(3/4): 243-272.

PROTIĆ, G., 1925. Hydrobiologische und Plankton-Studien an Seen Bosniens und der Hercegovina, Zweiter teil. *GZM* 36(1): 93-124. – [Bosnian, with Germ. s.]

PROTIĆ, G., 1927. Hydrobiologische und Plankton-Studien an Seen Bosniens und der Hercegovina, Vierter teil. *GZM* 39(1): 3-42. – [Bosnian, with Germ. s.]

PETROVIĆ, N.J., LJ. MILJKOVIĆ, P.A. TIPA, P.S. PAVLOVIĆ & Ž.J. JURIŠIĆ, 1891. The second journey of the teachers and pupils of the Second Belgrade secondary school, over Serbia and Bosnia. *Prosvetni Glasnik* 12(3): 104-116, (4): 189-194, (5): 247-254, (6): 320-325, (7/8): 384-398. – [Serbian]

PONGRAC, Z., 2000. *Morphometric characteristics of different populations of the species Calopteryx splendens (Harris, 1782) (Insecta: Odonata) in Croatia*. Master thesis, Univ. Zagreb. – [Croat., with Engl. s.]

PUSCHNIG, R., 1896. Bericht uber die reise des naturwissenschaftlichen Vereines a.d. U.W. nach Bosnien, der Herzegovina und Dalmatien. *Mitt. naturw. Ver. Univ. Wien* 1895: 33-54.

RADEVIĆ, M., M. MARKOVIĆ, D. MIKAVICA, V. BOJANIĆ & N. SAVIĆ, 2002. Abiotic and biotic characteristics of fishpond Bardaca. *Proc. 4th int. Conf. Reservoir Limnol. Water Quality*, Česke Budejovice, pp. 282-285.

REDŽIĆ, S., S. BARUDANOVIĆ & M. RADEVIĆ, 2008. Bosnia and Herzegovina: land of diversity, *First national Report of Bosnia and Herzegovina for the Convention on Biodiversity*, Sarajevo.

RIS, F., 1909-1910. Libellulinen monographisch bearbeitet, Vol. 1. *Collns zool. Edm. de Selys Longchamps*, Fasc. 9-11, pp. 1-384.

RIS, F., 1911-1912. Libellulinen monographisch bearbeitet, Vol. 2. *Collns zool. Edm. de Selys Longchamps*, Fasc. 12-14, pp. 385-836.

SCHORR, M., W. SCHNEIDER & H.J. DUMONT, 1998. Ecology and distribution of Lindenia tetraphylla (Insecta, Odonata, Gomphidae): a review. *Int. J. Odonatol.* 1(1): 65-88.

ŠENK, O., 1956. Prilog poznavanju režima ishrane potočnih pastrmki (*S. trutta fario*) izvorskog dijela rijeke Bosne. *Ribarst. Jugosl.* 11(3/4): 57-65. – [Serbian]

VILENICA, M., V. MIČETIĆ-STANKOVIĆ & M. FRANKOVIĆ, 2011. Dragonfly fauna (Insecta, Odonata) in the Turopolje region (Croatia). *Nat. Croat*. 20(1): 141-158.

VUKIĆ, M., 1992. *Vretenca u entomološkoj zbirci Jurečić*. Studentski rad, Univ. Zagreb. – [Croat.]

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ODONATA BIODIVERSITY IN SOME PROTECTED AREAS OF UMBRIA, CENTRAL ITALY

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Odonate assemblages of 4 wetlands included in the Biotopes Inventory of Italy (Natura 2000 project) have been investigated. A total of 36 species has been recorded and no species-area relationship was found. The richness observed is about 60-90% of the potential richness of the biotopes. The occurrence of *Trithemis annulata*, previously unknown from the Umbria region, and new findings for the biotopes are reported. The odon. flight period spanned from early April to the end of November. Diversity and evenness profiles have shown more diverse communities at sites with a greater habitat heterogeneity and multivariate dispersion analysis has revealed higher homogeneity for Zygoptera than for Anisoptera.

INTRODUCTION

The European Birds Directive (79/409/EEC) and the Habitats Directive (92/43/EEC) require that European Member States take measures to maintain or restore certain habitats and species to guarantee their favorable conservation status across the European Community (EUROPEAN COMMISSION, 1992). To support these Directives, several Special Areas of Conservation (SACs) and Special Protected Areas (SPAs) have been designated in order to make a significant contribution to conserving habitat types and species of conservation value. Moreover, managing SACs wetlands requires monitoring programmes to assess their status in relation to their overall conservation objectives and management prescriptions. Dragonflies have particular relevance in biodiversity assessment at

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various spatial scales and play a remarkable role in contemporary conservation biology (CORDOBA-AGUILAR, 2008). These insects are significant conservation subjects per se, excellent indicators of environmental quality (SIMAIKA & SAMWAYS, 2008, 2011) and sensitive indicators of landscape (DOLNÝ & HARABIŠ, 2012) and climate change (OTT, 2010).

Monitoring programs of Umbria's lakes designed as SACs and SPAs are in their early stages. Ecological data on fishes (LORENZONI et al., 2002, 2010a, 2010b; LA PORTA et al., 2010), amphibians and reptiles (RAGNI et al., 2006), birds (VELATTA et al., 2009) and mammals (RAGNI, 2002) are available, but very few investigations on invertebrates (DÖRR et al., 2006) have been carried out.

The Odonata fauna of Umbria's lakes has been sporadically documented by several authors over 20th century (CAPRA 1963, 1964; BUCHWALD, 1994; DI DOMENICO & CARCHINI, 1994) but available data are insufficient to map dragonfly distributions. Moreover, little is known about the diversity, abundance and flight season, since no survey has been conducted during a complete flying season. Answering these questions should improve our understanding of Odonata conservation value as well as their potential as biological indicators for monitoring environmental changes. This study has four objectives: (1) to provide an updated checklist of the dragonfly assemblages at four protected wetlands of Umbria (three lakes and one marsh), (2) to describe Odonata richness and community structure, (3) to investigate flight periods and (4) to analyze the regional diversity in order to develop conservation priorities in these protected areas.

MATERIAL AND METHODS

STUDY AREA − The investigation was carried out at 16 locations along the shores of four wetlands (1-4) of interest for biodiversity and nature protection in the Italian peninsula (Fig.1). They are included in the Biotopes Inventory of Italy (Natura 2000 project, Italian ratification of the UE Directives Habitat 92/43 − CEC, 1992), and characterized by the Mediterranean climate of wet winters and hot, dry summers.

(1) Lake Trasimeno (TRAS) is the largest lake in Central Italy with a total surface area of 126 km^2. It is a laminar and mesotrophic lake situated at 257 m a.s.l., and characterized by an average depth of 4.7 m. It is considered as a Site of Community Importance (SCI) and as Special Protection Area (SPA) according to BIOITALY (SCI IT5210018 and SPA IT5210070). The dominant aquatic vegetation includes the declining *Phragmites australis* (GIGANTE et al., 2011), *Typha angustifolia* and *Typha latifolia*. The macrophyte community is dominated by the vegetal associations *Charetum globularis, Charetum intermediae, Potametum pectinati, Potametum denso-nodosi* and *Ceratophyllum demersum* community (LANDUCCI et al., 2011).

(2) Colfiorito marsh (COLF) is a small wetland, with a total surface area of 1.5 km^2, located at 752 m a.s.l. in the calcareous zone of the Umbro-Marchigiano Apennines. The marsh is included in 'The Ramsar List of Wetlands of International Importance (1973)' and, since 1995, it has been considered as a SCI and a SPA according to BIOITALY (IT5210034 and IT5210072) for its habitat for breeding birds, high vegetation and floristic diversity mainly composed of *Phragmitetum australis, Scirpetum lacustris, Nymphaeetum albae* s.l., *Phalaridetum arundinaceae, Glyceretum*

maximae, Typhetum latfoliae and *Hordeo-Ranuculetum velutini* (ORSOMANDO et al., 2004).

(3) Lake Piediluco (PIED) is the second largest lake of Umbria with a total protected area of 4.1 km^2. The lake surface (375 m a.s.l.) is currently around 1.5 km^2 with a maximum depth of 19.2 m and its perimeter is about 13 km. The lake has a central body West-East oriented and some ramifications. It is considered as a SCI and a SPA according to BIOITALY (IT5220018 and IT5220026). The riparian vegetation mainly consists of *Phragmites australis*, which forms a reed belt intercalated with willow and poplar woods. The dominant aquatic vegetation includes the associations *Sparganium erectum, Mentho aquaticae-Caricetum pseudocyperi and Caricetum acutiformis* (VENANZONI & GIGANTE, 2000). lake Piediluco is used as a daily water store basin for the Galleto hydroelectric plant.

(4) Lake Ventina (VENT), as well as lake Piediluco, is the residue of the ancient lake called *lacus Velinus*, located at 370 m a.s.l., and with a total surface area of 0.45 km^2. lake Ventina is considered as a SCI according to BIOITALY (IT6020010) and characterized by dense vegetation of *Phragmites australis, Typha latifolia, Thyfa angustifolia, Carex pendular* and *Juncus atratus*. Other common water plants are *Nuphar luteum, Potamogeton crispus, Utricularia australis, Myriophillum spicatum, M. verticillatum* and *Ceratophillum demersum* (VENANZONI & GIGANTE, 2000).

SAMPLING METHOD − The sampling locations were coded using an alpha-numeric system. The first four letters, which start the code, represent the biotope, and the numbers indicate the locations. At lake Trasimeno were investigated seven locations: TRAS01-TRAS06, and ANGU01; at Col-

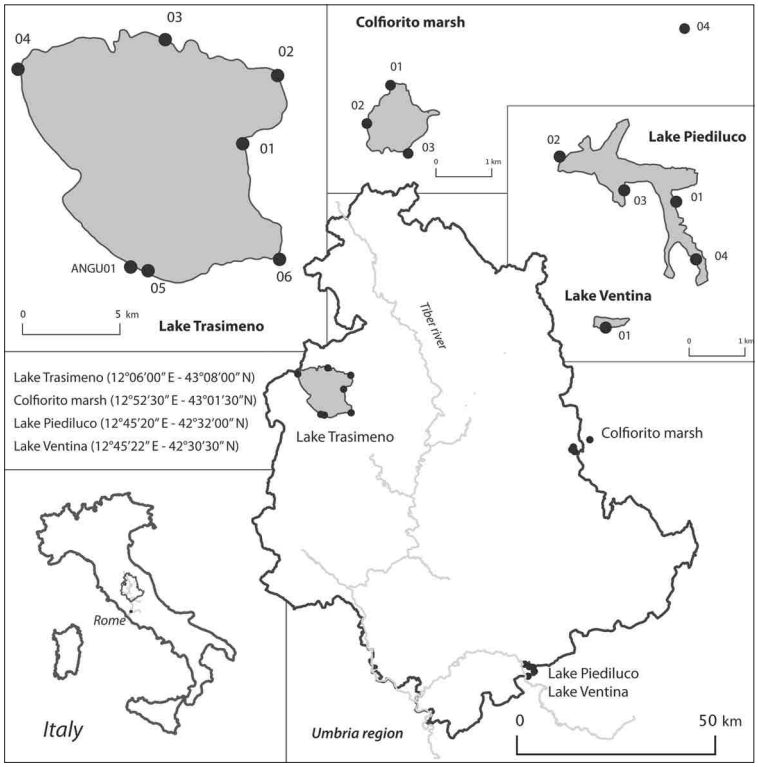

Fig. 1. Map showing the four investigated biotopes and their geographical coordinates.

fiorito marsh four locations: COLF01-COLF04; at lake Piediluco four locations: PIED01-PIED04; at lake Ventina one location: VENT01.

Sampling of dragonflies was carried out on fine, windless days between 9:00 and 18:00 hr, from April to November 2011. A team of 2-5 persons carried out intensive sampling and observation of exuviae, tenerals and adults for periods of 35-60 minutes. Five abundance classes were defined to describe the frequency of each species in the field session: class 1 (1-5 individuals), class 2 (6-20 individuals), class 3 (21-50 individuals), class 4 (51-100 individuals) and class 5 (more than 100 individuals). Occasionally, some voucher specimens were collected for further investigations.

In addition to the adult sampling, physical variables, such as air temperature, humidity and Discomfort Index (DI, obtained by a combination of temperature and humidity) were recorded for each sampling session by a digital thermo-hygrometer (H2101 Delta Ohm). Species identification followed ASKEW (2004) and DIJKSTRA & LEWINGTON (2006) and the latter was used as the reference for the specific nomenclature.

DIVERSITY MEASURE AND DATA ANALYSIS − In order to test the differences among the lakes, on the basis of species number encompassed in each family, a non-parametric Kruskal-Wallis analysis was used. The spatio-temporal variation in total richness was investigated using Anova on rank transformed data (AKRITAS, 1990). Factors significantly detected by Anova were further analyzed using Tukey's test set at 5% significance level. By means of Vegan R package version 2.0–2 (OKSANEN et al., 2011), various models (Chao, 1st order jackknife, 2nd order jackknife, bootstrap) were used to estimate the total species richness and the number of unseen species. The diversity profiles were calculated according to Renyi's formula:

$$H_\alpha = \frac{1}{1-\alpha} ln(\sum_{i=1}^{N} P_i^\alpha) \; for \; \alpha \; in \; 0, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, \inf$$

where P_i is the relative abundance of species i.

For any given community, Ha is a parametric measure of uncertainty in predicting the relative abundance of species. This formula allows a partial ranking of the diversity of ecological communities to be evaluated. For instance, a hypothetical community A is intrinsically more diverse than a community B, if, and only if, the community A has its intrinsic diversity profile everywhere above that of the community B. By examining the values of profile at Hill numbers of 0, 1, 2 and infinite, species richness and values of Shannon, Simpson, and Berger–Parker diversity indices can be inferred (HILL, 1973). Beta diversity, defined as non-directional variation among sample units (ANDERSON et al., 2011), was calculated and tested for giving evidence of the differences by means of Anova, using the 'BetaDispersion' code provided by BACARO et al. (2012). All statistical analyses were performed using the computing environment R (R DEVELOPMENT CORE TEAM, 2011).

RESULTS

A total of 16 locations were investigated in the four lacustrine biotopes, over eight months in 132 sampling sessions in 2011.

On the complex, 36 species belonging to eight families of Odonata were recorded (Tab. I). Only one individual belonging to the Cordulegasteridae was sighted, but not caught, near the Colfiorito marsh in early autumn. As expected, the Aeshnidae, Coenagrionidae and Libellulidae were the families best represented in the assemblages (Fig. 2), owing to the highest number of species, which showed no significant differences among the four locations (Kruskal Wallis = 2.75, df = 3, p-value = 0.432). By contrast, the Lestidae differed markedly, with five species at

Table I
Checklist of species recorded at the four wetlands, with their average class of abundance during the flying period. New findings in bold; emergence success (exuviae or tenerals) asterisked; months (April-November) numbered

Species	Lake Trasimeno (9)								Colfiorito marsh (10)								Lake Piediluco (12)								Lake Ventina (1)						
	4	5	6	7	8	9	10	11	4	5	6	7	8	9	10	11	4	5	6	7	8	9	10	11	4	5	6	7	8	9	10	11
Calopteryx haemorrhoidalis	-	-	-	-	-	**2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. virgo	-	-	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lestes barbarus	-	**2.0***	**5**	**4**	**5**	**2**	-	-	-	-	1.0*	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. dryas	-	**1**	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. virens vestalis	-	-	-	-	**1**	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	3	-
L. viridis	-	-	2.0*	-	-	**2**	**2**	-	-	-	-	-	-	-	1	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	**1**	-
Sympecma fusca	-	**1**	-	-	-	-	-	-	**1.3**	**1.5**	-	**1**	-	**1**	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Platycnemis pennipes	-	-	**1**	-	**1**	-	-	-	-	-	-	-	-	-	-	-	-	**1.0***	**3.4***	**3**	**1**	-	-	-	-	-	2.0*	4	-	-	-	-
Pyrrhosoma nymphula	-	**1**	-	-	-	-	-	-	-	2	3	-	-	-	-	-	**1.0***	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Erythromma lindenii	-	1	2.4	2.5	3.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**3**	-	-	-	-	-	-	3	2	-	-	-
E. viridulum	-	-	4.0*	2.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-
Coenagrion puella	-	-	1	1	-	-	-	-	-	3.3*	4	2	1	-	-	-	-	1	3.3	1.7	-	-	-	-	2.0*	-	3.5	-	-	-	-	-
C. pulchellum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1.0***	**2.8***	**3.4***	**1**	-	-	-	-	3.0*	4.0*	3.0*	-	-	-	-	-
Ischnura elegans	1.5*	2.3*	3.6*	2.9	3.6	2.4	3	-	2	3.7	3.3	1.3	2.5	2	-	-	1	2.3	4.6	3.3	3.3	2.3	1	-	4	5	4.5	5	4	2	1	-
I. pumilio	-	-	-	-	-	1.5	2.0*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aeshna affinis	-	-	**2.0***	**1**	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. isoceles	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	**1.5**	**1**	-	-	-	-	-	2	1.5	-	-	-	-	-
A. mixta	-	-	-	-	-	1	1.5	-	-	-	-	-	-	**2**	**3.3**	**2**	-	-	-	-	-	**1.5**	**1.8**	-	-	-	-	-	-	2	3	-
Anax imperator	-	1	1	-	1	1.3	-	-	-	1.5*	1.3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-
A. parthenope	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	1	-	-	-
Brachytron pratense	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-
Somatochlora meridionalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	-	-	-
Libellula depressa	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
L. fulva	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2	1.0*	-	-	-	-	2	1.5	1	1	-	-	-
L. quadrimaculata	-	-	-	-	-	-	-	-	-	**2.3***	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1	-	-	-	-	-
Orthetrum brunneum	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O. cancellatum	-	1.7*	2.5*	1.7*	1.9	1.5	-	-	-	-	-	-	-	-	-	-	-	-	1.0*	2.0*	1.7*	1	-	-	-	-	-	2	-	-	-	-
O. coerulescens	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	-	-
Crocothemis erythraea	-	-	1.0*	2	1.2*	2.5	2.0*	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	-	-	-
Sympetrum flaveolum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. fonscolombii	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. meridionale	-	-	-	-	1.5	1	-	-	-	-	-	**2.0***	-	**1.3**	**2**	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	-
S. sanguineum	-	-	1.3	1	-	1	-	-	-	-	**3.0***	**1**	**1**	**3.0***	**2**	-	-	-	-	**1**	**1**	**1.5**	-	-	-	-	2.5*	4	3	3	2	-
S. striolatum	-	-	-	-	-	2	2	2	-	-	-	-	-	**1**	**2.5**	**1**	-	-	-	-	-	-	**2**	-	-	-	-	-	-	1	-	-
Trithemis annulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	-	-	-	-	-	-	-	-	-	-
Total	1	9	14	10	11	16	7	1	2	8	9	5	5	8	6	2	3	5	7	10	8	6	3	0	5	8	11	9	10	6	6	0

lake Trasimeno and only one at lake Piediluco.

Spatio-temporal variations in the total number of species showed significant differences. Total species richness was slightly different at the four locations (ANOVA F = 3.58, df = 3, p-value = 0.031), being relatively low at lake Piediluco and Colfiorito marsh with 18 species, and high at lake Trasimeno with 26 species (Tukey-test p-value<0.01). Monthly variations, due to the seasonal activity pattern of adult dragonflies, were strongly marked (ANOVA F = 8.92, df = 7, p-value <0.001).

During field activities the mean temperatures varied between 33.6°C in July to 13.3°C in November and the relative humidity ranged from 26.7% in September to 71% in July (Tab. II). The Discomfort Index (DI) reached its maximum value of 80 in July and August and its minimum (ca 45) in October and November. A positive and significant correlation was found between species richness vs temperature and DI (R = 0.653 and 0.518 respectively, P <0.001), whereas independence occurred in relation to relative humidity (R = –0.243, P = 0.196).

The richness estimated by Chao, jackknife (1st and 2nd order) and bootstrap methods was larger than the richness observed at all four biotopes (Tab. III). On the other hand, the computed rarefaction curves tended to reach the asymptotes (Fig. 3). The 26 species recorded at lake Trasimeno represented more than 85-90% of the potential richness of this biotope. This high proportion indicated that the proposed survey strategy (about 35-60 minutes around 100 m from the station's central point in eight monthly sessions) was largely sufficient to gather the basic information needed to estimate the real number of species. Even for Colfiorito marsh and lake Ventina, the number of species was about 75-85% of their potential richness, whereas at lake Piediluco the number of observed species reached 58-75% of the potential.

A diversity profile of each site was calculated in order to compare the general diversity pattern (Fig.4). All trends showed a negative flexion in the interval between the Hill numbers 2 and 8, which was associated with the presence of rare species or with low evenness. The highest Renyi's curve was recorded at lake Ventina, followed by that at the Anguillara canal at lake Trasimeno. The remaining stations at lake Trasimeno were positioned below the median line, with the ex-

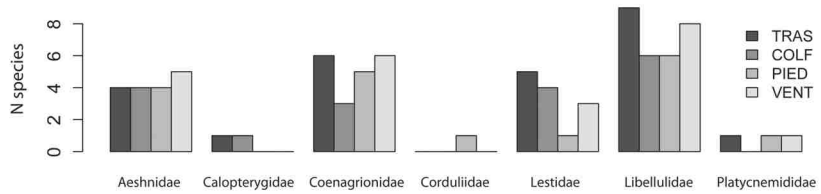

Fig. 2. Number of Odonata species and families at lake Trasimeno (TRAS), Colfiorito marsh (COLF), lake Piediluco (PIED) and lake Ventina (VENT).

Table II
Environmental conditions during monthly samplings

	Lake Trasimeno			Colfiorito marsh			Lake Piediluco			Lake Ventina		
Month	Temperature (°C)	Humidity (%)	DI	Temperature (°C)	Humidity (%)	DI	Temperature (°C)	Humidity (%)	DI	Temperature (°C)	Humidity (%)	DI
4	22.0	35.5	66.7	17.5	47.7	63.1	23.1	37.7	67.9	24.2	41.0	68.6
5	24.8	48.5	71.5	26.6	38.8	72.4	23.9	40.8	69.0	20.5	45.6	66.8
6	27.7	49.2	75.3	24.8	36.9	70.8	23.2	50.7	69.2	27.5	42.4	69.6
7	26.3	41.1	71.7	16.8	71.1	60.3	30.7	50.6	77.5	33.6	44.0	81.0
8	33.0	35.1	80.1	20.6	41.7	53.8	29.5	42.3	75.8	29.7	31.3	76.2
9	25.3	48.4	71.6	28.9	26.7	73.6	30.1	29.0	75.3	23.1	43.0	72.3
10	17.2	55.0	43.3	23.7	28.8	68.1	21.1	60.2	69.2	23.7	47.4	70.0
11	13.3	66.2	55.9	13.3	65.5	56.2	13.3	43.0	55.3	14.0	40.2	58.9
N stations	7			4			4			1		
N samplings	59			32			32			9		

ception of TRAS02 and TRAS06, which were positioned markedly above it. The locations at lake Piediluco and Colfiorito marsh exhibited similar trends around the median line, apart from PIED02, which showed a very low diversity pattern. Among the total 36 species, eight (22%) were common to the four wetlands and, as expected, the biotopes that shared the maximum number of species (15) were the neighbouring lakes Ventina and Piediluco. In particular, the latter lake showed a high dissimilarity index when compared with that of Colfiorito marsh (9 common species) (Tab. IV).

Beta diversity variation, calculated as average distance from the centroid in the principal coordinate space on a plot-to-plot dissimilarity matrix, was relatively high at Colfiorito marsh and at lake Trasimeno ($\beta = 0.80$) and low at lake Piediluco and at lake Ventina ($\beta = 0.73$ and 0.76 respectively). However, ANOVA analysis showed no significant differences among the average β diversity of

Table III
Biodiversity richness estimators

Biotope	N Species	Chao±se	Jackknife 1st order ∓ se	Jackknife 2nd order	Boot±se
Lake Trasimeno	26	28∓2.3	31.2∓3.9	30.0	29.1∓2.9
Colfiorito marsh	18	20.1∓2.5	22.4∓2.4	22.3	20.4∓2.0
Lake Piediluco	18	38.2∓20.2	25.7∓3.9	31.0	21.3∓1.9
Lake Ventina	23	25∓2.3	28.1∓2.1	27.1	26.0∓1.9

the different locations (F = 0.885, df = 3, p.value = 0.7). Repeating the ANOVA analysis separately for Zygoptera and Anisoptera again showed no significant differences (Tab. IV).

DISCUSSION

This study provides a significant update of our dragonfly knowledge at four key wetlands in Central Italy, included in the EU wide network of Nature Protection Areas. Several Zygoptera and Anisoptera species are added to the previous checklists of biotopes (RUFFO & STOCH, 2005). It is probable that some of these species have historically existed in the investigated wetlands, although we cannot exclude that the observed modifications in the Odonata assemblages may be due to environmental changes that have occurred in the last twenty years or so. Indeed, in the checklist of Giganti and Capra (GIGANTI, 1962; CAPRA, 1963, 1964) for Odonata from lake Trasimeno, some Lestidae, Coenagrionidae and Aeshnidae, namely *Lestes barbarus, L. dryas, L. virens vestalis, Sympecma fusca, Platycnemis pennipes, Pyrrhosoma nymphula* and *Aeshna affinis* were absent, whereas, they are now consistently present along the shores of the lake. Furthermore, the common Afrotropical species *Trithemis annulata* (Palisot de Beauvois, 1805), historically located only in southern Italy (CONCI & NIELSEN, 1956), has expanded its range in southwestern Europe in recent decades (BOUDOT et al., 2009) and was found at lake Piediluco. This finding is the first record of its presence for the Umbria region.

Our sampling activity extended over more than the normal flying period of Odonata (fpO), thus allowing an increase in the collected number of species, which varied from 11% at lakes Trasimeno and Piediluco up to 16% at Colfiorito marsh. This sampling success seems to be related to the autumnal air temperature (over 21°C), which favoured adult activity.

Somatochlora meriodionalis at IT6020010 is the only dragonfly species included in the four Natura 2000 sites' identity cards. It is worth stressing that the inves-

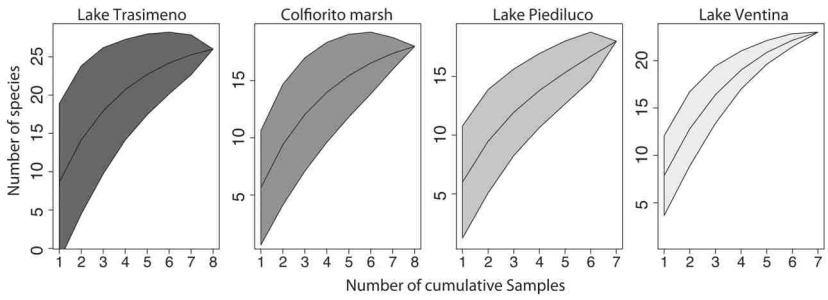

Fig. 3 Species accumulation curves at the four biotopes.

tigated areas represent important biotopes for Odonata conservation in Central Italy. In fact, in these protected wetlands, which represent less than 1.8% of the surface of the regional territory, about 74% of the total number of species already recorded in Umbria (RUFFO & STOCH, 2005) were found.

No species-area relationship was found. This is in agreement with investigations carried out on butterflies (KOELLNER et al., 2004) and on multiple invertebrate taxa (BÁLDI, 2008), which have suggested that the most important predictor of species richness is the habitat heterogeneity rather than the size of the area (HEISER & SCHMITT, 2010). Vegetation components clearly affects Odonata abundance and species richness (RAEBEL et al., 2011). In this regard, a great phytocenotic diversity due to 26 vegetation types was observed at lake Trasimeno (LANDUCCI et al., 2011). Similarly, a relevant specific diversity in the vegetation community occurred at lake Ventina (VENANZONI, 1992). In contrast, a limited number of species, belonging to the Coenagrionidae, Aeshnidae and Libellulidae, were recorded in the areas classified as urban areas (CO-

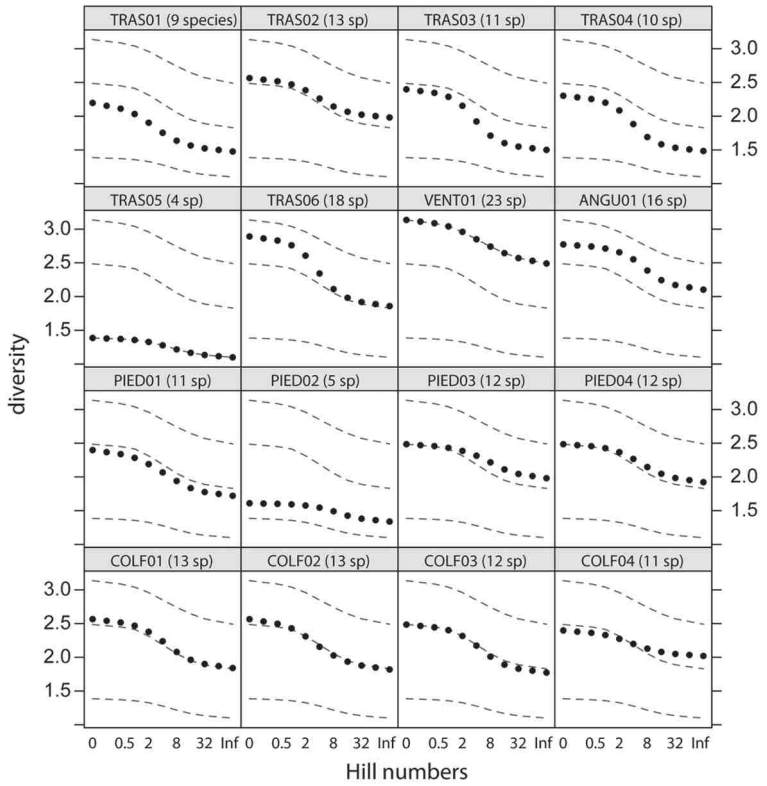

Fig. 4. Renyi's diversity profiles for the sixteen investigated sampling locations.

Table IV
Average ß diversity analysis

Biotope	ß Odonata	ß Zygoptera	ß Anisoptera
Lake Trasimeno	0.803	0.700	0.774
Colfiorito marsh	0.798	0.691	0.792
Lake Piediluco	0.730	0.590	0.813
Lake Ventina	0.760	0.701	0.800
ANOVA	F=0.885; P=0.72	F=1.34; P=0.59	F=0.118; P=0.98

RINE Land Cover database - EEA, 2010), where the vegetation had a poor floristic composition.

The analysis of α diversity performed by means of the Renyi's profiles highlights that the sites can be ordered from high to low diversity. On the basis of these data, it emerges that the highest profile is associated with lake Ventina, a biotope with a peculiar dragonfly assemblage (DI DOMENICO & CARCHINI, 1994) and a high dragonfly species richness. Similarly, at lake Trasimeno Renyi's profiles confirm high diversity in the southern sector of the lake. In fact, in this area, characterized by relevant habitat diversification and heterogeneity due to the presence of running and standing waters, there is the co-presence of lotic species, namely *Calopteryx haemorrhoidalis, Orthetrum brunneum,* and *O. coerulescens*, and many lentic species.

The comparison among the sample-based rarefaction curves reveals differences among the four wetlands. Whereas, in the case of lake Trasimeno, Ventina and Colfiorito marsh there is a clear tendency to reach the asymptotes, lake Piediluco maintains a steep slope. This feature probably indicates that, for the first group of sites, the estimated value of biodiversity could be a true reflection of the real richness, whereas the value of Odonata biodiversity at lake Piediluco is an underestimate.

The result of this study reveals that, in central Italy, the multivariate dispersion β values are fairly low and reflect a marked homogeneity in space and time. Even if there is a natural species turnover, a large 'core' of common species was shared among the locations. By considering Zygoptera and Anisoptera independently, no differences emerge among the β values of the wetlands. However, the β values of Zygoptera are always lower than those of Anisoptera. This is in accordance with the analysis of the biogeographical pattern of Odonata for the Palearctic region (HEISER & SCHMITT, 2010). In this regard, the Anisoptera biogeographical patterns reflect historical vicariance and dispersal events, while the relatively poorly dispersing Zygoptera seem to reflect the effects of climate.

From a conservation perspective, the results of the present dragonfly survey on lentic environments may help in selecting the appropriate spatial scale for conservation management. β analysis suggests that the Umbria region can be con-

sidered as a single entity. The lakes characterized by a high α diversity must be considered as the main nodes in the protected areas network and as biodiversity sources. Management plans of the wetlands with a lower α diversity should be given particular consideration for conservation interventions on the habitat for uncommon or exclusive species (see PRENDERGAST et al., 1993). Therefore, monitoring programs should include, as a focus point, the analysis of multivariate dispersion of species as a marker of environmental stress (WARWICK & CLARKE, 1995).

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REFERENCES

AKRITAS, M. G., 1990. The rank transform method in some two-factor designs. *J. Am. statist. Ass.* 85: 73-78.

ANDERSON, M.J., T.O. CRIST, J.M. CHASE, M. VELLEND, B.D. INOUYE, A.L. FREESTONE, N.J. SANDERS, H. CORNELL, L. COMITA, K. DAVIES, S. HARRISON, N. KRAFT, J. STEGEN & N. SWENSON, 2011. Navigating the multiple meanings of β diversity: a roadmap for the practicing ecologist. *Ecol. Lett.* 14(1): 19-28.

ASKEW, R.R., 2004. *The dragonflies of Europe*. [revised edn]. Harley Books, Colchester.

BACARO, G., M. GIORIA & C. RICOTTA, 2012. Testing for differences in beta diversity from plot-to-plot dissimilarities. *Ecol. Res.* 27(2): 285-292.

BÁLDI, A., 2008. Habitat heterogeneity overrides the species-area relationship. *J. Biogeogr.* 35(4): 675-681.

BOUDOT, J.P., V.J. KALKMAN, M. AZPILICUENTA AMORIN, T. BOGDANOVIĆ, A. CORDERO RIVERA, G. DEGABRIELE, J.-L. DOMMANGET, S. FERREIRA, M. GARRIGÓS, M. JOVIĆ, M. KOTARAC, W. LOPAU, M. MARINOV, N. MIHOKOVIĆ, E. RISERVATO, B. SAMRAOUI & W. SCHNEIDER, 2009. Atlas of the Odonata of the Mediterranean and North Africa. *Libellula* (Suppl.) 9: 1-256.

BUCHWALD, R., 1994. Vegetazione e odonatofauna negli ambienti acquatici dell'Italia centrale. *Braun-Blanquetia* 11: 3-77.

CAPRA, F., 1963. Odonati del lago Trasimeno e lista delle specie dell'Umbria. *Riv. Idrol.* 2: 157-196.

CAPRA, F., 1964. Odonati del lago Trasimeno, 2. *Riv. Idrol.* 3: 173-185.

CEC, 1992. Council of European Communities Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. *Off. J. Europ. Communities*, L206.

CONCI, C. & C. NIELSEN, 1956. *Odonata, Fauna d'Italia*. Calderini, Bologna.

CORDOBA-AGUILAR, A., 2008. *Dragonflies & damselflies, model organism for ecological and evolutionary research*. Oxford Univ. Press., Oxford.

DI DOMENICO, M. & G. CARCHINI, 1994. Odonata of lake Ventina, Lazio, with records of two

new species for central Italy. *Opusc. zool. flumin.* 119: 1-11.
DIJKSTRA, K.-D.B. & R. LEWINGTON, 2006. *Field guide to the dragonflies of Britain and Europe*. British Wildlife Publishing, Gillingham.
DOLNÝ, A. & F. HARABIS, 2012. Underground mining can contribute to freshwater biodiversity conservation: allogenic succession forms suitable habitats for dragonflies. *Biol. Conserv.* 145(1): 109-117.
DÖRR, A.J.M., G. LA PORTA, G. PEDICILLO & M. LORENZONI, 2006. Biology of Procambarus clarkii (Girard, 1852) in lake Trasimeno. *Bull. fr. Pêche Piscic.* 380/381(4): 1155-1170.
EEA [European Environment Agency], 2010. The European topic centre on land use and spatial information. Available on *http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version*.
EUROPEAN COMMISSION, 1992. *Conservation of natural habitats and of wild fauna and flora*. 92/43/EEC. Brussels: DGEnv.
GIGANTE, D., R. VENANZONI & V. ZUCCARELLO, 2011. Reed die-back in southern Europe? A case study from central Italy. *Cr. Biol.* 334(4): 327-336.
GIGANTI, A., 1962. La componente odonatologica dell'ecosistema trasimenico. *Riv. Idrol.* 2: 19-73.
HEISER, M., & T. SCHMITT, 2010. Do different dispersal capacities influence the biogeography of the western Palearctic dragonflies (Odonata)? *Biol. J. Linn. Soc.* 99(1): 177-195.
HILL, M.O., 1973. Diversity and evenness: a unifying notation and its consequences. *Ecology* 54(2): 427-432.
KOELLNER, T., A.M. HERSPERGER & T. WOHLGEMUTH, 2004. Rarefaction method for assessing plant species diversity on a regional scale. *Ecography* 27(4): 532-544.
LA PORTA, G., V. ANGELI, A. BICCHI, A. CAROSI, G. PEDICILLO, P. VIALI & M. LORENZONI, 2010. Variations in the fish community in lake Piediluco (Italy) caused by changes in the lake's trophic status and the introduction of alien species. *J. appl. Ichthyol.* 26: 53-59.
LANDUCCI, F., D. GIGANTE & R. VENANZONI, 2011. An application of the Cocktail method for the classification of the hydrophytic vegetation at lake Trasimeno (central Italy). *Fitosociologia* 48(2): 3-22.
LORENZONI, M., M. CORBOLI, A.J. MARTIN DOERR, M. MEARELLI & G. GIOVINAZZO, 2002. The growth of pike (*Esox lucius* Linnaeus, 1798) in lake Trasimeno (Umbria, Italy). *Fish. Res.* 59(1/2): 239-246.
LORENZONI, M., R. DOLCIAMI, L. GHETTI, G. PEDICILLO & A. CAROSI, 2010a. Fishery biology of the goldfish Carassius auratus (Linnaeus, 1758) in lake Trasimeno. *KMAE,* 396(1): 1-13.
LORENZONI, M., L. GHETTI, G. PEDICILLO & A. CAROSI, 2010b. Analysis of the biological features of the goldfish Carassius auratus auratus (Linnaeus, 1758) in lake Trasimeno (Umbria, Italy) with a view to drawing up plans for population control. *Folia zool.* 58(2): 56-70.
OKSANEN, J., R. KINDT, P. LEGENDRE & R.B. O'HARA, 2011. Vegan: Community Ecology Package Version 2.0–3. URL *http://cran.r-project.org/*.
ORSOMANDO, E., M. TARDELLA & S. BALLELLI, 2004. *Flora vascolare e fitocenosi nel parco regionale di Colfiorito*. Ass. Orfini-Numeister 204.
OTT, J., 2010. Dragonflies and climatic change: recent trends in Germany and Europe. *BioRisk* 5: 253-286. Pensoft, Sofia.
PRENDERGAST, J., R. QUINN & J. LAWTON, 1993. Rare species, the coincidence of diversity hotspots and conservation strategies. *Letters to Nature* 365: 335-337.
R DEVELOPMENT CORE TEAM, 2011. *R: a language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL *http://www.R-project.org/*.
RAEBEL, E.M., T. MERCKX, R.E. FEBER, P. RIORDAN, D.W. MACDONALD & D.J. THOMPSON, 2011. Identifying high-quality pond habitats for Odonata in lowland England: implica-

tions for agri-environment schemes. *Insect Conserv. Diver.* 1752-4598.
RAGNI, B., 2002. *Atlante dei mammiferi dell'Umbria*. Petruzzi, Città di Castello.
RAGNI, B., G. DI MURO, C. SPILINGA, A. MANDRICI & L. GHETTI, L., 2006. *Anfibi e rettili dell'Umbria: distribuzione geografica ed ecologia*. Petruzzi, Città di Castello.
RUFFO, S. & F. STOCH, 2005. *Checklist e distribuzione della fauna italiana: 10.000 specie terrestri e delle acque interne*. Mem. Mus. civ. Stor. nat. Verona (II).
SIMAIKA, J.P. & M.J. SAMWAYS, 2008. An easy-to-use index of ecological integrity for prioritizing freshwater sites and for assessing habitat quality. *Biodivers Conserv.* 18(5):1171-1185.
SIMAIKA, J.P. & M.J. SAMWAYS, 2011. Comparative assessment of indices of freshwater habitat conditions using different invertebrate taxon sets. *Ecol. Indic.* 11(2): 370-378.
VELATTA, F., G. LOMBARDI, U. SERGIACOMI & P. VIALI, 2009. *Monitoraggio dell'avifauna umbra (2000–2005) Trend e distribuzione ambientale delle specie comuni*. Quad. Osservatorio, Regione Umbria.
VENANZONI, R., 1992. I prati umidi e inondati dell'alta valle del Velino (Rieti-Italia centrale). *Doc. phytosoc.* (N.S.) 14: 149-164.
VENANZONI, R. & D. GIGANTE, 2000. Contributo alla conoscenza della vegetazione degli ambienti umidi dell'Umbria. *Fitosociologia* 37(2): 13-63.
WARWICK, R. & K. CLARKE, 1995. New 'biodiversity' measures reveal a decrease in taxonomic distinctness with increasing stress. *Mar. Ecol. Prog. Ser.* 129: 301-305.

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PREDATORY POTENTIAL OF *BRADINOPYGA GEMINATA* AND *CERIAGRION COROMANDELIANUM* LARVAE ON DENGUE VECTOR *AEDES AEGYPTI* UNDER CONTROLLED CONDITIONS (ANISOPTERA: LIBELLULIDAE; ZYGOPTERA: COENAGRIONIDAE; DIPTERA: CULICIDAE)

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The predatory potential of *B. geminata* and *C. coromandelianum* larvae on *Aedes aegypti* larvae was investigated under laboratory condition with a view to screening these predators for use in the control of *Ae. aegypti* breeding in dengue prone areas. The feeding rate of 8th instar *B. geminata* on *Ae. aegypti* showed maximum predation on 1st instar larvae (86%), followed by 2nd, 3rd and 4th instars (72%, 66% and 48%), respectively. In the first hour, the consumption rate was maximal for all instars and a low intake (about 5%) was observed in subsequent hours. In 12th instar *B. geminata* larvae maximum predation was observed for the 1st and 2nd instar larvae (98%) of *Ae. aegypti*, followed by 3rd and 4th instars (92% and 78%), respectively. The feeding rate of 12th instar *C. coromandelianum* larvae on *Ae. aegypti* larvae showed that the maximum predation was of the 1st instar larvae (82%), followed by 2nd, 3rd and 4th instars (51%, 35% and 24%) respectively. The first hour consumption rate was maximum for all instars and no significant intake was seen in the following hours. The predation of *Aedes* larvae by the 2 spp. of odonate larvae was compared for the 4 mosquito larval instars by using one way ANOVA. No significant difference was found between them for 1st instar larvae of *Ae. aegypti* but there was a significant difference ($P<0.05$) in predation on the other 3 instars, with *B. geminata* consuming more mosquito larvae. A single anisopteran larva is sufficient for eliminating the huge mass of larval mosquitoes breeding in a cement tank or a cement cistern. Therefore, this biological control agent could be released to control *Aedes* larval production in areas of dengue epidemics.

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INTRODUCTION

Mosquito borne diseases (MBD's) are emerging or resurging as a result of changes in public health policy, insecticide and drug resistance, shift in emphasis from prevention to emergency response, demographic and social status, and genetic aspects in pathogens (GUBLER, 1998). Dengue is an arthropod-borne viral disease widely distributed in the tropical and subtropical regions of the world. Dengue is now endemic in more than 100 countries in Africa, the Americas, the eastern Mediterranean, Southeast Asia, and the Western Pacific, threatening more than 2.5 billion people (GUBLER, 1997). The World Health Organization estimates that there may be 50 million to 100 million cases of dengue virus infections worldwide every year (WORLD HEALTH ORGANISATION, 1997). Within the Indian Subcontinent, India has been identified as one of the seven countries now regularly reporting incidences of DF/DHF outbreaks. Dengue has emerged as a serious public health problem in India. Historically, dengue has been reported predominantly among urban and suburban populations, where high population density facilitates transmission. However, evidence from recent outbreaks suggests that outbreaks are now occurring in rural areas. *Aedes aegypti* is the main vector of dengue transmission, although *Aedes albopictus* has also been incriminated in South Asian countries including India. In India, mainly in the state of Tamil Nadu, dengue has been reported from many places. Dengue epidemics were recorded during 2001 in Chennai city, Tamil Nadu and many dengue cases were reported (ASHOKKUMAR et al., 2010). The National Vector-Borne Disease Control Programme (NVBDCP) recommended an Integrated Vector Management (IVM) approach to control the larval and adult population of the dengue vectors. Using biological control agents is the only solution to control this vector borne disease. It has been demonstrated that larvicidal measures reduce mosquito population for only a short period and require repeated applications of chemicals and that, eventually, the larvae develop resistance against that chemical (GRATZ, 1990). Predatory fishes and zooplankton have been widely used as biocontrol methods to control vector populations (RUSSEL et al., 2001; KAY et al., 2002; MICIELI et al., 2001). Among insect predators, the role of odonate larvae has been explored less compared to other similar predatory insects, both in the Indian (MATHAVAN, 1976; SEBASTIAN et al., 1990; CHATTERJEE et al., 2007) and the world perspective (CORBET, 1980). Exceptions to this are their use in neotropical tree holes (FINCKE, 1999; CORBET, 2000; YANOVIAK, 2001) and in temporary desert pools (STAV et al., 2005). The longevity, predatory ability, trophic position and sharing of habitats with mosquito immature stages are all factors in favour of using odonate larvae for biological control (CHATTERJEE et al., 2007).

Biological control is based on the introduction of organisms that prey upon, parasitize, compete with or otherwise reduce populations of the target species.

While biological control avoids chemical contamination of the environment, there may be operational limitations – such as the expense and task of rearing the organisms on a large scale, difficulty in applying them and their limited utility in aquatic sites where temperature, pH and organic pollution may exceed the narrow requirements of the organism. However, considerable attention is being paid to alternative methods of vector control, especially the use of natural predators of mosquito immature stages (KUMAR & HWANG, 2006; VOYADJOGLOU et al., 2007). Many of these predators, such as crustaceans (SU & MULLA, 2002), dytiscid beetles (LUNDKVIST et al., 2003), *Rhantus sikkimensis* (ADITYA & SAHA, 2006), the belostomatid bugs *Diplonychus* (=*Sphaerodema*) *annulatus* and *D. rusticus* (ADITYA et al., 2004; PRAMANIK & RAUT, 2003, 2005), notonectid bugs *Notonecta maculata* (BLAUSTEIN, 1998), *Enithares indica* (WATTAL et al., 1996) and *Anisops bouvieri* (SAHA et al., 2007a; 2007b) and the odonates *Enallagma civile* (MIURA & TAKAHASHI, 1988) and *Anax imperator* (STAV et al., 2005) have shown potential as biological control agent against the immature stages of mosquito, in larger habitats such as rice fields, wetlands and ponds. In smaller, annual habitats such as containers and tree holes, copepods, especially *Mesocyclops thermocyclopoides* (MITTAL et al., 1997; KUMAR & RAO, 2003), and the larvae of the mosquitoes *Toxorhynchites splendens* (PRA) and *T. rutilus* (34) have been shown to be efficient in regulating populations of disease carrying mosquitos such as *Aedes albopictus* (NYAMAH et al., 2011).

Considering the predatory nature of odonate larvae, assessments were made of the larvae of *Bradinopyga geminata* (Anisoptera) and *Ceriagrion coromandelianum* (Zygoptera) as biological control agents against the dengue vector *Aedes aegypti*, under laboratory conditions. *B. geminata* larvae are commonly available in cement pond ecosystems and *C. coromandelianum* larvae are abundant in the ricefields, ponds and temporary pools in Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India.

MATERIAL AND METHODS

COLLECTION OF MOSQUITO LARVAE – Immature stages of *Aedes aegypti* were obtained from the Centre for Research in Medical Entomology (CRME) Mosquito Colony, Madurai. The laboratory colony was maintained at 25-30°C temperature with supplementary food consisting of a mixture of protein biscuit (60%) and dried yeast powder (40%). Larvae of instars I to IV were regularly supplied for the experiments which were carried out in the present study.

FIELD COLLECTION OF THE PREDATORS – The dragonfly and damselfly larvae were collected from the rice field / pond ecosystem of Tamil Nadu Agriculture College campus (latitude 9°58'08.25"N, 78°12'11.66"E), Madurai using a standard larval dipper (1.5 metre long handle with 350 ml enamel bowl at the end) and long-handled nets with 15 cm diameter × 30 cm long muslin sleeves. The specimens were identified using keys (SUBRAMANIAN, 2009) and *B. geminata* and *C. coromandelianum* were found to the most prevalent species of Anisoptera and Zygoptera, respectively Predators were transported alive from the field to the CRME laboratory in plastic boxes half-filled with water and debris from the breeding sites. In the laboratory, the predators were washed with

clean water and sorted into small plastic trays (15×11×15 cm), half-filled with de-ionized water, and maintained in small aquaria filled with tap water. Aquaria were small containers, oxygenated using air pumps and receiving indirect solar illumination through windows. The 8th and 12th instar larvae of the two odonate species were chosen for the laboratory experiment before conducting the experiment, the larvae were fed with a diet consisting of mosquito larvae and dried yeast powder for three days. They were then starved for two days before using them.

LABORATORY EXPERIMENT − To determine the predatory potential of anisopteran and zygopteran larvae, a series of experiments were conducted. Plastic bowls were used (14 mm diameter with a capacity of 400 ml). They were filled with water and both *Ae. aegypti* larvae and a predator were added. The rate of predation was determined by predatory impact and clearance rate. Three replicates with a control schedule were used for each test. In the control only *Ae. aegypti* larvae were added to the bowls. To determine the predatory impact the method of NABANEETA et al. (2010) was used with the slight modifications of ADITYA et al. (2006).

$$PI = \frac{\sum_{n=1}^{7} PE}{T}$$

where PI = Predatory impact (nos. of prey larvae / hr); PE = % of prey eaten or killed; T = Time in hours, (here T = 7).

In the first set of experiment, the prey: predator ratio was maintained at 25:1. Initially, 1st instar larvae of *Ae. aegypti* were used and one 8th instar of *B. geminata* larva was introduced. This was repeated for one 12th instar of *B. geminata* and one 15th instar of *C. coromandelianum*. Observation was made for a total duration of 7 hours. After each hour the number of prey consumed was calculated and fresh mosquito larvae were added to maintain the same prey density. The same procedure was followed for other larval instars (II, III & IV) of *Ae. aegypti*.

To determine the clearance rate (CR) as stated by GILBERT & BURNS (1999).

$$CR = \frac{V (\ln P)}{TN}$$

where, CR = clearance rate of predators (% of prey killed litres/day/predator); V = volume of water (l); P = % of prey killed; T = time (in day); N = number of predators.

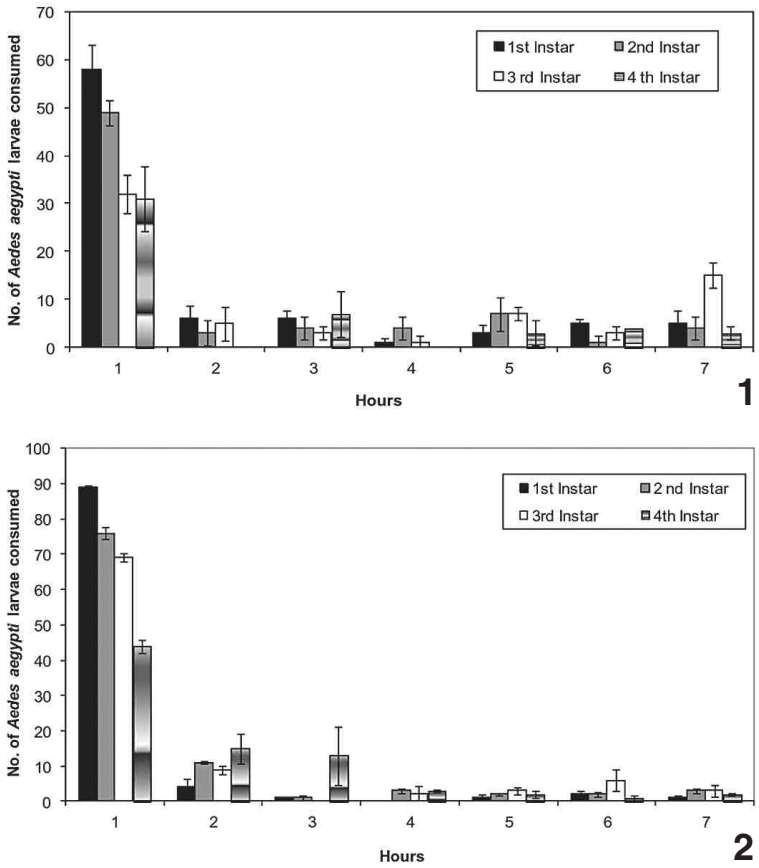
In these experiments, fifty 4th instar *Ae. aegypti* larvae were used and one *B. geminata* 12th instar larva was introduced. The experiment was repeated using *C. coromandelianum* 12th instar larva. and the observation was made every day for three consecutive days with daily replacements of new mosquito larvae. At the end of each day for three days the number of preys consumed and those that had died in the control were recorded and new mosquito larvae added to replace those that had been eaten or had died.

DATA ANALYSIS − The experimental data were analysed using SPSS ver.10 software. One way ANOVA was employed to determine any significant differences in predation by the two odonate predators.

RESULTS

The consumption rate of *Ae. aegypti* by an 8th instar *B. geminata* larva on showed the maximum predation to be of 1st instar larvae (86%), followed by 2nd , 3rd and

4th instars (72%, 66% and 48%) respectively. In the 1st hour the consumption was found to be maximal for all instars and only a low intake (about 5%) was seen in the subsequent hours (Fig. 1). 12th instar larvae of *B. geminata* showed maximum predation on the 1st and 2nd instar larvae (98%), followed by 3rd and 4th instars (92% and 78%) respectively (Fig. 2). In the 1st hour, the consumption was found maximal for all the instars and no significant intake was seen in the following hours. For 12th instar larvae of the maximum predation occurred on the 1st instar larvae (82%) of *Ae. aegypti*, followed by 2nd, 3rd and 4th instars (51%, 35% and 24%) respectively (Fig. 3). Compared to *B. geminata*, consumption of all instars of *Ae. aegypti* by *C. coromandelianum* during the 1st hour was lower. The size of the prey in relation to the predator influences the rate of predation. Analysis of



Figs 1-2. Predation of *Bradinopyga geminata* on *Aedes aegypti* larvae: (1) by the 8th instar; – (2) by the 12th instar.

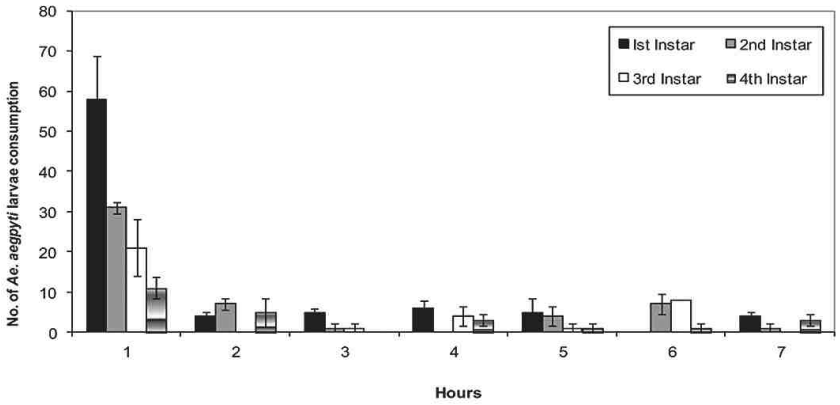


Fig. 3. Predation of *Ceriagrion coromandelianum* (12th instar) on *Aedes aegypti* larvae.

variance was used to determine the predatory efficiency between the predators. It was found that there was an overall significant difference ($P < 0.05$) in predation on *Ae. aegypti* larvae by the two odonate predators, except for the first instar larvae ($F = 1.971$; $P = 0.197$), implying that *B. geminata* was the greater consumer in comparison to *C. coromandelianum* (Tab. I). The reason for the decreased predation on later instars of immature mosquitoes was due to the increase in size of the prey, which resulted in a greater quantity of food intake per individual prey item and, therefore, a reduction in the number of prey consumed (Tab. II).

The predatory impacts (PI), reflecting the prey killing capability of *B. geminata* 8th and 12th instars were higher (PI values ranged from 6.8 to 26.6) than those of *C. coromandelianum*, which is a reflection on the smaller size and thus lower energy requirements of the latter. The consumption rate of *Ae. aegypti* larvae

Table I
ANOVA test showing predatory potential of *B. geminata* and *C. coromandelianum* on *Ae. aegypti* larvae

Mosquito species	Larval instars	8th instar of *B. geminata* consumption (%)	12th instar of *B. geminata* consumption (%)	12th instar of *C. coromandelianum* consumption (%)	One way Annova test
Ae. aegypti	I	86	98	82	NS
	II	72	98	51	S
	III	66	92	35	S
	IV	48	80	24	S

NS = not significant ($P > 0.05$)
S = significant ($P < 0.001$)

Table II

Predatory impact of *B. geminata* and *C. coromandelianum* on *Ae. aegypti* larvae

	Ae. aegypti											
	8th Instar of *B. geminata*				12th Instar of *B. geminata*				12th Instar of *C. coromandelianum*			
Hours	1st Instar	2nd Instar	3rd Instar	4th Instar	1st Instar	2nd Instar	3rd Instar	4th Instar	1st Instar	2nd Instar	3rd Instar	4th Instar
1	58	49	32	31	89	76	69	44	58	31	21	11
2	64	52	37	31	93	87	78	59	62	38	21	16
3	70	56	40	38	94	88	78	72	67	39	22	16
4	71	60	41	38	94	91	80	75	73	39	26	19
5	74	67	48	41	95	93	83	77	78	43	27	20
6	81	68	51	45	97	95	89	78	78	50	35	21
7	86	72	66	48	98	98	92	80	82	51	35	24

by *B. geminata* was higher for the 12th instar, due to its larger size and thus greater energy requirements. The predation of early instar mosquito larvae was observed to be higher than on later instars by both predators, except for the 12th instar of *B. geminata* (Tab. III).

The clearance rate (CR) reflects the combined effect of search ability, killing and consumption by the predator and prey evasion, in unit time and space. The CR for *B. geminata* and *C. coromandelianum* larvae of mosquito larvae ranged between 1.75 & 1.77 and 1.67 & 1.77, respectively and was similar on all the three days of observation. In the control set, no larval mortality was found (Tab. IV).

DISCUSSION

The results shows that the odonate larvae were able to consume mosquito larvae substantially, though the rate of consumption varied between the species as well as with the number of prey present. The only species of dragonfly known to oviposit in drums exposed in the field in Yangon is the libellulid *Bradinopyga geminata* (Rambur) which, according to (KUMAR, 1973), is a univoltine monsoon species with unusual breeding habits and phenology. Insects that are recognized as having predatorial capacity with regard to mosquito prey have been identified in the Odonata, Coleoptera, Diptera (primarily aquatic predators) and Hemiptera (primarily surface predators) (CANYON & SHAALAN, 2009). The odonates viz; dragonfly (Anisoptera and Zygoptera) are true enemies of mos-

Table III
Predatory impact (PI) of *B. geminata* and *C. coromandelianum* on the larval instars of *Ae. aegypti*

Instar	*B. geminata*		*C. coromandelianum*
	8th Instar	12th Instar	12th Instar
I	12.29	14.00	11.71
II	10.29	14.00	7.29
III	9.43	13.14	5.00
IV	6.86	26.67	3.43

quitoes as the larvae of these insects are able to utilize mosquito larvae as food and the adults are efficient predators of airborne adult mosquitoes (HWANG & RAMKUMAR, 2006). Dragonfly larvae have good predatory potential and can be used as a biological control agent for the control of mosquito breeding (SINGH et al., 2003). Successful results have been found using *Libellula* larvae as predators in the biological control of *Aedes* mosquitoes in laboratory and field conditions in Rangoon (SEBASTIAN et al., 1980). Use of odonate larvae in temporary pools or larger habitats, where they can be a potential biological resource in regulating the larval population of the vector and pest mosquitoes, has been demonstrated amply by MANDAL et al. (2008). BAY (1974) reported that dragonfly larvae are known to prey heavily on bottom feeder mosquitoes such as *Aedes* larvae. SEBASTIAN et al. (1990) conducted a pilot field study, involving periodic augmentative release of predaceous *Crocothemis servilla*, larvae to suppress *Ae. aegypti* during the rainy season in Yangon, Myanmar. CHATTERJEE et al. (2007) found that significant reduction in *Anopheles subpictus* larval density in dipper samples was observed 15 days after the introduction of "*Brachytron pratense*" larvae in concrete tanks under field conditions in India. Augmentative release of odonate larvae has been used as an effective means of regulating *Ae. aegypti* mosquitoes in Myanmar under controlled conditions (SEBASTIAN et al., 1990). In this study, the predatory potential of the larvae of an anisopteran and a zygopteran on the mosquito vector *Ae. aegypti* was evaluated in the laboratory. The conclusion is that both are effective as predators of dengue vector *Ae. aegypti* and may be useful in biocontrol of medically important mosquitoes like dengue. In particular, due to its larger size, *B. geminata,* which almost invariably breeds in cement tanks where dengue vector, *Ae. aegypti*, also copiously breeds, can be expected to consume good number of mosquito larvae and be effectively used as a strong biocontrol agent for the control of dengue in this type of habitat. However, zygopteran larvae tend to occur

Table IV
Clearance rates (CR) of *B. geminata* and *C. coromandelianum* against 4th instar of *Ae. aegypti*

Species	*B. geminata*			*C. coromandelianum*		
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Ae. aegypti	1.76	1.75	1.77	1.67	1.73	1.77

in greater numbers than anisopteran larvae if such a cement tank is harbouring vegetation. Hence experiments using individuals may conceal the true impact of a species such as *C. coromandelianum* which warrants further investigation.

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REFERENCES

ADITYA, G. & G.K. SAHA, 2006. Predation of the beetle Rhantus sikkimensis (Coleoptera: Dytiscidae) on the larvae of Chironomus Meigen (Diptera: Chironomidae) of the Darjeeling Himalayas of India. *Limnologica* 36(4): 251-257.

ADITYA, G., A. ASH & G.K. SAHA, 2006. Predatory activity of Rhantus sikkimensis and larvae of Toxorhynchites splendens on mosquito larvae in Darjeeling, India. *J. Vect.-Borne Dis.* 43: 66-72.

ADITYA, G., S. BHATTACHARYYA, N. KUNDU, G.K. SAHA & S.K. RAUT, 2004. Predatory efficiency of the water bug Sphaerodema annulatum on mosquito larvae (Culex quinquefasciatus) and its effect on adult emergence. *Bioresource Technol.* 95: 169-172.

ASHOKKUMAR, V., R. RAJENDRAN, R. MANAVALAN, S.C. TEWARI, N. ARUNACHALAM, K. AYANAR, R. KRISHNAMOORTHI & B.K. TYAGI, 2010. Studies on community knowledge and behavior following a dengue epidemic in Chennai city, Tamil Nadu, India. *Trop. Biomed.* 27(2): 330-336.

BAY, E.C., 1974. Predator-prey relationships among aquatic insects. *Annu. Rev. Ent*. 19: 441-453.

BLAUSTEIN, L., 1998. Influence of the predatory backswimmer Notonecta maculata, on invertebrate community structure. *Ecol. Ent*. 23: 246-252.

CANYON, D.V. & E.A. SHAALAN, 2009. Aquatic insect predators and mosquito control. *Trop Biomed.* 26(3): 223-261.

CHATTERJEE, S.N., A. GHOSH & G. CHANDRA, 2007. Eco-friendly control of mosquito larvae by Brachytron pratense larva. *J. environ. Health* 69(8): 44-49.

CORBET, P.S., 1980. Biology of Odonata. *Annu. Rev. Ent.* 25: 189-217.

CORBET, P.S., 2000. Use of odonate larvae for biocontrol of insect pests. *Agrion* 4(2): 22-27.

FINCKE, O.M., 1999. Organization of predator assemblages in neotropical tree holes: effects of abiotic factors and priority. *Ecol. Ent.* 24: 13-23.

GILBERT, J.J. & C.W. BURNS, 1999. Some observations on the diet of backswimmer Anisops wakefieldi (Hemiptera, Notonectidae). *Hydrobiology* 412: 111-118.

GRATZ, N.G., 1990. Emerging and resurging vector borne diseases. *Annu. Rev. Ent.* 44: 51-75.

GUBLER, D.J., 1997. Dengue and dengue haemorrhagic fever: its history and resurgence as a global public health problem. *In*: D.J. Gubler & G. Kuong, [Eds], *Dengue and dengue haemorrhagic fever*, pp. 1-22. CAB International, New York.

GUBLER, D.J., 1998. Resurgent vector-borne diseases as a global health problem. *Emerg. infect. Dis.* 4(3): 442-450.

KAY, B.H., V.S. NAM, T.V. TIEN, N.T. YEN, T.V. PHONG, V.T. DIEP, T.U. NINH, A. BEKTAS & J.G. AASKOV, 2002. Control of Aedes vectors of dengue in three provinces of Vietnam by use of Mesocyclops (Copepoda) and community-based methods validated by entomologic, clinical and serological surveillance. *Am. J. trop. Med. Hyg.* 66(1): 40-48.

KUMAR, A., 1973. The life history of Bradinopyga geminata (Rambur) (Odonata: Libellulidae). Gurukul Kangri Vishwa Vidayalya. *J. scient. Res.* 5: 50-57.

KUMAR, R. & J.S. HWANG, 2006. Larvicidal efficiency of aquatic predators: a perspective for mosquito biocontrol. *Zool. Stud.* 45(4): 447-466.

KUMAR, R. & T.R. RAO, 2003. Predation on mosquito larvae by Mesocyclops thermocyclopoides (Copepoda: Cyclopoida) in presence of alternate prey. *Hydrobiology* 88: 570-581.

LUNDKVIST, E., J. LANDIN, M. JACKSON & C. SVENSSON, 2003. Diving beetles (Dytiscidae) as predators of mosquito larvae (Culicidae) in field experiments and in laboratory tests of prey preference. *Bull. ent. Res.* 93(3): 219-226.

MANDAL, S.K., A. GHOSH, I. BHATTACHARJEE & G. CHANDRA, 2008. Biocontrol efficiency of odonate larvae against larvae of the mosquito, Culex quinquefasciatus Say, 1823. *Acta trop*. 106(2): 109-114.

MATHAVAN, S., 1976. Satiation time and predatory behaviour of the dragonfly larvae Mesogomphus lineatus. *Hydrobiology* 50(1): 55-64.

MICIELI, M.V., J.J. GARCIA & T.G. ANDREADIS, 2001. Epizootiological studies of Amblyospora albifasciati (Microsporidiida: Amblyosporidae) in natural populations of Aedes albifasciatus (Diptera: Culicidae) and Mesocyclops annulatus (Copepoda: Cyclopidae) in a transient floodwater habitat. *J. Invert. Pathol.* 77(1): 68-74.

MITTAL, P.K., R.C. DHIMAN, T. ADAK & V.P. SHARMA, 1997. Laboratory evaluation of the biocontrol potential of Mesocyclops thermocyclopoides (Copepoda: Cyclopidae) against mosquito larvae. *SEast Asian J. trop. Med. pub. Health.* 28(4): 857-861.

MIURA, T. & R. TAKAHASHI, 1988. A laboratory study of predation of damselfly larvae, Enallagma civile, upon mosquito larvae Culex tarsalis. *J. Am. Mosq. Cont. Assoc.,* 4(2): 129-131.

NABANEETA, S., G. ADITYA, G.K. SAHA & S.E. HAMPTON, 2010. Opportunistic foraging by heteropteran mosquito predators. *Aquat. Ecol.* 44(1): 167-176.

NYAMAH, M.A., SULAIMAN, S. & B. OMAR, 2011. Field observation on the efficacy of Toxorhynchites splendens (Wiedemann) as a biocontrol agent against Aedes albopictus (Skuse) larvae in a cemetery. *Tropical Biomed.* 28(2): 312-319.

PRAMANIK, M.K. & S.K. RAUT, 2003. Occurrence of the giant mosquito Toxorhynchites splendens in drains and its predation potential on some vector mosquitoes of Kolkata (Calcutta), India. *J. med. Ent. Zool.* 54(4): 315-323.

PRAMANIK, M.K. & S.K. RAUT, 2005. Predation rhythm of the water bug Sphaerodema rusticum Fabricius. *Environ. Ecol.* 23(3): 707-713.

RUSSELL, B.M., J. WANG, Y. WILLIAMS, M.N. HEARNDEN & B.H. KAY, 2001. Laboratory evaluation of two native fishes from tropical North Queensland as biological control agents subterranean Aedes aegypti. *J. Am. Mosq. Cont. Assoc.* 17(2): 124-126.

SAHA, N., G. ADITYA, A. BAL & G.K. SAHA, 2007a. A comparative study of predation of three aquatic Heteropteran bugs on Culex quinquefasciatus larvae. *Limnology* 8(1):73-80.

SAHA, N., G. ADITYA, A. BAL & G.K. SAHA, 2007b. Comparative studies on functional response of common heteropteran bugs of East Calcutta wetlands, Kolkata, India. *Int. Rev. Hydrobiol.* 92(3): 242-257.

SEBASTIAN, A., M.M. SEIN, M.M. THU & P.S. CORBET, 1990. Suppression of Aedes aegypti (Diptera: Culicidae) using augmentative release of dragonfly larvae (Odonata: Libellulidae) with community participation in Yangon, Myanmar. *Bull. ent. Res.* 80: 223-232.

SEBASTIAN, A., M.M. THU, M. KYAW & M.M. SEIN, 1980. The use of dragonfly larvae in the control of Aedes aegypti. *SEast Asian J. trop. Med. pub. Health*. 11(1): 104-107.

SINGH, R.K., R.C. DHIMAN & S.P. SINGH, 2003. Laboratory studies on the predatory potential of dragon-fly larvae on mosquito larvae. *J. Comm. Dis.* 35(2): 96-101.

STAV, G., L. BLAUSTEIN & Y. MARGALIT, 2005. Individual and interactive effects of a predator and controphic species on mosquito populations. *Ecol. Applic.* 15: 587-598.

SU, T. & M.S. MULLA, 2002. Introduction and establishment of tadpole shrimp Triops newberryi (Notostraca: Triopsidae) in a date garden for biological control of mosquitoes in Coachella Valley, southern California. *J. Vec. Ecol.,* 27(1): 138-148.

SUBRAMANIAN, K.A., 2009. *Dragonflies of India, a field guide*. Vigyan Prasar.

VOYADJOGLOU, A.S., V. ROUSSIS. & P.V. PETRAKIS, 2007. Biological control of mosquito populations: an applied aspect of pest control by means of natural enemies. *In*: A.M.T. Elewa, [Ed.], *Predation in organisms: a distinct phenomenon*, pp. 123-149, Springer, Berlin.

WATTAL, S., T. ADAK, R.C. DHIMAN & V.P. SHARMA, 1996. The biology and predatory potential of the notonectid bug Enithares indica (Fabr) against mosquito larvae. *SEast Asian J. trop. Med. pub. Health* 27(3): 633-636.

WORLD HEALTH ORGANIZATION, 1997. *Dengue haemorrhagic fever: diagnosis, treatment, prevention and control*, [2nd edn]. World Health Organization, Geneva.

YANOVIAK, S.P., 2001. Predation, resource availability, and community structure in neotropical water filled tree holes. *Oecologia* 126: 125-133.

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SHORT COMMUNICATIONS

THE LARVA OF *HELIAESCHNA SIMPLICIA* KARSCH, 1891 (ANISOPTERA: AESHNIDAE)

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The ♀ larva is figured and described for the first time, based on exuviae from a reared specimen and an F larva collected from runnels in peat swamp forest in Sarawak, Malaysia. The larva is compared with those of *Heliaeschna filostyla* Martin, 1906 and *H. uninervulata* Martin, 1909, the only other spp. of the genus so far described, as well as certain other aeshnid genera. Notes on habitat and behaviour are included.

INTRODUCTION

The genus *Heliaeschna* Selys is found in Africa and throughout tropical Asia as far eastwards as Sulawesi. Currently there are five species recognised from Africa (SCHORR & PAULSON, 2012) and six from Asia, but it is now thought unlikely that species from the two areas are congeneric (DIJKSTRA, 2005). Five of the Oriental species are currently recorded from Borneo, *H. bartelsi* Lieftinck, *H. crassa* Krüger, *H. idae* (Brauer), *H. simplicia* (Karsch) and *H. uninervulata* Martin, none of them endemic (ORR, 2003). Of these, only the larva of *H. uninervulata* has been described, having being discovered in Singapore (ORR & NGIAM, 2011). The larva of *H. filostyla* Martin, a species endemic to Sulawesi, was earlier described by KAWASHIMA & SASAMOTO (2007). Here we describe the larva of *H. simplicia*, a species ranging from Borneo and Sumatra (LIEFTINCK, 1954) to Peninsular Malaysia (ORR, 2008) and the Philippines (HÄMÄLÄINEN & MÜLLER, 1997).

The affinities of *Heliaeschna uninervulata* and *Gynacantha* have been discussed

by ORR & NGIAM (2011). There are striking differences between *H. uninervulata* and *H. filostyla*, suggesting that further division amongst Oriental species may be necessary. In further confirmation of this view, *H. simplicia* presents yet another very different set of characters, some of which are unique amongst known aeshnid larvae.

METHODS

The exuviae of 16-II-2012 and a preserved F larva were prepared, examined and illustrated using a stereomicroscope, camera attachment and scanner.

HELIAESCHNA SIMPLICIA KARSCH

Figures 1-9

M a t e r i a l. – Two ♀ larvae were collected from a small muddy runnel in peat swamp forest close to Sungai Subis, Niah N.P. Sarawak on 7-II-2012. The figured larva emerged on 16-II-2012 in a small emergence cage outdoors and no feeding behaviour was observed. The second larva, initially F-3, was bred to F instar when it died and was preserved in 70% ethanol. A third ♀ larva had been previously obtained from Bintulu, Sarawak in 2011, but the resulting adult was damaged and thus impossible to identify with certainty, however the exuviae was perfectly preserved and appears identical to the first mentioned.

HABITUS (Fig. 1). – length 38mm. A characteristically shaped aeshnid with a distinctive head. Coloration dark brown with pale markings on lateral spines, thorax, legs and head, both dorsally and ventrally.

H e a d (Fig. 2). – Somewhat pentagonal; ratio of length: breadth 5.0: 7.2. Antennae seven segmented, mainly dark, seg. 1 with a pale spot basally, segs 2-6 pale distally and seg. 7 with a pale ring near the base, plus a pale tip. Length ratio of segments 1-7 as follows: 1.0 : 1.1 : 1.2 : 1.7 : 1.6 : 1.3 : 1.1. The anterior portion of the head, consisting of labrum, clypeus and frons is pronounced, being produced both forwards and laterally by an extension of the postclypeus. The mandibles are particularly well developed and prominent in external dorsal view, being strongly produced laterally at their outer angles, which form an angle of about 80°, slightly truncated apically with sparse, short setae giving it a slightly rounded appearance. The posterior portion of head, including ocular and postocular areas is rather swollen and rounded, as seen in profile (Fig. 3). Vertex with the ocellar mound very prominent, bearing a distinctive tuft of long setae. Frons somewhat raised and on either side between the ocellar mound and the antennal socket there is a small low prominence, about the size of an ocellus. These are most evident in profile and in dorsal view may appear as small pale spots or dimples. The surface of the head is generally smooth, apart from a fringe of hairs on the labrum, which has setae on the lateral parts, the somewhat wrinkled clypeus is naked, while the frons and vertex have a scattering of small setae. The eyes are large, their sagittal length being slightly longer than the occipital length. In dorsal view the oc-

ciput has sub parallel sides, which taper to a rounded baso-lateral angle and continue inwards, producing a basal margin that is concave centrally, its surface has a patch of warts on either side of the central suture and there are similar warts around the bare markings typical of many larvae, these warts become larger and rather toothed on the lateral margins. Labium (Fig. 4) with prementum long with a strongly convex lateral margin distally tapering sinuously to a narrow base. There is a row of 20+ strong spines, large and marginal distally, becoming gradually smaller and, seen in dorsal view, curving inwards slightly from the margin towards the base, terminating about the midpoint of the lateral margin. Some of the spines have a smaller thin seta alongside. The anterior margin of the prementum has a deep central 'v' shaped incision, presumably shaped to receive the palpal hooks at rest, on either side is a well developed, rounded lobe. These lobes have a thin, naked, blade-like rim centrally, extending slightly beyond the fleshy part of the lobe; this rim ends with a slight step at approximately 2/3^{rds} of the distance from the centre, whence the margin continues smoothly with a row of 30+ small setae on its outer 1/3rd (Fig. 5). The labial palps bear long, thin, curved and somewhat sickle shaped hooks, with a row of tiny teeth on their inner margin; only a few tiny setae are present, unlike those present in *Gynacantha* spp. The movable hooks are long slender and curved. Mandibles in ventral view (Fig. 6) with protruding, acute outer corners and exceptionally long, well defined dentition arising from both incisor and molar surfaces.

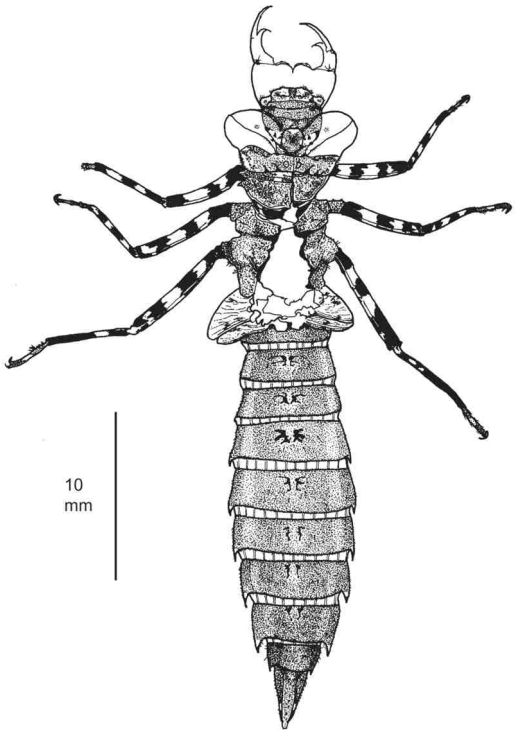
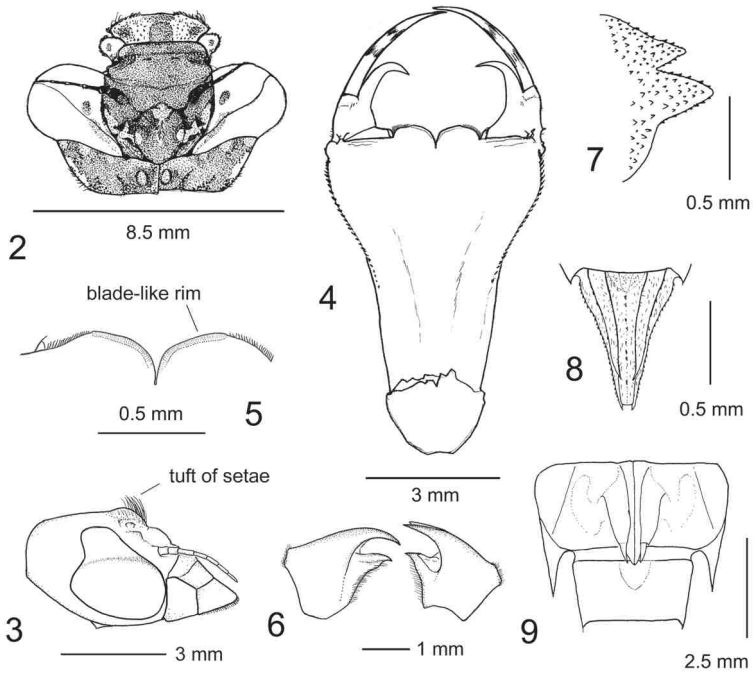


Fig. 1. *Heliaeschna simplicia* ♀ exuviae, habitus.

T h o r a x. – Prothorax (Fig. 1) the pronotum is saddle shaped and developed laterally into a pointed process. The supra coxal armature (Fig 7) has a short pointed frontal lobe separated from the longer, stouter recurved rear lobe by a v-shaped margin. The surface is covered in warty spines. Legs (fig 1) are moderately long and are strongly marked with 3 pale irregularly-shaped annules on tibiae

and femora, whilst tarsi have a pale spot on the 3rd segment. Carinae have rows of short spines and there is a scattering of setae on most surfaces. Wing cases are separated in the exuviae, projecting vertically downwards on either side of the abdomen, they are mid-brown in colour with a scattering of darker markings. In the F larva the outer left hindwing case reaches to just beyond the basal margin of S4 (the right wing case is clearly stunted), the inner forewing cases reach to just before the apical margin of S3.

A b d o m e n. – Dorsal surface dark grey-brown and covered in warts which provide bases for minute setae, some adpressed, some slightly raised. Longer setae are more numerous towards the lateral margins. Normal glabrous, aeshnid markings are present on the dorsum and near to the lateral margins. Ventrally the coloration is similar, but with more longer setae visible on the lateral thirds of each segment. Lateral spines present on segs 5-9, those on 5 being short, but obvious; the remainder becoming successively longer, those on 7-9 overlapping the succeeding segments. Ratio of length of 9th spine (measured from internal base) to dorsal length of seg. 9, 3.0 : 6.9. The margins of seg. 10 are produced distally



Figs 2-9. *Heliaeschna simplicia*: (2) head, dorsal view; – (3) head in profile showing tuft of setae on ocellar mound; – (4) anterior part of labium, dorsal view; – (5) ventral detail of anterior margin of prementum showing blade-like rim; – (6) mandibles, ventral view; – (7) detail, supra-coxal armature; – (8) anal appendages, dorsal view; – (9) gonapophyses.

and could be interpreted as spines. The tips of all spines are pale coloured. Anal appendages distinctive (Fig. 8); epiproct long, approximately 2.3 times length of seg. 10, its keel bearing a row of small spines and terminating bluntly. Paraprocts are of equal length to epiproct, terminating in a sharp point, inner and outer margins serrated with a few long fine setae and a sparse covering of short setae. Cerci are also long, 4/5th the length of epiproct, slightly sinuous apically and with a sharp, incurved tip. Gonapophyses (Fig. 9) reach to the base of seg. 10; outer gonapophyses same length as the sharply down-curved inner gonapophyses.
VARIATION. – No differences could be discerned between the F larva and the exuviae. However as an F-3 instar the larva was a lighter brown colour and had a dark central stripe on the dorsum of the abdomen.

HABITAT AND BEHAVIOURAL OBSERVATIONS

The described larva was found in a tiny runnel in alluvial swamp forest, which was muddy and contained leaf litter and twigs. A large stream was 20metres away, which originated in karst limestone. In captivity the larvae spent its time with the tip of the abdomen projecting out of water, emerging 11 days later.

No feeding was observed, but two other larvae have been observed taking shrimps, worms and tadpoles either actively hunting on substrate or striking from a semi vertical pose on emergent material. The larva collected April 2011 was taken from the bottom of a forest pool, which was close to a large stream but showed no indication of flow at all.

DISCUSSION

There are several striking differences between this *Heliaeschna* larva and the other two previously described (*H. filostyla* and *H. uninervulata*). The head has a similar large postclypeal shelf, but only *H. simplicia* has this developed laterally into a broad wedge shape which are associated with the extremely well developed mandibles. Such a structure is more like that of *Tetracanthagyna* species (MATSUKI 1988; ORR et al. 2010) in which the mandibles are also very robust, but only in *H. simplicia* is the outer angle acute and the dental armature is more pronounced than in any *Tetracanthagyna* species (Orr, unpublished data). Compared with known *Heliaeschna* larvae the lateral margins of the occiput appear to taper more towards the base. In profile the entire posterior part of the head is somewhat elevated and rounded. The vertex bearing the ocellar mound is very pronounced and topped by a tuft of long setae. This feature together with the overall shape of the head is quite distinctive in the field, easily visible to the naked eye, and has not been reported from any known aeshnid larva. It is in the labium however that the greatest differences from other *Heliaeschna* larvae appear. The shape of the labium with its strongly hooked palps is highly reminiscent of

Tetracanthagyna, but quite different from the typical gynacanthid shape found in *H. uninervulata*. The lack of setae on the palps and labial projections also show a separation from *Gynacantha* and *H. filostyla*. However in the absence of other unifying characters it is probable that the superficial similarity in the mask of *H. simplicia* and *Tetracanthagyna* arose from convergence and is associated with a similar diet and/or style of feeding. The distal margin of the prementum, with its wide and deep cleft, separating the large convex lobes present a condition even more exaggerated that that found in *Tetracanthagyna*. The smooth, blade like inner margins of this structure, succeeded laterally by rows of dense short setae is a remarkable and hitherto unknown condition among aeshnids.

The development of lateral spines on the 10th segment does not appear to be present in either of the other two species of *Heliaeschna.* These significant differences seem to confirm the possible separation of Oriental *Heliaeschna* into at least 3 different genera (ORR & NGIAM, 2011).

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REFERENCES

DIJKSTRA, K.-D.B., 2005. Taxonomy and identification of the continental African Gynacantha and Heliaeschna species (Odonata: Aeshnidae). *Int. J. Odonatol.* 8: 1-32.

KAWASHIMA I. & A. SASAMOTO, 2007. Descriptions of the last two instar larvae of Heliaeschna filostyla Martin, 1906 (Anisoptera, Aeshnidae, Aeshninae) from Sulawesi Island, Indonesia. *Tombo* 49: 9-14.

HÄMÄLÄINEN, M. & R.A. MÜLLER, 1997. Synopsis of the Philippine Odonata, with lists of species recorded from forty islands. *Odonatologica* 26: 249-315.

LIEFTINCK, M.A., 1954. Handlist of Malaysian Odonata: a catalogue of the dragonflies of the Malay Peninsula, Sumatra, Java and Borneo, including the adjacent small islands. *Treubia* (Suppl.) 22: i-xiii, 1-202.

MATSUKI, K., 1988. Description of the larva of Tetracanthagyna waterhousei (McLachlan) from Hong Kong and Thailand (Aeshnidae: Odonata). *Tombo* 31: 1-4.

ORR, A.G., 2003. *A guide to the dragonflies of Borneo, their identification and biology.* Nat. Hist. Publs. (Borneo) Kota Kinabalu/Sabah, Malaysia.

ORR, A.G., 2008. Eight days in Peninsular Malaysia and the benefits of hindsight. *Agrion* 12: 24-27.

ORR A.G., R.W.J. NGIAM & T.M. LEONG, 2010. The larva of Tetracanthagyna plagiata, with notes on its biology and comparisons with congeneric species (Odonata: Aeshnidae) *Int. J. Odonatonol.* 13: 156-166.

ORR A.G. & R.W.J. NGIAM, 2011. A description of the larva of Heliaeschna uninervulata Martin (Odonata: Aeshnidae) from Singapore, with notes on its relationships. *Int. J. Odonatol.* 14: 163-169.

SCHORR, M. & D. PAULSON, 2012. *World Odonata list*. http://www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/dragonflies/world-odonata-list/. University of Puget Sound, WA. − [Accessed 20 May 2012].

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HYLAEARGIA SIMPLEX SPEC. NOV., A THIRD SPECIES OF *HYLAEARGIA* LIEFTINCK FROM NEW GUINEA (ZYGOPTERA: PLATYCNEMIDIDAE)

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The new species is described from the upper Sepik Basin. Holotype ♂: Papua New Guinea, West Sepik Prov., 30-XI-2009; deposited in the Museum & Art Gallery of the Northern Territory, Darwin, Australia. The adults of both sexes are illustrated, habitat conditions are given, and the affinities of the new sp. are discussed.

INTRODUCTION

LIEFTINCK (1949) established the genus *Hylaeargia* for the single species *simulatrix*, a sombre-coloured species with rather complex male anal appendages. MICHALSKI (1995) added *H. magnifica*, a vividly coloured species with comparatively simple male anal appendages (MICHALSKI, 1996). *H. simplex* sp. n., a third species that is similar to *H. simulatrix* in colouration and close to *H. magnifica* in structure and shape of the male terminalia, was recently collected. It is described, illustrated and discussed below.

MATERIAL AND METHODS

The descriptive terminology largely follows CHAO (1953) and WATSON & O'FARRELL (1991). Colouration is given as detectable from the preserved material. Measurements are given in millimetres (mm). All illustrations were done with the aid of a camera lucida and are not to scale.

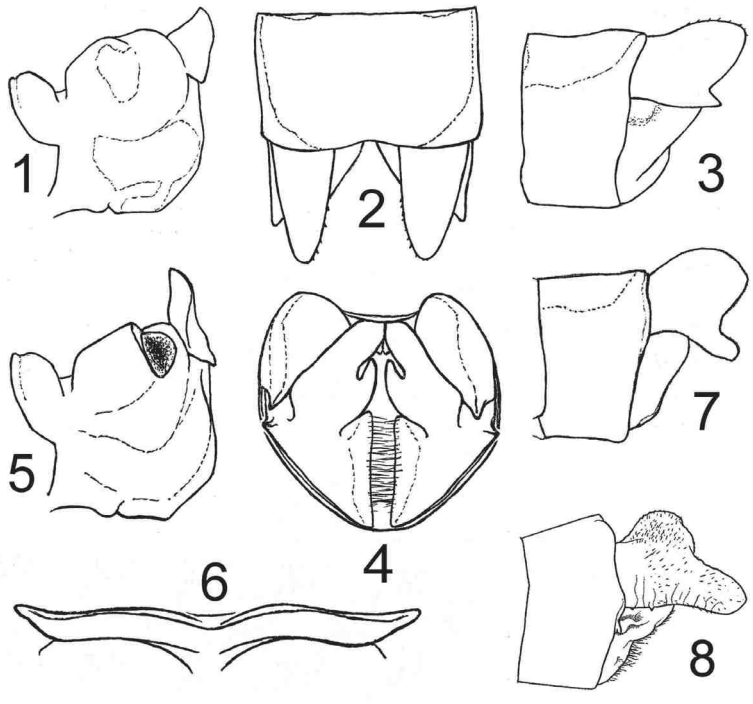
The type series of *Hylaeargia simplex* sp. n. is deposited in the collection of the Museum and Art Gallery of the Northern Territory (NTM), Darwin, Northern Territory, Australia.

HYLAEARGIA SIMPLEX sp. nov.

Figures 1-6, 9-10

M a t e r i a l. – Holotype ♂ (NTM I008591): Papua New Guinea, West Sepik Province, Creek adjacent Nena Camp (4°39.185S, 141°43.448E, 850 m asl), 30-XI-2009, S.J. Richards (NTM). Paratypes (NTM I008592-8600): Papua New Guinea: 1 ♂, same data as holotype, 1 ♂, Nena stream, 30-XI-2009, 2 ♂, Nena Base, 6-VI-2010, 1 ♂, Nena Camp, 7-VI-2010, 2 ♂, 1 ♀, Nena Base, 8-VI-2010, all S.J. Richards; 1 ♂, coll Michael Sale near Nena Camp, 3-XII-2009. Referred specimens: 2 ♀ (Naturalis, Leiden): Papua New Guinea, Ekwai Debom (4°41.738S, 141°44.881E; 1380 m asl.), 17-II-2010, S.J. Richards.

E t y m o l o g y. – The specific name (Latin simplex for simple) refers to the simplicity in structure and shape of the male anal appendages of the species.



Figs 1-8. *Hylaeargia* structural features: [Figs 1-6]: *H. simplex* sp. n., 1-4 male, 5-6 female: (1) prothorax, lateral view; – (2) anal appendages, dorsal view: – (3) same, lateral view; – (4) same, caudal view; – (5) prothorax, lateral view; – (6) posterior lobe, dorsal view. – Fig. 7: *H. magnifica* Michalski, male anal appendages; – Fig. 8: *H. simulatrix* Lieftinck, male anal appendages.

MALE. – Head. – Labium including lobes black, only narrowly pale along midline; labrum pale greenish blue with narrow black anterior and lateral margins narrowly connected with wide subtriangular black basal patch; mandible bases pale greenish blue, black adjacent to labrum, remainder black; clypeus, top of frons, antennae, vertex, postgenae and often median 1/2 or less of anterior frons adjacent to clypeus black; sides of anterior frons, sometimes also median portion of anterior frons and genae largely pale greenish blue, thus forming pale transverse bar from eye to eye.

Figs 9-10. *Hylaeargia simplex* sp. n. in life: (9) male; – (10) female.

Thorax. – Prothorax black with only a blue elongate mark on proepimeron along median lobe of pronotum, rarely an additional blue patch each side on top of median lobe. Synthorax black, each side with 2 blue lateral stripes, one across most of metepisternum and another across posterior half and anterodorsal corner of metepimeron; metakatepisternum narrowly tipped with blue; terga vivid blue and black; mesopostcoxae spotted blue laterally, metapostcoxae spotted blue laterally and marked blue ventrally; poststernum black with blue anterolateral patch connected to second lateral stripe and with blue posteromedian patch. Legs largely black; forelegs with inner face and a spot on outer face of coxa, anterior face of trochanter and inner face of femur blue; middle- and hindlegs with coxae except for most of outer face, anterior face of trochanters and inner face of femora largely blue.

Wings. – Membrane hyaline, venation and pterostigma black; postnodals 17-20/15-17.

Abdomen. – Tergum 1 black with irregular blue patch of variable size each side; terga 2-7 black with a small bluish patch dorsal to secondary genitalia and extreme ventral margin of terga 3-7 greyish yellow; terga 8 and 9 black with extensive bright blue dorsal patch across 3/4 respectively the entire length; segment 10 black with bright blue patch across entire length; sterna black. Anal appendages black; superiors bilobed in profile, the dorsal lobe wide and rounded, the ventral angulate and hardly projecting below the horizontal; inferiors with wide base and finger-shaped apex.

Measurements (in mm). – Hindwing 21.5-23.2; abdomen plus appendages 29.8-32.0.

FEMALE. – Head. – Labium narrowly pale also along base; labrum pale greyish- to whitish blue with base narrowly black and indistinctly to distinctly darker along anterior and lateral margins and along basal 2/3 of midline; mandible bases pale blue, black adjacent to labrum, remainder black; clypeus, top of frons, antennae, vertex and postgenae largely black; an extensive pale yellowish brown patch each side between antennal base and vertex and another on postocular lobe; anterior frons and genae pale bluish green.

Thorax. – Pronotum largely grey, yellowish brown and black, propleura black, pale greyish blue and pale greyish yellow. Synthorax black, each side with 2 yellowish brown lateral patches, one covering almost the entire mesanepisternum and another covering most of posterior 2/3 of mesepimeron; most of metepisternum, a large posterodorsal wedge of metepimeron and postero-ventral tip of each katepisternum whitish to pale greyish blue; outer face of postcoxae and much of poststernum also whitish to pale greyish blue. Legs largely black with only outer face of coxae black and pale greyish blue, and with inner faces of coxae, trochanters and femora largely pale greyish to whitish blue.

Wings. – Pterostigma greyish brown; postnodals 18-20/15-17.

Abdomen. – Tergum 1 black with large pale greyish blue dorso-lateral patch each side; tergum 2 each side with sub-basal elongate brown dorso-lateral patch about ½ as long as segment, yellowish brown also in latero-basal corner; terga 3-5 with increasingly smaller almond-shaped yellowish brown anterodorsal spot each side, tergum 3 in addition with narrow yellowish brown lateral ray across approximately 2/3 its length; terga 6 and 7 black; terga 8 and 9 black with blue patch across subapical 1/3 to almost 1/2 length and mid-dorsally not, partly or completely divided; segment 10 dorsally largely blue, laterally and ventrally black; anal appendages rather sharply pointed, black; valvae black with pale greyish brown basal and apical patch, and with a row of around 17 thin sharp teeth; ovipositor reddish to blackish brown.

Measurements (in mm). – Hindwing 22.7; abdomen plus appendages 27.6.

HABITAT. – At the type locality all specimens were found in sunny patches along a small, fast-flowing rocky stream in foothill rainforest (850 m asl), where *H. simplex* perched on leaves in low stream-side vegetation (Figs 9-10).Two females that are referred to this species were collected nearby on the summit ridge

of Ekwai Debom (4°41.738S, 141°44.881E; 1380 m asl.) far from permanent water. While only known from the vicinity of the type locality, given the extent of suitable habitat in northern New Guinea the new species almost certainly has a broad distribution in the region.

DISCUSSION. – The structure and shape of the male anal appendages indicate that *H. simplex* is probably the sister species of *H. magnifica*. Whereas the colouration of *H. magnifica* is very vivid, it is rather inconspicuous in *H. simplex*. In addition the ventral lobe of the superior anal appendages (Fig. 3) is simply angulate and hardly projecting beyond the horizontal in *H. simplex* (vs finger-shaped and significantly projecting beyond the horizontal in *H. magnifica;* Fig. 7). In the sombre-coloured *H. simulatrix* (Fig. 8) both cerci and papraprocts are much more elaborate in structure and shape than in the other two species.

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REFERENCES

CHAO, H.F., 1953. The external morphology of the dragonfly Onychogomphus ardens Needham. *Smithson. misc. Collns* 122(6): 1-56.

LIEFTINCK, M.A., 1949. The dragonflies (Odonata) of New Guinea and neighbouring islands, 7: Results of the Third Archbold Expedition 1938-39 and of the Le Roux Expedition 1939 to Netherlands New Guinea (II. Zygoptera). *Nova Guinea* (N. S.) 5: 1-271.

MICHALSKI, J., 1995. New Guinea continued. *Argia* 7(10): 12-17.

MICHALSKI, J.C., 1996. Description of Hylaeargia magnifica Michalski, a damselfly from Papua New Guinea (Odonata: Zygoptera). *Tijdschr. Ent.* 139: 29-32.

WATSON, J.A.L. & F.A. O'FARRELL, 1991. Odonata (dragonflies and damselflies). *In*: CSIRO, [Eds], *The insects of Australia*, [2nd edn], Melbourne Univ. Press, Melbourne].

ODONATOLOGICAL ABSTRACTS

1997

(19412) WATANASIT, S., 1997. Size and mating success in a non-territorial damselfly Xanthagrion erythroneurum (Zygoptera: Coenagrionidae). *J. Sci. Soc. Thailand* 23: 61-74. (With Thai s.). − (Dept Biol., Prince Songkla Univ., Haad Yai, Songkla-90112, Thailand).
The flight activity and reproduction behaviour were studied (XI/XII-1989, X/XI-1990) at Pelican Point near Perth (W Australia). Although the age had a significant effect on mating success, the size (head width and wing length) of ♂♂ and ♀♀ had none. Both ♂♂ and ♀♀ had the greatest chance of mating close to 7 d after emergence.

(19413) WATANASIT, S., 1997. Sperm displacement in the damselfly Xanthagrion erythroneurum (Zygoptera: Coenagrionidae): variance in female sperm count and genital morphology. *J. Sci. Soc. Thailand* 23: 115-122. (With Thai s.). − (Dept Biol., Prince Songkla Univ., Haad Yai, Songkla-90112, Thailand).
The study was conducted at a small lake in the Forestdale Lake Reaerve near Perth (W Australia). ♀♀ captured during copulation had fewer sperm in their storage organ than those during pre- and post-copula, suggesting that the ♂ removes the rival sperm during the copulation. The structure of the penis shows that the ♂ scoops sperm from the bursa copulatrix before or during deposition of its own sperm.

(19414) YABU, S. & A. NAKASHIMA, 1997. Ecological studies on the conservation of Nannophya pygmaea Rambur populations and habitats. *J. Jila* 60(4): 324-328. (Jap., with Engl. s.). − (Authors' current addresses unknown).
The vegetation, land morphology, water quality and relative light intensity were investigated at N. pygmaea habitats in Motegi, Tochigi pref. (Japan).

1998

(19415) BAMBARADENIYA, C.N.B., K.T. FONSEKA & C.L. AMBAGAHAWATTE, 1998. a preliminary study of fauna and flora of a rice field in Kandy, Sri Lanka. *Ceylon J. Sci.* (Biol.) 25: 1-22. − (First Author: Sri Lanka Country Office, IUCN, 53 Horton Place, Colombo-07, Sri Lanka).
The study was carried out during a single cultivation cycle in a terraced paddy field (0.5 ha), located at Ampitiya (May-Oct. 1992). Neurothemis tullia, Orthetrum sabina and Agriocnemis spp. were recorded.

(19416) BECKEMEYER, R.J. & D.G. HUGGINS, 1998. Checklist of Kansas damselflies. *Ks School Naturalist* 44(1): 3-15, col. pls incl. − (First Author: 957 Perry St., Wichita, KS 67230-3141, USA).
Produced in the same style and providing the same type of information as the Anisoptera pt, described in *OA* 11430, 40 spp. are listed and Erythemis vesiculosa is added to the Anisoptera list. The total number of Odon. spp. recorded for Kansas (USA) stands now at 121 (40 Zygoptera, 81 Anisoptera).

(19417) MANSFIELD, S. & B.H. MCARDLE, 1998. Dietary composition of Gambusia affinis (family Poeciliidae) populations in the northern Waikato region of New Zealand. *N.Z. Jl Marine Freshw. Res.* 32: 375-383. − (First Author: Sch. Biol. Sci., Univ. Auckland, P.B. 92-019, Auckland, New Zealand).
The odon. represent 0.4% in diet composition and they are consumed between Dec. and March.

(19418) MATHEW, G., P. RUGMINI & V.V. SUDHEENDRAKUMAR, 1998. *Insect biodiversity in disturbed and undisturbed forests in the Kerala parts of Western Ghats*. Kerala Forest Res. Inst., Peechi, Thrissur. 113 pp. ISBN none.
6 identified odon. spp. and Macromia sp. are listed from 4 regions in the study area, Kerala, India.

(19419) NILSSON, A.N., B. MALMQVIST, M. BÁEZ, J.H. BLACKBURN & P.D. ARMITAGE, 1998. Stream insects and gastropods in the island of Gran Canaria (Spain). *Annls Limnol.* 34(4): 413-435. (With Span. s.). − (First Author: Dept Anim. Ecol., Univ. Umeå, SE-901-87 Umeå).
The current status of the stream-dwelling taxa of Gran Canaria (Canary Isls) is documented. The odon. are represented by Orthetrum chrysostigma, Sympetrum fonscolombii, Trithemis arteriosa and Zygonyx torrida.

1999

(19420) FURRIOLS, M. et al. [13 joint authors], 1999. The Odonata of Osona and their distribution. *Butll. Inst. catal. Hist. nat.* 67: 131-140. (Catalan, with Engl. & Span. s's). − (Correspondence to: J. Turet, Univ. Vic. Sagrada Familia, 7, ES-08500-Vic).
36 spp. are listed and their distribution in Osona (Barcelona, Spain) is mapped. Some aspects of the regional abundance, distribution and ecology are discussed.

(19421) HAVENS, K., 1999. Dragonflies: hawks of the insect world. *Virginia Wetlands Rep.* 14(3): 1-2. − (Author's address not stated).
General, including a note on the use of dragonflies as food (Africa, Madagascar, Thailand, Indonesia) and for medical and magical purposes (China, Japan, Mesopotamia).

(19422) HERMANS, J.T., 1999. The dragonfly fauna of the Meinweg area, 1992-1999. *Natuurh. Maandbl.* 88 (Dec.): 308-310. (Dutch, with Engl. s.). − (Hertestraat 21, NL-6067 ER Linne).
The 42 spp. that were recorded from the Meinweg National Park (Limburg, The Netherlands) by 1999 are listed and the fauna is discussed. Some spp., such as Coenagrion lunulatum, Ceriagrion tenellum, Leucorrhinia dubia and L. rubicunda, showed a decline.

(19423) HOLIŠ, J., 1999. [Contribution to the knowledge of dragonflies (Odonata) of Žumberk and its environs]. *Orlicke Hory Podorlicko* 1999(9): 190-191. (Czech). − (Author's address not stated).
Records of 16 spp from 5 localities in the Žumberk area, Czech Republic.

(19424) HUBER, A., 1999. Odonatological survey on the river Somes/Szamos in Romania. *In*: A. Sárkány-Kiss & J. Hamar, [Eds], *The Somes/Szamos river valley: a study of the geography, hydrobiology and ecology of the river system and its environment*, pp. 207-213, Tiscia, Szolnok-Szeged-Târgu Mures. − (Dept Ecol., Kossuth Univ., Egyetem tér 1, HU-4010 Debrecen).
26 spp. are reported from the Romanian section of the river and from 4 adjacent water bodies, 16 of these as larvae and 20 as adults.

(19425) MIYASHITA, M., 1999. Studies on conservation and restoration of the habitat of the damselfly Mortonagrion hirosei. *Proc. Envir. Syst. Res.* 27: 293-304. (Jap., with Engl. s.). − (Natn. Inst. Envir. Stud., JA; postal address not stated).
M. hirosei was designated as an endangered sp. by the [Jap.] Environment Agency in 1991. Its habitat parameters (salinity, topography, vegetation) were studied at 9 tidal rivers in Ibaraki and Nagasaki pref., Japan. The salinity and the time required for the completion of a habitat were above 0.50 permil and 4 yr, respectively. The salinity of the habitat is considered to represent the most important environmental feature required by the sp.

(19426) MUKUNDAN, M., 1999. *On the banks of the Mayyazhi*. [Original title: *Mayyazhi Puzhayute Theerangalil*, translated from Malayalam by G. Krishnankutty]. EastWest Books (Madras). iv + 256 pp. Paperback. ISBN 81-86852-29-8. Price: Rs/Ind 185.—net. − (Publishers: 62A, Ormes Rd, Kilpauk, Chennai-600 010, India).
A novel on the transition period of the 1940s in Mayyazhi (Mahe), a former French territory in Kerala (India). The folklore has it that souls hover as dragonflies over a rock in the sea. − The Author is a well-known Malayalam writer, lives at present in New Delhi, and the French government conferred on him in 1998 the title of Chevalier des Arts et des Lettres.

(19427) SOLEM, B. & J. SOLEM, 1999. Howard county odonate update. *Goldfinck* 27(3): 2. − (10617

Graeloch Rd, Laurel, MD 20723, USA).
Nehalennia gracilis, Libellula auripennis and L. flavida are added to the Howard co. list, which stands now at 82 spp.; − Maryland, USA.

2006

(19428) AIRAUD, J.-Y., B. ROCHELET & N. COTREL, 2006. Anax napolitain (Anax parthenope). *Virgule /Bull. Liaison Groupe "Entomo" Deux--Sèvres Nat. Envir.* 1: 8. − (DSNE, Hôtel de la Vie Associative, 12 rue Joseph Cugnot, F-79000 Niort).
Records from 4 localities in the Sèvre region, France.

(19429) COTREL, N., 2006. Changements de synonimie. *Virgule /Bull. Liaison Groupe "Entomo" Deux--Sèvres Nat. Envir.* 1: 3. − (DSNE, Hôtel de la Vie Associative, 12 rue Joseph Cugnot, F-79000 Niort).
The French vernacular name of Lestes dryas is changed from "Leste dryade" to "Leste des bois".

(19430) COTREL, N., 2006. Les nouveaux petits sympétrums. *Virgule /Bull. Liaison Groupe "Entomo" Deux-Sèvres Nat. Envir.* 1: 8. − (DSNE, Hôtel de la Vie Associative, 12 rue Joseph Cugnot, F-79000 Niort).
Records of Sympetrum danae and S. flaveolum from the Sèvre region, France.

(19431) EHMANN, H., 2006. Libellenfunde im Bundesland Salzburg, 2000-2005 (Insecta: Odonata). *Mitt. Haus der Natur*, Salzburg 17: 91-117. (With Engl. s.). − (Hirschenhöhstr. 25, A-5450 Werfen).
55 spp. recorded (2000-2005) from 123 localities in the province of Salzburg (Austria) are listed. The localities are annotated with the information on their respective coordinates, altitudes and precise observation dates. The spp. are annotated with the information on their abundance at each locality, and the Austrian Red List category is stated where considered appropriate. Voucher specimens were not collected.

(19432) FERLETIČ, U., 2006. [Report on the work of the Odonata Working Group]. *In*: I. Kodela Krašna, [Ed.], *Biološko raziskovalni tabor "Breginj 2005"*, pp. 42-44. Zavod RS za varstvo narave, Ljubljana. ISBN none. (Slovene). − (Merezige 1, SI-6273 Merezige).
A list of 13 spp. from the surroundings of Kobarid (W Slovenia).

(19433) HARP, G.L. & H.W. ROBISON, 2006. Aquatic macroinvertebrates of the Strawberry river system in North-central Arkansas. *J. Ark. Acad. Sci.* 60: 46-61. − (First Author: Dept Biol. Sci., Arkansas St. Univ., State University, AR-72467, USA).
A list of previously published and unpublished records of 50 odon. spp.; − USA.

(19434) HUDOKLIN, A., 2006. Modri ploščec. [Libellula depressa]. *Dolenjski List* 57(29): 18; issue of 20 July). (Slovene). − (ZVNKD, Skalickega 1, P.O. Box 250, SI-6800 Novo mesto).
A note; − Slovenia.

(19435) IWAMOTO, H., K. INOUE & N. YAGI, 2006. Evolution of long-range myofibrillar crystallinity in insect flight muscle as examined by X-ray cryomicrodiffraction. *Proc. R. Soc.* (B) 273: 677-685. − (Res. & Utilization Div. SPring-8, Jpn Synchrotron Radiation Res. Inst., 1-1-1 Kouto, Sayo-cho, Sayo-gun, Hyogo, 679-5198, JA).
Among the 50 spp. of 17 major insect orders examined, the odon. were represented by Copera annulata, Calopteryx cornelia, Pseudothemis zonata and Macromia amphigena. The results show that the occurrence of a long-range crystallinity largely coincides with insect orders with asynchronous muscle operation. However, a few of the most skilled fliers among the lower orders apparently have developed various degrees of structural regularity, suggesting that the demand for skillful flight has driven the lattice structure towards increased regularity. The most notable example are the Zygoptera. The diffraction patterns from their flight muscle clearly show features of a hexagonal lattice, although the reflections are somewhat spread along the circumference. This type of pattern suggests that the lattice planes are in principle preserved for a long distance, although locally disordered. Higher order reflections are also observed. Interestingly, the more advanced Anisoptera have less-registered lattices, although the features of a hexagonal lattice are still evident. A weaker but similar tendency is observed also in Plecoptera, Megaloptera, Blattaria and Mantodea. As to the last 2 orders, the examined spp. are forest dwellers and fly well.

(19436) OBOLEWSKI, K., Z. OSADOWSKI & K. GLINSKA-LEWCZUK, 2006. Effect of hydrotechnical activities on macrophytes and fauna inhabiting Stratiotes aloides L. in oxbow lakes. *Pol. J. envir. Stud.* 15(5): 513-518. − (First Author: Inst. Biol. & Envir.

Prot., Pomeranian Acad., 22/B Arciszewskiego, PO-76-200 Słupsk).
The oxbow lake studied ("Konski Staw") is situated in the district of Słupsk, Poland. The odon. density and biomass increased after dredging. Its reclamation seems to have no influence of odon., represented by Ischnura sp., Lestes sp., Aeshna grandis and Libellula sp.

(19437) POITOU-CHARENTES NATURE, 2006. Atlas odonates: une liste rouge régionale. *Virgule /Bull. Liaison Groupe "Entomo" Deux-Sèvres Nat. Envir.* 1: 4.
Extract from the regional Red List, listing the odon. spp. per IUCN status categories.

(19438) VINKO, D., 2006. [*A list of dragonflies (Odonata) of the city of Mengeš and its vicinity*]. Individualna naloga, Dept Biol., Univ. Ljubljana. 13 pp. (Slovene). − (Slovenska 14, SI-1234 Mengeš).
A commented list of 28 spp.; − central Slovenia, ca 16 km N of Ljubljana.

(19439) XU, Q.-h., 2006. The genus Prodasineura Cowley in China (Odonata, Protoneuridae). *Acta zootaxon. sin.* 31(4): 807-810. (With Chin. s.). − (Dept Biol. & Envir. Eng., Zhangzhou City Univ., Zhangzhou, Fujian-363000, China).
P. fujianensis sp. n. is described and illustrated. Holotype ♂, Shaowu City, Fujian, China, 15-VII-2004; deposited in Zhanzhou Educ. Coll., Zhangzhou, Fujian). A key for the adults of the 9 Chinese Prodasineura spp. is also provided.

2007

(19440) BIBIČ, A., 2007. *Program upravljanja obmocij Natura 2000*. − [*Management program of the Natura 2000 areas (in Slovenia)*]. Ministerstvo za okolje in prostor, Ljubljana. 87 pp. ISBN 978-961-0392-57-0. (Slovene).
The 2007-2013 program is outlined. Coenagrion ornatum, Ophiogomphus cecilia, Cordulegaster heros and Leucorrhinia pectoralis are the monitored odon. spp. in Slovenia.

(19441) CHANG, X., B. ZHAI, X. LIU & M. WANG, 2007. Effects of temperature stress and pesticide exposure on fluctuating asymmetry and mortality of Copera annulata (Selys) (Odonata: Zygoptera) larvae. *Ecotoxicol. environ. Safety* 67: 120-127. − (Second Author: Key Lab. Monit. & Mngmt Plant Disease & Insects, Nanjing Agric. Univ., Nanjing-210095, China).
Although there have been some investigations into the effects of insecticide on the level of fluctuating asymmetry (FA) in adult Zygoptera, the cooperative effects of environmental factors on FA in their larvae were little known. Here are explored the effects of exposure to temperature and pesticide on larval development of C. annulata. A conventional life history trait (mortality) and developmental instability (estimated by calculating fluctuating asymmetry of bilaterally symmetrical structures) were used to measure stresses. The results showed that temperature and different concentrations of pesticide produced significant effects only on developmental stability of some characters. The FA values of 3 traits decreased at lower concentrations, then the interaction between different concentrations of insecticide and temperature was complicated and only produced significant effects on 5 traits. Insecticide treatment did not significantly affect mortality of the larvae. However, mortality was significantly positively associated with temperature. There were significantly negative associations between mortality and the FA values of 3 traits. These results may be caused by higher mortality and short rearing time although the significant effects of concentrations on mortality were not found. Therefore, the authors speculate FA may be induced if larvae were treated during longer term and FA has potential as a more specific bioindicator of stresses, if there is longer rearing time without higher mortality under stressful environment.

(19442) CORBET, P.S., 2007. Foreword. *In*: A.G. Orr & M. Hämäläinen, *The metalwing demoiselles (Neurobasis and Matronoides) of the eastern tropics, their identification and biology*. Nat. Hist. Publs (Borneo), Kota Kinabalu, p. vii. − (Author deceased).
A highly appreciative text on the volume described in *OA* 19450.

(19443) DAKOU, E., T. D'HEYGERE, A.P. DEDECKER, P.L.M. GOETHALS, M. LAZARIDOU-DIMITRIADOU & N. DE PAUW, 2007. Decision tree models for prediction of macroinvertebrate taxa in the river Axios (northern Greece). *Aquat. Ecol.* 41: 399-411. − (First Author: Lab. Zool., Sch. Biol., Aristotle Univ. Thessaloniki, Thessaloniki, Greece).
The decision tree models are here introduced to pre-

dict habitat suitability of 2 crustacean and 4 insect families, incl. the Gomphidae. The modelling techniques were applied on a dataset of 102 samples from 31 sites along the river. The database consisted of 8 physico-chemical and 7 structural variables and the abundances of 90 taxa, although no spp. are listed.

(19444) DYATLOVA, E.S., 2007. [Odonata of southwestern Ukraine in collection of the Zoological Museum of the Mechnikov National University in Odessa]. *Izv. muz. Fonda Braunera* 4(2/3): 29. (Russ.). − (Dept Zool., Fac. Biol., Odessa Natn. Univ., Dvoryanskaya 2, UKR-65026 Odessa).
A list of 2 pp., with localities and dates.

(19445) JUNG, K.-S., 2007. *Odonata of Korea*. Name of the Publishers not transliterated. 512 pp. Hardcover, with flappers (18.3 × 23.0 cm). ISBN 978-89-958060-3-6. Price: 48.000,-- Won. (Korean, with Engl. title & taxonomic nomenclature). − (Author: 6F, IBS Bldg, 1572-18 Seocho-dong, Seocho-ku, Seoul 137-070, Korea).
A beautifully illustrated and very well produced handbook. − For a similar monograph on the larvae see *OA* 18686.

(19446) KALASHIAN, M.Yu. et al., [Eds], 2007. *Must be conserved. IUCN Red List of species of invertebrate animals in the fauna of Armenia*. Publishers not stated, Yerevan. 27 pp. (Threelingual: Armen./ Russ./ Engl.
Listed are Onychogomphus assimilis (VU A2ac+3c ver 3.1) and Cordulegaster mzymtae (described from Georgia, no data from Armenia).

(19447) KALNINŠ, M. & M. MEDNE, 2007. The spatial allocation of dragonflies (Odonata) communities in raised bogs of Latvia. *Book Abstr. 4th int. conf. "Research and conservation of biological diversity in Baltic region"*, 1 p., Inst. Syst. Biol., Univ. Daugavpils. − (Dept Zool. & Anim. Ecol., Fac. Biol., Univ. Latvia, Kronvalds Bulv. 4, LV-1586 Riga).
[Extensive informative abstract] − The research was carried out in 4 named and several unnamed bogs (2005-2006), and 20 spp. were examined, though most are not listed. Aeshna subarctica occurred in Taures bog only (Valka distr.).

(19448) MARKOVIĆ, G.S., V.M. SIMIĆ, A.M. OSTOJIĆ & S.B. SIMIĆ, 2007. Seasonal variation in nutrition of chub (Leuciscus sephalus L., Cyprinidae, Osteichthynes) in one reservoir of West Serbia. *Zborn. Matice srp. prir. Nauke* 112: 107-113. (With Serb. s.). − (First Author: Fac. Agron., Univ. Kragujevac, Cara Dušana 34, RS-32000 Čačak).
At variance with the evidence from the Zapadna Morava river (see *OA* 19463), the odon. occurrence in the diet of fish from the Medjuvršja Reservoir was different per season. They were found in the spring and summer samples, but they were not represented in the autumnal diet.

(19449) NEL, A., D.-Y. HUANG & Q.-B. LIN, 2007. A new genus of isiphlebioid damsel-dragonflies (Odonata: Isophlebioptera: Campterophlebiidae) from the Middle Jurassic of China. *Zootaxa* 1642: 13-22. − (First Author: Entomologie, Mus. Nat. Hist. Nat., 45 rue Buffon, F-75005 Paris).
Sinokaratawia prokopi gen. n., sp. n. is described and illustrated from the Jiulongshan Formation, of Inner Mongolia, NE China. Holotype ♂ and allotype ♀ are deposited in Nanjing Inst. Geol. & Palaeontol. The synapomorphies for the Campterophlebiidae and Isophlebiidae are discussed.

(19450) ORR, A.G. & M. HÄMÄLÄINEN, 2007. *The metalwing demoiselles (Neurobasis and Matronoides) of the eastern tropics, their identification and biology*. Nat. Hist. Publs (Borneo), Kota Kinabalu. x + 115 pp., flappers. Hardcover (18.5 × 26,0 cm). ISBN 978-983-812-123-1. Price: euro 95.—net. − (Publishers: A913, 9th Floor, Phase 1, Wisma Merdeka, P.O. Box 15566, Kota Kinabalu-88864, Sabah, Malaysia).
Without exaggeration, this is in every aspect a splendid work. It covers 14 spp. of the 2 gen., distributed from Pakistan and Sri Lanka in the West, to southern China and New Guinea in the East. The excellent field photographs, and above all, the brilliant watercolour drawings of all spp., with marvellous reproduction of their wing iridescence, by A.G. Orr, are a unique feature of the book. No doubt, the latter are by far the best handmade dragonfly illustrations ever produced. The treatments of spp. include the synonymy, information on the distribution, descriptions of the adults of both sexes, various notes and an outline of taxonomic history of each sp. In all cases where the taxonomic name is dedicated to a person, his/her portrait is also included. The discovery, research and classification of metalwings are traced from Linnaeus to present. Aside of taxonomy

and systematics, during the past 5 decades much of the work has focussed on their biology, including analyses of their complex mating behaviour, territoriality, on the physical basis of their brilliant colours, etc. All this, coupled with numerous original observations by the Authors, is summarised in the book. Patterns of speciation are discussed in their biogeographical context and in the light of contemporary molecular studies on the higher classification of the Calopterygidae. Last but not least, lectotypes are designated for Neurobasis (N.) florida Hag., N. (N.) a. australis Sel. and Matronoides cyaneipennis Förster. Sinobasis Hämäläinen & Orr, subgen. n. is erected for Neurobasis anderssoni. – This monograph is a key contribution to the odonatol. literature and it is certainly to remain the definitive account on the taxa concerned for a long time to come.

(19451) SCHIEFENHÖVEL, P., 2007. *Libellen- und Köcherfliegengemeinschaften im Naturpark Soonwald-Nahe*. DiplArb. Tierökol. & Tropenbiol., Univ. Würzburg. 133 pp. – (Author's address not stated).
The diversity and composition of odon. fauna (25 spp.) was studied at 22 small forest ponds in the Soonwald-Nahe Nature Park, Hunsrück, Rhineland-Palatinate (SW Germany). In much detail, habitat selection is described of Lestes dryas, L. virens vestalis, Aeshna juncea, Leucorrhinia dubia and Sympetrum danae.

(19452) WANG, Z.-g., 2007. Catalogue of Chinese dragonflies (Insecta: Odonata). *Henan Science* 25(2): 1-20. (Chin., with Engl. s.). – (Henan Acad. Sci., Zhengzhou-450002, China).
Lists 659 spp. and sspp., pertaining to 154 gen. of 19 fam.

(19453) WARDHANI, T.S., 2007. *Comparative odonate larval population [Sic!] in selected rivers in Penang island in relation to the influence of habitats and water quality*. Tesis yang diserahkan utuk memenuhi keperluan bagi ljazah Sarjana Sains, Univ. Sains Malaysia, Ogos. viii + 152 pp. [?] (Malayan, with Engl. title and the "*Lorem ipsum*" text replacing an Engl. abstract).
Available are only pp. i-xviii and 1-24. As it stands, the publication cannot be used. – (*Lorem ipsum* is mostly, but not entirely Latin text, with the roots in Cicero's *De finibus bonorum et malorum* from 45 BC, and it is traditionally used, since the 16th century, by printers in the lay-outing process, to be subsequently replaced by the proper text).

(19454) ZHANG, D.-z. et al. [names of joint authors not transliterated], 2007. Research on the resources of dragonflies and damselflies in Ningxia. *J. Anhui agric. Sci.* 35(27): 86-88. (Chin., with Engl. s.). – (Sch. Life Sci., Ningxia Univ., Yinchuan, Ningxia-750021, China).
A commented list of 38 spp., 6 of which are new for the area; – Yinchuan, China.

2008

(19455) ANDERSON FULAN, J., R. RAIMUNDO & D. FIGUEIREDO, 2008. Habitat characteristics and dragonfly (Odonata) diversity and abundance in the Guadiana river, eastern of the Alentejo, Portugal. *Boln Asoc. esp. Ent.* 32(3/4): 327-340. (With Span. s.). – (First Author: Dept Zool., Inst. Biosci., St. Univ. São Paulo, Campus of Botucatu, BR-18618-000 Botucatu).
A total of 105 sites were investigated (1999-2000) and 19 spp. are listed. Canonical Correspondence Analysis indicated that environmental factors were related to some spp. The occurrence of Cordulegaster boltonii, Orthetrum coerulescens and O. nitidinerve was influenced by shade.

(19456) KOLSHORN, P., 2008. Kleinvieh & Co. *Naturspiegel* 70: 26. – (Redaktion Naturspiegel, Hustenfeld 32, D-41379 Brüggen).
A record of Sympecma fusca from its hibernation site in NSG Hülser Bruch, Krefeld (Germany), 17-II-2008.

(19457) MA, J., B. LIANG, S. ZHANG & W. METZNER, 2008. Dietary composition and echolocation call design in three sympatric insectivorous bat species from China. *Ecol. Res.* 23: 113-119. – (First Author: Inst. Zool., Chin. Acad. Sci., 25 Beisihuan Xilu, Haidian, Beijing-100080 China).
The droppings of Murina leucogaster, Miotis chinensis and Rhinolophus ferrumequinum from Bianfu Cave nr Sihe village in Fangsan distr., Beijing (China) were examined. Odon. remains occurred solely in those of M. chinensis.

(19458) MURÁNYI, D. & T. KOVÁCS, 2008. Review and contribution to the Odonata fauna of Maramures, Romania. *Stud. Univ. "Vasile Goldis"* (Life Sci.) 18(Suppl.): 229-234. – (First Author: Dept Zool., Hung. Nat. Hist. Mus., Baross u. 13, H-1088 Budapest).

A commented list of 36 spp., 11 of which are new to the region.

(19459) THOMAS, B., 2008. Spuren des Klimawandels in der Tierwelt vor unserer Haustür. *Naturspiegel* 70: 6-8, cover phot. Crocothemis erythraea exc. – (c/o Redaktion Naturspiegel, Hustenfeld 32, D-41379 Brüggen).
The climate of the southern Niederrhein (Lower Rhine, Germany) has warmed up during the past century for ca 3º C. The spring emergence of 17 common odon. spp. was taking place in the 1990s ca 2 weeks earlier than in the 1980s. In the region, Sympetrum striolatum was emerging more than a month earlier, though its oviposition was accelerated in the 1990s for 11 days at most. For some yr (1991, 1992) there are also indications for the appearance of 2 generations; the sp. was emerging still as late as in October. Its latest emergence date was probably in November; an individual was found perching in sunshine in Lüsekamp / Niederkrüchten on 15-XII-2006. This is said to be probably the latest seasonal date for S. striolatum in Germany. Various spp. (Erythromma lindenii, E. viridulum, Aeshna affinis, Anax parthenope, Orthetrum brunneum, Crocothemis erythraea, Sympetrum fonscolombii) were since the 1980s for the first time recorded from the Niederrhein, some became rather frequent or locally autochthonous.

(19460) WILLKOMMEN, J., 2008. The morphology of the pterothorax of Ephemeroptera, Odonata and Plecoptera (Insecta) and the homology of wing base sclerites and flight muscles. *Stuttgart. Beitr. Naturk.* (A) NS 1: 203-300. (With Germ. s.). – (Staat. Mus. Naturk., Rosenstein 1, D-70191 Stuttgart).
The ability to fly was the decisive factor for the evolutionary success of the most diverse group of insects, the Pterygota. Nevertheless, the ground plan of the functionally important wing base has not been sufficiently clarified. The aim of this study is to homologise the wing base sclerites of Ephemeroptera, usually regarded as sister group of the remaining Pterygota, with that of other basal pterygote lineages and to reconstruct the ground plan of the wing base of Pterygota. The pterothoracic musculature of representatives of the three basal lineages of Pterygota (Ephemeroptera, Odon. and Neoptera) is also described and discussed. Contrary to previous hypotheses, it is shown that most elements of the neopteran wing base are also present in Ephemeroptera and Odon. The wing base in the ground plan of Pterygota is presumably composed of three axillary sclerites. The proximal median plate is probably also present in the ground plan of Pterygota. The first axillary is provided with two muscles. The third axillary is equipped with a short muscle that originates from the epimeron. This muscle is interpreted as another ground plan character of Pterygota. In Plecoptera a second muscle inserts at the third axillary sclerite. It originates from the episternum and is most likely an autapomorphic character of Neoptera. The results imply that the wing base of the Plecoptera is close to the pterygote ground plan. It is assumed that the wing base of Ephemeroptera and Odon. is secondarily stiffened. The so-called basalare and its associated muscles in Ephemeroptera and Odon. are probably not homologous to the basalare and respective muscles in Neoptera. The enlarged subalare and associated muscles, the large dorsal longitudinal muscle, the small metathorax and shortened hindwings in Ephemeroptera suggest that mayflies have a derived flight apparatus in many respects. The Odonata on the other hand show different specialisations, namely a synthorax, large direct flight musculature, and a fusion of second and third axillary with the proximal median plate. Though the wing base in both taxa is secondarily stiffened, the specialisations of Ephemeroptera and Odon. may have evolved independently from each other.

2009

(19461) CHANG, X., B. ZHAI, B. WANG & C. SUN, 2009. Effects of the mixture of avermectin and imidacloprid on mortality and developmental stability of Copera annulata (Odonata: Zygoptera) larvae. *Biol. J. Linn. Soc.* 96: 44-50. – (Key Lab. Monit. & Mngmt Plant Disease & Insects, Nanjing Agric. Univ., Nanjing-210095, China).
The mortality of larvae treated with different concentrations of insecticide did not differ significantly. With respect to fluctuating asymmetry, there was a significantly negative relationship between first femur length and an absolute difference between the right and left sides. This emphasized that insecticide has potential effects on bilaterally symmetrical traits.

(19462) KOLSHORN, P., 2009. Kleinvieh & Co. *Naturspiegel* 75: 26. – (Redaktion Naturspiegel, Hustenfeld 32, D-41379 Brüggen).
Ceriagrion tenellum is recorded from garden ponds in Tönisvorst-St. Tönis (10-VII-2009, with a photo

of copula) and Brüggen-Bonn (31-VII-2009; 10 individuals), both Niederrhein, Germany.

(19463) MARKOVIĆ, G., T. KARAN-ŽNIDARŠIĆ & P. SIMONOVIĆ, 2009. Bryozoan species Hyalinella punctata Hancock in the gut content of chub Leuciscus cephalus L. *Pol. J. Ecol.* 57(1): 201-205. – (First Author: Fac. Agron., Univ. Kragujevac, Cara Dušana 34, RS-32000 Čačak).
In the gut contents of over 30 fish specimens from the Zapadna Morava river (W Serbia), the odon. were represented in the spring, summer and autumn samples. – For different information, see *OA* 19448.

(19464) SCHRÖTER, A. & S. KARJALAINEN, 2009. Hohtoukonkorento Aeshna affinis tavattiin Suomessa ensi kerran. – [First record of Aeshna affinis in Finland]. *Crenata* 2: 36-39. (Finnish). – (First Author: Rasenweg 10, D-37130 Gleichen).
[Abstract not available].

(19465) STRAND, L., M. BILLQVIST & T. KARLSSON, 2009. *Projekt trollsländor i Skåne 2009-2014: inventerinsmanual*. Entomologiska sällskapet, Lund. 36 pp. (Swed.). – (Authors' addresses not stated).
Includes a checklist of 47 spp. recorded from Skåne (Sweden), with an adult phenology graph. Various habitats are described and illustrated.

(19466) SUTTON, P.G., 2009. A checklist of the dragonflies (Odonata) of Corfu (Kérkira) including a new record for the Ionian islands, the Black Pennant Selysiothemis nigra (Vander Linden, 1825). *Bull. amat. Ent. Soc.* 68(485): 136-144. – (1 Fir Tree Close, Flitwick, Beds., MK45 1NZ, UK).
A commented list of 41 spp.; – Greece.

(19467) VRHOVNIK, M., 2009. [*Odonata records from the area of Kotlje*]. Poročilo o samostojnem terenskem delu, Dept Biol., Univ. Ljubljana. 9 pp. (Slovene). – (Dept Biol., Univ. Ljubljana, Večna pot 111, SI-1000 Ljubljana).
An undergraduate student work. The odon. fauna of the vicinity of Kotlje (Carinthia, Slovenia) was surveyed during 2-10 Aug. 2009. From 7 localities, 9 spp. are brought on record.

2010

(19468) ACHOURA, A. & M. BELHAMRA, 2010. Aperçu sur la faune arthropodologique des palmeraies d'El-Kantara. *Courr. Savoir* 2010(10): 93-101. (With Engl. s.). – (Dép. Agron., Univ. Mohamed Khider, Biskra, Algeria).
Aeshna cyanea and Orthetrum coerulescens are reported from 2 date-tree (Phoenixdactylifera) plantations in the Biskra area. NE Algerian Sahara (alt. 124 m).

(19469) CHAMBERS, C.P., M.R. WHILES, E.J. ROSI-MARSHALL, J.L. TANK, T.V. ROYER, N.A. GRIFFITHS, M.A. EVANS-WHITE & A.R. STOJAK, 2010. Responses of stream macroinvertebrates to Bt maize leaf detritus. *Ecol. Applics* 20(7): 1949-1960. – (Second Author: Dept Zool. & Cent. Ecol., Southern Illinois Univ., Carbondale, IL 62901, USA).
The study was conducted in agricultural streams in north-central Indiana, USA, where genetically modified Bt maize is commonly planted along streams. The average odon. abundance (ind./m^2) and ash-free dry biomass (mg/m^2) were much higher in Bt streams than in non-Bt streams. The precise figures are stated.

(19470) COSTA, J.M., C. CARRICO, T.C. SANTOS & B.J.A. MASCARENHAS, 2010. Description of the final instar of Macrothemis heteronycha (Calvert) (Anisoptera: Libellulidae). *Zootaxa* 2506: 65-68. – (First Author: Mus. Nac., Univ. Fed. Rio de Janeiro, Quinta da Boa Vista, São Cristovão, BR-20940-040 Rio de Janeiro, RJ).
A ♂ larva is described and illustrated from Rio de Janeiro state, and a key is provided to the known larvae of 10 Macrothemis spp.

(19471) DAVID, W., 2010. *Von Fallenstellern und Liebesschwindlern. Begegnungen im Naturgarten*. Pala-Verlag, Darmstadt. 175 pp. ISBN 978-3-89566-267-6. – (Publishers: Rheinstr. 35, D-64283 Darmstadt).
2 chapters are dealing with biology and behaviour of adult and larval dragonflies. The style is very popular and the language rather colloquial; – Germany.

(19472) DOMAINE, E., N. DESROSIERS & B. SKINNER, 2010. Les insectes susceptibles d'être désignés manacés ou vulnérables au Québec. *Naturaliste can.* 134(2): 16-26. – (Authors' addresses not stated).
Includes a commented list of 10 odon. spp. that are supposed to be threatened or vulnerable in Quebec, Canada.

(19473) EBERHARD, W.G., 2010. Evolution of genitalia: theories, evidence, and new directions. *Genetica* 138: 5-18. – (Smithsonian Trop. Res. Inst. & Escuola de Biol., Univ. Costa Rica, Ciudad Universitaria, San Pedro, Costa Rica).
Many hypotheses have been proposed to explain why ♂ intromittent genitalia consistently tend to diverge more rapidly than other body traits of the same individuals in a wide range of animal taxa. Currently the 2 most popular involve sexual selection: sexually antagonistic coevolution (SAC) and cryptic ♀ choice (CFC). A review of the most extensive attempts to discriminate between these 2 hypotheses indicates that SAC is not likely to have played a major role in explaining this pattern of genital evolution. Promising lines for future, more direct tests of CFC include experimental modification of male genital form and ♀ sensory abilities, analysis of possible ♂ – ♀ dialogues during copulation, and direct observations of genital behaviour.

(19474) GERAEDS, R.P.G. & U. HAESE, 2010. Rheophile Libellen in einigen grenzüberschreitenden Wasserläufen im deutsch-niederländischen Naturpark Maas-Schwalm-Nette. *Natuurh. Maandbl.* 100(10): 199-204. (With Engl. s.). – (First Author: Bergstraat 70, NL-6131 AW Sittard; – Second Author: Am Gut Bau 28, D-52072 Aachen).
A few brooks and rivers that cross the German--Dutch border in the Maas-Schwalm-Nette Nature Park are of special value regarding rheophilic odon. spp. The occurrence of some of these in the Netherlands is mainly or completely restricted to a few of these streams. Here, the habitats etc. of 7 spp. are described.

(19475) HUDSON, W.H., 2010. *Müssige Tage in Patagonien*. Achilla Presse, Butjadingen. 240 pp. ISBN 978-3-940350-02-2. – (Publishers: Hauptstr. 80, D-26969 Butjadingen).
This is the first German edn of his "*Idle days in Patagonia*", Chapman & Hall, 1893. (For a book review by A.R. Wallace, see *Nature*, Lond., issue of 23 March 1893, pp. 483-484). The book includes a single, passing reference to dragonflies (p. 23 of German edn). – Of considerable odonatol. interest, however, is W.H. Hudson's book, "*The naturalist in La Plata*", published in several edns (e.g. 3rd edn by Appleton, New York), where Chapter 9, titled "*Dragon-fly storms*", presents important information on dragonfly (mostly Aeshna bonariensis) large scale migrations in the Pampas and Patagonia, flying always before the SW wind, called pampero, blowing from the interior of the pampas. This is a dry, cold and exceedingly violent wind that bursts on the plains very suddenly and usually lasts only a short time. It comes irregularly and appears in all seasons of the year. It is in summer and autumn that dragonflies appear, not with the wind, but in advance of it, making their appearance ca 5-15 min before the wind strikes. The vernacular expression of the gauchos for these large dragonflies is "*hijo del pampero*", i.e. son of the SW wind. – W.H. Hudson (born 1841 in Argentina, deceased 1922 in London) was a well-known author of ca 40 Spanish and English belles-lettres and other books, was a renowned ornithologist and is regarded as an Argentine National Poet.

(19476) JARA, F.G. & M.G. PEROTTI, 2010. Risk of predation and behavioural response in three anuran species: influence of tadpole size and predator type. *Hydrobiologia* 644: 313-324. – (First Author: Lab Fotobiol., Centro Reg. Univ. Beriloche, Univ. Nac. Comahue, Quintral 1250, AR-8400 San Carlos de Beriloche, Rio Negro).
The study was conducted in Nahuel Huapi National Park, Patagonia, Argentina, with Pleurodema bufoninum, P. thaul and Rhinella spinulosa tadpoles. Among the most frequent and abundant predators were Rhionaeschna variegata larvae. The predatory effect and behaviour of these are described and discussed.

919477) OUTOMURO, D. & F.J. OCHARAN, 2010. Gomphus simillimus Selys, 1840 (Odonata, Gomphidae) in the river Segura basin and the south of the river Duero basin (SE and central Spain). *Boln Asoc. esp. Ent.* 34(1/2): 245-248. (Span. with Engl. title). – (Depto Biol. Organismos & Sistemas, Univ. Oviedo, c/Catedrático Rodrigo Uria s/n, ES-33071 Oviedo).
5 hitherto unpublished populations of this iberomagrebian sp. are brought on record from Albacete, Murcia and Segovia (2002-2006; alt. 300-853 m), and the known records from Spain are mapped.

(19478) SCHEIBLER, E.E. & N.F. CIOCCO, 2010. Distribution of macroinvertebrate assemblages along a saline wetland in harsh environmental conditions from Central-West Argentina. *Limnologica* 2010: 11 pp.; – DOI: 10.1016/j.limno.2010.03.001. – (JADIZA,CCT, CONICET Mendoza, sede Cricyt, Avda Rutz Leal s/n, Parque General San Marti,

CC507, AR-5500 Mendoza).
Ischnura fluviatilis and Rhionaeschna absoluta are reported from the Bañado Carilauquen, W of the saline lake Laguna Llancanelo (alt. ca 1300 m a.s.l.

2011

(19479) ACHARYA, S., 2011. Presage Biology: lessons from nature in weather forecasting. *Indian J. traditional Knowledge* 10(1): 114-124. − (Dept Bot., Tripura Central Univ., Suryamaninagar-799130, W Tripura, India).
The method used by local and indigenous peoples for predicting rainfall and other weather conditions solely on the basis of bio-indicators (plant phenology and animal behaviour) is coined here as a new term, *Presage Biology*. Some of these phenomena in plant and animal world are described in their application to predict the oncoming rain, based on a literature review as well as on Author's original observations in India and elsewhere. Thus, "dragonfly flying low" indicates the upcoming rain, and "movement of dragonflies", i.e. when humidity reaches saturation, a few hours before a dragonfly swarm starts, also means a short term forecast of rain.

(19480) ADEOGUN, A.O. & O.O. FAFIOYE, 2011. Impact of effluents on water quality and benthic macroinvertebrate fauna of Awba stream and reservoir. *J. appl. Sci. Envir. Mngmt* 15(1): 105-113. − (First Author: Dept Zool., Univ. Ibadan, Ibadan, Nigeria).
As often is the case with the native African authors, they are not familiar with the regional odonatol. literature. The listing of "Progomphus sp., Herlocordulia [?] sp. and Macromia magnifica" from the locality in Ibadan (Nigeria) shows the "identification" of taxa is worthless and the paper odonatologically meaningless.

(19481) ÁLVAREZ GÁNDARA, J., R. ESTÉVEZ RODRIGUEZ & T. SALVADORES RAMOS, 2011. Chorological notes on Orthetrum brunneum (Fonscolombe, 1837) (Odonata, Libellulidae) and new record for Galicia (NW Iberian peninsula). *Arqs ent.* 5: 149-152. (Span., with Engl. s.). − (First Author: Barrio do Souto 10/B, ES-36740 San Salvador de Tebra, Tomiño, Pontevedra).
The published and unpublished records from NW Iberian peninsula are compiled and mapped.

(19482) CAO, L.-z. et al. [names of joint authors not transliterated], 2011. Investigations on Libelluloidea (Odonata) in Guizhou province. *J. Anhui Agric. Sci.* 39(31): 89-92. (Chin., with Engl. s.). − (Jiangxi Normal Univ., Nanchang, Jiangxi-330022, China).
39 spp. are listed, a key to 16 gen. is produced, and the Orthetrum and Sympetrum spp. are keyed.

(19483) CIELOCHA, J.J., T.J. COOK & R.E. CLOPTON, 2011. Host utilization and distribution of nubenocephalid gregarines (Eugregarinorida: Actinocephalidae) parasitizing Argia spp. (Odonata: Zygoptera) in the central United States. *Comp. Parasitol.* 78(1): 152-160. − (First Author: Dept Ecol. & Evol. Biol., Univ. Kansas, Lawrence, KS 66045, USA).
Gregarine host specificity has been the cornerstone of gregarine taxonomy for nearly a century. Several laboratory experiments have accepted strict host specificity by failure to cross-infect distantly related hosts with unrelated gregarine spp. These empirical studies are not feasible for all gregarine hosts, especially non-domesticated groups. Additionally, studies of gregarine distributions have always focused on insect hosts of disparate groups, rather than targeting potential hosts spp. within a single genus and their congeneric gregarines. This study addresses host utilization of nubenocephalid gregarines parasitizing Argia. Populations of 9 spp. of adult Argia were collected, dissected and observed for gregarine infection during the April-Sept. flight seasons in 2007 from 17 localities in the central United States. On average, 2.5 spp. of Argia were collected at each locality. A sp. of Nubenocephalus (N. nebraskensis, N. secundus, or N. spp.) was collected from every infected population of Argia except for the S. vivida population at Prairie Dog Town Fork-Red river, Randall co., Texas. N. secundus utilizes at least 7 of the 9 argid hosts sampled, whereas N. nebraskensis was collected from only 2 argid spp. Only A. translata was observed to host both N. secundus and N. nebraskensis. These patterns of host utilization by nubenocephalid gregarines represent an ecotypic gregarine assemblage rather than a vicariant assemblage, demonstrating that nubenocephalid gregarines do not differentiate between spp. of Argia as hosts.

(19484) DAVID, S., 2011. The importance of anthropogenic water biotopes on the example of dragonflies (Odonata) of Slovakia. *Životné Prostredie* 45(4): 217-221. (Slovak, with Engl. s.). − (Dept Ecol. & Envir.,

Univ. Mitra, Hlinku 1, SK-949-74 Nitra).
The ecological significance was assessed at 252 sites of 4 water bodies of different types. Gravel pits had the highest species richness (50 spp.), followed by lowland channels (48 spp.) and water reservoirs (45 spp.). Basically, these are dynamic ecosystems, vulnerable to disturbances, such as change of water conditions, increased eutrophication and spread of alien and invasive plants. The relevance of old records is inevitably restricted to short periods only.

(19485) DIA, A. & H.J. DUMONT, 2011. The Odonata of Lebanon. *Zool. Middle East* 52: 63-70. – (Second Author: Dept Biol., Univ. Gent, Ledeganckstraat 35, B-9000 Gent).
In a year-long survey, 29 spp. of the approximately 49 known or expected to occur in Lebanon were recorded. A brief biogeographic analysis of the fauna is provided and the almost complete absence of spp. typical of semi-arid to arid environments is emphasized.

(19486) FARKAS, A., T. JAKAB & G. DÉVAI, 2011. Emergence behaviour of riverine dragonfly (Odonata: Gomphidae) larvae along the Tisza river system based on exuviae surveys. *Acta biol. debrecina Oecol. Hung.* 26: 53-66. (Hung., with Engl. s.). – (First Author: Dept Hydrobiol., Fac. Sci. & Technol., Univ. Debrecen, Egyetem tér 1, H-4032 Debrecen).
The emergence distance, selection of emergence support and mortality during the emergence in Gomphus flavipes, G. vulgatissimus, Onychogomphus forcipatus and Ophiogomphus cecilia are described and discussed.

(19487) FICSÓR, M., 2011. Contribution to the occurrence of riverine dragonfly species (Odonata: Gomphidae) in the north-eastern part of Hungary based on larval study. *Acta biol. debrecina Oecol. Hung.* 26: 67-74. (Hung., with Engl. s.). – (Lab. 4, North Hung. Reg. Nat. Conserv. & Water Mngmt Inspectorate, Minszent tér 4, H-3530 Miskolc).
A comprehensive list of records of Gomphus flavipes, G. vulgatissimus, Onychogomphus forcipatus and Ophiogomphus cecilia larvae, from 63 localities in Hungary.

(19488) FLECK, G., 2011. Phylogenetic affinities of Petaluridae and basal Anisoptera families (Insecta: Odonata). *Stuttgart. Beitr. Naturk.* (A) NS 4: 83-104. (With Germ. s.). – (Zool. Forschungsinst. & Mus. 'Alexander Koenig', Adenauerallee 160, D-53113 Bonn).
The petalurid genus Phenes has a larval proventriculus with only four dental folds. This genus is considered as the sister group of remaining Petaluridae and placed in the Pheninae subfam. nov. Two possible phylogenies of the Petaluridae are proposed and diagnoses of Tachopteryginae, Tanypteryginae, and Petalurinae are amended. The Petalurinae are split into Petalurini tribe nov. and Uropetalini tribe nov. The Petaluridae, Austropetaliidae and Aeshnidae are gathered in the new clade Siphonoprocta taxon nov. with Petaluridae sister taxa of (Aeshnidae + Austropetaliidae). The relative positions of the main basal clades Gomphida, Siphonoprocta and Cavilabiata are not solved. Within Cavilabiata the Cordulegastridae and Neopetaliidae are considered sister taxa and are gathered in the Cordulegastroidea comb. nov., and the Chlorogomphidae are considered to represent the sister group of all remaining Cavilabiata or to represent the sister group of the Cordulegastroidea.

(19489) FREDRICKS, T.B. et al. [10 joint Authors], 2011. Dietary exposure of three passerine species to PCDD/DFs from Chippewa, Tittabawassee and Saginaw river floodplains, Midland, Michigan, USA. *Envir. Monit. Assmt* 172: 91-112, tabs 3-10 excl. – (Dept Zool., Michigan St. Univ., East Lansing, MI 48824, USA).
Dietary exposure of house wrens (Troglodytes aeodon), tree swallows (Tachycineta bicolor) and eastern bluebirds (Sialia sialis) to polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) was evaluated based on residues in bolus samples etc. In a graph of percent mass dietary composition it is shown that odon. represent 7% in T. bicolor. Otherwise the paper contains hardly any reference to Odon.

(19490) FUJINO, Y. & S. WADA, 2011. Records of Sympetrum c. croceolum (Selys, 1883) (Odonata: Libellulidae) at Nakaikemi marsh, Tsuruga, Fukui prefecture, Japan. *Bull. Fukui City Mus. nat. Hist.* 58: 65-66. (Jap., with Engl. s.). – (First Author: 1-10-11, Tsunai-cho, Tsuruga, Fukui, 914-0056, JA).
S. croceolum was recorded in 2008 and 2011. It brings the known odon. fauna of the marsh up to the 70 spp. mark. For the complete list of spp., see *Res. Rep. natn. Inst. envir. Stud. Japan* 176 (2003).

(19491) GLIWA, B., 2011. On the names of dragon-

flies and damselflies. *New rare Insect Spec. Lithuania* 23: 115-119. (Lithuan., with Engl. s.). – (Lithuan. Ent. Soc., Akademijos 2, LT-08412 Vilnius).
The principles of the Int. Code Zool. Nomencl. are outlined and it is stated that there is no need for the additional Lithuanian taxonomic names in science, though vernacular names could be useful in a wider discussion.

(19492) KLINGENBERG, K., 2011. Biodiversität in der Schule: Vielfält, Anpassung und Verhalten von Tieren durch lebende Tiere lernen? Ein Beispiel aus dem Lebensraum Stillgewässer. *Treffpunkt biol. Vielfalt* 10: 111-118. – (Author's address not stated).
In accordance with the principle, the "… teachers should plan studies with easily seen and kept invertebrates …", the design is produced of an instruction program on the animal life in stagnant waters, in which a dragonfly larva is included. – (For an odonatol. paper by this Author, see *OA* 9997).

(19493) KOVÁCS, K., B. CSÁNYI, C. DEÁK, Z. KÁLMAN, T. KOVÁCS & J. SZEKERES, 2011. Results of the Rába survey 2009 on aquatic macroinvertebrates, 1: Faunistical results. *Acta biol. debrecina Oecol. Hung*. 26: 135-151. (Hung., with Engl. s.). – (First Author: Laboratory, North Transdanubian Reg. Nat. Conserv., Török Ignác u. 68, H-9028 Györ).
Records of 8 odon. spp. from 18 localities along the Rába river, Hungary.

(19494) LANGE, M., WW. WEISSER, M.M. GOSSNER, E. KOWALSKI, M. TÜRKE, F. JONER & C.R. FONSECA, 2011. The impact of forest management on litter-dwelling invertebrates: a subtropical-temperate contrast. *Biodivers. Conserv.* 20: 2133-2147. – (First Author: Inst. Ecol., Univ. Jena, Dornburger Str. 159, D-07743 Jena).
Litter-dwelling invertebrates were studied along a gradient of increasing land use intensity in subtropical forests (Rio Grande do Sul, Brazil) and in temperate forests (NW Thuringia, Germany). Effects of land use intensity on the entire community (Odon. incl.) were analyzed on the level of orders and feeding guilds. In both regions, land use intensity did not affect taxa richness, but invertebrate abundance was affected in opposite ways: while increasing land use intensity resulted in a decrease of abundance in the subtropics, an increase was observed in the temperate zone.

(19495) MANCI, C.-O., 2011. The dragonfly (Insecta: Odonata) collection of Iasi Museum of Natural History (Romania). *Trav. Mus. Hist. nat. Gr. Antipa* 54(2): 379-393. (With Fr. & Rom. s's). – (Dept Ecol. & Taxonomy, Fac. Biol. & Geol., Babes-Bolyai Univ., Clinicilor 5-7, RO-400006 Cluj-Napoca).
A catalogue of 3162 specimens, pertaining to 45 spp. from 53 localities in Romania is presented along with the localities, (incl. information on their topographic positions) and collection dates. The material includes important distribution records for 3 Natura 2000 spp., viz. Coenagrion ornatum, Gomphus flavipes and Cordulegaster heros. C. scitulum, Somatochlora meridionalis and Sympetrum danae are rarely reported from Romania.

(19496) MARIN, A.A., M. DUMBRAVĂ-DODOACĂ, M. PETROVICI & G. HERLO, 2011. The human impact on benthic community structure and dynamics of different ecosystems from Lunca Moresului Nature Park (West of Romania). *Int. J. Bioflux Soc.* 4(1): 72-78. – (First Author: Dept Biol., Univ. Timisoara, Pestalozzi St. 16/A, RO-300115 Timisoara).
The odon. larvae densities (ind/m^{-2}) are shown in a graph, but spp. names are not stated.

(19497) MIYAKE, M. & T. MIYASHITA, 2011. Identification of alien predators that should not be removed for controlling invasive crayfish threatening endangered odonates. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 2011: 7 pp.; – DOI: 10.1002/aqc.1178. – (Second Author: Lab. Biodiv. Sci., Sch. Agric. & Life Sci., Univ. Tokyo, Yayoi, Tokyo, 113-8656, JA).
When multiple invasive spp. coexist in the same ecosystem and their diets change as they grow, determining whether to eradicate any particular invader is difficult because of complex predator-prey interactions. A stable isotope food-web analysis was conducted to explore an appropriate management strategy for potential alien predators (snakehead Channa argus, bullfrog Rana catesbeiana, red-eared slider turtle Trachemys scripta elegans) of invasive crayfish Procambarus clarkia that had severely reduced the densities of endangered odon. in the Okegaya pond, Shizuoka pref., Japan. The stable isotope analysis demonstrated that medium- and small-sized snakeheads primarily depended on crayfish and stone moroko Pseudorasbora parva. Both adult and juvenile bullfrogs depended on terrestrial arthropods, and juveniles exhibited a moderate dependence on cray-

fish. The turtle showed little dependence on crayfish. These results suggest that eradication of snakeheads risks the possibility of mesopredator release, while such risk appears to be low in other alien predators.

(19498) PETZOLD, F. & W. ZIMMERMANN, 2011. Rote Liste der Libellen (Insecta: Odonata) Thüringens. 4. Fassung, Stand: 11/2009. *Naturschutzreport* 26: 74-78. – (First Author: Pappelallee 73, D-10437 Berlin).
Annotated and commented Red List of 26 spp. in Thuringia (Germany).

(19499) RIBEIRO LOIOLA, G. & P. DE MARCO, 2011. Behavioral ecology of Heteragrion consors Hagen (Odonata, Megapodagrionidae): a shade-seek Atlantic forest damselfly. *Revta bras. Ent.* 55(3): 373-380. (With Port. s.). – (Second Author: Lab. Ecol., Depto Biol. Geral, Inst. Ciên. Biol., Univ. Fed. Goiás, Rodovia Goiânia, Campus II, Setor Itatiaia, BR-74001-970, Goiânia, GO).
The behavioural analysis of H. consors is presented in an attempt to characterize its mating system, diel activity pattern, temporal budget, territoriality and reproductive biology. The data are based on field observations using the focal individual method and mark-recapture techniques along 120 m of a shaded Atlantic forest stream in Brazil. The ♂♂ were territorial, varying in local fidelity, while the ♀♀ appeared sporadically. ♂♂ were most of the time perched, but cleaning movements, longitudinal abdominal flexion, wing flexion and sperm transfer during perch were also observed. They presented a perched thermoregulatory behaviour, related to an exothermic regulation. Foraging and agonistic interactions were rare, but dominated the other behavioural activities. Abdominal movements, associated with the long lasting copula, point to the existence of sperm competition. ♂♂ performed contact post-copulatory guarding of the ♀♀. These observations are pointing to a non-resource mating system in this sp.

(19500) RUNEMARK, A., M. WELLENREUTHER, H.H.E. JAYAWEERA, S. SVANBERG & M. BRYDEGARD, 2011. Rare events in remote dark field spectroscopy: an ecological case study of insects. *JSTQU-INV-PES-04253-2011*: 11 pp. – (Last Author: Appl. Mol. Spectroscopy Gr., Dept Physics, Lund Univ., SE-22362 Lund).
A novel detection scheme for the monitoring of insect ecosystems is presented. Our method is based on the remote acquisition of passive sunlight scattering by Calopteryx splendens and C. virgo at the Klingavalsan river, Sweden. Procedures to identify rare events in remote dark field spectroscopy are explained. Further it is demonstrated how to reduce the spectral representation, and how to discriminate between sexes, using a hierarchical clustering analysis. One-day cycle showing the temporal activities of the 2 sexes, as well as data on activity patterns in relation to temperature and wind are presented. A few examples of the potential use of the technique for studying interactions between sexes on a time scale of milliseconds are also provided. – Biographic notes and the portraits of all authors are appended.

(19501) SÁNCHEZ-GUILLÉN, R.A., B. HANSSON, M. WELLENREUTHER, E.I. SVENSSON & A. CORDERO-RIVERA, 2011. The influence of stochastic and selective forces in the population divergence of female colour polymorphism in damselflies of the genus Ischnura. *Heredity* 107: 513-522. – (First Author: Depto Biol. & Ecol. Anim., EUET Forestal, Univ. Vigo, ES-36005 Pontevedra).
Disentangling the relative importance and potential interactions of selection and genetic drift in driving phenotypic divergence of spp. is a classical research topic in population genetics and evolutionary biology. Here, the role of stochastic and selective forces on population divergence of a colour polymorphism is evaluated in 7 Ischnura spp., with a particular focus on I. elegans and I. graellsii. Colour-morph frequencies in Spanish I. elegans populations varied greatly, even at a local scale, whereas more similar frequencies were found among populations in eastern Europe. In contrast, I. graellsii, I. damula, I. denticollis, I. fluviatilis, I. ramburii and I. senegalensis showed little variation in colour-morph frequencies between populations. F_{ST}-outlier analyses revealed that the colour locus deviated strongly from neutral expectations in Spanish populations of I. elegans, contrasting the pattern found in eastern European populations, and in I. graellsii, where no such discrepancy between morph divergence and neutral divergence could be detected. This suggests that divergent selection has been operating on the colour locus in Spanish populations of I. elegans, whereas processes such as genetic drift, possibly in combination with other forms of selection (such as negative frequency-dependent selection), appear to have been present in other regions, such as eastern Europe. Overall, the results indicate that both selective and stochastic pro-

cesses operate on these colour polymorphisms, and suggest that the relative importance of factors varies between geographical regions.

(19502) SÁNCHEZ-GUILLÉN, R.A., M. WELLENREUTHER & A. CORDERO-RIVERA, 2011. Strong asymmetry in the relative strengths of prezygotic and postzygotic barriers between two damselfly sister species. *Evolution* 66(3): 690-707. – (Last Author: Gr. Biol. Evolutiva, Dept Ecol. & Biol. Anim., EUET Forestal, Univ. Vigo, ES-36005 Pontevedra).
One of the longest debates in biology has been over the relative importance of different isolating barriers in speciation. However, for most spp., there are few data evaluating their relative contributions and one can only speculate on the general roles of pre- and postzygotic isolation. Here, the absolute and cumulative contribution of 19 potential reproductive barriers between the sympatric Ischnura elegans and I. graellsii is quantified, including both premating (habitat, temporal, sexual and mechanical isolation) and postmating barriers (prezygotic: sperm insemination success and removal rate, ovipositon success, fertility, fecundity; postzygotic: hybrid viability, hybrid sterility and hybrid breakdown). In sympatry, total reproductive isolation between I. elegans ♀♀ and I. graellsii ♂♂ was 95.2%, owing mostly to a premating mechanical incompatibility (93.4%), whereas other barriers were of little importance. Isolation between I. graellsii ♀♀ and I. elegans ♂♂ was also nearly complete (95.8%), which was caused by the cumulative action of multiple prezygotic (n = 4; 75.4%) and postzygotic postmating barriers (n = 5; 7,4%). These results suggest that premating barriers are key factors in preventing gene flow between spp., and that the relative strengths of premating barriers is highly asymmetrical between the reciprocal crosses.

(19503) STOLARZ, P., [Ed.], 2011. *Rezerwat Bagno Jacka, monografia przyrodnicza*. – [*The Jacek Marsh Reserve, nature monograph*]. – Centrum Ekologii Czlowieka, Warsaw. 61 pp., ISBN 978-83-930252-2--0. (Pol.). – (Publishers: Kościuszki 24, PO-05-075 Warszawa-Wesola).
The Reserve is situated on the northern outskirts of Warsaw (Poland). 22 odon. spp. are listed.

(19504) TENNESSEN, K.J., 2011. Perigomphus angularis spec. nov. from central Ecuador (Odonata: Gomphidae). *Zootaxa* 2915: 66-68. – (P.O. Box 585, Wautoma, WI 54982, USA).
The new sp. is described and illustrated from a single ♂. Holotype ♂: small stream 1 km S of Rio Pasanac bridge, Morona Santiago prov., Ecuador, alt. 820 m; deposited in FSCA, Gainesville, FL, USA.

(19505) TERZANI, F. & R. FABBRI, 2011. Odonata del Parco Nazionale delle Foreste Casentinesi, Monte Falterona e Campigna (Appennino Settentrionale). *Quad. Studi Notiz. Stor. nat. Romagna* 34: 21-46. (With Engl. s.). – (First Author: Mus. Stor. Nat. "La Specola", Univ. Firenze, via Romana 17, I-50125 Firenze).
An updated review of the odon. fauna (33 spp.) of the Park and its vicinity, N Appennino, Italy.

(19506) VARADINOVA, E.D., L.Z. PECHLIVANOV, S.A. STOICHEV & Y.I. UZUNOV, 2011. Recovering and succession of the species diversity of macrozoobenthos in Srebarba Biosphere Reserve (North-East Bulgaria). *Acta zool. bulg.* 63(1): 85-95. – (First Author: Inst. Biodiv. & Ecosyst. Res., Bulg. Acad. Sci., Yuri Gagarin 2, BG-1113 Sofia).
The published and the previously unpublished records are listed for 27 odon. spp.

(19507) VERBERK, W.C.E.P. & D.T. BILTON, 2011. Can oxygen set thermal limits in an insect and drive gigantism? *PLoS ONE* 6(7): e22610: 6 pp.; – DOI: 10.1371/journal.pone.0022610. – (First Author: Marine Biol. & Ecol. Res. Cent., Sch. Marine Sci. & Engin., Univ. Plymouth, Davy Bldg, Drake Circus, Plymouth, PL4 8AA, UK).
Based on Dinocras cephalotes (Plecoptera), it is demonstrated that upper thermal limits respond to external oxygen supply in its aquatic stages, suggesting that critical thermal limits of such aquatic larvae are set by oxygen limitation. These findings extend the generality of the hypothesis of oxygen limitation of thermal tolerance, suggesting that oxygen constraints on body size may be stronger in aquatic environments, and that oxygen toxicity may have actively selected for gigantism in the aquatic stages of Carboniferous arthropods, such as the Protodonata. – See also W.C.E.P Verberk, D.T. Bilton, P. Calosi & J.I. Spicer, 2011, *Ecology* 92(8): 1565-1572.

(19508) WAHIZATUL, A.A., S.H. LONG & A. AHMAD, 2011. Composition and distribution of aquatic insect communities in relation to water quality in two freshwater streams of Hulu Terengganu, Tereng-

ganu. *J. Sustainability Sci. Mngmt* 6(1): 148-155. – (Dept Biol. Sci., Fac. Sci. & Technol., Univ. Malaysia Terengganu, Kuala Terengganu-21030, Terengganu, Malaysia).
The study was conducted at 2 third-order streams of Sungai Peres and Sungai Bubu, Peninsular Malaysia. The abundance of 9 odon. fam. is stated, but a species list is not provided.

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(19509) AMAYA-PERILLA, C., G.E. FAJARDO--MEDINA, C.J. MORENO-FONSECA & G. HOLWELL, 2012. Dragonfly (Anisoptera: Odonata) diversity from the northern Meta region of Colombia. *Abstr. Pap. 61st Conf. New Zealand ent. Soc.*, Whangarei/NZ, p. 24. – (First Author: Sch. Biol. Sci., Univ. Auckland, Auckland, NZ).
An indicative abstract of an oral presentation of the results of Anisoptera sampling (May & Nov., 2003--2011) at 14 sites in the region. In all, 86 spp. were recorded, but they are not listed here.

(19510) ARMITAGE, P.D., A. HAWCZAK & J.H. BLACKBURN, 2012. Tyre track pools and puddles: anthropogenic contribution to aquatic biodiversity. *Limnologica* 42: 254-263. – (First Author: River Lab., Freshw. Biol. Assoc., East Stoke, Wareham, Dorset, BH20 6BB, UK)
12 sites of tyre track pools and puddles situated in woodland, heath and pasture in Dorset (UK) were examined to determine their macroinvertebrate species richness and community changes over the course of 1 yr. Pyrrhosoma nymphula, Aeshna cyanea, Libellula depressa, Libellula sp. and Sympetrum sp. were recorded. At 1 site, Libellula sp. was among the common taxa.

(19511) BEDJANIČ, M., 2012. *Kačji pastirji ribnika Vrbje pri Žalcu z okolico*. – [*Dragonflies of the fishpond Vrbje near Žalec and its surroundings*]. DPPVN, Rače. 20 pp. ISBN 978-961-93161-1-5. (Slovene). – (Author: Rakovlje 42/A, SI-3314 Braslovče).
The fishpond is located close to the Savinja river, Slovenia. Its dragonfly world (31 spp.) is outlined, with emphasis on conservation status of spp. and their photographs.

(19512) BERNARD, R. & P. BUCZYŃSKI, 2012. [Order dragonflies – Odonata]. *In*: C. Błaszak, [Ed.], *Zoologia*, Vol. 2, Pt 1, pp. 131-144, Wydawnictwo naukowe PWN, Warszawa. (Pol.). – (First Author: Dept Gen. Zool., Adam Mickiewicz Univ., Umultowska 89, PO-61-614 Poznan).
Odon. treatment in the Polish standard zoology handbook.

(19513) BEUKEMA, J.J. & R. MANGER, 2012. Threats of drought for dragonflies in dune areas. *Levende Nat.* 113(6): 288-291. (Dutch, with Engl. s.). – (First Author: Linieweg 19, NL-1783 BA Den Helder).
During more than a decade, dragonfly populations were monitored in dune habitats of the Noord Holland prov., Netherlands. During the periods of drought, the dune ponds and pools become shallow or some of them dry out completely. This triggers a very substantial decline in the numbers of dragonflies. After drought, the anisopteran fauna recovers rapidly through immigration, whereas the Zygoptera require 2-3 yr to reach its normal population size.

(19514) BLANKE, A., B. WIPFLER, H. LETSCH, M. KOCH, F. BECKMANN, R. BEUTEL & B. MISOF, 2012. Revival of Palaeoptera: head characters support a monophyletic origin of Odonata and Ephemeroptera (Insecta) *Cladistics* 28: 560-581. – (First Author: Forschungsmus. A. Koenig, Adenauerallee 160, D-53113 Bonn).
The earliest branching event in winged insects, one of the core problems regarding early insect evolution, is addressed using characters of the head. The head is arguable one of the most complex body regions in insects and the phylogenetic information content of its features has been demonstrated. In contrast, the wings and other body parts related to the flight apparatus and sperm transmission are not useful in the context of this problem, as the outgroups (Zygentoma and Archaeognatha) are wingless and transmit spermatophores externally. Therefore, they show profound differences in the organization of the postcephalic body, and assessment of homology and subsequent phylogenetic analysis of features of these body regions is extremely difficult. The core of this study is the investigation of head structures of representatives of the major clades of dragonflies. A detailed description of the head of Lestes virens is presented and was used as a starting point for the compilation of a character set and a character state matrix for the entire Dicondylia (Pterygota + Zygentoma), with a main focus on the placement of dragonflies and consequently the basal branching

event within winged insects. The results indicate a sister-group relationship between a clade Palaeoptera (Odon. + Ephemeroptera) and the megadiverse monophyletic lineage Neoptera. It is shown that despite considerable structural similarity between the odon. and neopteran mandible, the muscle equipment in dragonflies is more plesiomorphic with respect to Dicondylia than previously known. Odon. and Ephemeroptera also share presumably derived features of the antenna, maxilla, and labial musculature. Parsimony analyses of the head data unambiguously support a clade Palaeoptera.

(19515) *BOLETIN DE LA RED DE OBSERVADORES DE LIBÉLULAS EN ANDALUCIA (ROLA)*, ISSN 2254-5727, No. 1 (May 2012). Editor: F. Prunier, *aeaelbosqueanimado.info@gmail.com* (Span. with Engl. s's). – (No postal addresses are stated anywhere in the issue).
Coladas, B.: Editorial (pp. 2-3); – *ROLA*: Red the observadores de libélulas de Andalucia (ROLA) (pp. 6-20); – *Porrino, R.R.*: Odonatos de Sierra Morena: algunas citas de interés en el periodo 2010-2011 (pp. 22-29); – *Prunier, F., G. González, J.F. Moreno, J. Ripoli, V. Nilsson, I. Nieto & J.C. Salmanca*: Resumen annual ROLA 2011 (pp. 30-50).

(19516) BROCHARD, C., D. GROENENDIJK, E. VAN DER PLOEG & T. TERMAAT, 2012. *Fotogids larvenhuidjes van libellen*. – [*Photographic guide to dragonfly exuviae*]. KNNV Uitgeverij, Zeist. 320 pp. Hardcover (17.3 × 24.4 cm). ISBN 978-90-5011-409-7. Price: euro 49.95 net. (Dutch).
This is more than merely a complete description of, and a key to the exuviae of all the NW European spp. (Eire, UK, Luxemburg, Belgium, Netherlands, Germany, Denmark, Poland). Actually it is a monograph of about all what can be currently said on the subject, and it is presented in a unique style, with emphasis on the splendid photographs of exuviae specimens and of all their morphological details. Some of the given information has never been published before and/or presented in an as lucid, surveyable and conveniently arranged style (e.g. phenology of the emergence periods of all spp., etc.). The book is certainly to become a vademecum for professionals and non-professionals alike, and was presented as such also in some reviews (e.g. by R. BUITER, 2012, in the Netherlands national newspaper, *Trouw*, issue of 13 July, pp. 6-7). It will easily be used also by workers not in command of the language.

(19517) BUCZYŃSKI, P., L. DAWIDOWICZ, W. JARSKA & G. TOŃCZYK, 2012. On the occurrence of Cordulegaster boltonii (Donovan, 1807) (Odonata: Cordulegastridae) in the western part of the Lithuanian Lake District (Poland). *Zoology Ecology* 22(3/4): 198-202. – (First Author: Dept Zool., UMCS, Akademicka 19, PO-20-033 Lublin).
3 sites of C. boltonii occurrence in the Suwalki region NE Poland are analysed.

(19518) BUCZYŃSKI, P. & A. ZAWAL, 2012. Dragonflies (Odonata) of the nature reserve "Zródlisko Skrzypowe". *Parki nar. Rez. Przyr*. 31(3): 23-30. (Pol., with Engl. s.). – (First Author: Dept Zool., UMCS, Akademicka 19, PO-20-033 Lublin).
The Reserve is located in the S Pomeranian Lake District, NW Poland. 10 spp. were recorded, of which the occurrence of Cordulegaster boltonii is noteworthy.

(19519) CANO-VILLEGAS, F.J., A. BERNAL-SANCHEZ, I. FRUTO-CUADRADO & M.A. CONESA-GARCIA, 2012. On the status of Orthetrum nitidinerve (Selys, 1841) (Odonata: Libellulidae) in Andalusia (Spain). *Boln Asoc. esp Ent.* 36(3/4): 469-475. (Span., with Engl. title). – (First Author: C/Isla Mallorca 2, Portal 6, 4º-A, ES-14011 Córdoba).
3 adult ♂ from Parque Natural Los Alcornocalas (Cadiz prov.), 7/12-VII-2012 are brought on record, the habitat is described, the associated odon. spp. listed and the status of the sp. in Andalusia is discussed.

(19520) CANO-VILLEGAS, F.J., M.A. CONESA-GARCIA, A. BERNAL, P.C. RODRIGUEZ & M. LOCKWOOD, 2012. Notes on the situation of Cordulegaster bidentata Selys, 1843 (Odonata: Cordulegastridae) in the Lérida Pyrenees (NE Spain). *Boln Soc. ent. aragon.* 51: 337-339. (Span., with Engl. s.). – (First Author: C/Isla Mallorca 2, Portal 6, 4º-A, ES-14011 Córdoba).
Data on the reproduction in Iberian peninsula of C. bidentata is presented for the first time. Information on the composition of one of its larval colonies in Lérida is provided, pointing out that it shares the habitat with C. boltonii, which could be a sign of the deterioration of its colonies in the area.

(19521) DEONIZIAK, K. et al., 2012. [Inventarisation of dragonflies (Odonata) in the buffer zone of the Narwiański National Park]. *Ocena efektow re-*

naturalizacji strely buforowej Narwiańskiego Parku Narodowego, pp. 44-45, Pol. Tow. Ochrony Ptaków, Bialowieża. (Pol.). – (Publishers: PTOP, Ciepla 17, PO-15-471 Bialowieża).
A commented list of the 26 spp. recorded during the 2011 survey, whereas 47 spp. are known from the Park; – Poland.

(19522) DOLNÝ, A. & F. HARABIŠ, 2012. Underground mining can contribute to freshwater biodiversity conservation: allogenic succession forms suitable habitats for dragonflies. *Biol. Conserv.* 145: 109-117. – (First Author: Dept Biol. & Ecol., Fac. Sci., Univ. Ostrava, CZ-710-00 Ostrava).
Human-induced changes negatively affect all components of freshwater ecosystems and comprise the major cause of global loss of diversity and the biotic homogenization of freshwater faunas. The high odon. diversity in heavily industrialized areas is therefore paradoxical, to say the least. Here, diversity of odon. in 3 main freshwater habitat types (natural and human-made) occurring in Upper Silesia (central Europe) is compared. Multivariate methods and diversity indices are used for a general analysis, comprising both species richness and the species composition of assemblages. 50 spp. in mine subsidence pools from the total of 54 sampled spp. were recorded. These included a high proportion of habitat specialists (typically threatened spp). It is emphasized that secondary habitats (e.g. spontaneously originated mine subsidence pools) should not a priori be regarded as ecological traps, because these often are the available habitats with highest quality. These habitats significantly outweigh ponds in species richness and proportion of habitat specialists. The conservation potential of specific secondary habitats lies in the fact that these can substitute for very rare natural wetlands often restricted to higher elevations. It is assumed that high diversity in this type of secondary habitats is not random, but it rather depends on environmental heterogeneity caused by a specific allogenic succession process occurring as a direct consequence of mining.

(19523) FICETOLA, G.F., M.E. SIESA, F. DE BERNARDI & E. PADOA-SCHIOPPA, 2012. Complex impact of an invasive crayfish on freshwater food webs. *Biodivers. Conserv.* 21: 2641-2651. – (Dept Envir. Sci., Univ. Milano Bicocca, Piazza della Scienza 1, I-20126 Milano).
The relationships between the invasive Procambarus clarkii, amphibian larvae and predatory insects was evaluated in 34 ponds in Lombardy (Italy), in order to quantify crayfish impacts on multiple levels of food webs and to examine whether crayfish predation on aquatic insects has indirect consequences for their prey. Pearson's correlation between the abundance of P. clarkii and odon. is shown in a tab. It remains almost the same whether expressed as individuals/m^2 (-0.45) or as a mass (-0.47).

(19524) FLECK, G., 2012. The true larva and the female of Aeschnosoma marizae Santos, 1981 (Odonata: Anisoptera: Corduliidae s.s.). *Zootaxa* 3488: 80-88. – (32, avenue du Maréchal Joffre, F-31800 Saint-Gaudens).
The final larval instar and the adult ♀ are described and illustrated for the first time. A comparison with the other known larvae of the elegans group is presented. Reared larvae of both sexes unambiguously attributed to A. marizae differ significantly from the previously described larvae attributed to this sp., which probably do not belong to it.

(19525) FRANK, M., 2012. Neue Erkenntnisse zur Verbreitung der Libellen in Mecklenburg-Vorpommern. *Virgo / MittBl. ent. Ver. Mecklenburg* 15(1): 83-84. – (Traubenmühle 5/A, D-55268 Nieder-Olm).
A summary-report on the assessment of ca 200 publications related to the odon. fauna of the federal state of Mecklenburg-Vorpommern (E Germany). The oldest known publicationis that of J.M.G. Füldner (1855, *Arch. Ver. Freunde Naturg. Mecklenburg* 9: 49-79). Some information on historical occurrence of some spp. is provided.

(19526) GABEL, F., X.F. GARCIA, I. SCHNAUDER & M.T. PUSCH, 2012. Effects of ship-induced waves on litoral benthic invertebrates. *Freshw. Biol.* 57: 2425-2435. – (First Author: Inst. Landscape Ecol., Univ. Münster, Rober-Koch-Str. 28, D-48149 Münster).
Ship-induced waves can affect the physical characteristics of lake and river shorelines, and laboratory studies have shown effects on littoral invertebrates. Here was explored whether these effects could be observed under field conditions along a natural lake shore affected by wave sequences (trains) produced by boats. Individuals of 5 invertebrate spp., incl. Calopteryx splendens, were exposed to waves with increasing shear stress in 5 habitats differing in structural complexity. Detachment of invertebrates

increased with increasing shear stress and was best modelled using sigmoid response curves. Habitat structural complexity mitigated the effects of shear stress, and detachment rate was influenced more by habitat type than by species. A threshold (90% of the individual invertebrates unaffected) stress level of 0.64 N m^{-2} was found for a structurally complex reed habitat, compared to 0.37 N m^{-2} for a simple sand habitat. Shear stress associated with wave trains created by recreational boating at a distance of 35 m from the shore and at a speed of 11 km h^{-1} resulted in 45% detachment of littoral invertebrates. Decreasing the boat-to-shore distance to 20 m increased wave shear stress by 30% and invertebrate detachments up to 75%. Disturbance of littoral habitats and invertebrate assemblages are widespread in inland waters used for recreational and/or commercial navigation. The findings of the present Authors show that the integrity of littoral zones of navigable surface waters could be much improved by implementing management measures such as physically protecting complex habitats with dense reed belts and tree roots, and reducing boat speeds and increasing their minimum shoreline distance.

(19527) GAJIĆ, M., 2012. "Kolač u tiganju? Nemoguće …" *Simbioza* 2012(5): 13-14. (Serbian). – (Author's address unknown).
A narrative on various field- and other odonatological activities of the members of the Ent. Sect. of the Biological Research Society "Josif Pančić" at the Univ. of Belgrade (Serbia), in the bulletin of biology students of that university. The initiatives are coming largely from M. Jović, the odonatologist of the Nat. Hist. Mus. Serbia, Belgrade.

(19528) GETACHEW, M., A. AMBELU, S. TIKU, W. LEGESSE, A. ADUGNA & H. KLOOS, 2012. Ecological assessment of Cheffa Wetland in the Borkena Valley, northeast Ethiopia: macroinvertebrate and bird communities. *Ecol. Indicators* 15: 63-71. – (Last Author: Dept Epidemiology & Biostatistics, Univ. California, Box 0560, 185 Berry St., San Francisco, CA 94143-0560, USA).
The wetland is located 300 km NE of Addis Ababa. 10 sites were sampled, the water quality at all of these was degraded to varying degree as a result of human activities. After Hemiptera (24.4%) and Gastropoda (21.3%), the odon. were the most abundant group (19.6%), represented by 5 families, but neither the latter, nor the spp. are stated.

(19529) GHAHARI, H., A. THIPAKSORN, H. NADERIAN, H. SAKENIN & A.A. TAJALI, 2012. A faunistic study on the Odonata (Insecta) from Kurdistan province and vicinity, western Iran. *Linzer biol. Beitr.* 44(2): 1079-1085. (With Germ. s.). – (First Author: Dept Plant Prot., Shahre Rey Branch, Islamic Azad Univ., Tehran, Iran; – Second Author: ASESRU, Dept Zool., Kasetsart Univ., Chatuchak, Bangkok, Thailand).
Records of 25 spp.

(19530) HAYASAKA, D., T. KORENAGA, F. SÁNCHEZ-BAYO & K. GOKA, 2012. Differences in ecological impacts of systemic insecticides with different physicochemical properties on biocenosis of experimental paddy fields. *Ecotoxicology* 21: 191-201. – (First Author: Natn. Inst. Envir. Stud., Onogawa 16-2, Tsukuba, Ibaraki, 305-8506, JA).
The study was conducted in the Tsukuba prov., Japan. Small differences were found in odon. composition between imidacloprid- (9 unnamed spp.) and fipronil-treated fields (7 spp.) [control 9 spp.]. In nekton, Ischnura asiatica and I. senegalensis larvae were dominant, and there were no significant differences in their abundance between control and insecticide-treated fields.

(19531) HERRMANN, J., 2012. Chemical and biological benefits in a stormwater wetland in Kalmar, SE Sweden. *Limnologica* 42: 299-309. – (Sch. Nat. Sci., Linnaeus Univ., SE-391-82 Kalmar).
The wetland (surface 1 ha) is receiving water from residential and road areas and was monitored over the first 3 yr after inundation. Ischnura elegans, Aeshna grandis, Libellula depressa, Coenagrion sp. and Lestes sp. were reported.

(19532) HIPPKE, M., 2012. Die Feuerlibelle Crocothemis erythraea, eine neue Libellenart für das LSG "Schlosspark Ludwigslust". *Virgo /MittBl. ent. Ver. Mecklenburg* 15(1): 98. – (Wiesenring 29, D-19370 Parchim).
1 ♂, 30-VIII-2012; – Mecklenburg, Germany.

(19533) HIPPKE, M., 2012. Libellenmonitoring an neu angelegten Kleingewässern im Biosphärenreservat Schaalsee (2008-2011). *Virgo /MittBl. ent. Ver. Mecklenburg* 15(1): 47-62. – (Wiesenring 29, D-19370 Parchim).
The development of the odon. fauna was monitored (2008-2011) at 27 newly man-made small water bod-

ies in W Mecklenburg, Germany. 36 spp. were recorded, most of these are eurytopic, but some southern elements, such as Lestes barbarus, Aeshna affinis and Crocothemis erythraea were also present. During the observation years, the numbers of individuals and spp. were significantly increasing.

(19534) HORVÁTH, G., 2012. Assessment of riverine dragonflies (Odonata: Gomphidae) and the emergence behaviour of their larvae based on exuviae data on the reach of the river Tisza in Szeged. *Tiscia* 39: 9-15 – (Dept Ecol., Univ. Szeged, Közép fasor 52, HU-6726 Szeged).
The abundance, phenology, sex ratio pattern, mortality and larval emergence behaviour were studied in Gomphus flavipes and G. vulgatissimus.

(19535) HUANG, S.-C. & J. REINHARD, 2012. Color change from male-mimic to gynomorphic: a new aspect of signalling sexual status in damselflies (Odonata, Zygoptera). *Behav. Ecol.* 2012: 1269-1275; – DOI: 10.1093/beheco/ars112. – (Queensland Brain Inst., Univ. Queensland, Brisbane QLD-4072, AU).
Body colour variations are used by many animal spp. to communicate their sexual state and are believed to have evolved through sexual selection. The Zygoptera sometimes come in different colour morphs: gynomorphs and ♂-like andromorphs, pursuing different reproductive strategies. These distinct ♀ colour morphs are usually mature ♀♀ and their colour remains stable throughout their life. Here, it is shown for the first time that blue andromorph ♀♀ of the Australian Ischnura heterosticta are still sexually immature, and change their body colour to green-grey gynomorph when they are ready to mate. The colour change occurs within 24 h and is irreversible. I. heterosticta ♂♂ rarely recognize blue andromorphs as potential mates, but mistake them for other ♂♂. The andromorphs thus avoid ♂ sexual harassment, giving them the advantage of additional time to forage and sexually mature. The colour change to gynomorph signals the readiness to mate, and the former andromorphs have equal mating success after the colour change as other gynomorph ♀♀. These results demonstrate that andromorph I. heterosticta use a complete and unique body colour change from ♂-mimic to gynomorphic to signal sexual maturity and regulate reproduction. This discovery gives rise to a novel hypothesis regarding maintenance of ♀-limited polymorphism in Ischnura via this colour change mechanism.

(19536) HUMALA, A.E. & A.V. POLEVOI, 2012. Additions to the inset fauna of the "Kizhi Skerries" Reserve. *Trudy karel. nauch. Centra RAN* 2012(1): 141-145. (Russ., with Engl. s.). – (First Author: Forest Res. Inst., Karelian Res. Cent., Russ. Acad. Sci., Pushkinskaya 11, RUS-185910 Petrozavodsk, Karelia).
6 odon. spp. are listed from the Reserve, Karelia, Russia.

(19537) JAESCHKE, A., T. BITTNER, A. JENTSCH, B. REINEKING, H. SCHLUMPRECHT & C. BEIERKUHNLEIN, 2012. Biotic interactions in the face of climate change: a comparison of three modelling approaches. *PLoS ONE* 7(12): 10 + 4 pp., e51472. – (First Author: Dept Biogeogr., Univ. Bayreuth, Bayreuth, Germany).
The potential impacts of climate change on the obligate interaction between Aeshna viridis and its oviposition plant Stratiotes aloides in Europe are assessed, based on an ensemble modelling technique. The 3 different approaches for incorporating biotic interactions in distribution models are compared, and the use of the "reference area approach" is recommended, as this method allows a separation of the effect of climate and the host plant occurrence.

(19538) KONZE, K., 2012. Comet darner (Anax longipes): another record from the Hamilton study area and a review of Canadian records. *Wood Duck* 65(9): 201-203. – (Author's address not stated).
A sight record (July 8-12, 2011) from Puslinch Tract Conservation Area, Wellington co., Ontario. The 8 known Canadian records (1918-2011) are reviewed, all from Ontario and New Brunswick.

(19539) KUBOVČIK, V., I. GAJDOŠOVÁ, M. ŠULÁKOVÁ & M. SVITOK, 2012. Dragonflies (Odonata) of the Malá Vodárenská Nádrž and the life cycle of Aeshna cyanea. *Folia faun. slovaca* 17(3): 297-303. (Slovak, with Engl. s.). (Katedra Biol., Fak. Ekol. & Environmentalistiky, Tech. Univ. Zvolen, Masaryka 2117/24, SK-960-53 Zvolen).
The odon. larvae assemblage at the pond (alt. 733 m; Slovakia) is analysed. Out of the 8 spp., A. cyanea was dominant. Based on the measurements, at the locality A. cyanea is semivoltine and the instar distribution during the winter is that of a "summer speecies".

(19540) KUTSAROV, Y., D. BECHEV, R. KOSTADINOV & M. MARINOV, 2012. The Bulgarian Odonata database: current status, organisation and a case study new entries. *ZooNotes* 33: 1-25 [ISSN 1313-9916]. – (Last Author: Freshw. Ecol. Res. Gr., Univ. Canterbury, P.B. 4800, Christchurch-8140, NZ).
Bulgarian Odon. database is analysed for the period of the last 10 yr. It is concluded that during that time mountain areas and large Bulgarian rivers have been understudied.

(19541) LANKIKA, M.D.H., M.M.S.C. KARUNARATNE & K. CONNIFF, 2012. Species composition of odonate fauna in Meegahawatta, a wetland area in Hanwella, Sri Lanka. *J. trop. Forestry Envir.* 2(2): 37-42. – (First Author: Dept Zool., Univ. Sri Jayewardenepura, Nugegoda, Sri Lanka).
A commented list of 27 spp.

(19542) LI, Y., A. NEL, D. REN & H. PANG, 2012. Redescription of the damsel-dragonfly Parafleckium senjituense on the basis of a more complete specimen (Odonata: Isophlebioptera: Campterophlebiidae). *Zootaxa* 3597: 53-56. – (Second Author: Entomologie, Mus. Natn. Hist. Nat., 45 rue Buffon, F-75005 Paris).
P. senjituense is of great importance for clarification of the Isophlebioidea phylogeny; it has several significant structures considered as typical of either Campterophlebiidae or Isophlebiidae, but the gen. and sp. were based on forewings only. Here a new specimen is described, allowing precise description of some other important characters, especially those of the ♂ hindwing. On the basis of this specimen, the diagnosis of Parafleckium senjituense is amended.

(19543) MISZTA, A., 2012. [Dragonflies in the Katowice Forest Park, 1: historical changes in the valley of the Leśny stream]. *Przyroda Górnego Ślaska* 69: 8-11. (Pol.). – (Centrum Dziedzictwa Przyrody Górnego Ślaska, Katowice, Poland).
An account of the landscape/biotope changes since 1794 to present; – Poland.

(19544) MISZTA, A. & K. PRZONDZIONO, 2012. [Dragonflies in the Katowice Forest Park, 2: composition of the odonate fauna during 2002-2011]. *Przyroda Górnego Ślaska* 70: 7-10. (Pol.). – (First Author: Centrum Dziedzictwa Przyrody Górnego Ślaska, Katowice, Poland).
38 spp. recorded after 2002; Polish vernacular names only.

(19545) OTT, J., 2012. Zum starken Auftreten der Grossen Moosjungfer Leucorrhinia pectoralis (Charpentier, 1825) im Jahr 2012 in Rheinland-Pfalz nebst Bemerkungen zu Leucorrhinia rubicunda (L.) (Insecta: Odonata). *Fauna Flora Rheinland-Pfalz* 12(2): 571-590. (With Engl. s.). – (LUPO, Friedhofstr. 28, D-67705 Trippstadt).
L. pectoralis is classified in Rhineland-Palatinate (Germany) as extinct, but in 2012 it was found there at 13 water bodies, in 1 of them as autochthonous and in 5 others pairing and oviposition were observed. It is assumed, the warm weather triggered the expansion from N and E feeder populations. In addition, 2 L. rubicunda individuals were also recorded.

(19546) PAWLAK, S. & T. WILZAK, 2012. Natural values of the "Pastwa" mires in the middle Prosna river valley. *Przegl. przyr.* 23(1): 3-20. (Pol., with Engl. s.). – (First Author: Konopnickiej 15, PO-98-400 Wieruszów).
The locality is situated in the Łodz prov., Poland. Out of the 20 recorded odon. spp., Aeshna affinis, Ophiogomphus cecilia, Somatochlora flavomaculata and Sympetrum meridionale are of particular local interest.

(19547) [PETERS, G.] PAEPKE, H.-J., R. GÜNTHER & J. PLÖTNER, 2012. On the occasion of the eightieth birthday of Prof. Dr Günther Peters. *Zoosyst. Evol.* 88(2): 141-143. – (Leibnitz-Inst. Evolutions- & Biodiv.Forsch., Mus. Naturk., Invalidenstr. 43, D-10115 Berlin).
A brief biographic note and appreciation of his work, with a portrait and an update of his bibliography (1997-2011).

(19548) PETZOLD, F., D. SEIFERT (†) & W. ZIMMERMANN, 2012. Untersuchungen zur Libellenfauna (Insecta: Odonata) im Ostthüringer Holzland durch Dieter Seifert (†), ein beeindruckendes Beispiel ehrenamtlicher Forschung für den Naturschutz. *LandschaftPfl. NatSchutz Thüringen* 49(1): 26-34. (With Engl. s.). – (First Author: Pappelallee 73, D-10437 Berlin).
An overview of the fauna (46 spp.) of 2 protected areas in Thuringia (Germany).

(19549) PFAU, H.K., 2012. Functional morphology

of the head movability and arrestment of Aeshna cyanea and some other dragonflies (Insecta: Odonata). *Entomol. gener.* 33(4): 217-234. (With Germ. s.). – (Rathenaustr. 14, D-65326 Aarbergen).
The functional morphology of the neck sclerites and muscles, which are responsible for head movability and arrestment, is described. The musculature is divided (unsharp) in muscles for head-movements and muscles for head-arrestment and disengagement. A new mechanism of the cervicalia is described: the cervicalia-1/-3 constitute, together with the propleural suspension, a kinematic system with 5 links and 5 joints, which is activated by two pairs of antagonistic muscles. The muscles determine (on both sides) the distance between a pad of the cervical sclerite 2 and the head (which is articulated frontally to the cervicalia-1) by an alteration of both the lateral and longitudinal distances. The head-suspension of dragonflies represents a serious mechanical weak point. Since the head is continuously adjustable nearer or farther to the pads of the cervicalia-2 a gradual adaptation to risks of injury is possible. By strong contraction of the arrester-muscles an elastic bending property of the cervicalia-1 is utilized. The tangential approach and differently strong hooking of microtrichia fields effect a variable frictional damping of passive deflections of the head. Pressure-spring and tension-spring properties, mainly or the proximal bending zone of the cervicalia-1, also serve to protect the vulnerable head-joint. – The evolution of the punctiform head-articulation of the Odonata is reconstructed. Based on the different relative size of the cervical sclerites, the efficiency of different head arrester systems is evaluated. Epallage fatime, Epiophlebia superstes and the Anisoptera indicate an improved effectiveness of the head-arrester functions, which is possibly correlated to enhanced flight capabilities and increased risks of head-joint damage.

(19550) PRPIĆ, N.-M., 2012. Nomenclatural note on the identity of Agrion viridis Vander Linden, 1820: a plea for the selection of a neotype (Odonata: Zygoptera, Lestidae). *Nachr Bl. bayer. Ent.* 61(34): 76-79. (With Germ. s.). – (Abt. Entwicklungsbiologie, Inst. Zool. & Antropol., Univ. Göttingen, Justus-von-Liebig-Weg 11, D-37077 Göttingen).
It has been recognized previously that the name for Lestes viridis, in its original combination Agrion viridis Vander Linden, 1825, is a junior homonym of Agrion viridis Vander Linden, 1820, which is regarded as a junior synonym of Lestes barbara. The junior homonym normally must be replaced by its junior synonym Agrion Leucopsallis De Charpentier, 1825, which would remove a well established and widely used name. Here it is shown that Agrion viridis Vander Linden, 1820, is no synonym of Lestes barbara, but has been based on a heterogenous type series that also contained several other Lestes species. Since no types are preserved, it is suggested that a topotypic neotype should be selected to establish the identity of Agrion viridis Vander Linden, 1820, with the species currently called Lestes viridis. This action would conform to the regulations of the International Code of Zoological Nomenclature and preserve the usage of Lestes viridis.

(19551) ROSARIO, K., A. DAYARAM, M. MARINOV, J. WARE, S. KRABERGER, D. STAINTON, M. BREITBART & A. VARSANI, 2012. Diverse circular ssDNA viruses discovered in dragonflies (Odonata: Epiprocta). *J. gen. Virol.* 93: 2668-2681. – (First Author: Coll. Marine Sci., Univ. Sth Florida, 140 Seventh ave S, St Petersburg, FL-33701, USA).
Viruses with circular ssDNA genomes that encode a replication initiator protein (Rep) are among the smallest viruses known to infect both eukaryotic and prokaryotic organisms. In the past few years an overwhelming diversity of novel circular Rep-encoding ssDNA (CRESS-DNA) viruses has been unearthed from various hosts and environmental sources. Since there is limited information regarding CRESS-DNA viruses in invertebrates, this study explored the diversity of CRESS-DNA viruses circulating among insect populations by targeting dragonflies (Aeshnidae, Corduliidae, Libellulidae), top insect predators that accumulate viruses from their insect prey over space and time. Using degenerate PCR and rolling circle amplification coupled with restriction digestion, 17 CRESS-DNA viral genomes were recovered from 8 odon. spp., collected in tropical and temperate regions. 9 of the genomes are similar to cycloviruses and represent 5 spp. within this genus, suggesting that cycloviruses are commonly associated with insects. 3 of the CRESS-DNA viruses share conserved genomic features with recently described viruses similar to the mycovirus Sclerotinia sclerotiorum hypovirulence- associated DNA virus 1, leading to the proposal of the genus Gemycircularvirus. The remaining viruses are divergent spp. representing 4 novel CRESS-DNA viral genera, including a gokushovirus-like prokaryotic virus (microphage)

and 3 eukaryotic viruses with Reps similar to circoviruses. The novelty of CRESS-DNA viruses identified in odon. using simple molecular techniques indicates that there is an unprecedented diversity of ssDNA viruses among insect populations.

(19552) WELLENREUTHER, M., K.W. LARSON & E.I. SVENSSON, 2012. Climatic niche divergence or conservatism? Environmental niches and range limits in ecologically similar damselflies. *Ecology* 93(6): 1353-1366. – (First Author: MEMEG, Dept Biol., Ecol. Bldg, Lund Univ., SE-223 Lund).
The factors that determine species' range limits are of central interest to biologists. One particularly interesting group comprises odon., which show large differences in secondary sexual traits and respond quickly to climatic factors, but often have minor interspecific niche differences, challenging models of niche-based species coexistence. The environmental niches were quantified at 2 geographic scales to understand the ecological causes of northern range limits and the coexistence of Calopteryx splendens and C. virgo using environmental niche modeling. Niche divergence was quantified first across the whole geographic range in Fennoscandia, and second only in the sympatric part of this range. Evidence was found for interspecific divergence along the environmental axes of temperature and precipitation across the northern range in Fennoscandia, suggesting that adaptation to colder and wetter climate might have allowed C. virgo to expand farther north than C. splendens. However, in the sympatric zone in southern Fennoscandia only negligible and nonsignificant niche differences were found. Minor niche differences in sympatry lead to frequent encounters and intense interspecific sexual interactions at the local scale of populations. Nevertheless, niche differences across Fennoscandia suggest that spp. differences in physiological tolerances limit range expansions northward, and that current and future climate could have large effects on the distributional ranges of these and ecologically similar insects.

(19553) YOSHIHARA, A., A. MIYAZAKI, T. MAEDA, Y. IMAI & T. ITOH, 2012. Spectroscopic characterization of dragonfly wings common in Japan. *Vibrational Spectroscopy* 61: 85-93. – (First Author: Dept Basic Sci., Ishinomaki Senshu Univ., Ishinomaki, 986-8580, Miyagi, JA).
A series of Fourier Transform infrared (FT-IR) absorption, X-ray diffraction (XRD), and Brillouin light scattering (BLS) studies on the wings of Lestes temporalis, Sympecma paedisca, Anotogaster sieboldii, Sieboldius albardae, Sympetrum frequens and S. infuscatum was performed at room temperature. XRD and FT-IR results indicate that dragonfly wing is comprised of a randomly oriented microcrystalline or an amorphous-like α-chitin. A pair of longitudinal acoustic (LA) phonon peaks and a broad quasi-elastic scattering peak in backscattering BLS spectra were observed. LA phonon frequencies and full widths at half maximum were found to be 19.5 ± 0.4 GHz and 1.0 ± 0.2 GHz for the 488 nm excitation and independent of their sizes and species.

2013

(19554) ALMEIDA, D., R. MERINO-AGUIRRE & D.G. ANGELER, 2013. Benthic invertebrate communities in regulated Mediterranean streams and least-impacted tributaries. *Limnologica* 43: 34-42. – (First Author: Dept Ecol., Complutense Univ. Madrid, 2 José Antonio Novais, ES-28040 Madrid).
The study was conducted in the Bullaque river catchment, located in the Guadiana river basin, central Spain. A total of 12 spp. were selected to determine body conditions (fluctuating asymmetry levels), incl. Platycnemis latipes and Onychogomphus uncatus. A list of the recorded taxa is not provided.

(19555) ANDREW, R.J., 2013. Andromorphic female of the dragonfly Neurothemis t. tulia (Drury) (Odonata: Libellulidae), central India. *J. threatened Taxa* 5(1): 3571-3573. – (Post Grad. Dept Zool., Hislop Coll., Nagpur, Maharashtra-440001, India).
This is the second record of an andromorphic ♀ of this sp. from peninsular India (Nagpur area, 2-XI-2010). It was in gravid condition and produced viable eggs. The habitat and the specimen are described and illustrated and some notes on its behaviour are provided. Andromorphy in N. tulia is extremely rare. Bibliographic references to the 5 previously documented records are included.

(19556) CAÑEDO-ARGÜELLES, M., B.J. KEFFORD, C. PISCART, N. PRAT, R.B. SCHÄFER & C.J. SCHULZ, 2013. Salinisation of rivers: an urgent ecological issue. *Envir. Pollution* 173: 157--167. – (First Author: Freshw. Ecol. & Mngmt Res. Gr., Dept Ecol., Univ. Barcelona, Diagonal 643, ES-08028 Barcelona, Catalonia).
Secondary salinisation of rivers and streams is a

global and growing threat that might be amplified by climate change. It can have many different causes, like irrigation, mining activity or the use of salts as deicing agents for roads. Freshwater organisms only tolerate certain ranges of water salinity. Therefore secondary salinisation has an impact at the individual population, community and ecosystem levels, which ultimately leads to a reduction in aquatic biodiversity. The odon. are among the most tolerant insect groups (see e.g. *OA* 15102), Management of secondary salinisation should be directed towards integrated catchment strategies and identifying threshold salt concentrations to preserve the ecosystem integrity. Further research on the interactions of salinity with other stressors and the impact of salinisation on trophic interactions and ecosystem properties is needed.

(19557) *FAUNISTIC STUDIES IN SOUTH-EAST ASIAN AND PACIFIC ISLAND ODONATA*. Journal of the International Dragonfly Fund (ISSN 2195-4534), Vols 2 (22 Jan. 2013), 3 (18 March 2013). – (c/o M. Schorr, Schulstr. 7/8, D-54314 Zerf).
[Vol. 2]: *Choong, C.Y. & D.S.L. Cheah*: Odonata of Ayer Hitam Forest Reserve, Johor, Peninsular Malaysia (pp. 1-11); – [Vol. 3]: *Dow, R.A. & G.T. Reels*: Previously unpublished Odonata records from Sarawak, Borneo, 1: Kuching Division excluding Kubah National Park, and Samarahan Division (pp. 1-25).

(19558) GONZALEZ-BELLIDO, P.T., H. PENG, J. YANG, A.P. GEORGOPOULOS & R.M. OLBERG, 2013. Eight pairs of descending visual neurons in the dragonfly give wing motor centers accurate population vector of prey direction. *Proc. natn. Acad. Sci.* 110(2): 696-701. – (First Author: Janelia Farm Res. Campus, Howard Hughes Med. Inst., Ashburn, VA 20147, USA).
Intercepting a moving object requires prediction of its future location. This complex task has been solved by dragonflies, who intercept their prey in midair with a 95% success rate. In this study, it is shown that a group of 16 neurons, called target-selective descending neurons (TSDNs), code a population vector that reflects the direction of the target with high accuracy and reliability across 360º. The TSDN spatial (receptive field) and temporal (latency) properties matched the area of the retina where the prey is focused and the reaction time, respectively, during predatory flights. The directional tuning curves and morphological traits (3D tracings) for each TSDN type were consistent among animals, but spike rates were not. These results emphasize that a successful neural circuit for target tracking and interception can be achieved with few neurons and that in dragonflies this information is relayed from the brain to the wing motor centers in population vector form.

(19559) KARJALAINEN, S. & M. HÄMÄLÄINEN, 2013. *Damoiselle damselflies, winged jewels of silvery streams*. Caloptera Publishing, Helsinki. 223 pp. Hardcover, flappers (18.0 × 21.5 cm). ISBN 978--952-93-1045-6 (Bilingual: Finn. & Engl.). – (For the Publishers: Dr S. Karjalainen, Neidonpuistontie 6 D 8, FI-02400 Kirkkonummi).
It was worthwhile to invest 4 yr in collecting the photographs illustrating this esthetically very attractive and scientifically most informative book on the "Caloptera" (i.e. informal appellation used for the Calopterygoidea) of the World. The book is centred on the Calopterygidae, the 17 gen. and all spp. of which are listed and the principal features of many are outlined. Less complete is the coverage of Hetaerinidae, Chlorocyphidae and Euphaeidae, while the Polythoridae are not a subject of this book. The latest results of the DNA research are considered and the systematics, affinities, phylogeny and biogeography are briefly but lucidly presented. All European Calopteryx spp. are dealed with in considerable detail. Chapters are devoted to the calopteran habitats, adult structure, flight, egg, larva, emergence, adult life, feeding territoral behaviour, courtship, copulation and sperm competition, oviposition, predators and parasites. The superb photographs, including those of many spp. that were so far hardly every photographed in nature, represent a principle feature of the book that should certainly not be missed in any serious odonatological library.

(19560) MARINOV, M. & T. DONNELLY, 2013. Teinobasis fatakula sp. nov. (Zygoptera: Coenagrionidae), found on 'Eua Island, Kingdom of Tonga. *Zootaxa* 3609(6): 589-592. – (Second Author: 2091 Partridge Lane, Binghamton, NY 13903, USA).
The new sp. is described and illustrated. Holotype ♂: Kingdom of Tonga, 'Eua Island, alt. 175 m, 14-VII-2012; deposited at the Lincoln Univ. Ent. Res. Mus., NZ. Because 'Eua has aquatic habitats unique within the Kingdom, the new sp. is very likely endemic to that island and represents an extension of the verified range of this genus of at least 2800 km.

(19561) MITRA, Aniruddha, 2013. Cinderella's new shoes: how and why insects remodel their bodies between life stages. *Curr. Sci.* 104(8): 1-9. – (Dept Biol., Washington Univ., Monsanto 411, Campus Box 1137, One Brookings Dr., St Louis, MO, 63130--4899, USA).
A review paper, summarizing the current state of knowledge of both the mechanisms underlying metamorphosis, as well as the theories put forward to explain its evolution.

(19562) OBASI, K.O., N.D. IJERE & R.I. OKECHUKWU, 2013. Species diversity and equitability indices of some freshwater species in Aba river and Azumini Blue river, Abia state, Nigeria. *Int. J. Sci. Technol.* 2(3): 238-241. – (Dept Biol. Sci., Sch. Sci., Fed. Univ. Technol., Owerri, Imo state, Nigeria).
"Aeshna sp." larvae are recorded from 2 sampling stations at the Aba River.

(19563) PUKHNAREVICH, D.A., 2013. Zoobenthos in the lower reaches of the Oka river. *Vest. nizhegorod. Univ.* 2013(1): 128-135. (Russ., with Engl. s.). – (Author's postal address not stated).
The species composition of benthos in the Oka (Russia) is presented and Chalcolestes viridis and Aeshna sp. are listed.

(19564) TALMALE, S.S. & A.D. TIPLE, 2013. New records of damselfly Lestes thoracicus Laidlaw, 1920 (Odonata: Zygoptera: Lestidae) from Maharashtra and Madhya Pradesh states, central India. *J. threatened Taxa* 5(1): 3552-3555. – (First Author: Central Zone Regn. Cent., Zool. Surv. India, Jabalpur-482002, MP, India).
Several specimens of both sexes are brought on record (2010, 2011) from 4 localities in the 2 states.

(19565) TAKAHARA, T., H. DOI, Y. KOHMATSU & R. YAMAOKA, 2013. Different chemical cues originating from a shared predator induce common defense responses in two prey species. *Anim. Cogn.* 16: 147-153. – (First Author: Inst. Sustainable Sci. & Development, Hiroshima Univ., 701-3, ASoM, 1-3-1 Kagamiyama, Higashi Hiroshima, 739-8530, JA).
Glandirana rugosa and Hyla japonica tadpoles have different general activity levels and microhabitats. It was shown experimentally that they detect different chemical cues from Anax parthenope julius larvae, whereupon they respond by changing their activities to avoid predation. G. rugosa detected cues that had either high or low hydrophobic properties, whereas H. japonica responded only to chemical cues with hydrophilic properties.

(19566) THOMAS, J.A., J.W.H. TRUEMAN, A. RAMBAUT & J.J. WELCH, 2013. Relaxed phylogenetics and the Palaeoptera problem: resolving deep ancestral splits in the insect phylogeny. *Syst. Biol.* 2013: 13 pp.; – DOI: 10.1093/sysbio/sys093. – (First Author: Dept Biol., Univ. York, York, YO10 5DD, UK).
The order in which the 3 groups of the Pterygota diverged from their common ancestor has important implications for understanding the origin of insect flight. But despite this importance, the split between the Odon., Ephemeroptera and Neoptera remains very much unresolved. Indeed, previous studies have obtained strong apparent support for each of the 3 possible branching patterns. Here, a systematic reinvestigation of the basal pterygote split is presented. The results suggest that outgroup choice and limited taxon sampling have been major sources of systematic error, even for data sets with a large number of characters (e.g., in phylogenomic data sets). In particular, a data set of 113 taxa provides consistent support for the Palaeoptera hypothesis (the grouping of Odon. with Ephemeroptera), whereas results from data sets with fewer taxa give inconsistent results and are highly sensitive to minor changes in data and methods. Here it is also focused on recent methods that exploit temporal information using fossil calibrations, combined with additional assumptions about the evolutionary process, and so reduce the influence of outgroup choice. These methods are shown to provide more consistent results, for example, supporting Palaeoptera, even for data sets that previously supported other hypotheses. Together, these results have implications for understanding insect origins and for resolving other problematic splits in the tree of life.

(19567) VAN DIJK, T.C., M.A. VAN STAALDUINEN & J.P. VAN DER SLUIJS, 2013. Macro-invertebrate decline in surface water polluted with imidacloprid. *PLoS ONE* 8(5): e62374: 10 pp.; – DOI: 10.1371/journal.pone.0062374. – (Address incomplete: Envir. Sci., Univ. Utrecht, Utrecht, The Netherlands).
The regression analysis showed for Odon. a negative relationship between abundance and imidacloprid concentrations that is very close to the significance

threshold of 0.05 ($P = 0.051$). The values are stated for Ischnura elegans, Erythromma najas and E. viridulum.

(19568) WALKER, P.D., S. WIJNHOVEN & G. VAN DER VELDE, 2013. Macrophyte presence and growth form influence macroinvertebrate community structure. *Aquat. Botany* 104: 80-87. (First Author: Cent. Innovation & Enterprise, Oxford Univ., Begbroke Sci Park, Begbroke Hill, Woodstock Rd, Begbroke, Oxfords., OX5 1PF, UK).
Multivariate analysis demonstrated that in a small, eutrophic pond in Fleetwood, NW England, UK macroinvertebrate assemblages of macrophyte-dominated subhabitats differed markedly from those of open water and bottom substrate habitats. The occurrence is shown of Enallagma cyathigerum, Ischnura elegans and Aeshna grandis in each of the 7 habitats of the pond. The study highlights the importance of maintaining the ecological quality of small freshwater habitats in order to promote macrophyte growth and thus maintain a high level of species richness within such ecosystems.

(19569) WASSCHER, M., 2013. [Selys, a 19th century giant of nature]. *http://www.natuurbericht.be/index.php?id=10226*, 2 pp. (Dutch). − (Minstraat 15 bis, NL-3582 CA Utrecht).
This is the text of a paper presented at the Flanders Dragonfly Colloquium (Mechelen, Belgium, 23 Feb. 2013), published electronically by *Natuurpunt Studie* on 1 March 2013. − A brief outline of the biography of Edmond de Selys Longchamps (1813-1900), with a portrait (dated 1881, showing him as a senator). He started with descriptions of odon. spp. in 1837 (Agrion aurantiacum = Ischnura pumilio), and described during 63 years 707 currently valid spp.

(19570) WASSCHER, M.T. & J.G. VAN'T BOSCH, 2013. The true identity of Neoneura bilinearis Selys, 1860, with the synonymy of N. gaida Rácenis, 1953, and the description of N. confundens sp. nov. (Odonata: Protoneuridae). *Zootaxa* 3599(1): 19-36. − (First Author: Minstraat 15 bis, NL-3582 CA Utrecht).
Study of rough notes and sketches made by D.C. Geijskes in 1972 and the recently found original drawings by E. de Selys Longchamps done in 1884 from the ♂ syntype of N. bilinearis Selys, 1860, shows the syntype ♂ and ♀ (now lost for several decades) of N. bilinearis refer to the same sp., later described as N. gaida Rácenis, 1953. Therefore N. gaida is considered a junior synonym of N. bilinearis Selys, 1860. A neotype is chosen for the true N. bilinearis (neotype ♂, Suriname, Kabalebo, 15-VIII-1965, in RMNH). N. bilinearis sensu Williamson (1917) is redescribed as N. confundens sp. nov. (holotype ♂, Suriname, Jodensavanna, Koela-kreek, 13-II-1946, in RMNH). N. confundens has a wide distribution in South America north of the Tropic of Capricorn, but it is lacking from the central and lower Amazon. It occurs in several colour morphs and also varies in ♂ appendage, genital ligula, and ♀ pronotum morphology.

(19571) WATANABE, K., S. YAMAZAKI, K. SHOJI, Y. NAGASHIMA & K. SATO, 2013. Dragonfly fauna in Dainohara Forest Park. *Bull. Sendai Sci. Mus.* 22: 82-83. (Jap., with Engl. s.). − (Authors' addresses not provided).
A commented list of 17 spp.; − Japan.

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COWLEY, J., 1935. Remarks on the names of some odonates. *Entomologist* 26: 154-156.

FRASER, F.C., 1957. *A reclassification of the Odonata*. R. zool. Soc. N.S.W., Sydney.

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