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EMERGENCE PATTERNS AND LATITUDINAL ADAPTATIONS IN DEVELOPMENT TIME OF ODONATA IN NORTH SWEDEN AND POLAND

F. JOHANSSON¹, S. ŚNIEGULA² and T. BRODIN¹

¹ Department of Ecology and Environmental Science, Umeå University, SE-90187 Umeå, Sweden

² Department of Ecosystem Conservation, Institute of Nature Conservation, Polish Academy of Sciences, Mickiewicza 33, PO-31-120 Kraków, Poland

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Using exuviae, data are presented on emergence dates of dragonflies from northern Sweden and northwestern Poland. The 17 spp. sampled in Sweden showed considerable overlap in emergence periods. In Sweden, *Leucorrhinia rubicunda* was the first sp. to emerge (May 31) and *Sympetrum danae* the last (July 19). A comparison of first dates of emergence of spp. in Sweden and Poland showed a difference between 9 and 30 days, with all Polish spp. emerging first. Compared to spring species, summer species and obligate univoltine summer species showed less difference in first date of emergence between Swedish and Polish populations. In a laboratory experiment *Leucorrhinia dubia* was reared from both regions from the egg to final instar larva under northern Swedish and northwestern Polish photoperiods. Swedish larvae developed faster under a northern Swedish photoperiod compared to a northwestern Polish photoperiod. However, no such difference in development was found for northwestern Polish larvae. This suggests that there are genetic differences between both populations in response to photoperiod. The results are discussed in the context of compensation of larval development of northern populations in relation to photoperiod.

INTRODUCTION

Time of emergence and larval size at emergence are important fitness components in dragonflies (ANHOLT, 1991; DE BLOCK & STOKS, 2005; BANKS & THOMPSON, 1987; SOKOLOVSKA et al., 2000). Time of emergence is important because it must coincide with optimal conditions for dispersal, feeding and reproduction (BUTLER, 1984). In dragonflies, time of emergence varies within and among species. CORBET (1960) recognised three main life cycles among temperate species: “spring species”, “semivoltine summer species” and “univoltine summer species”. Spring species overwinter in the last instar, while summer

species may overwinter in any instar or in the egg stage. The variation within species is probably attributed to environmental conditions such as temperature, food and length of season that might differ between populations.

In general, populations that live at higher latitudes take longer time to complete the life cycle (CORBET, 2003; CORBET et al., 2005). This is believed to be an effect of low temperature and low prey availability (CORBET, 1980). However, in many species this variation is not as pronounced as expected despite differences in latitude, suggesting that some compensating mechanism is operating (CORBET, 2003). The compensating mechanism might be mediated by photoperiod such that odonates adjust their development relative to the photoperiod experienced at the latitude where the population lives. As a consequence, an odonate species living at high latitudes might be able to emerge earlier than it would have in the absence of these photoperiod cues. CORBET (2003) provided data on the flying season of odonates from western Canada and found that some species emerge at the same time in the south as in the north. This pattern of similar emergence time at different latitudes is to be expected if the photoperiodic compensation mechanism occurs. Such photoperiodic compensation occurs in other insects (MASAKI, 1978; NYLIN et al., 1993), but few studies have shown this in dragonflies at the level of populations (ŚNIEGULA & JOHANSSON, 2010). We should expect this kind of compensation because dragonflies do react to time stress mediated through photoperiod by speeding up their development (e.g. JOHANSSON & ROWE, 1999; ŚNIEGULA & JOHANSSON, 2010).

In this study we compare the emergence patterns of northern and southern populations of various species by presenting data from northern Sweden and north-western Poland, two regions that are separated by a distance of about 1100 km, with a difference of ca. 10° in latitude. In addition, in a laboratory experiment on *Leucorrhinia dubia* larvae from northern Sweden and northwest Poland, we compare development of specimens reared at northern Swedish and northwestern Polish photoperiods.

Our data set can also be used to evaluate future shifts in emergence times of odonates from natural habitats. Global warming is predicted to increase annual mean temperature during the 21st century (IPCC, 2001). Recent studies show that some odonates have expanded their ranges northward (OTT, 2001; HICKLING et al., 2005). Global warming can also have an effect on insects' time of emergence (HOGG & WILLIAMS, 1996; HARPER & PECKARSKY, 2006; HASSALL et al., 2007). Laboratory experiments show that higher temperature speeds up development in odonates (PICKUP & THOMPSON, 1990; KRISNARAJ & PRITCHARD, 1995) and two studies have shown that time of emergence is influenced by global warming in odonates (HASSALL et al., 2007; DINGEMANSE & KALKMAN, 2008). Here emergence data are provided that can be used in future comparative studies on the effect of global warming.

MATERIAL AND METHODS

EMERGENCE PATTERNS. – To estimate first and last emergence dates of dragonfly species from northern Sweden, we collected exuviae from 21 lakes and ponds during 1999-2001. All lakes are within 10 km of the city of Umeå (63°50' N, 20°15' E). The lakes were visited 2-3 times per week and each was sampled in one year only. Exuviae were sampled along a 16 m stretch of shore from the beginning to the end of the emergence period. The sampled shorelines were representative of a typical odonate habitat and were chosen to be as similar as possible among lakes.

To compare emergence patterns of species' northern and southern populations, we also collected exuviae in northwestern Poland. Suitable odonate habitats in 17 waterbodies within 23 km of the town of Borne Sulinowo (53°34' N, 16°32' E) were sampled in 2005 and 2006. The shoreline stretch sampled varied among the waterbodies. Hence, exuviae were collected quantitatively in Sweden but not in Poland, but we can see no obvious reason why this would bias our results. Collections of exuviae covered the whole emergence period in 2005, but in 2006 we missed the last 2-3 weeks of emergence for late emerging species such as *Sympetrum*. We therefore only compare first date of emergence between the two regions. More species were collected in Poland than in Sweden, but only emergence data for species found in both regions are presented. Comparisons between the two regions are based on the difference of first emergence date for each species irrespective of sex. Admittedly the weather condition between the Swedish and the Polish year of sampling might have differed. However, even if we had sampled the same years in both countries we might have encountered different conditions in each country compared to the average. By sampling more than one year we avoided this problem somewhat.

LABORATORY EXPERIMENT. – To examine if dragonflies are able to speed up their development and compensate for the shorter season in the north we set up a laboratory experiment to study larval rate of development in the semi- or partivoltine spring species, *Leucorrhinia dubia* (JOHANSSON, 2000; NORLING, 1984a). The experiment was run in climate rooms at Umeå University. Eggs from 14 females were collected on May 28 and 29, 2007 from a small, fishless, acidic pond near Borne Sulinowo, Poland (locality 3, ŚNIEGULA, 2006). Eggs from 9 females were collected on June 28 from two medium size fishless ponds near Umeå. Females were caught while copulating and induced to lay eggs by dipping the tips of their abdomens into water-filled plastic containers. All egg clutches contained more than 20 eggs. On May 29, samples collected in Poland were sent by regular post to Umeå. To simulate similar handling, the eggs collected in Sweden were kept dark at room temperature for 4 days, which corresponds to the shipping time of the Polish eggs.

On arrival from Poland, the egg clutch from each female was divided into two groups; each was placed in white plastic containers 10×10×6 cm high, filled with tap water. The containers and eggs were placed in two walk-in climate rooms at 22°C, one half of each egg clutch in each climate room. The light regime, from two fluorescent tubes, mimicked natural light on June 1 (excluding Civil Twilight conditions). In one room the light was set to simulate the Polish condition (light went on at 02:32 and off at 19:12) and in the other room to simulate northern Swedish conditions (light went on at 00:41 and off at 20:35). After four days in the dark the Swedish eggs (collected June 28) from each female were treated identically to the Polish samples. To simulate the natural progression of light conditions, the photoperiod regimes were changed once a week, following natural L:D conditions at each geographic locality. To minimize the environmental effects of the rooms, the containers were shifted between rooms once a month.

The eggs from southern and northern clutches started to hatch after about 2 weeks and the hatching was synchronized both within and between clutches. When the larvae entered instar 2-3, each group of samples was separated into two replicates (2×5 larvae) and these were used for rearing. The rest of the larvae were discarded.

During the first several instars, larvae were fed brine shrimp twice a day. After about a month, they were fed a mixture of brine shrimp and *Daphnia pulex* once a day. All larvae received the same food

ratio. The brine shrimp and *D. pulex* came from laboratory cultures.

To imitate natural winter conditions and to ensure that *L. dubia* larvae experienced a diapause initiated by photoperiod (see NORLING, 1984a), on October 14 all larvae were moved into a refridgerated room and held in constant darkness at 4°C. The larvae were kept unfed in dark conditions until November 13, when they were moved back to climate rooms. From this time the photoperiod regimes was set to simulate April 10: Polish L:D; 04:07 – 17:45 and Swedish L:D 03:28 – 17:55. The experiment was terminated on February 27, 2008, which corresponds a photoperiod date of July 15.

To get an estimate of development for the two populations under the different photoperiod regimes, larval head widths were measured 4 times: September 5, 2007, October 14, 2007, December 13, 2007 and February 27, 2008. The four dates correspond to the following photoperiod dates: September 5, October 14, May 9 and July 24. For the first, second and fourth measurement, first the largest individual for each female genotype was taken, preserved in 70 % ethanol and then measured. Due to the limited number of live larvae left in replicates before the third measurement (December 13, 2007), the largest live individuals for each female genotype were measured instead. Larval size was estimated as head width (distance between outer margin of eyes) using a microscope with an ocular scale. Larvae from each female within photoperiod and country did not differ very much within and among containers. Using a mean value of head width instead of taking the measurement of the largest individual did not change the main results. There was some mortality during the experiment, resulting in 5 and 6 larvae from each Swedish female remaining and 7 and 11 for the Polish ones.

Development of *L. dubia* larvae was analyzed with a repeated measures ANOVA. Head width was used as the dependent and photoperiod as the independent variable and time (date of size estimate) as repeated measures. Because the growth of the Polish and Swedish larvae did not begin at the same time a separate repeated measures analysis was undertaken for each country. Comparisons between countries were done by visual inspection of error bars. The date of each measurement was entered as a categorical variable. The experiment lasted for 196 and 169 days for Polish and Swedish larvae respectively, but since we shortened the winter period by several months the corresponding photoperiod days are 420 and 393 days respectively. We will use these days in our graphs although the real length of development was shorter. The logic behind this is that larvae do grow and develop very little during the winter period.

RESULTS

EMERGENCE PATTERNS

Exuviae of 17 species were collected in Sweden. Eight species were collected in 10 or more lakes and we collected more than 100 exuviae of nine species. The overlap between first and last emergence was quite high among species (Fig. 1). We suggest that the overlap in emergence times is due to the short season at this latitude. For most species the emergence data should be reliable, but for those species with very few exuviae (*Coenagrion armatum*, *Aeshna subarctica*, *Sympetrum danae*), data should be interpreted with caution.

Fourteen of the 17 species found in the Umeå region were also collected in Poland (Tab. I). The five species to emerge first in Poland were *Coenagrion hastulatum*, *Cordulia aenea*, *Leucorrhinia rubicunda*, *L. dubia*, and *Libellula quadrimaculata*. These species were also among the first to emerge at Umeå. Similarly, four of the last five species to emerge were the same at Umeå and in Poland: *Sympetrum danae*, *Lestes sponsa*, *Aeshna grandis*, and *A. subarctica*.

The mean difference among species in first date at emergence between the two regions was 17.5 (± 2.1 S.E.) days and the range is 8-27 days. Species that emerged late in both regions were those which differed the least in difference in emergence time between the regions. For example, the mean difference between species emerging in May in Poland and their corresponding Umeå populations is 24.4 days, while the difference for species emerging in June and July in Poland and their corresponding Umeå population is 10.6 days. This difference was statistically significant (t-test: $t = 8.74$, $df = 12$, $p < 0.001$).

LABORATORY EXPERIMENT

Polish larvae of *Leucorrhinia dubia* had reached a head width of 5.1 mm at the end of the experiment; this width corresponds to that of the final instar (Fig. 2). Larvae tended to develop faster in the northern Swedish photoperiod but light regime did not significantly affect larval size. At the end of the experiment there was no difference in the size of larvae growing in the two light regimes (Tab. II); an F-test showed this ($F_{1,16} = 0.002$, $P = 0.97$). Swedish larvae in the northern

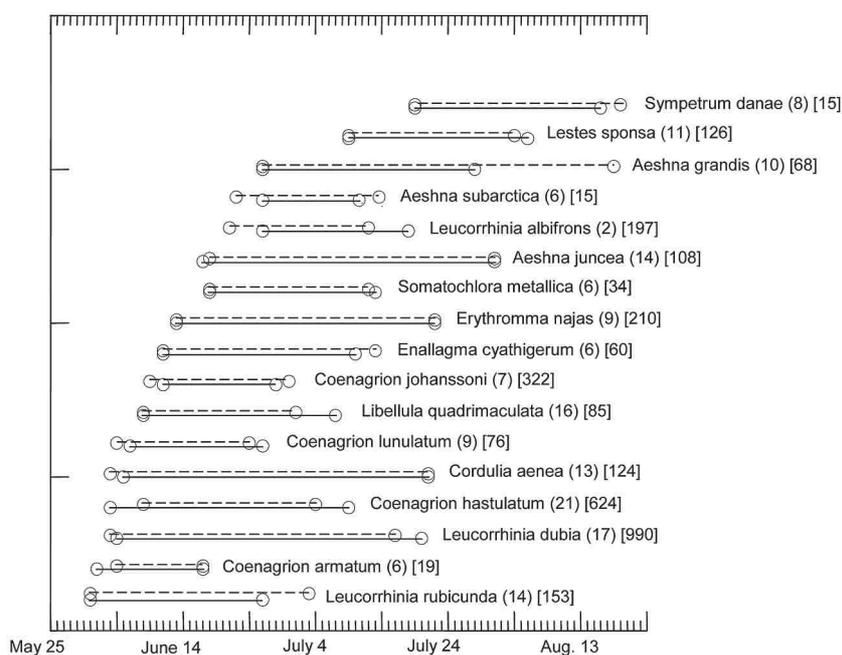


Fig. 1. First and last emergence dates for 17 species of Odonata in northern Sweden (Umeå). Solid lines are males and hatched lines are females. Numbers within parenthesis indicate the number of lakes at which each species was collected; numbers within square brackets are the number of exuviae collected. Data from 1999-2001.

Swedish photoperiod also reached the final instar at the termination of the experiment, while Swedish larvae in the Polish photoperiod had developed into a size corresponding to the penultimate instar (Fig. 2). Hence, in contrast to Polish larvae the northern Swedish ones did react differently to photoperiod in their development. Larvae reared in the northern Swedish light regime were much larger at the end of the experiment compared to those reared in the Polish photoperiod, suggesting that their development increased considerably in the northern Swedish light level (Fig. 2, Tab. II). The size of the northern Swedish larvae at the end of the experiment differed significantly between larvae reared in the two different light regimes ($F_{1,8} = 30.9$, $P = 0.001$).

DISCUSSION

Although there was a difference in date of emergence between the two regions our data cannot falsify the hypothesis that northern species compensate for latitude by emerging earlier. The reason is that we do not know what the emergence time would have been without the potential compensation mechanism. The laboratory results from our rearing of *L. dubia* larvae do, however, show that such a compensating mechanism does occur, because the larvae from northern Sweden developed faster under the northern Swedish photoperiod than those of Polish origin under the same light conditions. In addition, laboratory data are also available for three *Lestes* species and do support the hypothesis that larvae acceler-

Table I

First day of emergence of dragonflies from the Borne Sulnowo region in Poland, and the difference in mean date of first emergence between populations in northwestern Poland and northern Sweden. Symbols within parenthesis denote which sex emerged first

Species	Date	Difference in emergence between Polish and northern Swedish populations (days)
<i>Cordulia aenea</i>	May 8, 2005 (♂ & ♀)	26
<i>Coenagrion hastulatum</i>	May 10, 2006 (♂ & ♀)	24
<i>Leucorrhinia rubicunda</i>	May 11, 2006 (♂)	20
<i>L. dubia</i>	May 12, 2006 (♀ & ♂)	20
<i>Libellula quadrimaculata</i>	May 15, 2006 (♂ & ♀)	24
<i>Erythromma najas</i>	May 17, 2006 (♂ & ♀)	27
<i>L. albifrons</i>	May 22, 2006 (♂ & ♀)	30
<i>Enallagma cyathigerum</i>	June 2, 2006 (♂ & ♀)	9
<i>Somatochlora metallica</i>	June 5, 2006 (♂)	13
<i>Aeshna subarctica</i>	June 12, 2006 (♂)	8
<i>A. grandis</i>	June 16, 2005 (♂ & ♀)	10
<i>A. juncea</i>	June 26, 2005 (♀)	9
<i>Lestes sponsa</i>	June 27, 2006 (♂ & ♀)	12
<i>Sympetrum danae</i>	July 6, 2005 (♀)	13

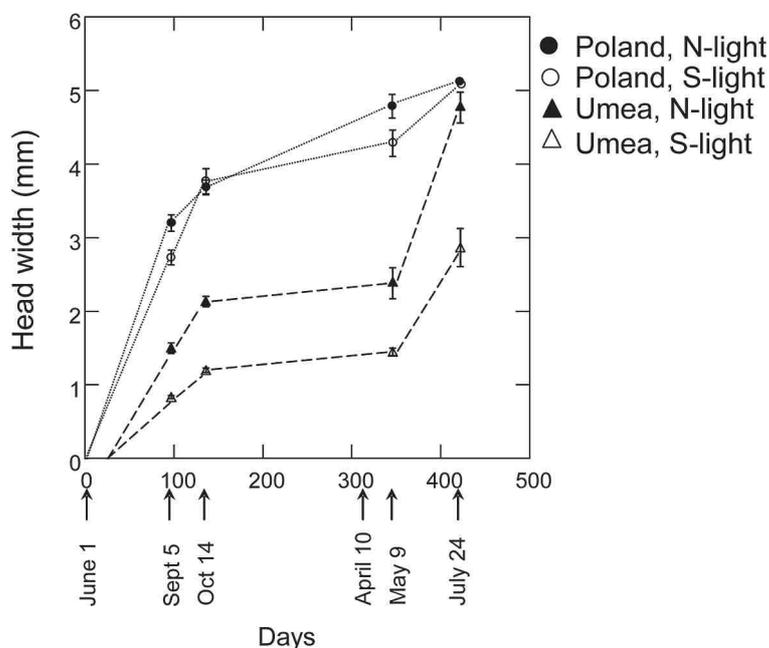


Fig. 2. Growth of *Leucorrhinia dubia* larvae from northwestern Poland (circles, Poland) and northern Sweden (triangles, Umeå) reared at two different photoperiods: northern Swedish (N-light) and northwestern Polish (S-light). Polish larvae were started from the egg stage on June 1 and Swedish larvae on June 28. The larvae were put into diapause on October 14 and out of diapause on April 10. They were measured on September 5, October 14, May 9, and July 24.

ate their development under longer photoperiods, such as those at higher latitudes (JOHANSSON & ROWE 1999; JOHANSSON et al., 2001; DE BLOCK & STOKS, 2004; ŚNIEGULA & JOHANSSON, 2010). However, data on more species are certainly needed.

The Swedish and Polish populations of *L. dubia* larvae differed in their response to photoperiod, suggesting that there is a genetic difference between the two in this response. Such differences in photoperiod response have been found in *Lestes sponsa* (ŚNIEGULA & JOHANSSON, 2010) and species of other insect groups (e.g. MASAKI, 1978; NYLIN et al., 1993; BRADSHAW & HOLZAPFEL, 2006), and are believed to be adaptive as populations at northern latitudes are time-constrained because of a short growth season. Several studies indicate that odonate larvae from different populations differ in their response to photoperiod (NORLING 1984a, b) but ours is one of the few that compares populations by simulating natural photoperiods of different latitudes (ŚNIEGULA & JOHANSSON, 2010). We hypothesise that many more examples will be found in odonates;

Table II
Results from repeated measures ANOVAs on the size of *Leucorrhinia dubia* from northwestern Poland and northern Sweden during development at different photoperiods. Light corresponds to photoperiod treatment and time to development day

POLAND				
Source	df	MS	F	P
Between subject				
Light	1,15	0.24	4.16	0.06
Within subject				
Time	3,45	5.29	107.7	<0.001
Time * Light	3,45	0.11	2.25	0.10
SWEDEN				
Between subject				
Light	1,4	1.65	58.4	0.002
Within subject				
Time	3,12	3.21	199.3	<0.001
Time * Light	3,12	0.05	3.06	0.07

indeed, there are several potential comparative studies that would be informative with respect to photoperiod. For example, comparative genetic studies of different latitude populations would extend our knowledge of the genetic basis of photoperiodic response within and between populations and species (BRADSHAW & HOLZAPFEL, 2007). We should expect the least difference in emergence date between summer species because these species spend the winter in the last three or four instars and therefore have a greater potential to adjust development compared to species in the other two categories. We found some support for this pattern. In our study, the aeshnids and *Enallagma cyathigerum*, which have been categorised as summer species (CORBET, 1960: 143), showed the least difference with respect to the first day of emergence between the two regions. Spring species spend the winter in the last instar and can, for that reason, not speed up their development as much as summer species. Examples of typical spring species in our study are the *Leucorrhinia* species, *Cordulia aenea* and *Libellula quadrimaculata*, all exhibiting the largest difference in first date of emergence between populations. Surprisingly, the obligate univoltine species, *L. sponsa* and *Sympetrum danae*, show a small difference between the regions with respect to first day of emergence. These species overwinter in the egg stage and, therefore, can adjust development time considerably during the spring and early summer. The fact that summer species and obligate univoltine species show the least difference between the regions lends some support to the hypothesis that the rate of larval development is positively correlated with photoperiod (CORBET, 2003; ŚNIEGULA & JOHANSSON, 2010).

We hope that our data from northern Sweden can be used to compare emergence patterns in future studies that evaluate the effect of global warming. Emerging at the right time is important for aquatic insects because terrestrial environmental conditions such as prey availability, mating opportunity and ambient flying temperature must be optimal for a sustainable population.

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CONTINUOUS AND STEPWISE OOCYTE PRODUCTION IN LIBELLULIDAE (ANISOPTERA)

M. KARLSSON^{1,2}, G. SAHLÉN¹ and K. KOCH³

¹ Ecology and Environmental Sciences, Halmstad University, P.O. Box 823,
S-30118 Halmstad, Sweden

² Department of Animal Ecology, Ecology building, Lund University, S-22362 Lund, Sweden

³ Department of Ecology, University of Mainz, Becherweg 13, D-55128 Mainz, Germany

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Compared to other insect groups, libellulids have a rather high mean number of ovarioles. In addition, the mean ovariole diameter differs greatly between and within species. In general, 2 different types of ovariole arrangement exist: (1) all developing oocytes mature and equal in size; in some species without, and in others with, surrounding connective tissue and (2) oocytes displaying gradual maturation, with only the outermost ovarioles mature. These differences have ecological consequences: the first arrangement occurs in spp. that have stepwise egg production. These spp. will lay one or more clutches, after which an interclutch interval of ovariole regrowth follows. Spp. with the second arrangement have continuous egg production and are able to lay at least some eggs all the time, reducing the length of interclutch intervals. However, no direct connection between mate-guarding strategies and ovariole arrangements can be seen. Nevertheless, it is believed that the process of ovariole maturation differs between these groups. It is concluded that ovary morphology in libellulids may exhibit evolutionary fixed traits, although the whole picture still remains complex. The ovariole arrangement may have a crucial impact on the reproductive ecology of the species.

INTRODUCTION

Clearly an important aspect of female reproductive success is egg production. Depending on evolutionary constraints or habitat requirements, eggs may vary in size, numbers and deposition rate, all of which factors have an impact on the survival rate of the offspring (WICKLUND et al., 1987; ALCOCK, 1993). In

* **Corresponding author:** kochka@uni-mainz.de, phone: 0049-(0)6131/ 3926717, fax: 0049-(0)6131/ 392 3731

insects a larger egg size correlates negatively to female fecundity (ROFF, 2000; SANTO et al., 2001; SEKO & NAKASUJI, 2004) but results in larger larvae (TESSIER & CONSOLATTI, 1991; CORKUM & HANES, 1992; RICCI, 1995), and a faster growth rate of the larvae (SINERVO & McEDWARD, 1988; GILLOOLY & DODSON, 2000).

Insect ovaries consist of a group of cylindrical or tapering units, the ovarioles, which usually converge at the anterior end of the corresponding lateral oviduct (SNODGRASS, 1935). The anterior part of an ovariole is called the terminal filament; this anchors it to other ovarioles and to the body wall, dorsal diaphragm or, in some insects, the adipose tissue (SNODGRASS, 1935). The terminal filament is followed by the germarium, where cell division leading to the formation of oocytes takes place (TILLYARD, 1917; SNODGRASS, 1935). The main part of each ovariole is the vitellarium, where yolk proteins etc. are added to the growing oocyte (HAGEDORN & KUNKEL, 1979; BRENNAN et al., 1982; BÜNING, 1994). At the posterior end of the vitellarium, the oocytes are mature and the eggs ready to be deposited.

The number of ovarioles in an ovary varies between different insects. Usually the number is not high, four to eight ovarioles being typical (SNODGRASS, 1935). In some insect groups the number is, however, much higher. SZKLARZEWICZ et al. (2000) report between 50 and 92 ovarioles per ovary in the primitive aphid family Adelgidae and there are 85 in earwigs (TORNEUR, 1999), 100 to 200 in Hymenoptera and Diptera (SNODGRASS, 1935), 300 in hemipteran scale insects (SZKLARZEWICZ, 1998) and no less than 2400 have been reported from Isoptera (SNODGRASS, 1935). It thus seems as though systematic position has no influence on ovariole numbers.

It is known from studies on butterflies and *Drosophila* that the number of ovarioles may vary with female age (KARLSSON, 1987; WAYNE et al., 2005) as well as between different genetic strains of the species. The number of ovarioles is positively correlated with maximum daily fecundity (TELONIS-SCOTT et al., 2005; WAYNE et al., 2006). Hence, the ovariole number is a morphological character associated with fitness, at least in *D. melanogaster*. Current research on *D. melanogaster* has focused on examining the sources of variation in ovariole number in relation to fitness, with a view towards elucidating how segregating variation is maintained in natural populations (TELONIS-SCOTT et al., 2005). WAYNE et al., (2005) found significant genetic variation in ovariole numbers between and within collection sites for *D. melanogaster* and also a phenotypic plasticity in response to temperature. In the beetle *Dastarcus helophoroides* TOGASHI & ITABASHI (2005) found a strong correlation between ovariole number and female body length. WAYNE et al. (2006) found that the ovariole number increased in response to maternal starvation, suggesting an evolutionary association between maternal environment and the reproductive system of female progeny.

Dragonflies have panoistic ovaries, i.e., the simplest form of insect ovaries, where

all germinal cells develop into oocytes and nutritive cells are lacking (TILLYARD, 1917). Synthesis and release of mRNA, rRNA and energy reserves such as lipids, glycogen and the yolk protein vitellin is performed directly by the follicular epithelium (SNODGRASS, 1935; HAGEDORN & KUNKEL, 1979; BRENNAN et al., 1982; DETTNER & PETERS, 2003). The number of ovarioles in dragonflies is not known, and authors such as WINKELMANN (1973) simply state that they are 'numerous.' Dragonflies are known to have a continuous oocyte-production during their mature life span, and egg-laying periods are interspersed with periods of feeding away from their oviposition sites (e.g., THOMPSON, 1990).

In the family Libellulidae, two guarding types can be distinguished: non-contact guarding, in which the male accompanies the female, and tandem guarding, in which the male is physically coupled to the female during oviposition (CONRAD & PRITCHARD, 1992). In a previous paper involving one of us (Koch, formerly Schenk) it was shown that non-contact guarding species perform microhabitat selection by laying all their eggs within a small area (SCHENK et al., 2004). Tandem species by contrast, perform a spatial risk, laying their eggs in different areas (SCHENK et al., 2004). In addition, the mate-guarding types differ in egg size distribution within their egg clutches (SCHENK et al., 2004). This inspired us to investigate more links between morphological and behavioural traits associated with egg laying. Hence, in this paper we focused on three questions: First, how many ovarioles are present in dragonfly ovaries and how variable is this number within and between species? Second, we wanted to explore whether such basic morphological traits can be related to the type of mate-guarding. Finally, we were interested in the size variation of mature ovarioles, relating the number of ovarioles to known clutch size in different species.

MATERIAL AND METHODS

For this study sixteen species of libellulid dragonflies from three different countries (Germany, Japan and Namibia) were used, six non-contact guarding species and ten tandem guarding species (Tab. I). Where possible, we used several females in order to detect within species variation, if present, but for six of the selected species only single specimens were available. The species were chosen to represent eleven different genera distributed over several branches of the current tentative phylogenetic tree of the family (WARE et al., 2008; but cf., CARLE & KJER, 2002; and MISOF, 2002). Hence, we hoped to eliminate, or at least limit, any effects of phylogenetically fixed traits. Females were captured immediately after copulation and their head width measured to correct for size differences, as neither all species nor all specimens were of the same size. Most individuals were fixed in 70% alcohol, where they were subsequently stored, but some individuals were fixed in an alcohol-formaldehyde solution (80% : 4%) and, after 24 h, transferred to 80% alcohol for storage.

The abdomen was opened up lengthwise and put in a solution of 80% alcohol and 37% formaldehyde (4:1) for one hour before removing the ovaries. Thus, the ovaries were stabilised and could be dissected without breaking. This procedure was not necessary in the case of individuals previously fixed in alcohol-formaldehyde. Where possible, three pieces from the vitellarium of each individual (i.e., six sections; three from each ovarium) were dissected and taken through a normal dehydration protocol with 80 to 99.5% alcohol followed by xylene for paraffin embedding. We also transferred

some of the ovarioles to acetone after dehydration for embedding in TAAB 812 (epoxy) plastic.

For paraffin embedded ovaries we cut 8 µm microtome sections, which were stained with haematoxylin, while 4 µm microtome sections were cut from the plastic and stained with methylene blue. In both cases we used standard manual microtomes with steel knives and standard staining protocols. Some samples deteriorated during the dehydration process and could not be used. Hence, one to six ovary sections of each female were used when counting ovarioles. The ovariole number is given per female, that is, the average of the sections used knowing that a female has two ovaries. The diameters of six to eleven mature ovarioles per female were measured. We defined mature ovarioles as being coated by epithelial cells (nurse cells). Ovarioles without well-defined nurse cells were thus considered immature (i.e. currently without growing oocytes). These were counted, but not measured. As the shape of a libellulid egg is oval, sometimes almost spherical (SAHLÉN, 1994; 1995), measuring all mature ovarioles in a section would result in varying diameters depending on what part of the developing egg was sectioned. However, as we were not concerned with actual egg size, we believe that the diameter will be equally variable for all studied species and, hence, that they are comparable. The measurements were performed using a Nikon Labophot 2 microscope and a Sony Exvawe-HAD-Digital camera in combination with the Easy Image™ Analysis program from Bergström Instruments AB, Lund, Sweden.

In order to analyse whether the number of ovarioles differs between the guarding types two ANCOVAs were performed using mate-guarding type as the independent variable and number of ovarioles or ovariole diameter as dependent variables, using female head width as a covariable. In addition, we

Table I

Libellulid species in the study. Country of collection (C) given as G = Germany, J = Japan and N = Namibia. Number of individuals (n/n) used in measurements given as two figures: the first indicating number of individuals examined for mean number of ovarioles ± SD (number), the second indicating number of individuals examined for mean diameter of mature ovarioles ± SD (diam.). Species displaying non-contact guarding or tandem guarding behaviour are given as NC or TG respectively. Under Category 1a refers to all oocysts mature and no tissue between oocytes, 1b refers to all oocytes mature and connective tissue between oocytes, 2 refers to only peripheral oocytes mature. Note that both guarding types have members with ovaries of category 1 and 2

Species	C	Category	n/n	number	diam. [µm]	behaviour
<i>Libellula depressa</i> Linnaeus 1758	G	1b	6/2	57.6 ± 17.0	273.1 ± 34.7	NC
<i>Orthetrum brachiale</i> (Beauvois 1805)	N	1b	1/1	76	177.2 ± 18.6	NC
<i>O. julia</i> Longfield 1955	N	1b	1/1	84	150.0 ± 21.3	NC
<i>Leucorrhinia dubia</i> (Vander Lind. 1825)	G	2	4/2	125.0 ± 19.4	78.9 ± 5.3	NC
<i>Crocothemis erythraea</i> (Brullé 1832)	N	2	2/2	136 ± 0	79.2 ± 18.9	NC
<i>Trithemis kirbyi</i> (Gerstaecker 1891)	N	2	3/3	171.3 ± 24.7	82.3 ± 19.1	NC
<i>Sympetrum vulgatum</i> (Linnaeus 1758)	G	1a	5/2	30.0 ± 6.9	169.6 ± 30.4	TG
<i>S. frequens</i> (Selys 1883)	J	1a	5/2	32.5 ± 9.6	176.6 ± 23.0	TG
<i>S. infuscatum</i> (Selys 1883)	J	1a	4/2	34.0 ± 7.5	266.4 ± 41.2	TG
<i>S. danae</i> (Sulzer 1776)	G	1a	1/1	36	172.6 ± 44.3	TG
<i>Urothemis edwardsii</i> (Selys 1849)	N	1b	1/1	38	158.4 ± 24.3	TG
<i>Sympetrum fonscolombii</i> (Selys 1840)	N	1a	4/2	46.0 ± 16.7	198.1 ± 43.2	TG
<i>Diplacodes luminans</i> (Karsch 1893)	N	1b	4/2	61.0 ± 13.7	243.5 ± 33.4	TG
<i>Tramea basilaris</i> (Beauvois 1805)	N	1b	1/1	68	214.5 ± 30.4	TG
<i>Diplacodes lefebvreii</i> (Rambur 1842)	N	2	1/1	146	154.73 ± 16.6	TG
<i>Pantala flavescens</i> (Fabricius 1798)	N	2	3/2	154 ± 87.0	153.7 ± 35.5	TG

calculated the mean number of mature oocytes per ovariole deposited in each egg clutch, using average clutch size values compiled from literature (SCHENK et al., 2004; KOCH & SUHLING, 2005; SCHENK & SÖNDGERATH, 2005; Tab. II). The mean number of ovarioles in these papers were derived from wild caught females in which clutch size theoretically may vary from zero to a very high value depending on time elapsed since the last egg laying event (cf., (SAHLÉN & SUHLING, 2002). However, in this paper we interpret the average values as representative for the species in question. Hence, we divided the observed average clutch size by the average number

of mature ovarioles for each species. Using ANOVA we analysed whether the guarding types (independent variable) differed in the calculated mean number of mature oocytes per ovariole (dependent variable). All analyses in this paper were performed in SPSS 13.0.

Table II

Clutch size ($\bar{x} \pm SD$) of eight libellulid species from SCHENK et al. (2004), KOCH & SUHLING (2005) and SCHENK & SÖNDGERATH (2005). Number of clutches counted given as n

Species	clutch size	n
<i>Leucorrhinia dubia</i>	405.2 \pm 170.7	17
<i>S. fonscolombii</i>	633.9 \pm 382.1	41
<i>Sympetrum danae</i>	681.3 \pm 275.6	10
<i>Trithemis kirbyi</i>	734.6 \pm 488.3	50
<i>Crocothemis erythraea</i>	870.0 \pm 363.5	6
<i>S. vulgatum</i>	930	1
<i>Libellula depressa</i>	984.3 \pm 398.4	17
<i>Pantala flavescens</i>	1246.0 \pm 623.0	23

RESULTS

In general, ovarioles in plastic sections were easier to count and measure than in paraffin embedded material. Although the plastic was regularly scratched during sectioning, which resulted in less sharp images, the tissue was better preserved and also withstood the cutting process better without breaking. There were no differences between the two fixation methods.

The mean number of ovarioles per female varied from 30 in *Sympetrum vulgatum* to 171.3 in *Trithemis kirbyi* (Tab. I). The specimen with the lowest number was a *S. frequens* with 22 ovarioles. The highest number was 254 in *Pantala flavescens*. In *P. flavescens* the standard deviation is over half the mean value, whereas in *T. kirbyi* (with a fairly similar mean) it is only about 15% of the mean (Tab. I). Average ovariole diameter varied from just 79 μm in *Leucorrhinia dubia* up to 273 μm in *Libellula depressa*. Both the intra- and interspecific size variation was, as expected, found to be high (Tab. I). Two different types of ovariole arrangement were found. In the first type the developing oocytes with their nurse cell epithelium were all mature and not varying much in size; all apparently ready to be deposited. No immature oocytes were observed. This could be divided into two sub-groups. In the first no other tissue was present between the oocytes and this arrangement was found only in the *Sympetrum* species, which all had rather few ovarioles in their ovaries (30-46). In the second sub-group all the developing oocytes were surrounded by connective tissue (confirmed by staining with polychrome methylene blue and orcein). This kind of ovary was found in *Sympetrum luminans*, *L. depressa* (Fig. 1), *Orthetrum brachiale*, *O. julia*, *Tramea basilaris* and *Urothemis edwardsii*. In the second type of ovariole arrangement, the oocytes

varied a lot in size and appearance (Fig. 2). Most of the oocytes were immature, lacking nurse cell epithelium and visible yolk, and hence only a small proportion of them (ca 15-25%) contained egg cells ready for deposition. This type of ovary was found in *T. kirbyi*, *Crocothemis erythraea*, *L. dubia*, *Diplacodes lefebvrei* and *P. flavescens*. The mature ovarioles with oocytes ready to deposit were situated in two or three irregular layers on the perimeter of the ovaries with immature ovarioles on the inside. The smallest ovarioles were situated furthest from the body wall, near the centre of the body, i.e., next to the alimentary canal (Fig. 2).

The mean number of ovarioles differed significantly between the two mate-guarding types ($F_{1,39} = 11.41$, $P < 0.002$). In non-contact guarding species the number of ovarioles was higher than in tandem species (Tab. I). Additionally, the ovariole diameter differed significantly between the two mate-guarding types ($F_{1,139} = 40.23$, $P < 0.0005$). In non-contact guarding species the mean ovariole diameter was smaller, but varied more than in tandem species (Tab. I). Species size had no influence on the mean number of ovarioles ($F_{1,39} = 2.43$, $P = 0.127$) but it affected the mean ovariole diameter ($F_{1,139} = 49.12$, $P < 0.0005$). The correlation between species size and ovariole number is not perfect but, on the whole, larger species had larger ovarioles. The calculated mean number of mature oocytes per ovariole deposited in each egg clutch of non-contact guarding species was 29.0 for *C. erythraea*, 13.5 for *L. dubia*, 17.1 for *L. depressa*, and 26.2 for *T. kirbyi*. In tandem guarding species the numbers were 31.1 for *P. flavescens*, 17.8 for *Sympetrum danae*, 21.1 for *S. fonscolombii* and 31.0 for *S. vulgatum*. The number of mature oocytes per ovariole did not differ between the two guarding types ($F_{1,6} = 0.56$, $P = 0.477$).

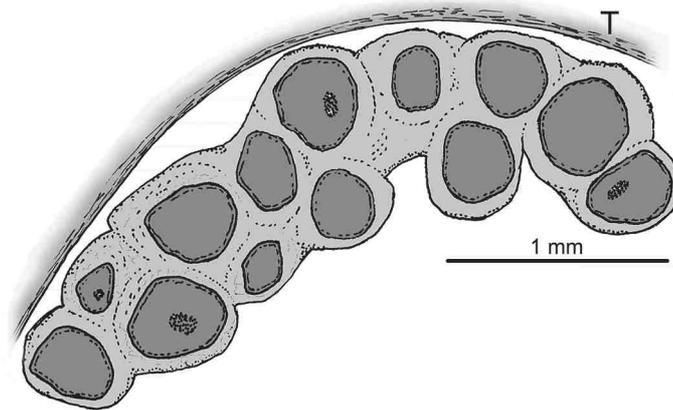


Fig. 1. Cross section through one ovary of *Libellula depressa* at the level of abdominal segment 7, redrawn from a paraffin mount. In this specimen there are 13 oocytes in the ovary (dark grey), all mature and surrounded by a thick layer of connective tissue (light grey). All oocytes are of almost the same size and at the same stage of maturation. T. Approximate position of the abdominal tergite.

Looking at the two types of reproductive behaviour in libellulids, tandem guarding and non-contact guarding, we see that there is no clear division between ovariole type and guarding types. Both guarding types have members with ovaries of both major groups (Tab. I). Considering our measurements (Tab. I) we see that there are some groups of species which seem to share the morphological features of their ovaries. One obvious group consists of *L. depressa* and the *Orthetrum* species, which have fewer ovarioles than the other non-contact guarding species. Their ovariole morphology is also the same as in most other tandem species. In contrast, *P. flavescens* and *Diplacodes lefebvreii* have a higher ovariole number than the other tandem species. In the former species even the ovariole appearance is that of most non-contact species.

DISCUSSION

In this study, libellulid dragonflies were found to have between 22 and 254 ovarioles per female. In this respect dragonflies differ from many other insects, in which the numbers are much lower (SNODGRASS, 1935). As in *Drosophila melanogaster* (e.g., CARLSON & HARSHMAN, 1999; WAYNE et al., 2005) the ovariole number varied within and between species, probably depending on female age and genetic differences as well as phenotypic responses as suggested in

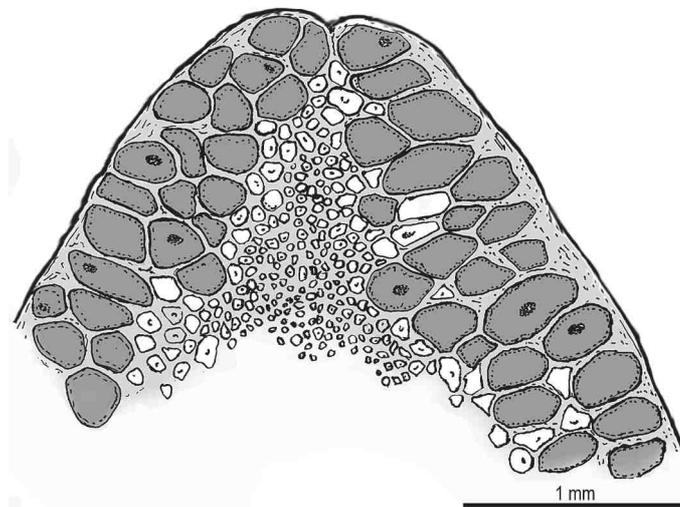


Fig. 2. Cross section through a pair of ovaries of *Pantala flavescens*, at the level of abdominal segment 7, redrawn from a paraffin mount. In this specimen there are 23 mature oocytes (dark grey) in each ovary arranged in double or triple rows in the periphery, next to the body wall. In addition there are 208 immature oocytes (white), the smallest toward the centre of the drawing, which is close to the alimentary canal. It is clear that oocytes mature continuously outwards from the inner region of the ovaries. The light grey areas between the oocytes consist of connective tissue.

studies on other insects. Species size had no influence on the number of ovarioles. Large species such as *Libellula depressa* and *Orthetrum brachiale* had few ovarioles; smaller species such as *Trithemis kirbyi* had a high number of ovarioles and the smallest species, *Sympetrum danae*, had only 36 ovarioles, which is among the lowest numbers found in the study. In general, larger insects have more ovarioles than small ones (CHAPMAN, 1988; RICHARDS, 1994) and the number is often reported as rather constant within a species. Hence, these general rules do not seem to apply to libellulid dragonflies. Instead, ovariole number and arrangement in libellulids probably correlate to phylogeny (cf., below).

The mean ovariole diameters noted in this study were often smaller than the diameters of deposited eggs from the same or closely related species found in other papers (e.g., SAHLÉN, 1994; SAHLÉN & SUHLING, 2002). We explain these size differences by the fact that we did not always section through the widest part of the eggs and, hence, the values should not be seen as corresponding to the actual egg diameters.

Looking at ovariole orientation and development within the ovaries, we found two different arrangements: The first type, with all developing oocytes mature and equal in size (Fig. 2) encompass species which seem to be adapted to deposit a large number of eggs during a short time span. As no immature ovarioles were present, we assume that these species should lay one or more egg clutches, after which a period (interclutch interval) of ovariole regrowth should follow. The old epithelial cells and, hence, most probably also any adjoining connective, are degraded before egg deposition (BÜNING, 1994). In the second group there is a gradual maturation process of the ovarioles with the outermost ovarioles (ca 15-25% of them) mature with less mature ovarioles inside them, the youngest, most immature ovarioles being placed at the centre of the female body close to the rectum (Fig. 2). We think that this arrangement makes it possible for these species to have a more continuous egg production, that is, the ovarioles mature in succession, which enables the females to lay a few eggs at all times, reducing the length of the interclutch intervals. So far all odonates have been assumed to have a continuous oocyte production during their whole mature life span, though the egg production speed as well as the size of the eggs of investigated species decline with increasing female age (e.g., WATANABE & ADACHI, 1987; WATANABE & HIGASHI, 1989; THOMPSON, 1990; HIGASHI & WATANABE, 1993; ELZINGA et al., 2005). However, we propose a division into species which we define as having stepwise egg production (with all of the oocytes mature) and those with continuous egg production (those with numerous immature ovarioles and only a few mature oocytes).

Both guarding types have members with ovaries of both major groups. There are some groups of species which seem to share the morphological features of their ovaries. One obvious group consists of *L. depressa* and the *Orthetrum* species, which have fewer ovarioles than the other non-contact guarding species and

an ovariole appearance as in most other tandem species. In contrast, *P. flavescens* and *D. lefebvreii* have a higher ovariole number than the other tandem species and an ovariole appearance is that of most non-contact species. Hence we conclude that ovary morphology in this family exhibits evolutionary fixed traits.

The two reproductive strategies do, however, differ in the morphology of the ovaries in other ways. Looking at clutch size, it is known that the number of eggs deposited does not differ between the mate guarding types (KOCH & SUHLING, 2005; SCHENK & SÖNDGERATH, 2005) but tandem species produce larger oocytes / eggs (KOCH & SUHLING 2005). To produce the same number of slightly larger eggs requires higher costs for egg production. As there is no clear distinction in ovariole numbers between the reproductive groups and nothing is known of metabolism speed variation in dragonflies, the only way for the animals to compensate the production of larger eggs would be longer breaks between oviposition events. Even so, the number of eggs deposited at each event is high in both groups, our calculated values of between 13 and 31 mature oocytes per ovary probably not showing the whole variation within the family. These values give an indication of how much energy is needed for egg production by the females when on a foraging / resting period between egg laying events, a period normally lasting one or two days (e.g., SIVA-JOTHY et al., 1998).

Several authors have described the morphology of the odonate ovaries (e.g., PRASAD & SRIVASTAVA, 1961; ANDO, 1962; TILLYARD, 1917; BÜNING, 1994) but these descriptive papers have not provided any way of explaining the fact that the egg size distribution differs between the two mate-guarding types. SCHENK et al., (2004) showed that, in clutches of species which perform non-contact guarding, the egg size is inversely proportional to the order of laying, whereas it is randomly distributed in tandem species. The idea of focusing on stepwise versus continuous egg production in these groups might be a thought-provoking idea, and as we only looked at a limited number of species we may not see the whole picture yet.

The differences in oviposition behaviour (SCHENK et al., 2004), life history traits (SCHENK & SÖNDGERATH, 2005) and morphological traits (KOCH & SUHLING, 2005) between the two guarding types examined may also, together with the morphological differences observed in this study, be related to migration. The non-contact guarding species in this study belongs, with the exception of *L. depressa*, to the residents or facultative migrants (CORBET, 1999; JOHANSSON & SUHLING, 2004). Interestingly *L. depressa* had the lowest number of ovarioles and the highest ovariole diameter of all the studied non-contact guarding species and would hence fit better among the tandem guarding species. Also phylogeny shows that, within the non-contact guarding species, *L. depressa* and the two *Orthetrum* species seem to establish a group of their own (CARLE & KJER, 2002; MISOF, 2002). In contrast, the tandem guarding species studied are obligate migrants (CORBET, 1999; JOHANSSON & SUHLING, 2004).

Migrating individuals often have a lower fecundity than residents as a result of large wings, flight muscles and the cost of flying (DENNO et al., 1991; ROFF & FAIRBAIRN, 1991; ROFF, 1994; ROFF & BRADFORD, 1996), and may also suffer from a higher mortality while in transit (HOPPER, 1999). If we assume we are studying the effects of migration we note that, in addition to the long distance flights to reach the reproduction sites, tandem / obligate migrant species seem to invest more energy in egg production due to producing larger oocytes / eggs while maintaining the same clutch size. It might therefore be worthwhile to compare the total egg production / fitness during the whole life span between the two reproductive strategies. As the two strategies have coexisted for a long time, we must assume that the tandem system is beneficial under certain circumstances. Most studies have discussed mating systems with the main focus on sexual selection (WAAGE, 1984; FINCKE et al., 1997; DAY, 2000; GAVRILETS et al., 2001; PANHUIS et al., 2001; TURELLI et al., 2001; HÄRDLING & KAITALA, 2004). To focus more on natural selection and morphology might bring new insights into the discussion of mating systems. Natural selection is a fundamental source of evolutionary diversification and a mechanism of speciation (SCHLUTER, 2000; TURELLI et al., 2001; BLACKLEDGE & GILLESPIE, 2004). The benefit of tandem guarding might be a greater ability to change microhabitat during oviposition (BUSKIRK & SHERMAN, 1984), which allows spatial risk spreading and therefore a better adaptation to variable and temporary habitats (WELLBORN & ROBINSON, 1987; STEARNS, 1992; LAAKSONEN et al., 2002; EINUM & FLEMING, 2004; LAAKSONEN, 2004). Recapitulating, this study gives more evidence of the complex interactions between behavioural, life history and morphological traits, and migration pattern. Hence, when conducting such studies it is important not to focus on single, isolated traits, as the performance of individuals may be regulated by multiple traits.

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**TWO NEW ANDEAN SPECIES OF THE GENUS *ISCHNURA*
CHARPENTIER FROM COLOMBIA,
WITH A KEY TO THE REGIONAL SPECIES
(ZYGOPTERA: COENAGRIONIDAE)**

E. REALPE

Laboratorio de Zoología y Ecología Acuática, Departamento de Ciencias Biológicas,
Universidad de Los Andes, Carrera 1 N° 18A 10 Bloque J, Bogotá, Colombia
erealpe@uniandes.edu.co

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I. chingaza sp. n. (holotype ♂: Cundinamarca Dept, Parque Nacional Natural Chingaza, Quebrada La Playa, alt. 3164 m a.s.l., 10-V-2005) and *I. cyane* sp. n. (holotype ♂: Cundinamarca Dept, Francisco de Sales, Vereda San Miguel, alt. 1984 m a.s.l., 1-XII-2004) are described and illustrated. The types are deposited at Mus. Hist. Nat., Univ. Andes, Bogotá. A key to the regional spp. is appended.

INTRODUCTION

The Coenagrionidae is one of the most diverse and ancient extant odonate families (JARZEMBOWSKI, 1984) and *Ischnura* is the most cosmopolitan genus of all odonates (FRASER, 1957), a very important component of lentic freshwater communities. Some 65 species were so far described, but the phylogeny and the distribution of the genus in the tropics are little known (CHIPPENDALE et al., 1999). Five species have hitherto been reported from Colombia, viz.: *I. ramburii* (Sel.) (RIS, 1916), *I. (Ceratura) capreola* (Hag.) (PRINZESSIN VON BAYERN et al., 1900), *I. fluviatilis* Sel. (in MIZA, Maracay, Venezuela), *I. (Ceratura) indivisa* (Ris) (RIS, 1916; RACENIS, 1958) and *I. (Anomalagrion) cruzi* DE MARMELS, 1987.

Here, two new species are described from the eastern Andes.

MATERIAL AND METHODS

Samples were collected in the high mountains of Colombia Eastern Cordillera, near Bogotá D.C., in Cundinamarca department; where a number of studies are ongoing. At Páramo de Chingaza, five samples were taken between September 2003 and May 2004. The captured specimens were placed in acetone for 24 hours and stored at the Museo de Historia Natural ANDES of the Universidad de los Andes ANDES-E. For the altitudinal profile study, samples were taken at each of the 14 chosen localities distributed in an altitudinal range between 242 and 4164 m a.s.l.

For the description of the species morphology, we used the terminology and protocols of DE MARMELS (1987; 1997) and WESTFALL & MAY (2006).

ISCHNURA CHINGAZA SP. NOV.

Figures 1-3

Material. – **Holotype** ♂ and **Allotype** ♀: COLOMBIA, Dept Cundinamarca, Parque Nacional Natural Chingaza, Quebrada La Playa, 4°33'05" N / 73°46'17" W, 3164 m a.s.l., 10-V-2005, E. Realpe leg.; deposited at ANDES-E 10571, 10575. – **Paratypes:** 9 ♂, 10 ♀ data as holotype; deposited at MIZA 17634, ANDES-E 2907-2911; – 4 ♂, 8 ♀, Dept Cundinamarca, Guasca, 4°51'14" N / 73°55'21" W, 2880 m a.s.l., 13-X-2007; – 4 ♂, 2 ♀, Bogotá, Humedal La Conejera, 4.75953° N / 74.10768° W, 2563 m a.s.l., 21-VIII-2008; deposited at ANDES-E.

Etymology. – Adjectivized name of the type locality: Parque Nacional Natural Chingaza.

MALE (holotype). – **Head.** – Labium white; labrum light yellow with a basal black stripe that shows a triangular projection in the medial part and widens

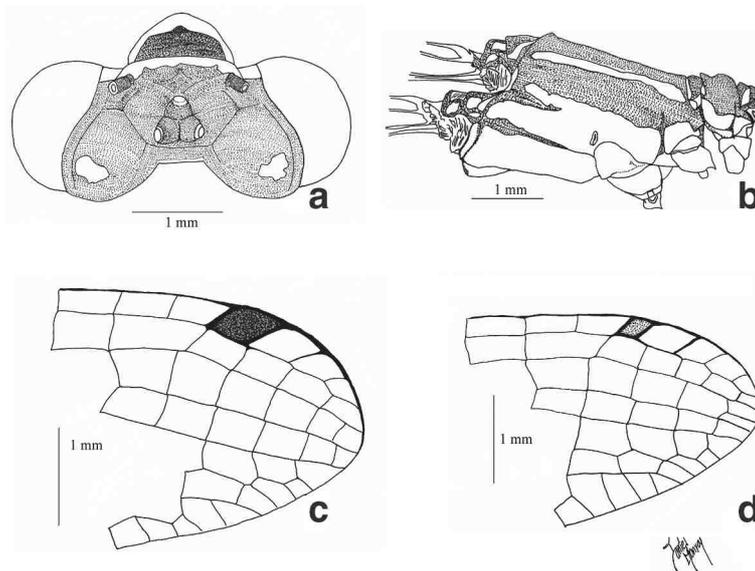


Fig. 1. *Ischnura chingaza* sp. n., male: (a) head, dorsal view; – (b) thorax, lateral view; – (c) forewing, pterostigma; – (d) hindwing, pterostigma.

at the extremes; anteclypeus greenish yellow, postclypeus black forming a roof over the anteclypeus; frons with a greenish yellow transversal stripe, with irregular superior border; frons dorsal portion and epicranium black, with conspicuous postocular spots, which are greenish yellow with irregular borders, and bilaterally asymmetric (Fig. 1a). Compound eyes dark above and light yellow below; genae and mandibles light yellowish green. Posterior part of head light yellow with margin along the compound eyes greenish yellow.

T h o r a x. — Anterior lobe of pronotum black, each side with wedge-shaped, yellow spot; middle lobe mostly black with two small, discrete, yellow dorsal spots on posterior part, laterally greenish yellow. Pronotal hind lobe narrow, black with

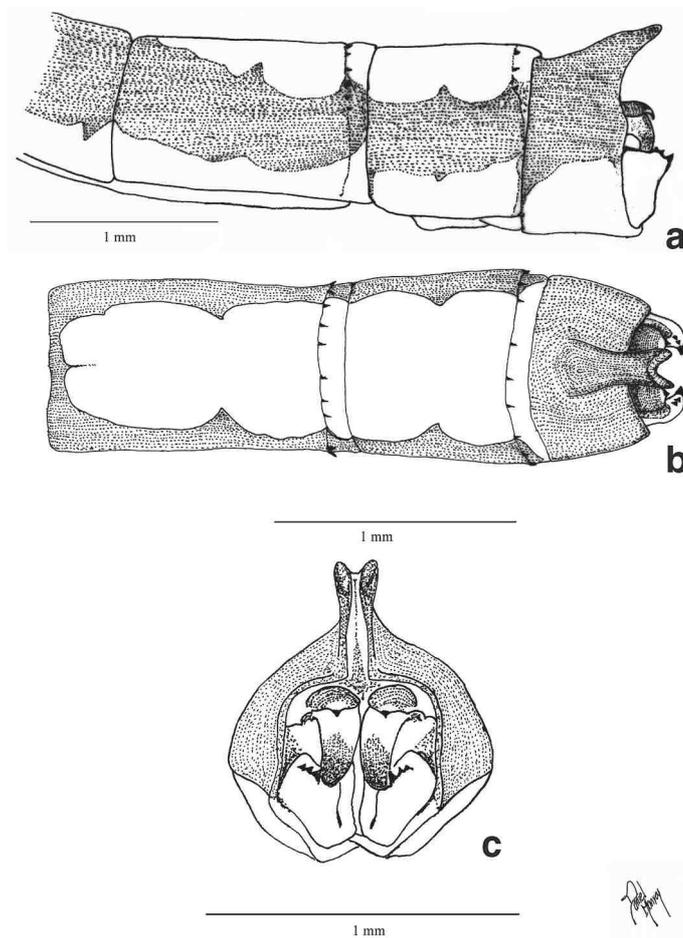


Fig. 2. *Ischnura chingaza* sp. n., male abdomen: (a) lateral view; — (b) dorsal view; — (c) posterior view.

yellow spot at lateral angle; propleuron, coxae and trochanters greenish yellow (Fig. 1b). Pterothorax: Mesepisternum iridescent black with greenish yellow an-
tehumeral stripe, humeral stripe black and wide (Fig. 1b). Mesepimeron, me-
tepisternum and metepimeron and rest of the smaller pleural sclerites, including
sternites, all greenish yellow (Fig. 1b). Interpleural suture with a cuneiform black
spot at antealar carina, and metapleural suture narrowly black with pigmented
metapleural fossa (Fig. 1b). Femora black externally, light yellow internally; tibi-
ae yellow with a well marked black line externally. Both femoral and tibial spurs,
black and well developed. Dark yellow tarsi with black rings at articulations,
claws long, yellow, with brown tip and a small subapical tooth.

claws long, yellow, with brown tip and a small subapical tooth.

Wings hyaline; forewing pterostigma black, rhomboidal, much larger
than the yellowish hindwing pterostigma (Figs 1c-d), forewing with
seven postnodal cross-veins, hindwing with eight; forewing with three
(two) cross-veins after pterostigma in costal space, hind wing with three
(Figs 1c-d). RP_2 arises between third and fourth postnodals in forewing
and between second and third in hindwing.

A b d o m e n. — Black above, first segment presenting a bluish-green
transverse stripe at the inter-segmental membrane, segments 8 and
9 light blue dorsally (Figs 2a-b). All abdominal segments lateroventrally
yellowish-green (Fig. 2a) pale sternites from third to eighth sternites
with a black median carina. Tergum of segment 10 is ending posteriorly
in a large black median spine with bifid tip (Figs 2a-c). Cerci are color-
ed yellow and black, hook-shaped, with distal half arched downwards
in a right angle and bearing a distally directed spine dorsally at angulation
(Figs 2a-c). Paraproct short, yellowish, and directed upwards, ending
with a black, medially directed hook

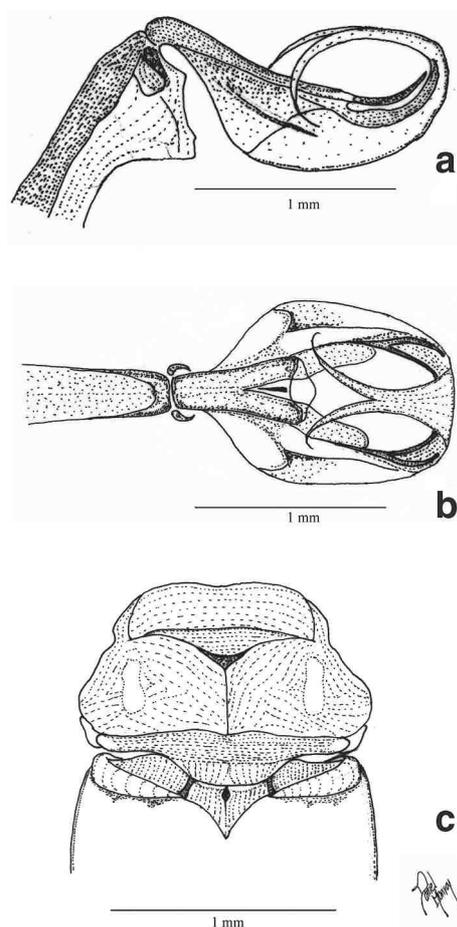


Fig. 3. *Ischnura chingaza* sp. n.: (a) distal segment of penis, lateral view; — (b) same, ventral view; — (c) female prothorax, dorsal view.

and proximally of it with two smaller black teeth (Figs 2a-c).

Penis: distal segment oval shaped deeply bifid tip. There is a pair of sclerotized, spine-shaped and slightly curved internal processes (Figs 3a-b).

M e a s u r e m e n t s (in mm). — Total length with caudal appendages 25.5, abdomen 20, forewing 14.5, hindwing 13.5.

FEMALE (allotype). — **H e a d.** — Similar to the male but with partly differing coloration; labium white; labrum greenish yellow with a black basal stripe, anteclypeus yellow with some bluish; vertical portion of frons greenish yellow, pruinose black dorsally, as well is epicranium; postocular spots brown with regular margins. Compound eyes dark brown dorsally, and light blue below. The genae and mandibles are yellowish-green. The rear of head yellow, a little bit more intense along eye border.

T h o r a x. — In dorsal view prothorax as wide as pterothorax (Fig. 3c). Anterior, median and posterior lobes of pronotum are black and a bit pruinose. Median lobe showing two greenish yellow laterodorsal stripes; posterior lobe narrow with well defined trapezoidal median projection, and with a small yellowish-green spot at each lateral angle; middle part with golden iridescences, overlapping mesostigmal plates (Fig. 3c). Propleuron light yellow next to coxae and trochanters. Black mesostigmal plates are oval shaped, with thick edges (Fig. 3c). Pterothorax: as in male but with slightly differing coloration. Mesepisternum pruinose black with brownish-yellow ante-humeral stripe; humeral stripe wide and black. Mesepimeron, metepisternum, metepimeron, and the rest of lower pleural sclerites to the coxae, and sternites yellowish-green. Interpleural suture shows a wedge-shaped black spot at antealar carina. Metapleural suture is complete and pigmented. All femora black externally and light yellow internally; tibiae yellow with external black line; tarsi pale, and claws as in male.

Wings hyaline; pterostigma in all wings yellowish, but the difference in size between the fore- and hindwings is slightly smaller. Forewing with ten post-nodal cross-veins, and hindwing with eight. Three cross-veins after pterostigma in costal space are present in all wings; second cross-vein in hindwings bifurcate. RP_2 arises between third and fourth post-nodals in forewings, and between second and third in hindwings.

A b d o m e n. — All abdominal terga black dorsolaterally, strongly pruinose: lateroventral parts of terga yellow, anteriorly paler and posteriorly darker. All sternites are pale with fine black carina. The carina of eighth sternite produced into a short vulvar spine. Valvae of ovipositor light yellow ending at the posterior edge of tenth segment. Cerci black, paraprocts light-yellow reaching to mid-length of the cercus.

M e a s u r e m e n t s (in mm). — Total length with cerci 26, abdomen 20, forewing 15, hindwing 15.

ISCHNURA CYANE SP. NOV.

Figures 4-6

Material. – **Holotype** ♂ and **Allotype** ♀: COLOMBIA, Cundinamarca Dept, Municipality of San Francisco de Sales, Vereda San Miguel, Finca la Soledad, 5°00'05" N / 74°15'30" W, 1984 m a.s.l., 1-XII-2004, Pérez & S. Cardona leg.; deposited at ANDES-E 10582, 10584. – **Paratypes:** 5 ♂, 2 ♀, same place and date as holotype; – 4 ♂, 4 ♀, Boyacá Dept., Villa de Leyva, 5°38'31" N / 73°31'50" W, 2112 m a.s.l., 11-XI-2007, E. Realpe leg.; – 4 ♂, Cundinamarca Dept, Municipality of San Francisco de Sales, Vereda San Miguel, Lago Verde (fish pond), 4.98960° N / 74.28824° W, 1627 m a.s.l., 11-V-2008, E. Realpe leg.; – 13 ♂, 8 ♀, Cundinamarca Dept., Anolaima, finca Limaná, Vereda San Agustín, 4°47'07" N / 74°28'42" W, 1370 m a.s.l., 7-V-2006, 15-VI-2006, N. Valencia, L. Pérez, M. Sánchez & E. Ortiz leg.; all deposited at ANDES-E.

Etymology. – (Greek: *kyanos* = blue); this is the species with the greatest extension of blue color in males of all *Ischnura* species caught in the region studied.

MALE (holotype). – **Head.** – Labium white; labrum lemon green with a black basal stripe that shows a projection in medial part and widens towards lateral angles, anteclypeus blue, postclypeus deep black (Fig. 4a). Frons with greenish blue transversal stripe and black anteromedial part as a continuation of postclypeus, antenna black (Fig. 4a); epicranium black with large, oval, symmetric, blue postocular spots. Occiput superior edge of occiput with a short, blue stripe (Fig. 4a). Compound eyes dark in superior third, rest yellow with two horizontal dark lines. The genae and mandibles are bluish-green, as the frons. Posterior part of

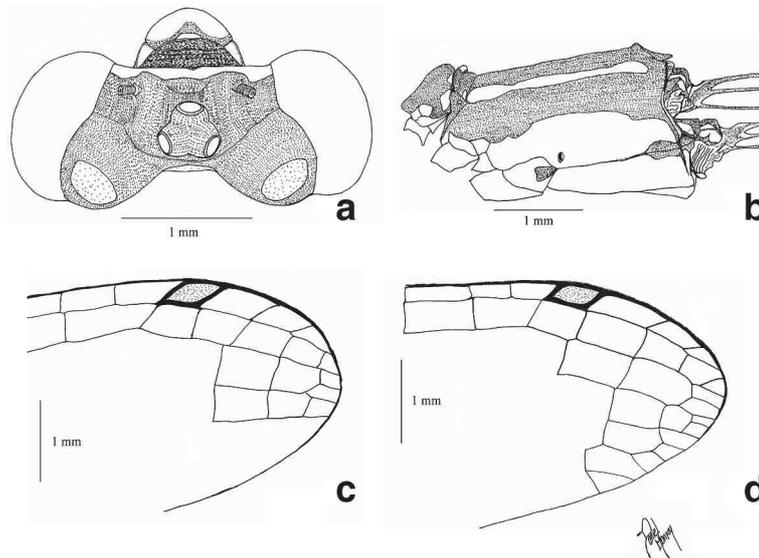


Fig. 4. *Ischnura cyane* sp. n., male: (a) head, dorsal view; – (b) thorax, lateral view; – (c) forewing, pterostigma; – (d) hindwing, pterostigma.

head is light blue in proximity of the eyes and black in the medial part.

T h o r a x. – Prothorax with anterior lobe of pronotum black and with a long, blue with dorsolateral stripe. Median lobe of pronotum black with a blue spot at each lateral end. Posterior lobe of pronotum narrow, black and blue (Fig. 4b). Pterothorax: mesepisternum shiny black with well defined blue ante-humeral stripes; broad, black humeral stripe; mesepimeron, metepisternum, metepimeron along with lower pleural sclerites until the coxae and sternites, are blue (Fig. 4b). Metapleural suture narrowly black with metapleural fossa also black (Fig. 4b).

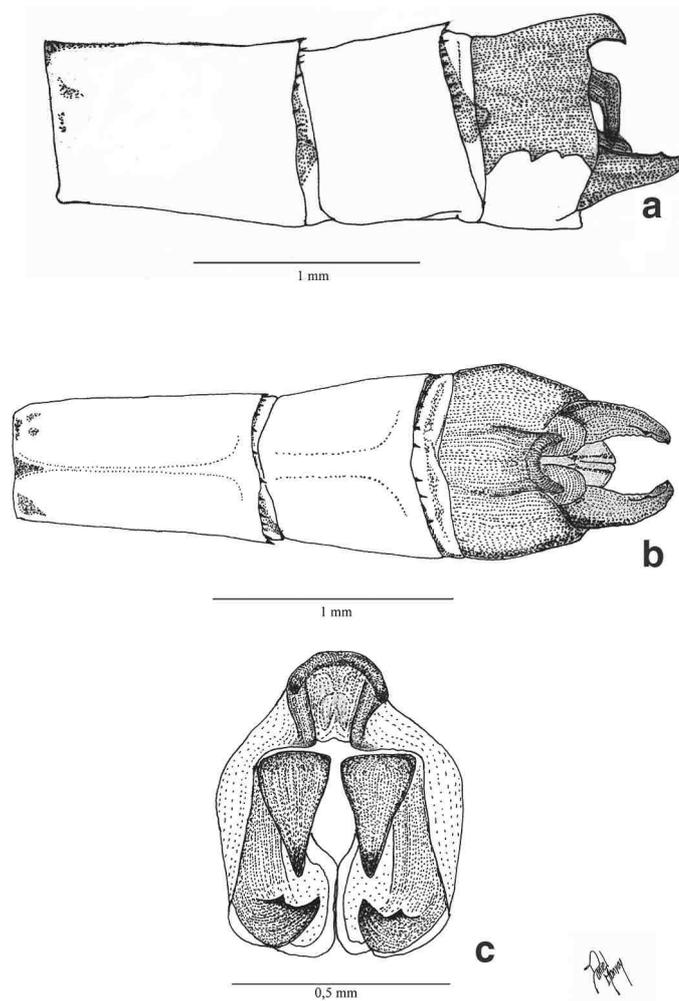


Fig. 5. *Ischnura cyane* sp. n., male abdomen: (a) lateral view; – (b) dorsal view; – (c) posterior view.

All femora are light cream colored with some pigmentation laterally. Tibial spines more or less twice as long as femoral spines; tarsi pale, dark at articulations; claws pale with dark tips and a short subapical tooth.

Wings hyaline, pterostigma rhomboidal, and brown, and of similar size in fore- and hindwing (Figs 4c-d). Forewing has nine post-nodals and hindwing has seven. There are three (two) cross-veins after pterostigma in forewing costal space, and three in hindwing (Figs 4c-d). RP_2 arises between third and fourth post-nodals in forewing and between second and third in hindwing.

A b d o m e n. — Segments 1-7 and 10 dorsolaterally black; segment 1 later-

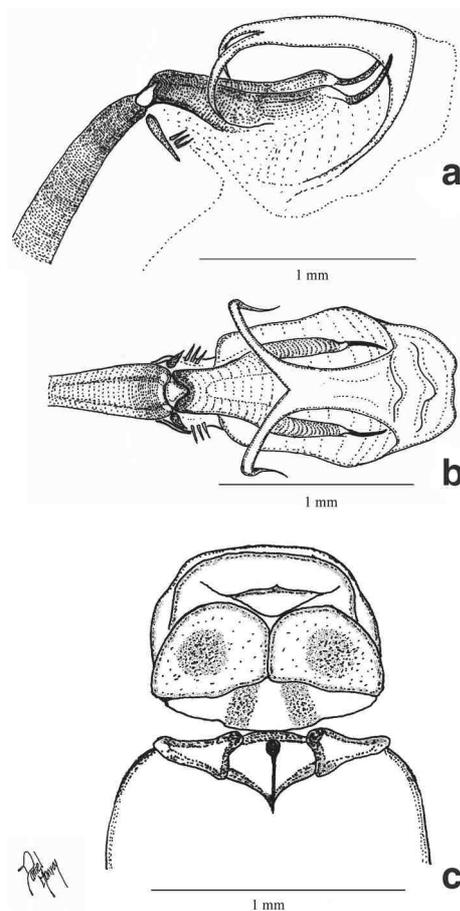


Fig. 6. *Ischnura cyane* sp. n.: (a) distal segment of penis, lateral view; — (b) same, ventral view; — (c) female prothorax, dorsal view.

ally blue, and with a blue stripe distally; segment 2 also blue laterally; segment 3 with a blue basal ring. Lateroventral parts of terga from third to seventh segment light yellow or cream coloured. Sternites from third to seventh segment are black-lined; segments 8 and 9 are intensely blue, including sternites, genital plates and lateroventral part of segment 10 also blue (Figs 5a-b). Anterior dorsal part of segment 8 shows variable black marks; black lines also along the subapical spines in segments 8 and 9 (Figs 5a-b). The tenth segment shows a robust postero-dorsal projection robust bifid in the end. (Figs 5a-c). Cerci black, hook-shaped, arched ventral in an almost right angle (Figs 5a, c); paraprocts as long as segment ten, black, conical with tip directed mesad and presenting a small, dorsal-lateral sub-apical tooth (Figs 5a-c).

Penis: distal segment long, deeply bifid with both lobes long and slightly curved; second segment internally with a pair of slender, sclerotized distal processes. There are three short spinules on each side near the shaft's articulation with second segment (Figs 6a-b).

M e a s u r e m e n t s (in mm). — Total

length including caudal appendages 26; abdomen 22.5; forewing 14; hindwing 13.

FEMALE (allotype). — **H e a d.** — Similar to the male's but with differing coloration. Labium white; labrum bluish-green pruinose, with a black basal stripe, forming a semicircle in the medial part, anteclypeus bluish-green, postclypeus intense black, with a purple iridescence and forming a roof over the anteclypeus. Antenna black. Frons and anterior part of black epicranium greenish-yellow; postocular spots bluish green, more or less rounded with a light tip mesad. A blue occipital line present; compound eyes black above and bluish-green below; genae and mandibles also bluish-green. Posterior part of head light bluish-green with dark spots towards occiput.

T h o r a x. — Prothorax in dorsal view narrower than pterothorax (Fig. 6c). Anterior lobe of pronotum blue, median lobe darker above with well marked medial suture, laterally blue colored. Posterior lobe of pronotum is small and crescent-shaped, with medial part darker, laterally blue (Fig. 6c); propleuron pale blue. Pterothorax: mesostigmal plates triangular and black (Fig. 6c). Mesepisternum with blue antehumeral stripe narrower than in male, but broadening at each end. The humeral stripe is wide and black. Mesepimeron, metepisternum and metepimeron, and the remaining lower pleural sclerites are blue. Metapleural fossa dark brown. The coxae and sternites are between light-yellow and greenish. Femora of all legs are black externally, and light yellow and somewhat pruinose internally; tibiae are yellow with a black lateral stripe. Spines, tarsi and claws as in the male.

Wings hyaline, pterostigma similar in all wings, rhomboidal, dark yellow. Right forewing has nine post-nodals and left forewing has ten. Both hindwings have eight post-nodals. There are three cross-veins after the pterostigma in costal space of hindwing; RP_2 arises between post-nodals three and four in forewing; and between post-nodals two and (close to) three in hindwing.

A b d o m e n. — Segments 1-8 black dorsally, yellow laterally and ventrally, except for segments 1 and 2, which are blue laterally. The first segment has a blue stripe along distal border. Segment 9 blue dorsally and yellow laterally. Anterior dorsal portion of segment 10 blue, posterior part narrowly black and lateral-ventral parts are yellow. Sternites of segments 2-9 pruinose black-lined, including the vulvar spine. Valves of ovopositor yellowish-green and slightly surpassing distal border of segment 10, stylus dark brown. Cerci black, short and rounded; paraprocts black dorsally and light yellow ventrally.

M e a s u r e m e n t s (in mm). — Total length including caudal appendages 26.5; abdomen 21; forewing 16; hindwing 14.5.

PARATYPES. — In males, the color pattern of head and thorax very constant, but the black spots in the blue anterior dorsal part of segment 8 are variable, and may even be absent in some. There is some variability in the pattern of the lateral markings of segments 1 and 2. Number of cross-veins also varies, and although the predominant formula of postnodals is 9 + 7, the number 8 + 6 is also found;

the cross-veins in costal space distally of pterostigma Usually 2 + 2, but in one case that a single cross-vein is present in one wing, and four in one other. In one specimen RP2 originates between second and third post-nodal in one forewing. Total length averages 25.2 mm

DISCUSSION

The species described here, *I. chingaza* sp. n. and *I. cyane* sp. n., together with *I. (Anomalagrion) cruzi* De Marmels 1987, form a group of species vertically distributed between 1300 and 3200 m a.s.l. in a particular area of the eastern Andean mountain range. At lower elevations (1300 and 2000 m a.s.l.), *I. cyane* is sharing habitats with *I. capreolus* and *I. ramburii*. At 2600 m a.s.l., in the Sabana de Bogota, *I. cruzi* and *I. chingaza* occur, and towards the higher elevations (3200 m a.s.l.) only *I. chingaza* is found. Morphologically at first sight, the males show similarities in size and color pattern, but with a gradient from dominant blue (*I. cyane*), passing through blue-green (*I. cruzi*) to yellow-green or dominant green (*I. chingaza*). The main differences can be observed in the morphology of the male caudal appendages and the female pronotum, as traits that support their reproductive isolation. In populations of these species, female color polymorphism was not found so far, in contrast to the lowland species *I. capreolus* and *I. ramburii*, where androchromous females occur along with the gynochromous individuals (CORDERO & ANDRES, 1996; SVENSSON et al., 2007; VAN GOSSUM et al., 2008). We observed the intense yellow in juvenile females (especially *I. cyane*) and less intense in *I. chingaza*. Mature *I. chingaza* females were more robust than those of *I. cyane*, as noted by a thicker abdomen. Dark color and pruinescence give both species a greyish appearance. This interesting phenomenon may perhaps be related to their occurrence at high mountain sites.

KEY TO THE *ISCHNURA* MALES OF COLOMBIAN EASTERN CORDILLERA

- | | | |
|-------|---|---------------------------|
| 1 | Paraproct at least as long as segment 10 | 2 |
| 1' | Paraproct shorter than segment 10 | 4 |
| 2(1) | Paraproct divided into a short dorsal branch and a falciform, pointed ventral branch | <i>I. capreola</i> |
| 2' | Paraproct not divided into two branches | 3 |
| 3(2') | Cercus undivided in lateral view; pterostigma similar in all wings | <i>I. cyane</i> sp. n. |
| 3' | Cercus bifid in lateral view; pterostigma of forewing notably larger and darker than hindwing pterostigma, which is pale | <i>I. cruzi</i> |
| 4(1') | Paraproct directed dorsally, its truncated tip armed with three denticles; forewing pterostigma larger and darker than pterostigma of hindwing, which is yellowish | <i>I. chingaza</i> sp. n. |
| 4' | Paraproct directed distally with pointed tip; pterostigma not as above | 5 |
| 5(4') | Cercus in lateral view without finger-like dorsal-lateral process; pterostigma of similar size and shape in both wings, in forewing darker than in hindwing | <i>I. ramburii</i> |
| 5' | Cercus with finger-like dorsal-lateral process; forewing pterostigma orange colored and | |

separated from costal margin by a cross-vein; hindwing pterostigma normal, smaller, dark colored *I. hastata*

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**ADULT ODONATA COMMUNITY IN DINAGAT ISLAND,
THE PHILIPPINES: IMPACT OF CHROMIUM ORE MINING
ON DENSITY AND SPECIES COMPOSITION**

R.J.T. VILLANUEVA

D3C Gahol Apartment, Lopez Jaena St., PH-8000 Davao, Philippines
rjtvillanueva@gmail.com

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Mining modifies the surrounding environment and causes habitat deterioration along river systems receiving mine tailings. Here it is assessed whether chromium ore mining affects the odon. abundance and diversity. Line transect surveys were conducted during 4 months at the Henry river (along a pristine section and a previously mined section), and at the Lecing river, which is currently receiving tailings from chromium ore mines. The density of adult odon. was 10 times higher in the pristine than in the mined river. Species richness was reduced in both the currently and in the previously mined sections (5 spp.) as compared to that of the pristine river (12 spp.), showing a detrimental effect of chromium mining on dragonfly diversity and abundance.

INTRODUCTION

Freshwater is currently the fastest dwindling resource for humans as a consequence of domestic, agricultural and industrial consumption, and lack of maintenance leading to its depletion and contamination (DUDGEON, 1992; TWUMASI & MEREM, 2007; FAIRLESS, 2008). Additionally, freshwater represents less than 1% of the global surface water and is thus an important resource of limited availability. The United Nations General Assembly recognized this issue and declared the years 2005-2015 the International Decade for Action 'Water for Life'.

Freshwater systems host an extremely rich vertebrate and invertebrate biodiversity, and in some areas high level of endemism is noted where some species are confined to a single river system (PONDER, 1997; DUDGEON et al., 2006; BALIAN et al., 2008). However, inadequate biological information and lack of prioritization by policy makers hamper protection and conservation efforts re-

lated to freshwater ecosystems worldwide (ABELL, 2002; DUDGEON et al., 2006; TWUMASI & MEREM, 2007).

Mining is a recognized contributor to water pollution leading to biodiversity decline in river systems (PUSCH & HOFFMANN, 2000; TARRAS-WAHLBERG et al., 2001). The main consequence of mining is the discharge of unused material into freshwater systems; these so-called tailings vary depending on the mineral extracted, but act as chemical or physical pollutants and eventually alter freshwater ecology (PUSCH & HOFFMANN, 2000; TARRAS-WAHLBERG et al., 2001). While the chemical and physical consequences of mining are well documented, there is limited information on how biological communities are affected by mining (WOOD & ARMITAGE, 1997; WANTZEN, 2006).

Mining for minerals has become a fast growing industry in many tropical countries, including the Philippines. On Dinagat Island, nickel and chromium ore are the most sought-after minerals currently being extracted at industrial scales. The most commonly used method for removing chromium ore in Dinagat Island is a modification of strip mining by allowing water to erode the soil to remove silt and clay, leaving the heavy sandy ore behind. This leads to high level of sediment load in rivers with ongoing mining activity upstream. Though various media reports on mercury contamination, fish kills and mine/tailing accidents, no published paper is available concerning biodiversity impact in the Philippine settings.

Sediment load and water turbidity have been shown to affect aquatic organisms (WOOD & ARMITAGE, 1997; WANTZEN, 2006), thus there is a clear potential for mine tailings to affect biological communities, including Odonata, in waterways receiving mine tailings.

Odonata belong to a group of insects where adult and larvae live in two habitat types; terrestrial and aquatic (CORBET, 1999; KALKMAN et al., 2008). This life cycle renders the group vulnerable to changes affecting either its terrestrial or aquatic habitat (REMSBURG & TURNER, 2008). Due to sensitivity to habitat alteration, dragonflies are used as biological indicator in grazing effect, forest and in landscape structure, and habitat integrity studies (BUTLER & DEMAYNADIER, 2008; CLARK & SAMWAYS, 1996; FOOTE & HORNUNG, 2005; JONSEN & TAYLOR, 2000; OSBORN, 2005; RITH-NAJARIAN, 1998). The conspicuous nature of some species makes them easy to spot even for non-odonatologist. This conspicuousness, close association with freshwater and their sensitivity to habitat alteration make them a useful tool for ecologist working on ecological assessments of freshwater habitats.

Presently no published account on Odonata in chromium ore mining areas is available. Here, the adults are used as an indicator of water quality in rivers exposed to varying levels of chromium mining activity on Dinagat Island by assessing the composition and density of their assemblage in a river system.

For a general review of the Dinagat Island odonate fauna, see VILLANUEVA (2009).

METHODS

The study was conducted on Dinagat Island, the Philippines. This is the third largest island in the Mindanao biogeographic subregion, situated NE of Mindanao. The island has a unique faunal and floral composition, with a high level of endemism (HEANEY et al., 1982; ROSS & LAZELL, 1991; HÄMÄLÄINEN & MÜLLER, 1997).

Besides having very rich biological resources, the island also has abundant mineral deposits that are currently being utilized by various mining firms. The major minerals extracted are nickel and chromium ore, using tunnel and strip mining methods.

The Odonata were studied at three sites in the north-central part of the island. The climate at the study sites is seasonal, with a dry season (April-October) and a rainy season (November-March) periods. The study area comprises two small rivers (the Lecing and the Henry) that are about 3 km apart and are separated by a gently sloping hill.

These two rivers were chosen for their similar ecological characteristics, but different level of mining activity. They fluctuate from 3-6 m in width, and have slow to moderate flow depending on the season. During the study period the rivers were 3-4 m wide with a depth ranging from 10 to 200 cm at various points. The surrounding areas are mostly forested, except for some open portions of about 100-200 m² due to cutting for firewood and logging activity.

The Lecing (10°17'33" N / 125°34'58" E; alt. 34 m a.s.l.) is currently being mined for chromium ore. Mining is daily and more intense during the wet season when there is an abundant supply of water. Mining sites are located in the forest approximately 100 m away from the river. The heavy ore is collected in artificial canals up to 3 m deep and 1-2 m wide, and sediment-laden water from those canals is flushed out into the river system. The mine tailings from over a hundred canals drain into the river, resulting in a high content of sediments in the water. The turbidity is very high, and in slow-moving sectors the sediment content is so high that water consistency is highly viscous. The study site was surrounded by 15 draining canals with several dozen more canals upstream from the study site (hereafter referred to as site 1, mining).

The Henry (10°15'53" N / 125°34'45" E; alt. 60 m a.s.l.), is located along the northern border of the Paragua Forest Reserve, a newly established protected area in the municipality of Libjo. The reserve used to be a mining concession that was relinquished two years prior to the present study. The Henry river running West to East, was dissected by the "largest highway" on Dinagat Island (same with the Lecing river) and divided into two sections, one with pristine (least altered of the three sites) waterway upstream of the road (site 2 started 50 m West from roadside and going further West, control), and one with previous chrome ore mining history downstream of the road (site 3 started 50 m East from roadside and going further East, recovering). Site 2 is over 100 m from the nearest transects.

At site 2, the water was clear with a sandy substrate and occasional gravel interspersed with rocks and boulders. Site 3, which had been exposed to mine tailings until two years prior to the present study, also had clear water, but the bottom substrate was covered by fine muddy sediments, especially in deeper parts of the river.

FIELD SAMPLING. – A total of 15 random 50 m-transect lines were established, with a total transect length of 750 m along 3 km of the Lecing river (site 1, mined). At site 2, I also established 15 transect lines with a total length of 750 m along a 3 km section of the river. At site 3, only 9 transect lines were set up with a total length of 450 m along a 1 km section of the river, since a large creek converge with the river beyond the last transect line. Transect length was set to 50 m in order to obtain at least one record, based on trial transect walk conducted prior the actual survey.

Transect surveys were conducted monthly: 5 at sites 1 and 2, and 3 at site 3, between May and August 2008. Each site was sampled on randomly selected days except for August 21, 2008 when all sites were sampled on the same day. These months were selected due to fair weather conditions during this period and relatively stable water current. I sampled the three sites between 09:00 h to 15:00 h on sunny days with very little cloud coverage. Transect surveys were conducted only when the river

was exposed to sunlight.

Sampling was carried out along random transect lines parallel to the river (OPPEL, 2006a) with transects 5-30 m apart. I moved upstream or downstream in a straight line from a fixed point maintaining a speed of 3 m per minute. I followed the distance sampling protocol (BUCKLAND et al., 1993), surveyed both sides of the transect line and recorded each individual on the spot where I first noticed it. I then captured Corduliidae individuals with a hand-held net to identify the species and returned to the exact spot where I left and continued the transect walk. All other species were identified to species level without capture, save for *Neurothemis*, the females of which are difficult to identify at a distance.

The distance of each encountered individual from the transect line was recorded in four categories: 0.5 (0-1 m), 1.5 (1-2 m), 2.5 (2-3 m) and 3.5 (3-4 m). The species noted more than 4 m away from the transect line, were not included.

ANALYSIS. – The density and encounter rate were estimated using the program Distance v. 5.0 (THOMAS et al., 2006). Sample size was insufficient to estimate density parameters for each species separately, therefore all species were pooled in order to estimate overall density (OPPEL, 2006a).

RESULTS

In all, 17 species were recorded (Tab. I): 5 for sites 1 and 3, and 13 for site 2. The odonate assemblage at site 1 was composed entirely of oriental Anisoptera; sites 2 and 3 were inhabited predominantly by endemic Zygoptera. The most common species encountered were *Agrionoptera insignis* (Ramb.) at site 1, *Rhinocypha turconii* Sel. at site 2, and *R. colorata* (Hag.) at site 3. *Orthetrum s. sabina* (Dru.)

Table I
List of species recorded as adults during summer 2008 in the Lecing (site 1, mined) and the Henry rivers (sites 2 and 3, pristine and previously mined, respectively), Dinagat Island, the Philippines

Species	Site 1	Site 2	Site 3
<i>Agrionoptera insignis</i> (Rambur)	X		
<i>Amphicnemis cantuga</i> (Needham & Gyger)		X	
<i>Coeliccia dinocerus</i> Laidlaw		X	
<i>Cyrano angustior</i> Hämäläinen		X	
<i>Diplacodes trivialis</i> (Rambur)	X		
<i>Euphaea amphicyana</i> Ris		X	
<i>Heteronaias heterodoxa</i> (Selys)		X	
<i>Idionyx philippa</i> Ris		X	
<i>Neurothemis r. ramburii</i> (Brauer)	X		
<i>Orthetrum pruinosum clelia</i> (Selys)	X		
<i>Orthetrum sabina sabina</i> (Drury)	X	X	X
<i>Prodasineura integra</i> (Selys)		X	X
<i>Pseudagrion pilidorsum</i> (Brauer)		X	
<i>Rhinocypha colorata</i> Hagen		X	X
<i>Rhinocypha turconii</i> Selys		X	X
<i>Risocnemis praeusta</i> Hämäläinen		X	
<i>Vestalis melania</i> Selys		X	X

Table II
Estimates (\pm standard error) of adult Odonata density, encounter rate, and effective strip width (ESW) using distance sampling at three sites with different mining intensity on Dinagat Island, the Philippines, in summer 2008

Site	Encounter rate [individual./km]	ESW [m]	Density [individual/hectares]
Site 1 (mined)	40	1.98 \pm 0.48	101 \pm 36
Site 2 (pristine)	280	1.93 \pm 0.98	725 \pm 69
Site 3 (previously mined)	100	3.23 \pm 0.61	161 \pm 40

was the only species recorded in all three study sites, but it was encountered more frequently in the Lecing (site 1) than in the Henry (sites 2 and 3) river.

Estimated odonate density (Tab. II) in the pristine site was approximately seven times higher than in the site polluted by mine tailings. The area that had experienced previous mining activity had an estimated density 1.6 times as high as the presently worked mine site, but less than a quarter of the pristine site.

DISCUSSION

The results of this study suggest that mine tailings have a detrimental effect on Odonata communities in rivers. The estimated Odonata density was about seven times higher in a pristine river. Cessation of mining did not result in a quick recovery of the community, and it remained at the site with previous mining history was depauperate both in species richness and in density compared to a pristine site in the same river after two years.

In general, pristine forest has higher species richness and diversity, and also has different species composition (OPPEL, 2006b). In the Philippines, a large majority of Odonata are forest specialists dependent on forested habitats. The Platystictidae, Platycnemididae and *Amphicnemis* (Coenagrionidae) comprise the bulk of forest species. The inconspicuous and rheophilous nature of many members of this group usually results in lower encounter especially in river areas. In this study, some members of the group were occasionally encountered in the pristine site, but not in the presently or previously mined sites.

The Calopterygidae and Chlorocyphidae prefer open spaces in forested waterways, and their metallic reflections are highly visible, consequently they represent the most recorded group. They were recorded mainly in the pristine and some also in the previously mined site. No species was noted though in the presently mined site. Among the *Rhinocypha* (Chlorocyphidae) species encountered, *R. colorata* dominated in the previously mined site, suggesting fast recovery of this species compared to its congener *R. turconii*. The available data are too limited to assess rates of Odonata recovery in mining areas (D'AMICO et al., 2004)

especially chromium ore mine, but it seems that *R. colorata* is more tolerant to silty sediments than *R. turconii*, thus facilitating faster recolonization. These data suggest that both *Rhinocypha* species could be used as indicator species for the assessment of habitat quality in forested small rivers.

Land use influences stream biological diversity (ALLAN, 2004; SUBRAMANIAN et al., 2005), and DUDGEON (1999) emphasized that it is difficult to assess changes resulting from human activity due to natural variability in tropical Asia. The sites chosen for the present study have similar human disturbance levels, and differ only in the intensity of mining. The closeness of the study sites and similarity of habitat most likely eliminate natural variability as explanatory factor for differences in Odonata assemblages among sites. Though traffic pollution from the road may confound the results for the previously mined river at site 3, it is considered negligible since less than one motor bike passes every hour, and only one or two cars per day. It is therefore assumed that Odonata density and species composition are affected primarily by mining activity.

The majority of Philippine Odonata are forest specialists especially the endemic species that are confined to very restricted ranges. However, forest specialists were not encountered at site 1, despite the presence of similar forest characteristics at the other sites. The absence of forest specialists in forested river with mine tailings suggests that forest species are highly sensitive to water quality where the most notable difference exists. Although the water is presumably free of chemical pollutants, the physical pollution by high sediment load in the water possibly is not favourable for larval growth, consequently affecting adult density and composition. This is in agreement with a similar study that showed that erosion or siltation affected aquatic species (WANTZEN, 2006). Further study is suggested to validate this finding in other regions with chromium ore mining sites.

The odonate community at the site that had previously experienced mining activity was depauperate similar to site 1, despite clear flowing water and forest cover. The presence of only five species, including the generalist *Orthetrum s. sabina*, and low species density nearly two years after mining showed the slow recovery of forest species. The pristine and the formerly mined sites were located in the same river, and the nearest transects were separated by only 100 m. This distance should facilitate rapid recolonization of the formerly mined site from the pristine area by active dispersing of adults and downstream drift of larvae. However, despite this recolonization potential, only few species became established within two years, indicating that habitat quality at this site does not permit the continued existence of many species. While more research is required to understand what factors limit recolonization by Odonata, the habitat degradation demonstrates the negative effect of chromium ore mining on aquatic invertebrate diversity.

The odonate larvae are vulnerable to high sediment load in the water and the adverse effects of chromium ore mining on the adult odonate assemblage are here demonstrated, but further research is required to examine the mechanism

by which odonata larvae are affected by sediment loads in tropical streams.

In conclusion, this study clearly shows the negative effect of chromium ore mining on adult Odonata density and composition, and I recommend careful consideration of these impacts before approving future mining operations.

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SHORT COMMUNICATIONS

**THE PROCESS OF MOULTING DURING FINAL EMERGENCE
OF THE DRAGONFLY *PANTALA FLAVESCENS* (FABRICIUS)
(ANISOPTERA: LIBELLULIDAE)**

R.J. ANDREW and N. PATANKAR

Department of Zoology, Hislop College, Civil lines, Nagpur-440 001, India
rajuandrew@yahoo.com

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The chain of events occurring during emergence in *P. flavescens* is described in detail. The moulting process is divided into 3 stages. The larva climbs out of the water a few hours after sunset. If disturbed while climbing, it exhibits thanatosis i.e. death feigning and crab-like side-ways crawling. It stops at a suitable vertical emergent support. Manipulation from vertical to horizontal of this support stops commencement of ecdysis. – Stage I starts from the moment the larva finds a suitable site for moulting. Soon, it starts shuddering, quivering and shaking its body in a synchronized pattern. The imago inside the exuviae exerts pressure on the thoracic tergites until the cuticle splits. This stage varies from 8 to 20 min and occupies 16% of the moulting period. – During stage II, the head and thorax of the imago emerge out of the split thoracic cuticle. The imago exhibits an antero-posterior humping movement and the body hangs out downwards with folded legs. The half suspended, upturned imago starts ‘breathing’ heavily. Unfolding of the legs and movements of the packed wings takes place in a characteristic manner. The imago turns upwards, grips the head of the exuviae and jerks out the remaining terminal portion of the abdomen from the exuviae. This stage takes 18 to 35 min and occupies 31% of the moulting time. Pigmentation of the head region is completed during this stage. – In stage III, the imago is released from the exuviae, it starts hardening its cuticle and extending the wings. The imago moves a few inches above the exuviae. The abdomen is pale green and curved upwards. The wings expand but are opaque. Simultaneously, pigmentation of the body starts around the thoracic region and the terminal tip of the abdomen. Within 10-14 min the whole body of the imago develops a species-specific teneral pattern of colouration. Meanwhile, the expanding wings unfold and separate out and the teneral adult is ready for flight. This stage takes 40-55 min and occupies 53% of the total moulting period. Observations on incomplete metamorphosis indicate that gravitational force is responsible for uniform wing expansion.

INTRODUCTION

Moulting during final emergence, or final metamorphosis, is one of the most spectacular events in the life history of a dragonfly (MILLER, 1995). This process has been observed and discussed by various workers (TILLYARD, 1917; CORBET, 1951; PAJUNEN, 1962; TROTTIER, 1966; BULIMAR, 1971). Moulting is a highly complex process in which many different types of rhythmic movements participate.

CORBET (1999) noted that it was not easy to determine stage I and stage IV of metamorphosis in Odonata. The larvae of many species leave the water partly or wholly and intermittently, days or even weeks before emergence and it is not easy to time stage IV in Odonata because various extrinsic factors like dawn, twilight and temperature and even endothermic warming control the first flight, which concludes stage IV.

MATERIAL AND METHODS

The city of Nagpur (21°10' N / 79°12' E) lies at the southern fringe of the Satpuda mountain range in central India. It is located on an undulating plateau with altitude ranging between 274-305 m above mean sea level. The collection site was a 15 m long stretch of a 120 m long open cement drain running in a west-east direction. It has a width of 34 inches and a depth of 32 inches. Depth of water of about 5 inches accumulates at the bottom due to the presence of a single brick layer placed across the floor of the drain. The drain is located at the large grass covered playground surrounded by shrubs and few trees of the St John's School in the centre of the city.

Mature F-0 larvae were collected from this site and kept in buckets and plastic containers, partially filled with the water from where they were collected. Wooden sticks, twigs and branches were placed in the containers as emergence supports. Natural conditions were maintained by keeping the containers in a veranda, near large open windows. With the help of an aim-n-shoot 35 mm Yashica camera (model: EZX-105, 38/105 mm) the various stages of the process of moulting during final metamorphosis were photographed.

All the movements of the larva/emerging pharate were documented and a Nokia 1100 cell phone's stopwatch was used to record the time (one of the major merit of using this cell phone was the inbuilt tiny cool torch which was of great help during the recording of observations in the dark).

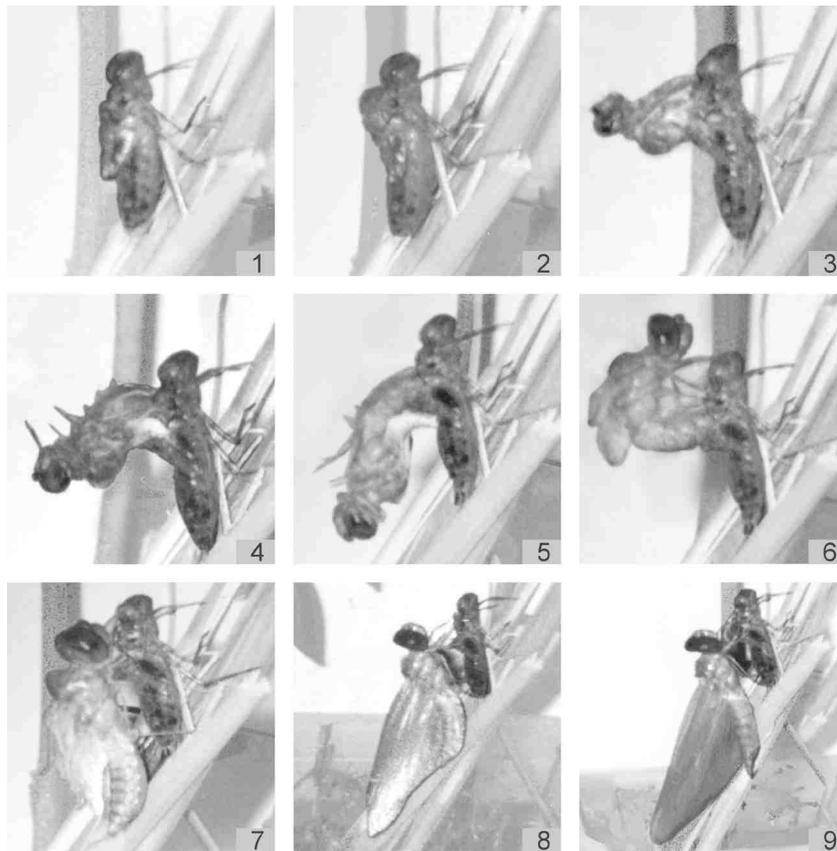
RESULTS

The following documentation is of one complete session of moulting during the final emergence of *Pantala flavescens*, which was observed on the night of 15th April 2004.

The larva rested with its head and thorax out of water since early evening (6:25 pm.). At 11:10 pm, it moved out of the water and climbed 13 inches, stopping at a suitable emergent support (dried branches, stick).

Stage I (Figs 1-2). – After a rest of 96 seconds, the larva started jerking its head sideways 'left and right' 19 times. Then it pushed the head and thorax

upwards seven times with legs spread and the posterior region of the abdomen firmly pressed against the base. The larva moved the head sideways twice and curved up the abdominal tip once. It reset the grip of its legs and pushed up the head and thorax but the abdomen lay pressed against the base. The head moved sideways eight times, slowly rising with every move (as if taking a deep breath). It re-gripped and repositioned its legs and slightly elevated the thorax. The fore-legs started twitching, while the hind legs re-positioned themselves. The fore legs started quivering without losing their grip. At this stage, the terminal end of the abdomen was firmly pressed against the base. The head lifted and the fore legs displayed clawing movements which stopped after eight seconds. The head and thorax jerked up and down 14 times. The right wing pad elevated slightly in six tiny jerks but returned to its original position. A dark split appeared in between the wing pads. This stage concluded at 11:35 pm.



Figs 1-9. *Pantala flavescens*, final metamorphosis: (1-2) stage I; – (3-6) stage II; – (7-9) stage III.

Stage II (Figs 3-6). — The larva remains motionless but the right wing buds exhibited slight lateral movement which stopped after 28 seconds and the larva again became motionless.

At 11:40 pm the wing buds rose while the thorax lifted. The head and thorax of the adult emerged out of the split. Initially, the thorax emerged, followed by the head. It did not wriggle but moved up and down. By 11:45 pm the head and thorax hung out and jerked once. The abdomen of the adult lay trapped in the exuviae of the larva. The legs, which were folded against the thorax, started twitching but in a folded position. The body of the adult hanging out expanded and relaxed as if 'breathing' heavily. It started an antero-posterior conspicuous 'humping' movement, trying to loosen its skin from the larval exuviae. The body of the pharate was filled with haemolymph and appeared green. The legs were still folded against the thorax but now they started moving. The first pair of legs was folded but started to jerk at the tibia-femur joint. The joint moved up and down along the neck region. The folded legs started jerking at a rate of 2-3 jerks per second. The second pair of legs unfolded (just the angle of femur and tibia increased from 10 to 40 degrees around the neck). The 1st and 2nd pairs of legs started twitching. The twitching intensity of the 1st pair of legs was much higher than the 2nd pair. The hind wing pads, which initially lay parallel to the body, now hung outwards and downwards perpendicular to the abdomen. The forewings lay parallel and close to the abdomen. The pharate turned upward, gripped the head of the exuviae and at the same time pulled out the abdominal tip from the exuviae, ending stage II of metamorphosis at 12:06 am.

Stage III (Figs 7-9). — The pharate gripped the head of the exuviae with the 1st and 2nd pair of legs. The 2nd pair gripped firmly but the 1st pair tried to get a better hold by re-gripping the head. The 3rd pair of legs hung down without touching any substrate. The abdomen and wings started to stretch. By 12:18 am, the opaque white wings were completely stretched but still stuck to each other, while the abdomen was still curved but by 12:24 am, the abdomen was completely elongated, straight and started to sclerotize. Simultaneously, the wings stretched out completely and became transparent. Pigmentation of the body started from

Table I
Pantala flavescens: the duration (minutes) of the three stages of the final metamorphosis in three observed moultings

Specimen	Stage I	Stage II	Stage III	Total
1	12	18	42	72
2	20	25	55	100
3	08	37	40	85
Average %	16%	31%	53%	100%

the thorax and the terminal tip of the abdomen (the head was already pigmented by the end of stage II). The teneral moved 2.5 inches above the exuviae. After forty minutes since turning upward, by 12:36 am, the wings became unstuck from each other, separated and now lay perpendicular to the body.

The abdomen became completely sclerotized and was coloured with its species-specific pattern. This ended stage III of metamorphosis.

The time duration of the three stages for three observed final ecdysis is illustrated in Table I.

THANATOSIS

One larva was resting on the outer surface of the bucket, we caught it and placed it horizontally on the rim so that the body was parallel to the ground. It stiffened and straightened all three pairs of legs along the side of its abdomen and dropped outside on the ground. For more than 15 seconds, it exhibited thanatosis (acted dead), then darted quickly up the side of the bucket and, after climbing up only three inches, it quickly started the process of eclosion within four minutes. It was 11:45 pm. The main survival value of this thanatosis behaviour is probably to avoid further attack by a large predator. The emerging larva of *P. flavescens* is prone to attack from land predators and it is only physical stimuli that can excite this behaviour since moulting takes place in darkness. ARAI (1987) reported that thanatosis or reflex immobilization can occur shortly before ecdysis and before emergence. It is strongly exhibited if the larva is grasped by the thorax out of water, thus responding to physical stimuli rather than visual as found in the present study. The haste to moult almost immediately after exhibiting thanatosis behaviour in *P. flavescens* should be noted as a survival instinct as found in *Hemigomphus heteroclitus*, which completed ecdysis within 10 minutes before an impending storm (TILLYARD, 1917). At 2:00 am, a completely sclerotized, motionless adult was resting on the exuviae, legs clutching the exuviae head.

Generally we find that the pharate adult, just after final ecdysis, is found a few inches above its exuviae. Since extra energy was spent before moulting (in pretending thanatosis), it may be possible that now the pharate has no energy left to move a few inches above the exuviae as noted in normal circumstances. At 6:00 am, we gently carried the bucket out; the adult flew upwards (18-20 inches) and darted away towards the East.

ANGLE OF ECDYSIS

Aeshna juncea can complete ecdysis at 0 degree (vertical) (MAITLAND, 1967) whereas *Stylurus annulatus* can be forced to emerge at 180 degrees on a mesh net. *Orthetrum albistylum speciosum* could not do so at 0 degree (INOUE, 1964). HEYMER (1972) found that a *Calopteryx* larva tried to regain its vertical position when the angle of the vertical substrate was manipulated. Inverted emergence occurs in *Xanthocnemis sinclairi* and three species of *Ischnura* (ROWE, 1987; CORBET, 1999) while horizontal emergence is common in Zygoptera and

Gomphidae. We manipulated the position of a larva ready for ecdysis from vertical to horizontal by placing it on a flat surface but the larva did not moult but always re-oriented itself in the vertical position, by darting quickly towards an erect vertical substrate. If a physical obstacle was kept in its path, it moved sideways crab-like, without changing the orientation of its body. As far as is known this is the first time that such crab-like side-ways locomotion of a mature odonate larva on land has been reported.

PHARATE TRAPPED AT STAGE II

On 11th April 2004 at 10:40 pm, one pharate adult was found hanging down from its exuviae. It tried desperately to arch upwards so as to catch the head

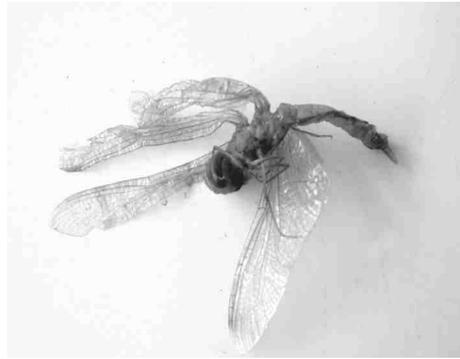


Fig. 10. *Pantala flavescens*: pharate trapped at stage II. — Note the forwardly directed wings and the uneven stretching of the wings on the left- compared to the right side.

of the exuviae and release itself, but could not succeed. It hung down, legs thrashing, but it could only turn up half-way and then fell back to its hanging position. Soon, the wings started expanding in the hanging position and 90% of the wings spread lengthwise but pointing downwards. It stayed in this position for more than 30 minutes. Then it again tried to up-right its position and, after four attempts, it caught hold of the emergent support towards the left of the exuviae but could not proceed further to regain the natural symmetrical position. It held this position with the abdominal tip still trapped in the exuviae. The wings continued stretching even while the imago was held immovable in this lopsided position. Within ten minutes, the wings hardened and were now pointing upwards. The pharate was still struggling to remove its trapped abdominal tip from the exuviae but could not succeed. Later, at 2:00 am, we found the pharate floating on the water surface with its abdomen almost stretched and tanned and with its wings pointing forward and exhibiting asymmetrical stretching. A close examination of the wings revealed that the fore- and hindwings of the right side had stretched more than the wings of the left side (Fig. 10).

DISCUSSION

EDA (1963) distinguished two types of posture during emergence, the upright type found in most Coenagrionidae, Gomphidae, Lestidae, Petaluridae, Platycne-

mididae and Pseudolestidae and the hanging type reported in Aeshnidae, Calopterygidae, Coruliidae, Epiophlebiidae, Libellulidae and sometimes in Petaluridae, and proposed that this reflected the larva's taxonomic position. In the upright type, the larva completes moulting with the angle of 0 degree between body and exuviae during stage II whereas in the hanging type as found in *P. flavescens* the angle is between 90-130 degrees. The other major difference is in the expansion of the wings, which in the upright type starts from the base whereas in the hanging type they expand uniformly.

CORBET (1999) noted that it was not easy to determine stage I and stage IV of metamorphosis in Odonata. The larvae of many species leave the water partly or wholly and intermittently, days or even weeks before emergence. They usually leave the water by climbing emergent vegetation or by walking onto the shore and, when emergence supports are few, some individuals walk up to 30 m to find an emergence support. Thus it is difficult to measure the time of stage I because it is directly dependent upon the distance and/or the presence of an available emergence support. The present paper proposes that the time period of stage I should therefore start from the time the larva finds a suitable spot for ecdysis rather than the time it leaves the water. Further it is proposed to end the process of metamorphosis in Odonata at stage III since, by the end of stage III, the individual has attained all the morphological characters of a pharate adult and

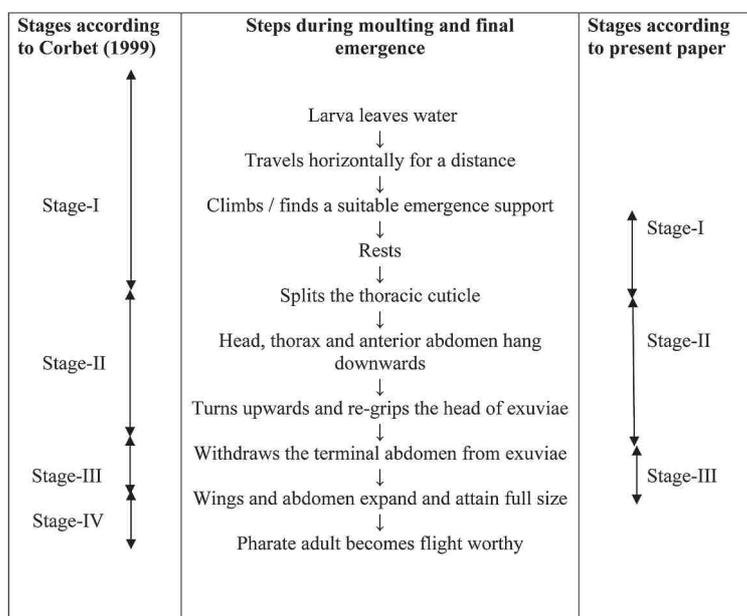


Fig. 11. Proposed stages of moulting during final emergence.

also because it is not easy to time stage IV in Odonata because various extrinsic factors like dawn, twilight, temperature and even endothermic warming control the first flight, which concludes stage IV (CORBET, 1999).

The changes proposed in the stages demarcated during the final moult of Odonata are compared and illustrated in Figure 11.

From the present observations of forwardly directed, asymmetrical stretching and spreading of the wings, it appears that gravitational force plays an important role in uniform wing expansion of dragonflies adopting the hanging type posture during emergence.

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**PHILOGENIA MARINASILVA SPEC. NOV.
FROM THE STATE OF ACRE, BRAZIL
(ZYGOPTERA: MEGAPODAGRIONIDAE)**

A.B.M. MACHADO

Departamento de Zoologia, Instituto de Ciências Biológicas,
Universidade Federal de Minas Gerais, Avenida Antonio Carlos, 6627, Caixa Postal 486,
BR 31270-901, Belo Horizonte, Minas Gerais, Brasil; – angelo@icb.ufmg.br

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The new sp. is described and illustrated from a single specimen, representing the second unquestionable *Philogenia* record from Brazil. Holotype ♂: Brazil, state of Acre, Mancio Lima, 11/15-VII-1996; deposited in author's collection. It is close to *P. schmidti*.

INTRODUCTION

Philogenia Selys, 1862 is a genus of neotropical forest zygopterans, with 35 species, most of which occur in South America. Although surrounded by countries rich in *Philogenia* species, Brazil had so far a single unquestionable record, i.e. *P. margaritae* Selys, 1862, from Tefé, Amazonas (LENCIONI, 2005). Here a new Brazilian species, *P. marinasilva* sp. n., is described from the state of Acre.

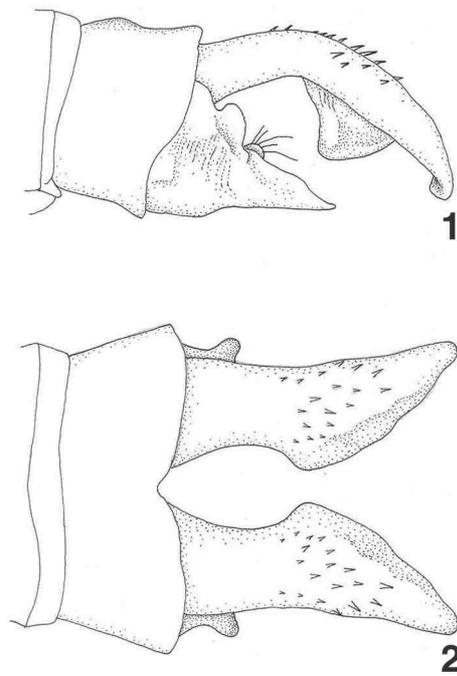
PHILOGENIA MARINASILVA SP. NOV.

Figures 1-2

Material. – **Holotype** ♂: Brazil, State of Acre, Mancio Lima (7°21'23'' S / 73°40'41'' W), Terra firma forest at the left bank of the Moa river, Dionisio leg.; 11/15-VII-1996.

Etymology. – Named in honor of senator Marina Silva, the former Minister of Environment of Brazil in recognition for her outstanding contribution to the protection of the Amazonian forest, especially that of the state of Acre.

MALE (holotype). – **Head.** – Labium brownish except for median lobe that is black. Base of mandibles, genae, labrum and anteclypeus yellow, antefrons black, upper part of head brownish with a fine transverse stripe between the eyes and a



Figs 1-2. *Philogenia marinasilva* sp. n., holotype: (1) cerci, lateral view; — (2) same, dorsal view.

Cercus in lateral view (Fig. 1) 3 times longer than S10, dorsal margin smoothly rounded, ventral margin raised until about 1/3 of its length then sloping ventrally, apex turned ventroanteriorly. Meso-ventral process large, subtriangular, projecting ventrally more than the width of cerci (Fig. 1). In dorsal view (Fig. 2) cercus divaricate with lateral margins slightly concave, medial margin strongly concave to about the proximal half, slightly convex at distal half, then tapering to the apex that is slightly directed laterad. Paraprocts in lateral view (Fig. 1) straight tapering into a fine tip, with a strong basal tubercle also visible in dorsal view (Fig. 2).

Measurements (mm). — Hw 32.7; abdomen 40.0.

DISCUSSION

Philogenia marinasilva sp. n. belongs to the *cassandra* species-group. In BICK & BICK (1988) it keys out to *P. schmidti* Ris, from which it differs in characters shown in Table I, all related to the anal appendages. A comparison with a *P. schmidti* specimen from Bolivia shows that the pleuron in the latter is much darker

postocular transverse band that are black. Rear of head pale.

T h o r a x. — Prothorax: pronotum brown, propleuron black. Pterothorax: mesepisternum brownish with middorsal carina and a narrow stripe anterior to humeral suture black. Other parts of mesopleuron yellowish with 3 black stripes at the mesepimeron, metepisternum and metepimeron, respectively. Legs yellow. Wings hyaline with an apical brown area distal to the level of pterostigma, broader on the hindwings. Pterostigma brown. Venation as described for the genus (CALVERT, 1924).

A b d o m e n. — S1 dorsally yellow, laterally black. S2 dorsolaterally black with a lateral yellow stripe, ventrally yellow. S3-7 black with a basal yellow ring, S8-10 and appendages black.

STRUCTURAL CHARACTERS. —

Hind prothoracic lobe smoothly

Table I
 Characters separating *P. marinasilva* sp. n. from *P. schmidtii*

Characters	<i>marinasilva</i>	<i>schmidtii</i>
Upper margin of cercus in lateral view	Smoothly convex	Straight with distal third concave
Apex of cercus in lateral view	Turned ventro-anteriorly	Straight
Meso-ventral process in lateral view	Projecting ventrally a distance slightly longer than width of cercus	Projecting ventrally a distance twice longer than width of cercus
Paraprocts in lateral view	Distally straight with a prominent basal tubercle	Distally slightly upcurved with no basal tubercle
Cercus in dorsal view	Outer margin concave. Apex fine, directed laterad	Outer margin convex. Apex broad directed mediad

than that in *P. marinasilva* holotype. This difference is most likely ontogenetic; as pointed out by RIS (1918), in *P. schmidtii* the thoracic colour is age-dependent. *P. marinasilva* was collected in the northern part of the state of Acre and represents the second unquestionable record of the genus in Brazil. The first record is that of two *P. margarita* Sel. males, listed by SELYS (1862).

The same author (SELYS, 1886) listed also two *P. cassandra* Sel. males from the MacLachlan collection, collected at "Haut-Amazone: Pebas; Tefé". The possible significance of the information on this label, used also in several other species studied by Selys, was discussed by MACHADO (1985). The problem is that Pebas is located in Peru and Tefé in Brazil, both on the Amazon. While the country of provenance of the single *Forcepsioneura ephippigera* (Sel.) specimen studied cannot be identified, the two countries could be represented by one each of the two *P. cassandra* specimens. RACENIS (1959) interpreted the Selysian 1886 *P. cassandra* record as an indication the species occurs in Brazil. TSUDA (2000) questioned its country provenance, whereas LENCIONI (2005) and HECKMAN (2008) do not regard *P. cassandra* as a member of the Brazilian fauna.

With only two known species, *P. margarita* and *P. marinasilva*, the Brazilian *Phylogenia* fauna is poor compared to that of Peru, Colombia, Venezuela and Bolivia – all countries with Amazonian Forest. It is reasonable to expect, therefore, that many more Brazilian congeners are still to be discovered and described, particularly so from the Amazon Forest.

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**DESCRIPTION OF THE LARVA OF
PROTONEURA ROMANAE MEURGEY
FROM THE WEST INDIES
(ZYGOPTERA: PROTONEURIDAE)**

F. MEURGEY

Muséum d'Histoire Naturelle, 12 rue Voltaire, F-44000 Nantes, France
francois.meurgey@mairie-nantes.fr

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The larva from Guadeloupe is described, illustrated for the first time, and compared to the other described larvae. Additional notes on ecology are also given.

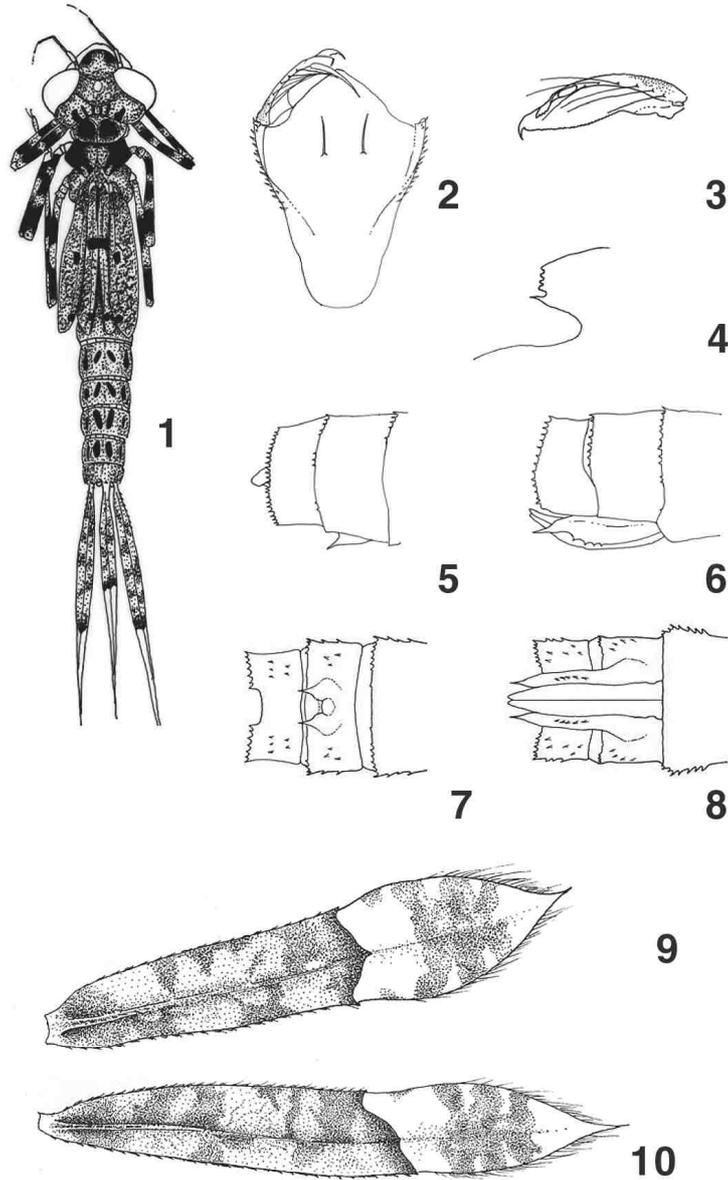
INTRODUCTION

The recently described *Protoneura romanae* Meurgey from Guadeloupe is currently restricted to Guadeloupe (French West Indies) and seems to be present on Montserrat, 70 km N of Guadeloupe (DONNELLY, 2007). As an uncommon endemic, this species is in need of further studies, notably to point out its distribution and ecological requirements. The Parc National de Guadeloupe and the Nantes Museum of Natural History financed a three weeks mission in June 2007, which allowed describing larval habitats and to determine the conservation status of *P. romanae*. In the present paper, I describe and illustrate the final larval instar of *P. romanae*, based on specimens from Guadeloupe, and give additional notes on the ecology.

***PROTONEURA ROMANAE* MEURGEY**

Figures 1-10

M a t e r i a l. – 48 last instar larvae (17 reared). GUADELOUPE: Basse-Terre, ravine Boudoute, 14-III-2007, F. Meurgey leg.; Basse-Terre, Sofaïa, rivière Sale, F. Meurgey leg. All material is deposited in the Natural History Museum of Nantes (France).



Figs 1-10. *Protoneura romanae*, last larval instar: - (1) general aspect, dorsal view; - (2) prementum, dorsal view; - (3) right palpal lobe, movable hook omitted, dorsal view; - (4) female gonapophyses, lateral view; cerci omitted; - (5, 7) male gonapophyses and cerci, lateral view; - (6, 8) female gonapophyses and cerci, lateral view; - (9) central lamella, lateral view; - (10) lateral lamella, lateral view.

DESCRIPTION. – **H e a d.** – Trapezoidal, widest at eye level, larger than prothorax (Fig. 1). Posterior lobes prominent, fringed with a row of 10-12 small, strong setae. Occipital margin strongly concave. Prementum (Fig. 2) short, trapezoidal. Prementum-mentum articulation reaching the inferior margin of procoxae. Margins sinuate with 15-20 strong setae on the distal half. Ligula prominent, strongly convex and finely serrated, unclft. Premental setae one on each side. Labial palps each with 6 setae (rarely 5), movable hook long, slender and curved, longer than palpal setae (Fig. 3). Distal margin of palp with a long sinuous medial hook and a short, almost square and four-toothed lobe (Fig. 4). Antennae seven segmented, ringed with black and white on antennomeres 2-5, third antennomere the longest.

T h o r a x. – Pronotum quadrangular with a black spot on each side. Thorax dark, marked with four whitish spots on each side. Wing pads parallel, translucent, each with a median and apical black spot. Inner wing pads reaching the end of abdominal segment 5. Legs white, each with three dark bands on femora and tibiae, 1 on each tarsal segment.

A b d o m e n. – Cylindrical, brown to yellowish, segments 1-8 with each two black lateral spots and two dorsal black spots. Lateral carina of segment 7-10 each with a row of strong spines, lateral carina of segment 6 with a row of small setae, remainder segments bare. Female gonapophyses surpassing distal end of segment 10, and outer ones denticulate (Figs 6, 8). Male gonapophyses and cerci as in Figures 5 and 7. Caudal lamellae (Figs 9, 10) lanceolate, planate except for the midrib, and terminally acute. Lateral lamellae about six times as long as wide, with a strong, S-shaped nodus ending in a small spine, located at 0.80 of its length. Dorsal carina with approximately 20-26 setae, ventral carina with approximately 40-52 setae. Central lamella about five times as long as its maximum wide; nodus located at 0.75 of its length, triangular and ending in an acute spine on each side. Dorsal carina with approximately 29-30 setae, ventral carina with approx. 31-33 setae. Basal portion of the lamellae strongly sclerotized, patterned with black transverse spots. Distal portion paler, whitish with a distinct dark XX-shaped mark.

Early stages do not present the characteristic XX black pattern on caudal lamellae.

M e a s u r e m e n t s (mm; females N = 33, males N = 12). – Total length without caudal lamellae, females and males: 9.8-10.1; – inner wing pads, females and males: 3.9-4.0; – abdomen length without caudal lamellae, females and males: 6.0-7.2; – central caudal lamellae, females and males: 4.4-4.8; – lateral caudal lamellae, females and males: 4.8-5.0.

DIAGNOSIS. – The larva of *Protoneura romanae* is close to that of *P. ailsa* Donnelly. It differs from *P. ailsa* by the following set of criteria: (1) greater size, with body length (including lamellae) comprised between 14.6 and 15.1 mm (11.3 and 12.6 in *P. ailsa*); – (2) labial palps with 6 setae (5 in *P. ailsa*); – (3) median lobe of labial palp almost square bearing four teeth (truncate and serrulated in *P. ailsa*); – (4) male gonapophyse directed downward (parallel to the 9th segment in *P. ailsa*); – (5) distal end of caudal lamellae with a distinct black XX-shaped

mark (always white and unspotted in *P. ailsa*); – (6) nodus of central lamella triangular in form (trapezoidal in *P. ailsa*).

Larvae of *P. romanae* also differ from *P. capillaris* Rambur in having 6 palpal setae (5 in *P. capillaris*), and by the shape of caudal lamellae.

ECOLOGICAL NOTES. – *Protoneura romanae* is an uncommon species in Guadeloupe, observed mainly in forested areas of Basse-Terre and in few flooded forests on the west coast of Grande-Terre. On Basse-Terre, adults can be seen flying along shaded banks of montane rivers and streams between 150 and 700 meters altitude. On Grande-Terre, a few, isolated, small populations were found in bloodwood forests (*Pterocarpus officinalis*) at sea level.

Males present a strong territorial behaviour consisting in patrolling a 2-3 m long territory with the head turned facing the streambank. Mating takes place while in flight until the tandem pair reaches a suitable oviposition site. The tandem pair skirts the banks, never more than 15 cm above the water, stopping on dead floating debris, like fallen branches, leaves, or flower petals. The oviposition begins as soon as the female chooses a good site. The male always stays on the female, beating wings constantly. Eggs are laid in floating dead leaves or small branches. This can take more than half an hour to be completed.

Larval habitat consists of calm areas of montane rivers and streams under the overhanging vegetation. The typical habitat consists of dead branches of a fast flowing mountain river or stream in rain forest, with at least one abrupt bank colonized by spikemoss (*Selaginella* sp.) or ferns. In these types of habitats, water depth exceeds one meter and the substrate is constituted by dead leaves and rocks. Larvae are found clinging on liana or other plant roots, and sometimes on the underside of leaves. Emergence takes place during the day, between 10:00 a.m. and 16:00 p.m. The larva climbs on rocks, plants or roots but always in the shadiest part of the support. The maximum height observed was 5 cm from the water level. Teneral stay a long time beside their exuviae, about one hour and then rapidly fly into the canopy.

Flooded bloodwood forest is endangered in the French West Indies, due to a high anthropogenic pressure and resulting in forest fragmentation. The low dispersal capability of *P. romanae* does not allow a good genetic exchange between distant forests, and we are now face to a high risk of extirpation of the Grande-Terre populations.

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**DIURNAL CHANGES IN MALE MATE PREFERENCE TO
FEMALE DIMORPHISM IN *ISCHNURA SENEGALENSIS*
(RAMBUR) (ZYGOPTERA: COENAGRIONIDAE)**

Y. TAKAHASHI and M. WATANABE*

Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki,
305-8572 Japan; – yuyuyuyu@ies.life.tsukuba.ac.jp

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I. senegalensis ♀♀ exhibit colour dimorphism as andromorphs and gynomorphs, to which males seem to switch their mate preference according to prior copulation experience. In the field where andromorphs were dominant, the binary choice experiments were conducted both in the early morning, which marks the onset of daily copulation activity, and in the afternoon, which marks the end of the copulation activity. During the former period, ♂♂ showed fair selectivity, while they preferred the andromorphs in the afternoon, suggesting that ♂ mate preference to each ♀ morph switched in relation to copulation experience; i.e. the mating attempts of ♂♂ were biased to the dominant ♀ morph. Mating attempts in the afternoon were considered to inhibit ♀ oviposition behaviour, resulting in a decrease of her reproductive success. Therefore, biased ♂ mate choice toward the dominant morph in the afternoon might be a selective force to maintain the ♀ colour dimorphism.

INTRODUCTION

Studies of female colour dimorphism have been reported in several odonate species (CORDERO & ANDRÉS, 1996), among which female coenagrionid damselflies appear as andromorphs, being quite bright and resembling the conspecific males, and gynomorphs, exhibiting cryptic coloration. FINCKE (2004) suggested that female colour dimorphism has evolved as a response to sexual harassment resulting from the mate-searching behaviour of males. In general, males prefer the dominant female morph in the female population, because forming a search-image of the dominant female morph might be advantageous in terms of reduced the searching time (VAN GOSSUM et al., 2001), resulting in more fre-

* Corresponding author: watanabe@kankyo.envr.tsukuba.ac.jp

quent mating attempts for the dominant female morph than for the other female morphs (MILLER & FINCKE, 1999). Such male mating attempts might hinder the dominant female morphs from foraging, and consequently reduce their egg development rate and the number of eggs laid (SVENSSON et al., 2005). Therefore, a low frequency of male harassment allows rare female morphs to forage freely and to lay more eggs. Selective male harassment of dominant female morphs consequently equilibrates the fitness of both female morphs; that is, female dimorphism seems to be balanced by a negative frequency-dependent selection (SVENSSON & ABBOTT, 2005).

MILLER & FINCKE (1999) suggested that male mate preference for a particular female morph changed with the frequency of encountering each female morph. Although the effects of sexual interactions on male mate preference have not yet been clarified (e.g. VAN GOSSUM et al., 2001), TAKAHASHI & WATANABE (2008) indicated that male mate preference for female morphs in *Ischnura senegalensis* was switched depending not on males' experience with encountering female morphs but rather on their copulation experience. Male mate preference might change with the diurnal rhythm of mating activity, because *I. senegalensis* males copulated in the morning when females showed sexual receptivity (SAWADA, 1999). However, there have been no reports on changes in male mate preference in relation to mating activity in the field. In the present study, we compared the male mate preference after mating activity with that before mating activity in the field.

MATERIAL AND METHODS

Both males and females of *I. senegalensis* stay in the grassland near water all day long. Males actively search for their mates throughout the day but do not establish any territories along the water-side. Copulation is observed in the early morning and lasts until noon, and then females alone start to oviposit on the leaves or stems of floating plants (e.g. SAWADA, 1995). Males try to mate with the females that are ovipositing in the afternoon, though few females accept the copulation. When ovipositing females encounter mate-searching males, most females escape from the males, or reject the males using a mate refusal display, i.e. hovering face-to-face, fluttering, and bending the abdomen.

Field experiments were conducted in grasslands along a pond located in Omitama-city, Ibaraki, Japan (36°15'N, 140°19'E). To estimate the frequency of each female morph in the local population, we used a line transect method. Four lines (40 m each) were set up in the grassland by the water. Each line was patrolled in the morning (10:00-11:00), during which most females stayed in the grassland. We recorded the sex, female morph and age (mature and immature) of each individual detected within 1 m to either side of the line while walking.

The binary choice experiment was conducted with the wild males perching in the grassland. Both andromorphs and gynomorphs, which were captured in the same local population, were pinned on each end of a Y-shaped stick (ca 1 m) just after being killed by carbon dioxide gas. The female pair was gently put in front of a perching male, in order to release the mating behaviour of the males. A male mating attempt directed at a female morph was judged as an indication of the male's preference. According to the diurnal activity rhythm of *I. senegalensis*, the binary choice experiment was carried out in the early morning (07:00-08:00) and afternoon (13:00-14:00), corresponding to periods before and after copulation activities in the field, respectively.

RESULTS AND DISCUSSION

Solitary males and females that perched on the tips of grass blades with intermittent flying were observed in the survey grassland in the early morning. After that, males began to search for females on the wing in the grassland, dashed to females and then the copulation began. Most of the copulation was continued through the morning, and terminated at around noon.

According to the line transect in the morning, 28 males and 27 females in total were detected along the 4 census lines. Twenty-six out of the 28 males were identified as sexually mature. There were one immature andromorph and 2 immature gynomorphs. Fourteen mature females found were copulating (8 andromorphs and 6 gynomorphs). Ten mature females were perching alone, including 8 andromorphs and 2 gynomorphs. Thus, the andromorph was the dominant morph (66.6%) in the female population, though there have been no reports on andromorph-biased populations in female dimorphic *Ischnura* species. For *I. damula* and *I. demorsa*, the frequencies of andromorphs were less than 27% and less than 42%, respectively (JOHNSON, 1975). For *I. ramburii*, 25 to 31% of females were andromorphs (ROBERTSON, 1985). Therefore, the male mate preference for female dimorphism in the *Ischnura* species has hitherto been investigated in such gynomorph-biased populations, and the males were expected to prefer gynomorphs (e.g. SIROT et al., 2003).

In the binary choice experiment in the field, each male immediately dashed to the pinned females and tried to copulate. In the early morning, males exhibited fair selectivity between female morphs (Tab. I). MILLER & FINCKE (2004) also reported that the male mate preference for female morphs of *Enallagma civile* is fair early in the day, while the males preferred the dominant female morph in the afternoon.

In the afternoon, solitary *I. senegalensis* females visited near the water to start to oviposit. Although males were still searching for females during the afternoon, females did not accept copulation, showing mate-refusal behaviour or escaping from the males. The binary choice experiment in the afternoon indicated that the males significantly chose andromorphs, which were the dominant morph in the female population (Tab. I). *E. boreale* males also preferred andromorphs

Table I
The number of males that chose each female morph in the binary choice experiment both in the early morning and the afternoon

	Andromorphs	Gynomorphs	χ^2	
Early morning	8	10	0.22	n.s.
Afternoon	15	3	8.00	P<0.01

when andromorphs outnumbered gynomorphs (FORBES, 1994), though males were usually apt to prefer gynomorphs over andromorphs, as suggested by ROBERTSON (1985). *I. senegalensis* males in the laboratory preferred the same female morph with which they had mated (Y. TAKAHASHI & M. WATANABE, 2008), suggesting that wild males that had copulated with andromorphs in the morning might be apt to prefer andromorphs in the afternoon. Consequently, male mating attempts in the afternoon might interfere with dominant female that attempts to oviposit, or might directly interrupt oviposition behaviour, probably reducing the reproductive success of dominant female morphs.

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ODONATOLOGICAL ABSTRACTS

2000

- (17800) MIYASHITA, M., 2000. Studies on the conditions of location and restoration of the habitat of the damselfly *Mortonagrion hirosei*. *Proc. annu. Meet. Envir. Syst. Res.* 28: 475-483. (Jap., with Engl. s.). – (Natn. Inst. Envir. Res., JA; postal address not stated).

The sp. occurs from the Kitakamigawa river (Miyagi pref.) to the Tsushima Isls (Nagasaki pref.), Japan. Its habitats are located from the estuary up to a distance of 40 km from the mouth of the river; 4 types were distinguished, viz.: riverside, movable dam, brackish lake, and tidewater control pond. It is suggested that fluctuations in the salinity and water level are among the most important habitat features of the sp.

- (17801) MIYASHITA, M., 2000. Studies on the method for assessment of the habitat of the damselfly *Mortonagrion hirosei*. *Proc. Jpn Soc. civil Engin.* 657: 65-73. (Jap., with Engl. s.). – (Transliteration of Author's address not provided).

The *M. hirosei* population was studied at the Tone Kamome Chashi bridge on the Tonegawa river (Japan). The changes of water level and the salinity were measured. The larvae were recorded only from a pond on a sunken place on the riverside, covered with dead reed leaves. It is suggested that the distribution pattern of this sp. can be used as an excellent tool in the environment assessment.

2001

- (17802) CZECZUGA, B. & A. GODLEWSKA, 2001. Aquatic insects as vectors of aquatic zoosporic fungi parasitic on fishes. *Acta ichthyol. piscicat.*

31(2): 87-104. (With Pol. s.). – (First Author: Dept Gen. Biol., Medical Univ. Białystok, Kilińskiego 1, PO-15-230 Białystok).

32 aquatic spp. of 6 insect orders were collected in the field (Białystok distr., Poland), killed by decapitation, then transferred into the water originating from 6 trophically different water bodies (limnokrenic spring, river, lake, pond) and the mycoflora was examined. In all, 127 zoosporic fungus spp. were found. In *Aeshna grandis*, *Anax imperator* and *Erythromma najas* larvae 32, 12 and 26 fungus spp. were identified, respectively.

- (17803) NGUYEN, V.V., D.H. HOANG, T.K.T. CAO, X.Q. NGUYEN & Y.J. BAE, 2001. Altitudinal distribution of aquatic insects from Tam Dao National Park in northern Vietnam. *In: Y.J. Bae, [Ed.], The 21st century and aquatic entomology in East Asia [Proc. 1st Symp. AESEA]*. pp. 123-133, Korean Soc. Aquat. Ent., Seoul. – (First Author & Ed.: Dept Biol., Seoul Women's Univ., Seoul 139-774, Korea).

The distribution was investigated at 9 sites (alt. 360-1000 m a.s.l.). 26 odon. gen. (no names of spp.) are listed, with the highest richness in the middle-stream reaches. *Aeschnophlebia*, *Davidius*, *Labrogomphus* and *Phaenandrogomphus* were represented in samples at the elevation of 1000 m.

- (17804) SCHMIDT, B.R. & A. AMEZQUITA, 2001. Predator-induced behavioural responses: tadpoles of the neotropical frog *Phyllomedusa tarsius* do not respond to all predators. *Herpetol. J.* 11: 9-15. – (First Author: Zool. Inst., Univ. Basel, Rheinsprung 9, CH-4051 Basel).

Using aeshnid larvae and belostomatid bugs as predators, it was tested whether an induced behav-

journal response is predator-specific and whether the strength is related to the risk of being killed by a predator. Belostomatids killed twice as many tadpoles within 24 h as aeshnids did. Tadpoles reduced their activity in the aeshnid presence by 30%, but did not respond at all to the more dangerous bugs. It is suggested that tadpoles did not respond to belostomatids because these are encountered too rarely for evolution to favour an induced response.

2002

- (17805) DE KNIJF, G., 2002. Libellen (Odonata) in de provincie Antwerpen: een belangrijke taak weggelegd voor het provinciale natuurbeleid. – [Dragonflies (Odonata) in the province of Antwerp: an important task for the provincial nature management]. *Jaarb. Antwerp. Koepel Natuurstud.* 2002: 51-63. (Dutch). – (Inst. Natuurbehoud, Kliniekstraat 25, B-1070 Brussel).
A review is presented of the odon. fauna (60 spp.) of the province based on over 15.000 records. The Antwerpse Oosterkempen is considered odonatol. the richest region of Benelux. The comparison of the 1980-1989 and 1990-2000 periods indicates the decrease of the abundance in 20 spp. (incl. 14 Red List spp.), whereas 20 sp. are stable, and mostly southern spp. show an increase. 4 spp. became extinct in the region.
- (17806) GALLARDO MAYENCO, A., 2002. Macroinvertebrados acuáticos de la red hidrográfica del Campo de Gibraltar: una revisión. *Almoraima* 27: 351-364. – (Inst. Estud. Campogibraltares, c/o Ed.: Depto de Cultura, Mancomunidad de Municipios del Campo de Gibraltar, Parque Las Acacias s/n, ES-11207 Algeciras/Cádiz).
7 odon. spp. are listed from 4 localities in Campo de Gibraltar, Spain.
- (17807) ROCHA, C.F.D., G.F. DUTRA, D. VRCIBRADIC & V.A. MENEZES, 2002. The terrestrial reptile fauna of the Abrolhos Archipelago: species list and ecological aspects. *Braz. J. Biol.* 62(2): 285-291. (With Port. s.). – (First Author: Depto Ecol., Inst. Biol., Univ. Rio de Janeiro, Rua São Francisco Xavier 524, Maracanã, BR-20550-019 Rio de Janeiro).
The odon. are listed among the diet items of the lizard, *Tropidurus torquatus*, on Abrolchos Archipelago, i.e. a group of 5 islands located ca 70 km of the southern coast of the state of Bahia, Brazil.
- (17808) STICH, M., E. STICH, W.E. HOLZINGER & C. WIESER, 2002. Zwei bemerkenswerte Libellenfunde in den Karawanken (Insecta: Odonata). *Carinthia* (II) 112: 511-516. (With Engl. s.). – (First Author: Griesgasse 62, A-9170 Ferlach).
Somatochlora arctica is for the first time recorded from Carinthia, Austria (Meerauge in Bodental). The record of *S. meridionalis* from Singerberg nr Ferlach is only the second for this sp. in the province.
- (17809) WORTHEN, W.B., 2002. The structure of larval odonate assemblages in the Enoree river basin of South Carolina. *SEast. Nat.* 1(3): 205-216. – (Biol. Dept, Furman Univ., Greenville, SC 29613, USA).
The larvae were collected at 127 sites in the Enoree river and 9 of its tributaries in the summers of 1999 and 2000. Mean odon. abundance, species richness, and Simpson's diversity were compared across tributaries and the main channel of the Enoree with one-way ANOVA. These indices were significantly lower in Brushy creek, Rocky creek and the Upper Enoree than in the other streams (Tukey multiple comparison test, $p < 0.05$). These 3 streams also differed from the others in species composition (MANOVA $p < 0.0001$), as measured by changes in the relative abundances of the 5 most abundant spp.: *Progomphus obscurus*, *Boyeria vinosa*, *Macromia illinoiensis*, *Cordulegaster maculata* and *Ophiogomphus mainensis*. For example, *O. mainensis* was nearly absent from Brushy, Rocky, and the Upper Enoree, but was a significant component of the assemblages in other streams. *C. maculata* was rare in Rocky creek but dominated the Upper Enoree where other spp. were less abundant. Brushy, Rocky, and the Upper Enoree are areas of either rapid residential development or known industrial contamination. The different structure of odon. assemblages in these streams may reflect the impact of these local anthropogenic effects.

2003

- (17810) BIRKIN, E., B. QUIN & A. JELINEK, 2003. *Hemiphlebia damselfly* / *Hemiphlebia mirabilis*. *Flora & Fauna Action Statement* 46: 1-5. – (Publishers: Dept Sustainability & Environment, 8 Nicholson St., East Melbourne, Victoria

- 3002, AU).
Its distribution and conservation status are described, and the major conservation objectives and intended management actions are listed. The respective bibliography is appended.
- (17811) CRAMPTON, W.G.R., N.R. LOVEJOY & J.S. ALBERT, 2003. *Gymnotus ucamura*: a new species of neotropical electric fish from the Peruvian Amazon (Ostariophysi: Gymnotidae), with notes on ecology and electric organ discharges. *Zootaxa* 277: 1-18. — (First Author: Fla Mus. Nat. Hist., Univ. Florida, Gainesville, FL 32611-7800, USA).
The odon. larvae are listed in a tab. showing proportional composition of food items in stomachs of the paratypes and museum specimens of the new sp.
- (17812) DYER, M.C., 2003. *Identification and distribution of various species of adult Odonata at Brookhaven National Laboratory*. Prepared in partial fulfilment of the requirements of the Office of Science, DOE Student Undergraduate Laboratory Internship (SULI) Program, Brookhaven Natn. Lab., Upton. 18 pp. — (Envir. & Waste Mngmt Serv. Div., SULI Progr., Univ. Rhode Island, Brookhaven Natn. Lab., Upton, NY 11973, USA).
A commented list of 25 spp.; — Upton, NY, USA.
- (17813) HAAS, F., D. WALOSZEK & R. HARTENBERGER, 2003. *Devonohexapodus bocksbergensis*, a new marine hexapod from the Lower Devonian Hunsrück Slates, and the origin of Atelocerata and Hexapoda. *Organisms Diversity Evolution* 3: 39-54. — (First Author: Staat. Mus. Naturk., Rosenstein 1, D-70191 Stuttgart).
The new arthropod is described from the Lower Emsian nr Bundenbach (W Germany). It is ca 75 mm long, has a small head with large compound eyes and long, filiform antennae, a 3-segm. thorax with 3 pairs of slender legs, and a post-thoracic domain composed of ca 35 limb-bearing segments of which the anteriormost are paired, stout and ventrally-oriented leglets; the 3 ultimate limb-bearing segments bear longer, posteriorly-oriented and apparently specialised appendages. The overall appearance of the animal is reminiscent of Archaeognatha or Odonata.
- (17814) JONES, C.D., 2003. [Ontario] N[atural] H[eritage] I[nformation] C[entre] participates in the National Odonata Assessment Workshop. *NHIC Newsl.* 8(1): 5-6. — (Box 182, Lakefield, ON, K0L 2H0, CA).
A brief report on the Workshop, with emphasis on the presentations from Ontario. The meeting was held in Winnipeg, and it was part of the General Status of Wild Species in Canada process.
- (17815) MUÑOZ-RIVEAUX, S., C. NARANJO-LÓPEZ, G. GARCÉS-GONZÁLEZ, D.D. GONZÁLEZ-LAZO, Y. MUSLE-CORDERO & L. RODRIGUEZ-MONTOYA, 2003. Benthonic macroinvertebrates as bioindicators of water quality. *Revta Chapingo* (Forest. & Ambiente) 9(2): 147-153. (Span., with Engl. s.). — (First Author: Centro Dessarollo Montaña., Limonar de Monte Ruz, C.P. 99500, El Salvador, Guantánamo, Cuba).
A new methodology is designed for the evaluation of water quality in lotic environments in Cuba, using freshwater macroinvertebrate tolerance to pollution. This is defined on a scale, 0-10, odon. having the following indices: Leeseide & Libellulidae: 3, Protoneuridae: 4, Coenagrionidae: 5, Aeshnidae & Gomphidae: 8, and Megapodagrionidae: 9.
- (17816) SCHWARZ-WAUBKE, M., M. SCHWARZ, F. GUSENLEITNER, J. GUSENLEITNER, M. MALICKY, H. MALICKY-RUZICKA & P. VOGTENHUBER, 2003. Insekten-Typen am Biologiezentrum Linz, 1. *Beitr. Naturk. Oberösterreich* 12: 407-450. (With Engl. s.). — (First Author: Eben 21, A-4202 Kirchschlag).
Among the 1765 types listed along with bibliographic references of the respective descriptions, there are 11 odon. types of taxa described by G. Theischinger (some with joint authors).
- (17817) WUST, E., 2003. Die Libellen des Frastanzer Riedes (Insecta: Odonata) (Vorarlberg, Österreich). *Vorarlberg. Naturschau* 13: 195-210. (With Engl. s.). — (Elserweg 3a, A-6714 Nüziders).
The odon. fauna of the Frastanzer Ried (Vorarlberg, W Austria) was surveyed in 1994 (19 spp., 11 autochthonous; OA 13857) and 2000-2002 (18 spp., 8 autochthonous). In all., 23 spp. were recorded. The differences between the inventories of the 2 surveys are discussed and habitat protecting measures are advocated.

2004

- (17818) BOELTER, R.A., 2004. *Predation of native anurans by bullfrogs (Rana catesbeiana: Ranidae) in the South of Brazil*. Diss. Mestrado, Univ. Fed. Santa Maria, Santa Maria, RS. 36 pp. (Port.; main text Engl., with S. Zanini Cechin as joint Author). – (Curso Mestrado Biodiv. Animal, Univ. Fed. Santa Maria, BR-97105-900 Santa Maria, RS). Among the prey types in the *R. catesbeiana* diet, the anurans are most important (over 40% of the Index of Relative Importance), while (among 20 prey types) the odon. occupy the 5th place, with IRI over 7%. The field work was conducted in the Agudo-Nova Palma area, Rio Grande do Sul (Brazil).
- (17819) CLAUSNITZER, V., 2004. Ecology and biogeography of the dendrolimnetic *Coryphagrion grandis* (Odonata). In: S.-W. Breckle, B. Schweizer & A. Fangmeier, [Eds], *Results of worldwide ecological studies*, pp. 243-256, Heimbach, Stuttgart. – (Gräfestr. 17, D-06110 Halle).
A study on the ecology of this sp. was undertaken in coastal forests of E Africa. The results are compared with other odon. spp., known to breed in phytotelmata. The ecological and additional morphological and genetic results of this study show, that the monotypic *C. grandis*, which was placed for convenience within the Megapodagrionidae, belongs to the otherwise S and Central American Pseudostigmatidae. Although the separation from the neotropical Pseudostigmatidae occurred at least 100 million yr ago, the morphology and biology of *C. grandis* are still very similar to the former. These findings support biogeographical considerations about historical forest distribution in Africa, stability of E African coastal forests and the species loss due to extinctions in W and Central Africa. Since the future of *C. grandis* depends on the survival of the last coastal and lower Eastern Arc forests in E Africa, a short conservation chapter is added.
- (17820) DICKE, M., 2004. From Venice to Fabre: insects in western art. *Proc. Neth. ent. Soc.* 15: 9-14. – (Lab. Ent., Univ. Wageningen, P.O. Box 8031, NL-6700 EH Wageningen).
The representation of insects in the works on display was recorded in 180 art museums in Europe and the US. Insects are depicted in 3045 works (14th century to present), odon. are represented in close to 400 pieces of art.
- (17821) GAWROŃSKI, A., 2004. New localities of dwarf dragonfly *Nehalennia speciosa* (Odonata: Coenagrionidae) in northern Poland. *Przegl. Przyr.* 15(1/2): 126-127. (Pol., with Engl. s.). – (Author's address not stated).
The sp. is reported from 2 localities, viz.: nr Bytow and nr Chojnice (at both sites in *Carex limosa* vegetation).
- (17822) GILBERT, R., 2004. The disjunctive dragonfly: a study of disjunctive method and definitions in contemporary English-language haiku. *Stud. Engl.-Language & Lit.* 47: 1-18. – (Kumamoto Univ., Kumamoto, JA).
The J. Kacian's haiku, */ my fingerprints / on the dragonfly / in amber /*, which won Third-Place in the 2003 Kusamakura International Haiku Contest, is considered in great detail. It contains a selection of elements based on an inward poetic aesthetic. In terms of images alone, it is a fine microcosmic *shasei*, but it goes beyond *shasei* and realism, utilizing 4 modes of disjunction, termed here, “perceptual disjunction”, “misreading as meaning”, “disjunction of semantic expectation” and “linguistic oxymoron”. Apparently it has no *kireji* or clearly defined “traditional” juxtaposition of images. In its form, the haiku is strikingly similar to a simple declarative sentence. Here, it is analytically explained what makes this short declaration an excellent haiku.
- (17823) HAHN VON HESSBERG, C.M. & A. GRAJALES QUINTERO, 2004. Importancia del orden Odonata para la producción de peces en ambientes controlados. *Revta electr. Ingeniería Produc. acuícola* 1(1): 1-12 [ISSN 1909-8138]. – (Depto Sist. Produccion, Programa Medicina Veterinaria & Zootecnia, Fac. Cien. Agropecuarias, Univ. Nariño, San Juan de Pasto, Colombia).
A calculation is presented of the financial losses caused by *Pantala flavescens* larvae in the *Oreochromis niloticus* pisciculture in Colombia, but it is not clear whether the US or the Colombian currency is used.
- (17824) HAYA, V., 2004. Libélulas, luciérnagas y mariposas: 39 haikús japoneses. *Estud. Asia Africa* 39(3): 711-723. – (Author's address not stated).
13 haiku on dragonflies, fireflies and butterflies, by Japanese poets (17th-20th cent.), in original,

- transliteration and Spanish translation. In the introductory section (pp. 711-716), this poetry style is explained.
- (17825) PLASKA, W., 2004. The influence of predators on the forming of species diversity of zoopluston of some water ecosystems of the Lezna-Vłodawa Lakeland. *Teka Kom. Ochr. Kszt. Środ. Przynr.* 1: 180-183. (With Pol. s.). – (Katedra Hydrobiol. & Ichtiobiol., Akademia Rolnicza, Akademicka 13, PO-20-950 Lublin).
By counting the occurrence of zooplustonic (associated with water surface) spp. of Collembola, Coleoptera, Diptera and Heteroptera and the co-occurring predator spp. (Odon., fish) in the littoral samples from 2 lakes and 2 retention reservoirs it is concluded that the high pressure of predators goes along with the zoopluston species diversity. The names of the spp. are not provided.
- (17826) SAMWALD, O., 2004. Die Libellenfauna eines rückgebauten Bachlaufes bei Rudersdorf im südlichen Burgenland, Österreich (Odonata). *Joannea zool.* 6: 247-256. (With Engl.s.). – (Überbachgasse 51c/6, A-8280 Fürstenfeld).
24 spp. are recorded from a 750 m restored stretch of the Lahn, nr Rudersdorf, Burgenland, Austria.
- (17827) TORRALBA-BURIAL, A. & F.J. OCHARAN, 2004. Presencia y comportamiento invernal de adultos de *Sympetrum striolatum* en el NE de España (Odonata: Libellulidae). *Boln Asoc. esp. Ent.* 28(3/4): 189-191. – (Depto Biol. Organ. y Sistemas, Univ. Oviedo, ES-33071 Oviedo).
At Hoya de Huesca (Bandalíes, NE Spain) adult *S. striolatum* ♂♂ were observed in numbers on wing on 26 & 29 Dec., 13 & 21 Jan. and 2 Feb. 2001/2002 (medium air temp. range 5.5-7.0°C). They were territorial and defended the territories, though there were no ♀♀. The phenomenon of winter survival in this sp. is possibly due to the recent climate change. No other odon. spp. were seen at the locality.
- (17828) VAN BUSKIRK, J., J. ASCHWANDEN, I. BUCKELMÜLLER, S. REOLON & S. RÜTTIMAN, 2004. Bold tail coloration protects tadpoles from dragonfly strikes. *Copeia* 2004(3): 599-602. – (First Author: Dept Zool., Melbourne Univ., Victoria-3010, AU).
Some amphibian larvae develop brightly coloured or black tail fins when reared in ponds with predaceous insects. The conspicuous tail has been proposed to lure predator strikes toward the tail and away from the more vulnerable head/body region. This hypothesis was tested by presenting to *Aeshna* larvae model tadpoles that differed only in colouration. The models had either a dark body and pale tail, a dark spot in the middle of the tail, or a dark spot near the tip of the tail. Almost all models with plain tails were struck on the head/body, whereas those with dark spots in the tail were struck significantly more often on the tail. Because living tadpoles survive better when attacked on the tail than on the head, the results show that tail colouration can protect tadpoles from predators at close range.
- (17829) VIDAL-ABARCA, M.R., R. GÓMEZ & M.L. SUÁREZ, 2004. Los rios de las regions semiáridas. *Ecosistemas* 13(1): 16-28. – (Depto Ecol. & Hidrol., Fac. Biol., Univ. Murcia, Campus de Espinardo, ES-30100 Murcia).
A concise synthesis of the known information on morphology, hydrology and ecology of the rivers in the semiarid zone of SE Spain. The odon. are adapted to the habitat peculiarities by their active dispersal. The legal status of *Coenagrion mercuriale* is mentioned.
- (17830) WALKER, I., 2004. The benthic insect fauna of the blackwater forest stream Rio Tarumã-Mirim (Manaus, Amazonas): patterns of population dynamics and their implications for ecosystem stability. *Amazoniana* 17(3/4): 471-480. (With Port. s.). – (INPA, Caixa Postal 478, BR-690.11-970 Manaus, AM).
Only 6 emerged individuals of 2 odon. spp. (Zygoptera, names not stated) were recovered from 351 traps set for 24 h in an area of less than 90 m², while in the work listed in OA 14010 the occurrence of the adults of 31 spp. is documented for this river; – Brazil.

2005

- (17831) GARCIA RUIZ, A., 2005. Importancia de las lagunas temporales para la conservación de la biodiversidad de artrópodos edáficos en zonas agrícolas de Castilla-La Mancha. *Limnetica* 24(1/2): 83-90. (With Engl. s.). – (Depto Didácticas Específicas, Fac. Formación Profesorado & Educación, Univ. Auton. Madrid, ES-28049 Madrid).

The relative abundance and frequency of Odon. in 2 temporary lagoons are (orderwise) stated; – Ciudad Real prov., Spain.

- (17832) GYSSELS, F.G.M. & R. STOKS, 2005. Threat-sensitive responses to predator attack in a damselfly. *Ethology* 111: 411-423. – (Lab. Aquat. Ecol., Univ. Leuven, Bériotstraat 32, B-3000 Leuven).
The threat sensitivity hypothesis predicts that prey species assess and adjust their behaviour flexibly in accordance with the magnitude of the threat imposed by a predator. Here, this hypothesis was tested with regard to escape behaviour and thanatosis (feigning of death to escape predation) in *Ischnura elegans* larvae. The perceived predation threat of the larvae was manipulated by changing 3 factors: lamellae autotomy (an escape strategy where animals sacrifice a body part when grasped by a predator; lamellae present or absent), kairomone type (odours released by predators; control, dragonfly kairomones or fish kairomones), and population of origin (fishpond or fishless pond). It is demonstrated that thanatosis increased survival both when confronted with dragonfly and fish predators. It is shown, for the first time, costs of past autotomy to be predator-dependent: larvae without lamellae suffered higher predation mortality but only in the presence of a dragonfly predator and not in the presence of a fish predator. This is in accordance with the observed reduced escape speed of larvae after autotomy, which may affect escape probability toward dragonfly predators but not to the very fast fish predators. Unexpectedly, kairomone type did not affect the escape response of the larvae. In accordance with the threat sensitivity hypothesis, after an unsuccessful attack, larvae without lamellae had a higher frequency to enter thanatosis than larvae with lamellae and larvae from the fishpond showed longer thanatosis durations than larvae from the fishless pond. Consistent with the hypothesis, the reaction of the larvae to a simulated attack depended jointly on lamellae status and population. In fishless ponds, larvae with lamellae swam away more frequently than larvae without lamellae; in fishponds both groups almost never swam away and relied mostly upon immobility. Given the obvious benefits of adaptively varying escape responses, it is hypothesized, this threat sensitivity to be widespread. It is argued that former inconsistencies between studies with regard to escape behaviour may have been partly because of such adaptive variation.
- (17833) KAWAKAMI, Y., K. ICHISAWA & K. WATANABE, 2005. A list of the insect collection of Mt Daisen Museum of Nature and History, Tottori, Japan. *Bull. Tottori pref. Mus.* 42: 21-27. (Jap., with Engl. title). – (Tottori Prefectural Mus., Higashimachi 2-124, Tottori, 680-0011, JA).
Includes a list of 19 odon. spp.
- (17834) NICOARA, A., M. NICOARA & F. BIANCHINI, 2005. Diet composition during breeding period in populations of *Bufo viridis*, *Pelobates fuscus* and *Rana esculenta* complex from Ciric river's basin (Iași, Romania). *Anal. știint. Univ. Al. I. Cuza* (Biol. anim.) 51: 179-187. – (Authors' postal addresses not stated).
P. fuscus is the sole of the 3 frog spp. that feeds on odon. during its breeding season in the Iași area. In its stomach contents they represent 3% of the food items.
- (17835) NIEHUIS, M., 2005. Schlupfnachweise zweier bemerkenswerter Libellenarten (*Aeshna affinis* und *Gomphus vulgatissimus*) im Süden von Rheinland-Pfalz (Odonata: Aeshnidae, Gomphidae). *Fauna Flora Rheinland-Pfalz* 10: 1125-1130. – (Abt. Biol., Inst. Naturwiss, Univ. Koblenz, Fortstr. 7, D-76829 Landau).
From Rhineland-Palatinate (Germany) are reported *A. affinis* (teneral adult & 3 exuviae: Jockgrim, Germersheim distr., 15 & 23-VI-2005 and *G. vulgatissimus* (teneral adults: Berg/Neue Lauter, 2 & 4-V-2005; Odenbach/Glan, 12-V-2005).
- (17836) SRINIVASULU, B. & C. SRINIVASULU, 2005. Diet of the Black-bearded tomb bat *Taphozous melanopogon* Temminck, 1841 (Chiroptera: Emballonuridae) in India. *Zoo Print J.* 29(8): 1935-1938. – (First Author: Wildl. Biol. Sect., Dept Zool., Osmania Univ., Hyderabad, Andhra Pradesh-500007, India).
The forest bats roosting at Borra caves (Ananthagiri Hills, Andhra Pradesh) and the semi-urban bats mist netted in Ranga Reddy distr. (Andhra Pradesh) were studied. The dietary composition was analyzed from faecal pellets. In the forest the percentage volume (percentage frequency) of Odon. in the diet amounted to 3.66 (33.33), while in the semi-urban individuals these values were 3.7 (76.66). 30 specimens from each habitat type were examined.

- (17837) STOLEN, E.D., 2005. Great egrets gleaning dragonflies. *Fla Fld Naturalist* 33(1): 15-16. – (Dynamac Corp., Mail Code: DYN-2, Kennedy Space Cent., FL 32899 USA).
Although mainly piscivorous, the Great egret (*Ardea alba*) takes a variety of food items incl. dragonflies. In the latter case, its foraging strategy is gleaning, which is described here from a locality in Florida, USA. Thus, the bird's search for dragonflies appears systematical rather than incidental and opportunistic captures during foraging for other prey.
- 2006**
- (17838) CRAVES, J.A., 2006. *Archilestes grandis* (Rambur) (Odonata: Lestidae): new for Michigan. *Gt Lakes Ent.* 39(1/2): 88-90. – (15911 Andover Dr., Dearborn, MI 48120, USA).
In 2005, a population was found in Wayne co., Michigan, USA. The habitat is briefly described.
- (17839) CRAVES, J.A., 2006. First Michigan specimens of *Libellula virbrans* Fabricius (Odonata: Libellulidae). *Gt Lakes Ent.* 39(1/2): 91-93. – (15911 Andover Dr., Dearborn, MI 48120, USA).
In 2005, 2 small populations were found in Wayne co., Michigan, USA. The habitats are described.
- (17840) GONZÁLEZ DE CASTRO, I., 2006. *Estudio del mantenimiento del polimorfismo en larvas de Ischnura graellsii Rambur, 1842 (Odonata: Coenagrionidae)*. Tesis de Licenciatura, Univ. Vigo, Pontevedra. 66 pp. – (c/o Prof. A. Cordero, Depto Ecol. & Biol. Animal, Univ. Vigo, EUET Forestal, Campus Universitario, ES-36005 Pontevedra).
An attempt is made to ascertain whether in *I. graellsii* polymorphism also occurs in the larval stage. Although polymorphism in this sp. has an effect on larval biometrics, a further study is required to clarify the question.
- (17841) GUTIERREZ MORENO, L.C., R.A. BORJAS, M.I. MORENO, M. ALTAMIRANDA & M. LOBO, 2006. *Odonatos. Sistema de areas protegidas del departamento de Atlántico*. Grupo de investigación en biodiversidad del Caribe Colombiano, Fac. Cien. Basicas, Univ. Atlantico, Barranquilla. vi+43 pp., 3 pls excl.
A comprehensive treatment of the fauna (51 morphosp., i.e. listed mostly on the genus level) of the Atlántico distr., Colombia.
- (17842) HAAS, F., 2006. Evidence from folding and functional lines of wings on inter-ordinal relationships in Pterygota. *Arthr. Syst. Phyl.* 64(2): 149-158. – (Staat. Mus. Naturk., Rosenstein 1, D-70191 Stuttgart).
The odon. wings are not folding; the paper includes a few passing references to the order.
- (17843) INBERGA-PETROVSKA, S. [Sarmite Inberga-Petrovska (?)], 2006. Spāru daudzveidība. *Sabiedriskā monitrināga rokasgrāmata*, pp. B33-B57. (Latvian). [In the copy of the chapter bibliographic data unclear and incomplete]. – (Author's address not provided).
The odon. chapter in a handbook for monitoring and species recording in Latvia, with a list of 62 spp., registration forms and a pictorial key for identification of the adults.
- (17844) JONIAK, T. & P. DOMEK, 2006. Influence of humification on biodiversity of lake benthic macroinvertebrates. *Acta agrophysica* 7(2): 363-368. (With Pol. s.). – (Dept Water Prot., A. Mickiewicz Univ., Drzymaly 24, PO-60 613 Poznan).
The taxonomic composition and abundance of macrozoobenthos in 3 small, humic, postglacial mid-forest lakes in the Drawieński National Park (Poland), each undergoing different stages in the process of humification, are presented. 6 odon. spp. were recorded, most of them from a mesohumic lake.
- (17845) JOOP, G., M.T. SIVA-JOTHY & J. ROLFF, 2006. Female colour polymorphism: gender and the eye of the beholder in damselflies. *Evol. Ecol.* 20: 259-270. – (Third Author: Dept Anim. & Plant Sci., Univ. Sheffield, Western Bank, Sheffield, S10 2TN, UK).
Zygoptera provide a classic example of ♀ colour polymorphism. Usually, one ♀ morph resembles the blue ♂ colour (andromorph) while one, or more, ♀ morphs are seen as typically ♀ (gynomorph). Zygoptera fall in 2 distinct groups with respect to recent developments in mimicry theory: in some spp. ♀♀ are perfect, they match ♂ colouration and black patterning, and in other spp. they are supposed to be imperfect mimics, only matching ♂ colouration. However, the underlying assumption of one ♀ morph looking ♂-like is mostly based on human vision. Therefore the black patterning and colour of the 3 ♀ morphs were investigated here in

Coenagrion puella, an imperfect mimic, using image analysis. In *C. puella* the blue ♀ morph is perceived as ♂-like. It was found that the black patterning of such ♀♀ cannot be distinguished from the other ♀ morphs, and is clearly different from ♂♂. Furthermore, the blue colour of andromorph ♀♀ differs from the blue colour of ♂♂. Intriguingly, however, the red content did not differ between blue ♂♂ and ♀♀.

- (17846) LUQUE PINO, P. & A. SERRA SORRIBES, 2006. *Macromia splendens* and *Gomphus graslinii*, two new species of Odonata for Catalonia. *Butll Inst. cat. Hist. nat.* 74: 113-116. (Catalonian, with Engl. title). – (First Author: Museu Comarcal de Montsià, ES-43870 Amposta).

The breeding of the 2 spp. in Catalonia (Spain) is confirmed, and they are reported from various localities.

- (17847) ŠÁCHA, D., 2006. New data on dragonflies (Odonata) in the Poprad region. *Folia faun. slovac* 11(9): 49-54. (Slovak, with Engl. s.). – (Podtatranského 31, SK-03101 Liptovský Mikuláš).

The records are presented of 31 spp. from 10 localities; – Slovakia.

- (17848) SCHULTZ, H., G. JANECEK, M. HESS, H. REUSCH & W. GRAF, 2006. Das Makrozoobenthos des Natura 2000-Gebietes St. Lorenzener Hochmoor (Andertal, Kärnten) unter besonderer Berücksichtigung der Libellenfauna (Insecta: Odonata). *Carinthia* (II) 116: 343-358. (With Engl. s.). – (First Author: Theodor-Kramer-Str. 12/1/14, A-1220 Wien).

9 odon. spp. are reported from Lorenzener Rised Bog in Andertal, Carinthia (Austria). The occurrence of *Leucorrhinia pectoralis* is of particular interest.

2007

- (17849) BELENKOVA, N.I., M.M. DJURTUBAEV & Yu. M. DJURTUBAEV, 2007. The Danube lakes dragonfly larvae (Odonata). *Visn. odes'. nac. Univ.* 12(5): 159-166. (Russ., with Engl. & Ukr. s's). – (Dept Hydrobiol. & Gen. Ecol., Odessa Natn. Univ., Dvoryanskaya 2, UKR-65058 Odessa).

The larvae of 16 sp. were represented in samples taken at 45 stations from 5 lakes (Yalpug, Kugurluy, Kotlabuh, Kagul and Kitay) in the Danubian plain

(Odessa district, the Ukraine). The information on the distribution of the spp. and data on their abundance and biomass are presented.

- (17850) BERNOTIENĖ, R. & G. VIŠINSKIENĖ, 2007. The diversity of benthic invertebrates in three rivers in Lithuania. *Acta biol. Univ. daugavpil* 7(2): 87-96. – (Inst. Ecol., Vilnius Univ., Akademijos 2, LT-08412 Vilnius).

The peculiarities of the fauna and the abundance and biomass of aquatic invertebrates were examined in 3 rivers located in different regions of Lithuania, viz. the Dubysa, the Merkys and the Šventoji. 6 odon. spp. were recorded (Dubysa 5, Merkys 4, Šventoji 3); *Ophiogomphus cecilia* was common in all investigated rivers. A species list is not provided.

- (17851) DA SILVA BERNARDO, C.T., 2007. *Seleção intra-sexual na libélula Homeoura nepos (Zygoptera: Coenagrionidae): conflito sexual e sistema de acasalamento*. Diss. Mestre em Ecologia, Depto Ecol., Inst. Ciên. Biol., Univ. Brasília. v + 54 pp. (Port., with Engl. s.). – (Author's address not stated).

Sexual dimorphism, agonistic interactions and the type of association between ♂♂ and their sexual partners are characteristics subjected to selective pressures that determine the type of mating system of a sp. In Odon., 2 types of mating system occur: resource defence polygyny and polygyny through scramble competition. In the latter type, there is no consensus concerning the role of sexual dimorphism, the influence of individual size in agonistic interactions and the type of selective pressures that influence the occurrence of tandem (post copulation guarding). Here, *H. nepos* is used as the model sp. to analyze: (1) type of sexual dimorphism; – (2) effect of environmental temperature, body size and local density of ♂♂, ♂ distance to the shore, and residency upon agonistic interactions; – (3) influence of ♂ and ♀ density at the oviposition site, and the effects of environmental temperature and wind upon tandem duration and upon oviposition events that occur during tandem; – and (4) the effect of ♂ body size on tandem duration. In the sp. analyzed, ♀♀ had longer wings than ♂♂, ♂ density at the sites where interactions occurred influenced agonistic encounters and resident ♂♂ won more fights, supporting the hypothesis of asymmetric contest. Tandem duration was longer when other ♀♀ were

- abundant in the immediate area and there was also a positive tendency between tandem duration and temperature, which suggests that environmental temperature can contribute to δ permanence in tandem. Oviposition events were more abundant in sites with higher δ density. The wind had no effect on the behaviours evaluated. It is assumed that *H. nepos* presents scramble competition polygyny. Nevertheless, some predictions of this hypothesis concerning post copulatory association were not met, indicating the necessity of more studies on the behaviour of tropical Zygoptera.
- (17852) DUFFY, A., 2007. *Genetic structuring among naturally isolated dune lake populations: a microcosm of evolutionary processes on oceanic islands*. PhD thesis, Queensland Univ Technol. xiii+121 pp. The study was conducted on the perched dune lakes of Fraser Island, Australia. Chapter 5 is titled: "Dispersal among lacustrine habitats in the libellulid dragonfly *Orthetrum boumiera*" (pp. 67-81). 192 individuals were sampled across 6 lakes (surface 2.3-12.2 ha), regions of the mitochondrial genome were targeted and molecular screening methods developed and employed to assess the relative levels of post-colonisation gene flow among lake populations.
- (17853) DYATLOVA, E.S., 2007. Phenology of dragonflies (Insecta: Odonata) in the south-western Ukraine. *Visn. odes'.nac. Univ.* 12(5): 167-176. (Ukr., with Engl. & Russ. s's). — (Dept Zool., Odessa Natn. Univ., Dvoryanskaya 2, UKR-65026 Odessa).
- According to the period they are on the wing, 38 spp. of the SW Ukrainian fauna are divided into 6 groups, viz.: the summer, summer-autumnal, spring, spring-summer-autumnal, spring-summer, and the group of spp. hibernating at the adult stage. Most of the spp. are simultaneously on the wing in the second half of June.
- (17854) FOUMEAU, J. & J. LAMBRECHTS, [Eds], 2007(?) [no date]. *Gemeenten adopteren Limburgse soorten, Actieplan Variabele waterjuffer, gemeente Ham*. — [Municipalities adopt species of (Belgian) Limburg. Action plan *Coenagrion pulchellum*, municipality Ham]. Provincie Limburg, Hasselt. 107 pp. ISBN none. (Dutch). — Provincie Limburg, Universiteitslaan 1, B-3500 Hasselt).
With the objective to provide for the regionally rare or threatened spp. a new chance, the provincial government of Limburg (Belgium) developed the initiative, called "Limburgse soorten", i.e. a kind of a "foster-parents-plan" for the municipalities to adopt one of such spp. So far, 44 municipalities adopted as many locally rare or endangered plant and animal taxa. — See also OA 17860.
- (17855) HAYASHI, M., K. YAMAGUCHI, H. NAKANO, S. TERAOKA & T. KOSHIKAWA, 2007. Records of freshwater invertebrates and vertebrates of irrigation canal in Izumo-heiya, Shimane prefecture, Japan. *Bull. Hoshizaki Green Found.* 10: 1-18. (Jap., with Engl. s.). — (Hoshizaki Green Foundation, Okinoshima 1659-5, Sono, Izumo Shimane, 691-0076, JA).
19 odon. spp. are listed from 16 sampling sites on the canal and the retention reservoir.
- (17856) HAYS, J.J., R.E. CLOPTON, T.J. COOK & J.L. COOK, 2007. Revision of the genus *Nubenocephalus* and description of *Nubenocephalus secundus* n. sp. (Apicomplexa: Actinocephalidae) parasitizing adults of *Argia sedula* (Odonata: Zygoptera: Coenagrionidae) in the Primitive Texas Big Thicket, U.S.A. *Comp. Parasitol.* 74(2): 286-293. — (Third Author: Dept Biol. Sci., Sam Houston St. Univ., Huntsville, TX 77341, USA).
The new gregarine sp. is described from *A. sedula* specimens collected from Harmon Creek, Walker co., Texas.
- (17857) IRUSTA, J.B., 2007. *Ecologia comportamental reproductiva de Diastatops obscura Fabricius (Insecta, Odonata)*. Tese Doutor em Psicobiologia, Univ. Fed. Rio Grande do Norte, Natal/RN. 99 pp. (Port., with Engl. s.). Includes also the reproduction of Author's paper (2006) from *Odonatologica* 35: 289-295, and the reproductions of 2 Author's papers (2007) from *J. Insect Sci.* 7 (no pagination) that were at the time of the defence of dissertation still in the press). — (Sector Psychobiology, Dept Physiol., Univ. Fed. Rio Grande do Norte, C.P. 1511, BR-59072-970 Campus Universitário, Natal/RN).
The field work was conducted at the middle stretch of the Pitimbo river (Parnamirim, Rio Grande do Norte, Brazil) during 2002-2004. The description of δ and ♀ strategies are provided with special reference to intra- δ competition for territories and ♀ ♀ , ♀ mate selection, and to the importance of δ

- body size and other secondary characters for their reproductive success. *D. obscura* ♀♀ participate in mate selection by rejecting the non-territorial ♂♂ or substituting their sperm by that of the individuals of a higher status.
- (17858) JESCHKE, J.M. & R. TOLLRIAN, 2007. Prey swarming: which predators become confused and why? *Anim. Behav.* 74: 387-393. – (First Author: Dept Biol. II, Sect. Evol. Ecol. Ludwig-Maximilians Univ., Grosshaderner Str. 2, D-82152 Planegg-Martinsried).
When confronted with a swarm of their prey, many predators become confused and are less successful in their attacks. Despite the general notion that the confusion effect is a major reason for prey swarm formation, it is largely unknown how widespread it is and which predator or prey traits facilitate or impede it. Here, experiments were carried out with odon. larvae / *Daphnia magna*, at various prey densities. In *Aeshna cyanea* a prey swarm triggered a confusion effect (empirical observation in *A. juncea* were similar), whereas in *Libellula depressa* there was no negative correlation between attack efficiency and prey density, though occasionally some of the swarming *Daphnia* were killed but not consumed.
- (17859) JOHN, H., A. GÜNTHER, R. REISSMANN, D. TOLKE & H. HEILMEIER, 2007. Bedeutung und Schutz des FFH-Lebensraumtyps „Fließgewässer mit Unterwasservegetation“ im Gebiet der oberen Freiburger Mulde. *Mitt. Naturschutzinst. Freiberg*. – (First Author: AG Biol./Ökol., Inst. Biowiss., TU Bergakademie Freiberg, Leipzigerstr. 29, D-09599 Freiberg).
In the Freiburger Mulde, situated between Chemnitz and Dresden (Germany), *Calopteryx splendens*, *C. virgo*, *Platycnemis pennipes* and *Pyrrhosoma nymphula* directly use the habitats of submersed vegetation, while the latter is (where sparse) indirectly advantageous also to *Ophiogomphus cecilia*.
- (17860) PEUSENS, E. & J. LAMBRECHTS, [Eds], 2007 (?) [no date]. *Gemeenten adopteren Limburgse soorten. Actieplan Bosbeekjuffer, gemeente Maaseik*. – [*Municipalities adopt species of (Belgian) Limburg. Action plan Calopteryx virgo, municipality Maaseik*]. Provincie Limburg, Hasselt. 105 pp. ISBN none. (Dutch). – (Provincie Limburg, Universiteitslaan 1, B-3500 Hasselt).
See also OA 17854.
- (17861) PORT STEPHENS FISHERIES CENTRE, 2007. Threatened species in NSW: Sydney Hawk dragonfly, *Austrocordulia leonardi*. *NSW DPI Primefacts* 184: 1-3. – (Locked Bag 1, Nelson Bay, NSW 2315, AU).
The known distribution, habitat and ecology of the sp. are summarized, the threatening circumstances are outlined and protective measures are suggested; – New South Wales, Australia.
- (17862) SCHNEIDER, D., 2007. Damselflies and dragonflies are the insect “birds of prey”. *Lotus / Newsl. Norfolk Fld Naturalists* 2007(Oct.): 2. – (Norfolk Field Naturalists, P.O. Box 995, Simcoe, ON, N3Y 5B3, CA).
The text of a talk at the Annual General Meeting of the society, including the dragonfly poem of Alfred, Lord Tennyson (1833).
- (17863) SCHORR, M., 2007. Vorläufige Bibliographie der Veröffentlichungen zu den Libellen (Insecta: Odonata) in Deutschland mit Registern zu den Bundesländern und Arten. (Arbeitsstand: 02. Februar 2007). *Dragonfly Res.* 4: 1-246. (With Engl. s.). – (Schulstr. 7/B, D-54314 Zerf).
A bibliography of 3624 works related to the odon. fauna of Germany, crossreferenced to the federal states and species.
- (17864) UEMA, Y. & T. SAGAWA, 2007. A preliminary report on Odonata and such like faunas of Hangando Moor in Mt Hakusan. *Bull. Hakusan Nature Conserv. Cent.* 34: 31-33. (Jap., with Engl. title). – (Hakusan Nature Conserv. Cent., Ishikawa, JA).
6 odon. spp. are listed.

2008

- (17865) BECHLY, G. & W. WICHARD, 2008. Damselfly and dragonfly nymphs in Eocene Baltic amber (Insecta: Odonata), with aspects of their palaeobiology. *Palaeodiversity* 1: 37-73, pls 1-9 incl. (With Germ. s.). – (First Author: Staat. Mus. Naturk., Rosenstein 1, D-70191 Stuttgart).
All 7 previously known Zygoptera larvae from Baltic amber are revised and 8 new specimens are described but not named. Some of these can be attributed to the extant family-group taxa Calopterygidae: Calopteryginae, Hypolestidae: Hypolestini, Megapodagrionidae: Argiolestinae, Synlestidae,

and Lestida (= Lestinoidea sensu Fraser 1957), while others can only be attributed to different unidentified spp. of the paraphyletic "megapoda-grionid" grade. A further new specimen is a rather strange larva, which seems to represent the first genuine Anisoptera larva in amber (probably Aeshnidae). Various taphonomic, palaeoecological and palaeobiological aspects of these amber inclusions are discussed. The relative abundance of zygopteran larvae with saccoid caudal gills suggests the presence of well-oxygenated and fast flowing habitats.

- (17866) BUDEN, D.W., 2008. First records of Odonata from the republic of Nauru. *Micronesica* 40(1/2): 227-232. — (Div. Nat. Sci. & Math., Coll. Micronesia-FSM, P.O. Box 159, Kolonia, Pohnpei-96941, Fed. St. Micronesia).

Ischnura aurora, *Anax guttatus*, *Diplacodes bipunctata*, *Pantala flavescens*, *Tholymis tillarga* and *Tamea transmarina* are brought on record from Nauru, a small (21 km²) rised atoll in the west-central Pacific, approx. 2100 km NE of New Guinea. Breeding is confirmed for all spp.

- (17867) CRAIG, C.N., B.A. REECE & N.C. McINTYRE, 2008. Nestedness in playa odonates as a function of area and surrounding land-use. *Wetlands* 28(4): 995-1003. — (Dept Biol. Sci., Texas Tech Univ., Lubbock, TX 94409, USA).

As degradation of wetlands continues to occur as a result of human activities, it is important to identify aquatic and amphibious species' extinction risks and the relative hospitalities of sites to support intact biotic communities; one such technique involves comparing the nestedness of assemblages as an assay of predictability and stability. The degree of nestedness of odon. communities was measured in the playa wetland complex of the Texas panhandle (data from 23 spp. and 73 playas in the summers of 2003-05) under current conditions as well as 4 simulations of future socioeconomic and climate change. Compared to randomized (null model) assemblages, significant nestedness was found for the system as a whole as well as for each yr separately and for playas within each of the 2 dominant regional forms of land cover (cropland and grassland). Cropland and grassland playas were further split into 3 size categories, based on natural size breaks. Although departures from nestedness (idiosyncrasy) were unrelated to playa size or surrounding land use, larger playas surrounded by cro-

pland displayed lower nestedness than did smaller ones whereas grassland playas showed the opposite pattern. This relationship between playa area and surrounding land-use type showed that there is lower stability in odon. community composition in even large playas if those playas are surrounded by agriculture. Departures from nestedness mainly consisted of unexpected spp. presences rather than absences, with idiosyncratic spp. being larger in total body length and including 2 range extensions. Under simulations of playa losses, community patterns were similar to contemporary data, suggesting that the ephemeral and dynamic nature of playas may already expose the odon. community to selective pressures possible under future land conversion.

- (17868) DE BLOCK, M. & R. STOKS, 2008. Compensatory growth and oxidative stress in a damselfly. *Proc. R. Soc. (B)* 275: 781-785. — (Lab. Aquat. Ecol. & Evol. Biol., Univ. Leuven, Deberiotstraat 32, B-3000 Leuven).

Physiological costs of compensatory growth are poorly understood, yet may be the key components in explaining why growth rates are typically submaximal. Here, the hypothesized direct costs of compensatory growth were tested in terms of oxidative stress. Oxidative stress was assessed in a study where compensatory growth in body mass was generated by exposing *Lestes viridis* larvae to a transient starvation period followed by ad libitum food. Compensatory growth in the larval stage was associated with higher oxidative stress (as measured by induction of superoxide dismutase and catalase) in the adult stage. The results challenge 2 traditional views of life-history theory. first, they indicate that age and mass at metamorphosis not necessarily completely translate larval stress into adult fitness and that the observed physiological cost may explain hidden carry-over effects. Second, they support the notion that costs of compensatory growth may be associated with free-radical-mediated trade-offs and not necessarily with resource-mediated trade-offs.

- (17869) GAMA, G. & F. FRANCIS, 2008. Étude de la biodiversité entomologique d'un milieu humide aménagé: le site du Wachnet, le long du Geer à Waremme (province de Liège, Belgique). *Faun. Ent.* 61(1/2): 33-42. (With Engl. s.). — (Second Author: Unité Ent. fonctionnelle & évolutive, Fac. Univ. Sci. Agr., Gembloux, Belgium).

- 13 odon. spp. are reported from 8 ecologically different sites at Wachnet in Waremme (Liège prov., Belgium).
- (17870) GARDINER, T. & A. VAUGHAN, 2008. Responses of ground flora and insect assemblages to tree felling and soil scraping as an initial step to heathland restoration at Norton Heath Common, Essex, England. *Conservation Evidence* 5: 95-100. – (First Author: 2 Beech Rd, Rivenhall, Witham, Essex, CM8 3PF, UK).
There was a noticeable increase in the number of odon. spp. recorded in the heathland restoration area (although none are heathland indicator spp.): 3 spp. were using the restoration area in the first yr after restoration and 6 in the second.
- (17871) HECKMAN, C.W., 2008. *Encyclopedia of South American aquatic insects: Odonata-Zygoptera. Illustrated keys to known families, genera, and species in South America*. Springer Science, Dordrecht. viii+691 pp. Hardcover (16.5 × 24.5 cm). ISBN 978-1-4020-8175-0; – e-ISBN 978-1-4020-8176-7. Price: UK £ 181.- net.
The companion volume to that described in *OA* 16465.
- (17872) HERCUT, R., D. CUPSA, S. PURTAN & B. BALOG, 2008. Studies upon the structure of the macrozoobenthic invertebrate communities in three habitats from Arginesti surroundings (Mehedenti co., Romania). *Bihorean Biologist* 2: 14-20. (Rom., with Engl. s.). – (Catedra Biol., Fac. Stiinte, Univ. Oradea, Universitatii 1, RO-410087 Oradea).
Aeshna isosceles is reported from 2 of the ponds studied; – Romania.
- (17873) HERCUT, R., S. PURTAN & B. BALOG, 2008. Contributions to the study of the macrozoobenthic invertebrate communities from two habitats in Dobrudja (Romania). *Bihorean Biologist* 2: 21-26. (Rom., with Engl. s.). – (Catedra Biol., Fac. Stiinte, Univ. Oradea, Universitatii 1, RO-410087 Oradea).
5 odon. spp. and their abundance are reported from 3 semipermanent ponds in the counties of Tulcea and Constanta; – Romania.
- (17874) JANSKÝ, V. & S. DAVID, 2008. Occurrence of the dragonfly *Cordulegaster heros* ssp. *heros* (Odonata: Cordulegasteridae) in Slovakia. *Acta rer. nature. Mus. natn. Slov.* 54: 61-68. (Slovak, with Engl. s.). – (First Author: Prirodovedné Múzeum, Vajanského nábr. 2, P.O. Box 13, SK-81006 Bratislava-16).
C. heros is currently known from 27 localities in Slovakia. Its distribution is reviewed.
- (17875) MAES, D., A. ANSELIN, K. DECLEER, G. DE KNIJF & V. FICHEFET, 2008. Insecten en klimaatswijziging in België. – [Insects and climate change in Belgium]. *Natuur Focus* 7(3): 107-111. (Dutch). – (First Author: Inst. Natuur & Bosonderzoek, Kliniekstraat 25, B-1070 Brussel).
The consequences for the Belgian fauna of butterflies, grasshoppers and odon. are explored along 3 theoretical options, if the current climate change is to progress. It is concluded that all 3 options are likely to trigger a significant biodiversity decrease in all 3 orders.
- (17876) McMUNN, M., 2008. *Oviposition preference in the Dark-Winged Damselfly (Calopteryx maculate)*. Joint project for Evolution and Natural History, Univ. Michigan, Ann Arbor. 13 pp. – (c/o S. Pruet-Jones, Dept Biol., Univ. Michigan, Ann Arbor, MI 48109, USA).
Artificial odon. territories were created using several leaves of *Sparganium americanum* fixed in place in a river at known flow rates for 48 h. On each leaf the eggs were counted and the algal coverage was measured. It was found that *C. maculate* oviposits more frequently in areas of intermediate flow rate, approx. 0.2-0.4 m/s, where algal coverage was more common. It is suggested that oviposition choice is not affected by the presence of algae and that there is a relatively narrow window of optimum flow rate for oviposition.
- (17877) NG, Y.F., H.S. YONG, R.A. DOW & M. HÄMÄLÄINEN, 2008. Dragonflies (Insecta: Odonata) from the Maliau Basin, Sabah, Malaysia. *J. Sci. Tech. Tropica* 4(1): 13-18. – (Last Author: Sunnankalliontie 13, FIN-02760 Espoo).
An annotated list of 15 spp. is presented. It is based on a limited collecting period, 18-23 Apr. 2006.
- (17878) NIKOLAEVA, N.E., 2008. A new construction of an underwater light trap and its use for catching of hydrobionts. *Zool. Zh.* 87(9): 1134-1136. (Russ., with Engl. s.). – (Dept Zool., Tver St. Univ., RUS-170002 Tver).

A detailed and illustrated technical description of the facility. Odon. are listed among the taxa in collecting of which the trap is particularly effective.

- (17879) PERCSY, C. & N. PERCSY, 2008. La réserve naturelle de Gentissart (Villers-la-Ville, Brabant Wallon): colonisation d'une ancienne sablière par les odonates et autres insectes. *Naturalistes belg.* 89(2/3): 34-56. (With Engl. s.). – (First Author: Ch. du Bon Air 12, B-1380 Ohain).
Based on a long-term odon. survey (1997-2007) at the old sand quarry (surface 26 ha) of Gentissart (Belgium), 27 spp. are listed and their local occurrence annotated.
- (17880) POLHEMUS, D.A., J. MICHALSKI & S.J. RICHARDS, 2008. Pseudagrion fumipennis, a remarkable new species of damselfly from New Guinea (Odonata: Zygoptera: Coenagrionidae). *Tijdschr. Ent.* 151: 51-56. – (First Author: Dept Nat. Sci., Bishop Mus., 1525 Bernice St., Honolulu, HI 96817, USA).
The new sp. is described and illustrated from widely separated localities in the lowlands of New Guinea and immediately adjacent islands. Holotype ♂: Papua New Guinea, Gulf prov., Sapoi river, 29-XI-1996; deposited in Aust. Mus. Nat. Hist., Sydney. Structurally it is most similar to *P. farinicolle* from New Guinea and *P. ustum* from Sulawesi.
- (17881) POTT, C., C.C. LABANDEIRA, M. KRINGS & H. KERP, 2008. Fossil insect eggs and ovipositional damage on bennettitalean leaf cuticles from the Carnian (Upper Triassic) of Austria. *J. Paleont.* 82(4): 778-789. – (First Author: Forschungsstelle Paläobot., Geol.-Paläont. Inst., Univ. Münster, Hindenburgplatz 57, D-48143 Münster).
2 types of evidence for insect ovipositional activity (i.e., actual egg chorions and ovipositional damage) occur on Nilssoniopteris (bennettitalean foliage) leaf cuticles from the Carnian of Austria (Lunz Formation, ca 100 km W of Vienna) and provide a rare direct insight into insect egg morphology and oviposition in the Late Triassic. The egg chorions have exclusively been found on *N. haidingeri* leaves, where they are attached to the outer surface of the abaxial cuticle; one specimen suggests that the eggs were arranged in circles. It is impossible at present to determine the affinities of the eggs. Ovipositional damage occurs on *N. angustior* leaves in the form of lenticular egg impressions surrounded by a narrow, elevated margin. The impressions are visible on the ad- and abaxial cuticle, and coincide when both cuticles are superimposed, which indicates that the eggs producing these impressions were injected into the interior of the leaf. Producers of eggs that may have caused these damages are perhaps odon. The restricted occurrence of the 2 types of ovipositional activity suggests that some kind of host specificity existed, perhaps related to specific preferences in larval diet.
- (17882) PRYKE, J.S., 2008. *Conservation of the invertebrate fauna of the Cape Peninsula*. PhD thesis, Fac. Sci., Stellenbosch Univ., Matieland/SA. xii+262 pp. (With Afrikaans s.). – (c/o Prof. Dr M.J. Samways, Dept Conserv. Ecol., Univ. Stellenbosch, P. Bag X1, Matieland-7602, Sth Afr.)
The Cape Peninsula (S Afr.) is regarded as a centre of endemism for many invertebrate groups, incl. Odon. (cf. M.J. Samways, 2006, *Odonatologica* 35: 341-368). Previously 22 odon. spp. had been recorded from the Cape. Here, in the Appendix, recent data are listed for 19 spp., incl. *Azuragrion nigridorsum* and *Trithemis dorsalis* that are new for the Cape. The 2 spp. were both found next to artificial dams, suggesting the records are not due to sampling effort but represent rather the actual range extensions due to anthropogenic influence.
- (17883) RIVERA-USME, J.J., D.L. CAMACHO-PINZÓN & A. BOTERO-BOTERO, 2008. Numeric structure of the aquatic entomologic fauna in eight streams of the department of Quindío, Colombia. *Acta biol. colomb.* 13(2): 133-146. (Span., with Engl. s.). – (Carrera 7, No. 12-55, La Tabaida, Quindío, Colombia).
The paper deals with a quantitative review of the aquatic insect fauna in the streams of La Tabaida and Calarcá. Samples contained 216 odon. specimens; the taxa are mostly genus-wise listed. Notes on their habitat preferences are provided.
- (17884) SMEENGE, H., 2008. *Natuurherstelplan Gorsse Heide*. – [Nature restoration schedule for Gorsse Heide]. Ministerie van Landbouw, Natuur en Voedselkwaliteit, The Hague. 43 pp. (Dutch).
An odonatol. important former military training ground (heath) area, Gelderland prov., the Netherlands.

- (17885) SRYGLEY, R.B. & R. DUDLEY, 2008. Optimal strategies for insects migrating in the flight boundary layer: mechanisms and consequences. *Integr. comp. Biol.* 48(1): 119-133. – (USDA-Agric. Res. Serv., 1500 N Central Ave, Sidney, MT 59270, USA). Directed aerial displacement requires that a volant organism's airspeed exceeds ambient wind speed. For biologically relevant altitudes, wind speed increases exponentially with increased height above the ground. Thus, dispersal of most insects is influenced by atmospheric conditions. However, insects that fly close to the Earth's surface displace within the flight boundary layer where insect airspeeds are relatively high. Over the past 17 yr, the present Authors have studied boundary-layer insects by following individuals as they migrate across the Caribbean Sea and the Panama Canal. Although most migrants evade either drought or cold, nymphalid and pierid butterflies migrate across Panama near the onset of the rainy season. Dragonflies of the genus *Pantala* migrate in Oct. concurrently with frontal weather systems. Migrating the furthest and thereby being the most difficult to study, the diurnal moth *Urania fulgens* migrates between Central and South America. Migratory butterflies and dragonflies are capable of directed movement towards a preferred compass direction in variable winds, whereas the moths drift with winds over water. Butterflies orient using both global and local cues. Consistent with optimal migration theory, butterflies and dragonflies adjust their flight speeds in ways that maximize migratory distance travelled per unit fuel, whereas the moths do not. Moreover, only butterflies adjust their flight speed in relation to endogenous fat reserves. It is likely that these insects use optic flow to gauge their speed and drift, and thus must migrate where sufficient detail in the Earth's surface is visible to them. The abilities of butterflies and dragonflies to adjust their airspeed over water indicate sophisticated control and guidance systems pertaining to migration.
- (17886) STRAND, L. & M. FRANZEN, 2008. *Basin-ventering av trollsländor i Skåne 2006*. Länsstyrelsen i Skåne Län, Malmö. 52 pp. ISBN 978-91-86079-23-0. (Swed.). – (Orders to: Miljöafdelningen, Länsstyrelsen i Skåne Län, S-205 15 Malmö). A report on the 2006 survey of the occurrence of *Aeshna viridis*, *Leucorrhinia albifrons*, *L. caudalis* and *L. pectoralis* in Skåne, Sweden. Also included are notes on *Aeshna isosceles* and *Anax imperator*.
- (17887) WHITEMAN, N.K. & R.W. SITES, 2008. Aquatic insects as umbrella species for ecosystem protection in Death Valley National Park. *J. Insect Conserv.* 12: 499-509. – (First Author: Dept Organismic & Evol. Biol., Mus. Comp. Zool., Harvard Univ., 26 Oxford St., Cambridge, MA 02138, USA). Under the US Endangered Species Act, critical habitat for listed spp. is also protected. This paper deals with the Heteroptera, but a list of the 7 currently protected or proposed candidate odon. spp. is also included.
- (17888) YAKUBOVICH, V.S., 2008. To the fauna of dragonflies (Insecta, Odonata) of the Lower Amur region. *AI Kurentsov's annu. mem. Meet.* 19: 96-102. (Russ., with Engl. s.). – (Inst. Water & Ecol. Problems, FEB RAS, Kim Yu Chen 65, RUS-680063 Khabarovsk). A checklist of the 53 spp. hitherto known from the region (with new records of some of these) is given, and a biogeographic analysis of the fauna is provided.
- (17889) YOSHIMURA, M., 2008. Longitudinal patterns of benthic invertebrates along a stream in the temperate forest in Japan: in relation to humans and tributaries. *Insect Conserv. & Div.* 1: 95-107 – (Forest Prod. Res. Inst., Nagaikyutaro 68, Momoyama, Fushimi, Kyoto, 612-0855, JA). In order to clarify the influence of human residence on benthic invertebrate assemblages, seasonal and site differences among benthic samples collected from a 15-km stretch of the Kuroson stream (the Shimanto river watershed, Shikoku) and their relation with land use were examined. The abundance of *Calopteryx*, *Davidius*, *Epiophlebia* and *Lanthus* at each sampling site is stated and a statistical analysis is provided. Species names are not given.

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- (17890) ALTAMIRANDA SAAVEDRA, M., 2009. Actualización de registros del orden Odonata del Museo Entomológico Francisco Luis Gallego. *Boln Mus. ent. Gallego* 1(3): 6-18. – (Mus. Ent. Francisco Luis Gallego, Apto Aéreo 3840, Medellín, Colombia). A checklist, with locality data of ca 600 (out of the 1180) identified Colombian Odon. specimens in the collection of the Museum.

- (17891) BECKEMEYER, R.J., 2009. Kinematics of a territorial defense maneuver by the dragonfly *Pachydiplax longipennis* (Odonata: Anisoptera: Libellulidae). *Trans. Kans. Acad. Sci.* 112(3/4): 169-180. — (957 Perry Ave, Wichita, KS 67203-3141, USA).
A high speed (1000 frame/s) video segment, 0.367 seconds long, showing a territorial ♂ responding in the field to a challenge from a conspecific ♂, reveals that the defender used a high rate yaw-turn to position itself to drive off the challenger. In-phase flapping of the fore- and hindwings was used during the yaw turn and in the following pursuit of the challenger. During the right yawing turn, the dragonfly flapped its right wings to a more negative stroke amplitude than its left wings on the first 2 downstrokes (1st downstroke: -65° right wing, -45° left wing; 2nd downstroke: -90° right wing, -50° left wing). Upstroke amplitudes were the same for both wings throughout the yaw turn. The 135° yaw turn was executed, in 3 wing beats (0.085 s) and in about 6/10ths of a body length of horizontal travel, at an average yaw rate of 1590°/s, and a peak turn rate of 3000°/s. This rapid yawing rotation was accompanied by a significant deceleration in flight path speed, which dropped from 30 to 7 body lengths per second (1.1 m/s to 0.3 m/s) as the dragonfly yawed through 90° in the first half of the yaw turn. The wingbeat frequency dropped from 41.7 Hz at the beginning of the yaw turn to 33.3 Hz at the end. The horizontal and vertical flight velocity components both reached zero near the completion of the yaw turn, during the upstroke portion of the third wing beat. Within 1/10th of a second after completing the yaw turn, the defender had reached speeds of 8 body lengths per second (0.3 m/s) upward and 14 body lengths per second (0.55 m/s) horizontally, and was accelerating along its flight path at approximately 150 body lengths per second² (5.5 m/s²) in its pursuit of the challenger.
- (17892) BERNARD, R., P BUCZYŃSKI, G. TOŃCZYK & J. WENDZONKA, 2009. *A distribution atlas of dragonflies (Odonata) in Poland*. Bogucki Wydawnictwo Naukowe, Poznan. 256 pp. ISBN 978-83-61320-54-8. Hardcover (22.0 × 30.0 cm). (Bilingual: Pol./Engl.). — (Publishers: Górna Wilda 90, PO-61-576 Poznań).
This is by far the most perfect Atlas of a European region yet published. It is based not solely on the assessment of (published and unpublished) historical and recent records but, above all, on thorough analytical work, which resulted in a significant contribution to our understanding of the European odon. biogeography. — The distribution of each sp. is presented in 2 maps, viz. a basic UTM grid map (records) and a map of the area of occupancy. Special chapters are devoted to the geographical background, outline of odonatol. studies in Poland (1781 to present), biogeographical description of odon. fauna, species in decline and those in expansion, updated Red List, etc. The odonatol. literature related to the present territory of Poland consists of over 700 works, 543 of which contain original data on odon. occurrence. The bibliography is divided in 5 sections: “References”, “Source literature” (1825 to present), “MSc theses and PhD dissertations”, “Internet sources”, and “Unpublished works and expert evaluations”. — The style is concise and throughout refreshing. The book is of a significant extralimital importance, the bilinguality makes it easily accessible to the non-polish readers. — A corrective note: with reference to, e.g. *OA* 15754, it was recently shown persuasively that Hagen’s New World *Enallagma annexum* is not conspecific with *E. cyathigerum*, therefore the latter is a palearctic rather than a holarctic sp., though the N American taxon has been for long time considered as a junior synonym of *E. cyathigerum*.
- (17893) BUCZYŃSKI, P. & P. JEDRYCZAK, 2009. On the occurrence of *Orthetrum brunneum* (Fonscolombe, 1837) (Odonata: Libellulidae) in the Polish part of the South Baltic Sea coast region. *Wiad. ent.* 28(3): 141-147. (Pol., with Engl. s.). — (First Author: Dept. Zool., UMCS, Akademicka 19, PO-20-033 Lublin).
The sp. is for the first time reported from an area above 54°N in Poland, situated ca 1.5° of latitude N of the hitherto known localities. The localities in N Poland and the distribution of *O. brunneum* in the northern part of central Europe are discussed.
- (17894) [CANNINGS, R.A.] McCREA, E., 2009. Press release: *Robert Cannings receives national award from Alliance of Natural History Museums of Canada*. Alliance Nat. Hist. Mus. Canada, Ottawa. 4 pp., incl. recipient’s address upon the receipt of the award. — (c/o Dr R.A. Cannings, Roy. Brit. Columbia Mus., 675 Belleville St., Victoria, BC, V8W 9W2, CA).
Bruce Naylor Award, 27-X-2009. A short appre-

- ciation of his scientific (largely odonatol.) work is provided.
- (17895) CANO-VILLEGAS, F.J. & M.A. CONESA-GARCIA, 2009. Confirmation of the presence of *Lestes macrostigma* (Eversmann, 1836) (Odonata, Lestidae) in the "Laguna de Fuente de Piedra" Natural Reserve (Malaga, South Spain). *Boln Asoc. esp. Ent.* 33(1/2): 91-99. (With Span. s.). – (First Author: Montemayor 4, 1°-2, ES-14003 Córdoba). Fresh records are presented for 14 spp. in the Reserve. The *L. macrostigma* occurrence is highlighted, since during the past 14 yr this sp. has not been seen in Andalusia (Spain).
- (17896) CHEREVATOV, V.F., 2009. [Interesting invertebrate fauna of the European Bison Reserve "Zubrovicya"]. *Mater. nauk. Konf. "Stan i bioriznomanitya ekosistem Shac'kogo nacional'nogo prirodnogo parku*, pp. 120-121, Spolom, l'viv. (Ukr.). – (Author's address not stated). *Calopteryx virgo* is listed from the Reserve, situated in the Chernivecka distr., the Ukraine.
- (17897) CHIN, K.S. & P.D. TAYLOR, 2009. Interactive effects of distance and matrix on the movements of a peatland dragonfly. *Ecography* 32: 715-722. – (Dept Biol., Acadia Univ., 24 University Ave, Wolfville, NS, B4P 2R6, CA). A mark-release-recapture survey of *Leucorrhinia hudsonica* was conducted in 2002 and 2003 in a harvested forest landscape in western Newfoundland, Canada. The odds of an individual ♂ moving between peatlands was influenced by both the distance between peatlands and the type of intervening habitat (the matrix). Specifically, at meso scales (> 700 m) there was a positive effect of the amount of cut matrix between peatlands on the odds of moving, but at fine scales (< 700 m) there was the opposite effect; proportionally fewer individuals moved between peatlands. The odds of moving out of a peatland decreased as the surface area of water in the peatland increased. Multi-state mark-recapture models showed that the daily probability of a ♂ moving between any 2 peatlands was 1.9% in 2002 and 6.9% in 2003 (n = 1527 and 1280 marked individuals, respectively). The results suggest that additional empirical studies that directly measure patterns of movement with respect to landscape structure at multiple spatial scales in other taxa and situations are needed in order to uncover other possible non-linear changes in behaviour.
- (17898) CORAM, R.A. & A. NEL, 2009. A new petalurid dragonfly from the Lower Cretaceous of southern England (Odonata: Petalurida: ?Cretapetaluridae). *Palaeodiversity* 2: 205-208. (With Germ. s.). – (Second Author: Entomologie, Mus. Natn. Hist. Nat., 45 rue Buffon, F-75005 Paris). *Anglopetalura magnifica* gen. n., sp. n. is described and illustrated from the Duriston Formation, Upper Berriasian of Duriston Bay, Dorset, UK. Holotype (♂ hindwing): Maidstone Mus. & Art Gallery, Kent, UK.
- (17899) COSTA, J.M. & T.C. SANTOS, 2009. Description of the larva of *Orthemis schmidtii* (Odonata, Libellulidae). *Iheringia* (Zool.) 99(2): 129-131. (With Port. s.). – (Depto Ent., Mus. Nac., UFRJ, Quinta da Boa Vista, São Cristovão, BR-20940-040 Rio de Janeiro, RJ). The larva is described and illustrated for the first time based on 4 ♂ and 1 ♀ larvae and on a ♂ exuviae from Maranhão (NE Brazil). Diagnostic characters, separating it from the known congeners, are stated and some notes on the habitat are provided.
- (17900) DARAZ, B., 2009. Dragonflies (Odonata) of the Przemyśl Foothills and adjacent areas along the San river. *Wiad ent.* 28(1): 5-32. (Pol., with Engl. s.). – (Kościelna 41, PO-35-505 Rzeszów). A comprehensive treatment of the fauna (54 spp.); – SE Poland.
- (17901) DELIRY, C., 2009. *Bibliographie d'odonatologie Provençale (Provence, Alpes, Côte-d'Azur)*. www.deliry.com, synthèse Pdf Internet, version 2 (1er juin 2009). 13 pp. 168 titles, covering the period 1837-2000; – France.
- (17902) DIOMANDÉ, D., Y.K. BONY, E.O. EDIA, K.F. KONAN & G. GOURÈNE, 2009. Diversité des macroinvertébrés benthiques de la rivière Agnéby (Côte d'Ivoire; Afrique de l'Ouest). *Europ. J. scient. Res.* 35(3): 368-377 (With Engl. s.). – (Lab. Envir. & Biol. Aquat., Univ. Abobo-Adjamé, 02, B.P. 801, Abidjan-02, Ivory Coast). 6 odon. taxa are reported from the middle stream of the Agnébi, Ivory Coast.

- (17903) [DOMMANGET, J.-L.], 2009. *Liste et statuts des odonates de la région Île-de-France*. Soc. fr. Odonatol. www.libellules.org – pdf, version 15 May 2009, 3 pp. – (7 rue Lamartine, F-78390 Bois-d'Arcy).
An annotated list of 58 spp; – France.
- (17904) FERRO, M.L., R.W. SITES & A. VITHEE-PRADIT, 2009. Contributions to the faunistics of Odonata in Thailand. *Insecta Mundi* 0104: 1-24. – (First Author: Dept Ent., Louisiana St. Arthrop. Mus., LSU Agric. Cent., Baton Rouge, LA 70803, USA).
Distribution and habitat information are provided for 1578 specimens (127 spp.) from 134 (49 lentic, 85 lotic) sites throughout Thailand. Of the spp. collected, 25 were represented by a single specimen and 40 were collected from a single location.
- (17905) GU NADARRACH ALBANNACH (publisher; authorship anonymous), 2009. *The dragonfly / An tarbh-nathrach*. Scottish Natural Heritage. 24 pp. <http://www.snh.org.uk/> (Gaelic).
General, with a list of Gaelic names of 30 spp. recorded from Scotland. A Gaelic/Engl. glossary for explanation of the meaning of the names is also provided.
- (17906) GYSELS, J. & H. PULS, 2009. Beekschaaftenrijder en bosbeekjuffer in de provincie Antwerpen (1995-2008). – [Aquarius najas (Hemiptera) and Calopteryx virgo in the province of Antwerp (1995-2008)]. *Antenne* 3(1): 4 pp. (Dutch). – (Authors' postal addresses not stated).
As apparent from a recent survey, the Calopteryx virgo populations are increasing in the province of Antwerp, Belgium. The Aa in Turnhout and the Laarse Beek in Brasschaat are examples of streams re-populated after many yr of absence of this sp.
- (17907) HACET, N. & N. AKTAC, 2009. Contribution to the knowledge of Odonata fauna of southern Marmara region of Turkey. *Türk. ent. Derg.* 33(3): 171-178. (With Turk. s.). – (Dept Biol., Fac. Arts & Sci., Trakya Univ., TR-22030 Edirne).
A commented list of 17 spp. For the first time Libellula fulva is recorded from the region.
- (17908) HONKAVAARA, J., M.J. RANTALA & J. SUHONEN, 2009. Mating status, immune defence, and multi-parasite burden in the damselfly *Coenagrion armatum*. *Entomologia exp. appl.* 132: 165-171. – (Sect. Ecol., Dept Biol., Univ. Turku, FIN-20014 Turku).
Immunity and reproductive effort are both physiologically costly and often a trade-off between these functions has been shown. In studies with Zygoptera, parasite load has been associated with fitness costs, such as reductions in mating success, ♂ condition, and survival. Although each individual may be simultaneously infected by various parasite spp., most studies have concentrated on the effects of a single parasite taxon. Here, natural ecto- and endoparasite infection levels in ♂ *C. armatum* are examined in relation to their mating status, fat reserves, and ability to further mount an immune response measured as encapsulation of an experimentally introduced foreign object. Encapsulation response was lower for mated (paired) ♂♂ than for single ♂♂ and declined with increasing water mite abundance. Mated ♂♂ had fewer water mites than single ♂♂. ♂ weight or fat reserves did not explain variation in encapsulation response. The number of gregarine gut parasites was not related to the level of encapsulation response and did not differ between mated and single ♂♂. However, there was a negative correlation between mite abundance and gregarine load. The data suggest that current mite infection may compromise a ♂'s resistance against further infections by pathogens and parasites, and there may be a trade-off between reproductive effort and encapsulation response in ♂ *C. armatum*.
- (17909) *INTERNATIONAL JOURNAL OF ODONATOLOGY* (ISSN 1388-7890), Vol. 12, No. 2, P.S. Corbet memorial issue (1 Dec. 2009).
Orr, A.G.: Reproductive behaviour of *Libellago semiopaca* on a Bornean rainforest stream (Odonata: Chlorocyphidae) (pp. 157-180, pls 1-2 excl.); – *Wildermuth, H.*: Season and temperature dependent location of mating territories in *Somatochlora flavomaculata* in a heterogeneous environment (Odonata: Corduliidae) (pp. 181-193, pl. 3 excl.); – *Hilfert-Rüppell, D. & G. Rüppell*: Males do not catch up with females in pursuing flight in *Calopteryx splendens* (Odonata: Calopterygidae) (pp. 195-203, pl. 4 excl.); – *Gorb, S., K. Tynkkynen & J.S. Kotiaho*: Crystalline wax coverage of the imaginal cuticle in *Calopteryx splendens* (Odonata: Calopterygidae) (pp. 205-221); – *van der Poorten, N.*: *Libellago corbeti* sp. nov. from Sri Lanka (Odonata: Chlorocyphidae) (pp. 223-230, pl. 5 excl.); –

- Villanueva, R.J.T.*: Two new Risicnemis species from northern Sierra Madre, Luzon, Philippines (Odonata, Platycnemididae) (pp. 231-236); – *Dijkstra, K.-D.B. & M. Matushkina*: Kindred spirits: 'Brachythemis leucosticta', Africa's most familiar dragonfly, consists of two species (Odonata: Libellulidae) (pp. 237-256); – *Purse, B.V. & D.J. Thompson*: Oviposition site selection by Coenagrion mercuriale (Odonata: Coenagrionidae) (pp. 257-273); – *Watts, P.C.*: Characteristics of microsatellite loci in Odonata (pp. 275-286); – *Suhling, F., A. Martens & E. Marais*: How to enter a desert: patterns of Odonata colonisation of arid Namibia (pp. 287-308); – *Tennessen, K.*: Aeolagrion philippi sp. nov. from Bolivia, and a review of the genus Aeolagrion (Odonata: Coenagrionidae) (pp. 309-322); – *Costa, J.M., T.C. Santos & L.O.I. de Souza*: Cyanallagma corbeti sp. nov. from Brazil (Odonata: Coenagrionidae) (pp. 323-329); – *Machado, A.B.M.*: Tukano-basis gen. nov., with the description of T. corbeti sp. nov. from the Amazonian region of Brazil (Odonata: Coenagrionidae) (pp. 331-336); – *Carvalho, A.L., A.P. Pinto & N. Ferreira-Jr*: Castoraeschna corbeti sp. nov. from Floresta Nacional de Carajás, Pará state, Brazil (Odonata: Aeshnidae) (pp. 337-346, pl. 6 excl.); – *von Ellenrieder, N.*: Five new species of Orthemis from South America (Odonata: Libellulidae) (pp. 347-381, pl. 7 excl.); – *Samraoui, B.*: Seasonal ecology of Algerian Lestidae (Odonata) (pp. 383-394); – *Lorenzo-Carballa, M.O., C.B. Beatty, C. Utzeri, V. Vieira & A. Cordero-Rivera*: Parthenogenetic Ischnura hastata revisited: present status and notes on population ecology and behaviour (Odonata: Coenagrionidae) (pp. 395-411, pl. 8 excl.); – *Ferrera-Romero, M., J. Márquez-Rodríguez & A. Ruiz-García*: Implications of anthropogenic disturbance factors on the Odonata assemblage in a Mediterranean fluvial system (pp. 413-428).
- (17910) *KALKMAN, V.J., H. VAN MASTRIGT & S.J. RICHARDS*, 2009. First records of dragonflies (Odonata) from the Foja Mountains, Papua province, Indonesia. *Suara Serangge Papua* 4(1): 14-19. (With Bahasa Indonesian s.). – (First Author: Naturalis, P.O. Box 9517, NL-2300 RA Leiden). A commented list of 21 taxa, 6 of which identified to the gen. level only, including an undescribed Argiolestes sp.
- (17911) *KÜ*, 2009. *Artenliste Schweiz: Libellen (Odonata). 1997-2008*. Bundesamt für Umwelt, Schweiz. Eidgenossenschaft. 4 pp. Ref.: 800 225.2 Z3 Artenliste Schweiz Libellen 1997-2008.doc. (Trilingual: Germ./Fr./Engl.). Annotated checklist.
- (17912) *KUKALOVA-PECK, J.*, 2009. Carboniferous protodonatoid dragonfly nymphs and the synapomorphies of Odonoptera and Ephemeroptera (Insecta: Palaeoptera). *Palaeodiversity* 2: 169-198. (With Germ. s.). – (Dept Earth Sci., Carleton Univ., Ottawa, ON, K1S 5B6, CA). 3 fossil protodonatoid dragonfly larvae are described from the middle Pennsylvanian (Moscovian) of Mazon reek, Illinois: *Dragonympha srokai* gen. n., sp. n. (Meganisoptera), a large, nearly complete young larva with an extended labial mask and uplifted wing pads; *Alanympa richardsoni* gen. n., sp. n. (Meganisoptera), a larval forewing with 2 articular plates attached to it, and *Carbonympha herdinai* gen. n., sp. n. (Eomeganisoptera), a detached larval forewing. Plesiomorphic states in *Dragonympha* indicate homologies unresolved in modern Odonata. The segmented head bears 3rd tergum ventrally invaginated. The extended labial mask still shows limb segments. The prothorax bears a pair of winglets. The short wing pads are fully articulated, twisted, uplifted and streamlined with body. The mesothoracic anepisternum is placed between acrotergite and prescutum. The abdominal leglets form long, segmented, serial gill filaments. In the ontogenesis of modern dragonflies, the wing and articulation disc occurs just above subcoxal pleuron and far from tergum. Wing sclerites are arranged in 8 rows protecting 8 blood pathways running towards 8 wing veins. The sistergroup of Odonoptera has not yet been convincingly resolved with computer cladistic approaches. Reasons are examined and discussed. More accurate, evolution-based character evaluations are shown with examples. The role of a correct model of the pan-arthropod limb and the origin of insect wing is discussed. Groundplan characters in dragonflies and mayflies are compared in their Paleozoic and modern states, their obscurity is clarified and complex synapomorphies are proposed. Palaeoptera is confirmed as a monophyletic group and the following sistergroup relationships are suggested: Pterygota = Palaeoptera + Neoptera; Palaeoptera = Palaeodictyopteroidea + Hydropalaeoptera; Hydropalaeoptera = Odonoptera + Ephemeroptera.

- (17913) LE DU, P., M. COCHU & F. GULLY, 2009. Compte-rendu sortie entomo du 15 août aux marais de Magoar (Glomel VU73): Odonates. *Lett. Réseau Naturalistes Costarmoricains* 2009: 2. – (Authors' addresses not stated).
15 spp. are recorded from the Reserve and its vicinity; – Brittany, France.
- (17914) LOZANO, F., J. MUZÓN & S. TORRES, 2009. Description of the final instar larva of *Homoura lindneri* (Ris, 1928) and redescription of the larva of *H. chelifera* (Selys, 1876) (Odonata: Coenagrionidae). *Zootaxa* 2231: 47-54. (With Spanish). – (Inst. Limnol. "R.A. Ringuelet", C.C. 712, AR-1900 La Plata).
The descriptions and illustrations of the 2 spp. are based on reared specimens from Argentina. A generic diagnosis is provided, as well as a key to the larvae of the most common genera of Coenagrionidae occurring in Argentina. – See also *OA* 17932.
- (17915) [MALÉ], 2009. Die Meister der Langstrecke. *Fressnapf J.* 14 (Oct.): 8. – (Author's name and address unknown).
A casual note on migratory flights of *Pantala flavescens*, in a pet-store magazine.
- (17916) MATUSHKINA, N.A., E.K. GUGA, D.D. BUY & D.A. LIMARENKO, 2009. Dragonflies (Insecta, Odonata) of the Udai river part of the Sulava river ecological corridor (central Ukraine): a preliminary checklist. *Zapovidna Sprava v Ukraini* 15(1): 70-71. – (Dept Zool., Fac. Biol., Kiev Natn. Univ., Volodymirska 64, UKR-01033 Kyiv).
14 spp. are listed from 7 localities in Poltava region, Pyriatyn district.
- (17917) MEURGEY, F., 2009. The Odonata of Grenada (Lesser Antilles). *Herminier nat. Hist. Soc. Contr. Odonatol.* 1: 1-35. – (Mus. Hist. Nat., 12 rue Voltaire, F-44000 Nantes).
A survey report (1-14 May 2009), listing 19 spp. Biogeographically, the odon. fauna of Grenada is a mix between the Caribbean and S American fauna, with 3 spp. originating from S America (not shared with other islands) and *Argia concinna* is a Caribbean endemic.
- (17918) MILLÁN-JIMÉNEZ, C., 2009. Insectos acuáticos del humedal Timbique en el corregimiento del Bolo-Palmira (Valle del Cauca, Colombia). *Boln Mus. Ent. Univ. Valle* 10(1): 30-36. (With English). – (Depto Biol., Univ. Valle, Calle 13 No. 100-00, Sede Meléndez Cali, 25360 Cali, Colombia).
Sampling of aquatic insects associated with the Timbique wetland (Palmira, Valle del Cauca, Colombia) was conducted between May 2008 and Jan. 2009. Coenagrionid, aeshnid and libellulid larvae are reported, but specific names are not stated.
- (17919) MUZÓN, J., 2009. Estado actual del conocimiento del orden Odonata en la Patagonia. *Revta Soc. ent. argent.* 68(1/2): 163-167. (With English). – (Inst. Limnol. "R.A. Ringuelet", CC 712, AR-1900 La Plata).
A commented and updated list of the Patagonian fauna (36 spp., 18 gen.), Argentina. Approx. 60% of the spp. and 40% of the gen. are endemic. An analysis of the main distribution pattern is provided. – See also *OA* 10301.
- (17920) NAGEL, L., T. ROBB & M.R. FORBES, 2009. Parasite-mediated selection amidst marked inter-annual variation in mite parasitism and damselfly life history traits. *Ecoscience* 16(2): 265-270. (With French). – (Dept Biol., Carleton Univ., Ottawa, ON, K1S 5B6, CA).
Parasite-mediated selection in host populations is thought to vary in magnitude temporally. Here, variation in life history traits that are known or suspected to influence fitness was monitored in a *Lestes disjunctus* population, parasitized by larval water mites. Mite prevalence and intensity varied considerably over 5 yr and was often higher in ♀♀. Prevalence and intensity were highest in the years when the *Lestes* emergence periods were early and of short duration, which also corresponded to emerging at larger sizes. Mites appeared to exert negative effects on apparent survival in some years only, and only for ♀♀, suggesting that parasite-mediated selection on Zygoptera is variable and dependent on other factors such as emergence times, weather, and sex and body size of hosts.
- (17921) NEL, A., G. BECHLY, X. DELCLÒS & D.-Y. HUANG, 2009. New and poorly known Mesozoic damsel-dragonflies (Odonata: Isophlebioidea: Camptero-phlebiidae, Isophlebiidae). *Palaeodiversity* 2: 209-232. (With German). – (First Author: Entomologie, Mus. Natn. Hist. Nat., 45 rue de Buffon, F-75005 Paris).

- The diagnoses of the families Campteroptelebiidae and Isophlebiidae are emended. *Campteroptelebia elegans* Bode, 1905, type of the Campteroptelebiidae, and *Sinitsia sophiae* Pritykina, 2006 are redescribed. The latter is transferred from the Isophlebiidae into the Campteroptelebiidae *sit. nov.* 2 new campteroptelebiids are described: *Pritykinia rasnitsyni* gen. n., sp. n. (Lowermost Cretaceous of Russia) and *Qibinlina sinica* gen. n., sp. n. (Middle Jurassic of China). 3 new isophlebiids are described: *Walleria magnifica* gen. n., sp. n. (Upper Jurassic of Kazakhstan), *Parawalleria mongolica* gen. n. sp. n. and *Parawalleria incompleta* sp. n. (Upper Jurassic of Mongolia).
- (17922) NEL, A. & D.-y. HUANG, 2009. First Chinese Cymatoptelebiidae from the Middle Jurassic of Inner Mongolia (Odonata: Anisoptera: Aeshnoptera). *Palaeodiversity* 2: 199-204. (With Germ. s.). – (First Author: Entomologie, Mus. Natn. Hist. Nat., 45 rue Buffon, F-75005 Paris). *Sinacymatoptelebia mongolica* gen. n., sp. n., the oldest and the first Chinese record of the Mesozoic aeshnopteran dragonfly family Cymatoptelebiidae, is described from the Jiulongshan Formation of Inner Mongolia. Holotype ♂: print and counterprint of almost complete hindwing, part of forewing and trunk with the 4 basal abdominal segments; deposited at Nanjing Institute of Geology and Palaeontology, Nanjing.
- (17923) NGIAM, R.W.-J., 2009. The record of *Archibasis rebecca* Kemp, 1989 in Singapore (Odonata: Zygoptera: Coenagrionidae). *Nature Singapore* 2: 449-452. – (Natn. Biodiv. Cent., Natn Parks Bd, 1 Cluny Rd, Singapore-259569). The first published record from Singapore (1 ♂, small sandy stream in Central Catchment Nature Reserve, 22-V-2009). The specimen is described and an unpublished Singapore specimen in RMNH (Leiden), collected by M.A. Lieftinck, is mentioned.
- (17924) OBER, S.V. & A.H. STANICZEK, 2009. A new genus and species of coenagrionid damselflies (Insecta, Odonata, Zygoptera, Coenagrionidae) from Vanuatu. *Zoosystema* 31(3): 485-497. (With Fr. s.). – (Abt. Ent., Staat. Mus. Naturk. Stuttgart, Rosenstein 1, D-70191 Stuttgart). *Vanuatubasis santoensis* gen. n., sp. n. is described and illustrated. Holotype ♂: Vanuatu, Sanma prov., Espiritu Santo. Penaoru river, 13-XI-2006; deposited in SMNS. *Nesobasis bidens* Kimmins and *N. malekulana* Kimmins are transferred to the new genus.
- (17925) OLTHOFF, M. & E. SCHMIDT, 2009. Die Libellen (Insecta, Odonata) des Truppenübungsplatzes Haltern-Borkenberge (Kreise Coesfeld und Recklinghausen). *Abh. westf. Mus. Naturk.* 71(3): 223-261. (With Engl. s.). – (Second Author: Coesfelder Str. 230, D-48249 Dülmen). 44 spp. are recorded from the Haltern-Borkenberge Military Training Area (surface ca 1800 ha), SW of the city of Münster (NW Germany). They are categorized in ecological groups and discussed in detail.
- (17926) PALACINO-RODRIGUEZ, F., 2009. Dragonflies (Odonata: Anisoptera) in the collection of the Instituto de Ciencias Naturales, Universidad Nacional de Colombia. *Boln Mus. Ent. Univ. Valle* 10(1): 37-41. (With Span. s.). – (Inst. Cienc. Nat., Univ. Nacn. Colombia, Bogotá-7495, Colombia). The collection at Bogotá holds ca 2900 odon. specimens (53% of which are Anisoptera), collected since 1940 across 27 departments of the country. The 91 anisopteran spp. are here listed along with the alt. range of the localities and the distribution across the departments. The presence of *Uracis siemensi*, *U. infumata* and *Zenithoptera viola* in Colombia is confirmed.
- (17927) PEREZ GUTIERREZ, L.A., 2009. Crisis de la taxonomía en la odonología colombiana. *Boln Mus. ent. Gallego* 1(3): 4-5. – (Author's postal address not stated). An Editorial, with emphasis on the required priorities in the odonatol. research in Colombia (ca 350 recorded spp., ca 600 potentially expected spp.).
- (17928) REMSBURG, A.J. & M.G. TURNER, 2009. Aquatic and terrestrial drivers of dragonfly (Odonata) assemblages within and among north-temperate lakes. *Jl N. Am. benthol. Soc.* 28(1): 44-56. – (First Author: Biodiv. Cent., Unity Coll., Unity, ME 04988, USA). The physical structure of vegetation influences diversity, interactions, movement and thermoregulation of animals. Vegetation structure might be a good indicator of habitat requirements of generalist predators, such as Odon., and thereby affect species diversity. Odon. use aquatic and terrestrial habi-

tats during larval and adult life stages, respectively, but the relative importance of vegetation in these habitats is poorly understood. Here, a comparison is made how aquatic and riparian habitat variables affected odon. larvae from 41 sites (each 30 m in shoreline length) on 17 lakes in northern Wisconsin, USA. Principal components analysis was used to reduce multiple habitat variables to 2 lake-level axes (lake size and development, lake wetlands and predators), 2 site-level littoral axes (littoral macrophytes, littoral muckiness), and 2 site-level riparian axes (riparian structural complexity, riparian tall wetland plants). Most (61.6%) of the variance in larval species richness occurred at the site level. Density of the most abundant fam., Gomphidae, was positively related to riparian tall wetland plants, whereas species richness was positively correlated with abundance of littoral macrophytes (on the basis of multiple linear regression with an information theoretic approach). Surveys in 18 paired littoral microsites in 9 lakes indicated that larvae from the clasper and sprawler behavioural guilds were most abundant in microsites with submerged macrophytes. However, predation risk, assessed by tethering larvae in patches of submerged macrophytes, did not differ between habitats with and without macrophytes. It was tested whether shoreline plants affected recruitment from the adult stage by comparing adult odon. behaviours in response to 2 riparian vegetation treatments. Adult Zygoptera abundance was higher where potted wetland plants were placed than at manicured lawns without tall vegetation. The results indicate that odon. larvae might be influenced by vegetation structure in both aquatic and riparian habitats and demonstrate how animals with complex life histories link aquatic and terrestrial communities.

- (17929) SCHMIDT, E., 2009. Am Beispiel Karpfenzucht im Teichgut Hausdülmen: Artenvielfalt durch Fischkultur. *Naturzeit im Münsterland* 6(11): 14-15. – (Coesfelder Str. 230, D-48249 Dülmen). The specific, man-controlled environmental conditions required for carp-breeding ponds in Münsterland (NW Germany) are described. They are responsible for high biodiversity in these habitats. In particular, they trigger the occurrence of southern odon. spp., among which *Sympetrum depressiusculum* is the most noteworthy. – See also E.G. Schmidt, 2008, *Notul. odonatol.* 7: 5-10.
- (17930) [SCHMIDT, E.G.] MANNINGHAUS, R., 2009. Ein ökologisches Kleinod: das Teichgut Hausdülmen ist einzigartig in Nordrhein-Westfalen. *Dülmen Streiflichter* 16(506): 1, 3. – (c/o Prof. Dr E. Schmidt, Coesfelder Str. 230, D-48249 Dülmen). With Prof. Eb. Schmidt in the Teichgut Hausdülmen, a wetland area nr Dülmen (NW Germany), with highlights of the local fauna. The effects of carp breeding on odon. community are emphasized. In the article, published in a local house-to-house advertisement periodical, 2 field portraits of E.S. are also included.
- (17931) SUHLING, F., A. MARTENS, K.G. LEIPPELT, C. SCHÜTTE & B. HOPPE-DOMINIK, 2009. Libellen Braunschweigs: Verbreitungsmuster und Bestandstrends der Libellenfauna einer Grossstadt (Odonata). *Braunschweig naturk. Schr.* 8(2): 449-476. (With Engl. s.). – (First Author: Inst. Geoökol., Abt. Umweltsystemanalyse, Langer Kamp 19c, D-38106 Braunschweig). During 1980-2009, 51 spp. were recorded in the city area of Braunschweig (Germany). With a data base of 4405 records from 180 localities and relatively continuous field work throughout this period, distribution patterns as well as long-term trends in the occurrence of spp. were analysed. For several spp. distinct trends of decline (*Coenagrion pulchellum*, *Ischnura pumilio*, *Sympetrum danae*, *S. pedemontanum*) or increase (*Sympetma fusca*, *Gomphus vulgatissimus*, *Ophiogomphus cecilia*, *Orthetrum brunneum*, *O. coerulescens*) could be detected and related to local habitat variation and general population trends. The diversity of the Braunschweig odon. fauna can be explained by the presence of pond systems in the urban periphery and by the presence of 2 rivers and their floodplain remnants: both habitat types were improved by restoration and conservation measures.
- (17932) TENNESSEN, K.J., 2009. Description of the final instar nymph of *Homeoura nepos* (Selys, 1876) (Odonata: Coenagrionidae). *Zootaxa* 2286: 65-68. – (125 N Oxford St., Wautoma, WI 54982, USA). The description of *H. nepos* larva by P.P. Calvert (1948, *Bolm Mus. nac. Rio de J. [Zool.]* 887: 1-34) was based on a single immature specimen from São Paulo, Brazil which lacked gills. The larvae of *H. chelifera* and *H. lindneri* were described by F. Lozano et al. (see OA 17914), who considered Cal-

vert's *H. nepos* description doubtful. Here, description and illustrations of *H. nepos* reared specimens from Bolivia are provided. The structural features of the 3 spp. are compared, whereas *H. obrieni* and *H. sobrina* larvae remain unknown.

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- (17933) DAMM, S., K.-D.B. DIJKSTRA & N. HADRY, 2010. Red drifters and dark residents: the phylogeny and ecology of a Plio-Pleistocene dragonfly radiation reflects Africa's changing environment (Odonata, Libellulidae, Trithemis). *Mol. Phylog. Evol.* 54: 870-882. — (Second Author: Naturalis, P.O. Box 9517, NL-2300 RA Leiden). In the last few million years, tropical Africa has experienced pronounced climatic shifts with progressive aridification. Such changes must have had a great impact on freshwater biota, such as Odon. With about 40 spp., *Trithemis* dominates dragonfly communities across Africa, from rain-pools to streams, deserts to rainforests, and lowlands to highlands. Red-bodied spp. tend to favour exposed, standing and often temporary waters, have strong dispersal capacities, and some of the largest geographic ranges in the genus. Those in cooler habitats, like forest streams, are generally dark-bodied and more sedentary. Here, molecular analyses of ND1, 16S, and ITS (ITS1, 5.8S, and ITS2) is combined with morphological, ecological and geographical data for 81% of known *Trithemis* spp., including 3 Asian and 2 Madagascan endemics. Using molecular clock analyses, the genus's origin was estimated 6-9 Mya, with multiple lineages arising suddenly around 4 Mya. Open stagnant habitats were inferred to be ancestral and the rise of *Trithemis* may have coincided with savanna-expansion in the late Miocene. The adaptation of red spp. to more ephemeral conditions leads to large ranges and limited radiation within those lineages. By contrast, 3 clades of dark spp. radiated in the Plio-Pleistocene, each within distinct ecological confines: (1) lowland streams, (2) highland streams, and (3) swampy habitats on alternating sides of the Congo-Zambezi watershed divide; together giving rise to the majority of species diversity in the genus. During *Trithemis* evolution, multiple shifts from open to more forested habitats and from standing to running waters occurred. Allopatry by habitat fragmentation may be the dominant force in speciation, but possibly genetic divergence across habitat gradients was also involved. The study demonstrates the importance of combining ecological and phylogenetic data to understand the origin of biological diversity under great environmental change.
- (17934) DOW, R.A., 2010. Two new Platystictidae (Odonata, Zygoptera) from Sarawak, Malaysian Borneo. *Zootaxa* 2412: 63-68. — (Naturalis, P.O. Box 9517, NL-2300 RA Leiden). *Drepanosticta sbong* sp. n. (holotype ♂: Malaysia, Sarawak, Kapit div., Sungai Sbond, 11-II-2008) and *Protosticta tubau* sp. n. (holotype ♂: Malaysia, Sarawak, Bintulu div., Planted Forest zone, Tubau area, block E2K, 16-VII-2009) are described and illustrated. The types are to be deposited in RMNH, Leiden.
- (17935) 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. SAHLÉN, 2010. *European Red List of dragonflies*. Publication Office of the European Union, Luxembourg. viii+28 pp. ISBN 978-92-79-14153-9. DOI: 10.2779/84650. Available from: Publication Office of the European Union, <http://bookshop.europa.eu>; and from IUCN Publication Services, www.iucn.org/publications.

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

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