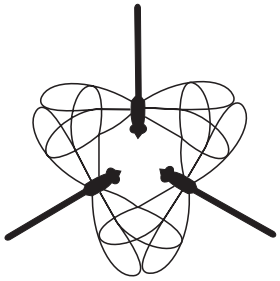

ISSN 0375-0183

Indexed in *Current Contents, Science Citation Index* and *Research Alert*, and covered by most of the major abstracting services

# ODONATOLOGICA

JOURNAL OF THE SOCIETAS INTER-NATIONALIS ODONATO-LOGICA S.I.O.



| Odonatologica | Vol. 40 | No. 3 | pp. 169-276 | September 1, 2011 |
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*ODONATOLOGICA* publishes original papers in all fields of odonatology. It is a quarterly, published for the International Odonatological Foundation, SOCIETAS INTERNATIONALIS ODONATOLOGICA (S.I.O.). It is general policy that submitted papers will be refereed.



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*Odonatologica 40(3): 169-178* *September 1, 2011*

# OVIPOSITION AND DETAILS OF EGG SHELL FINE STRUCTURE IN *CERIAGRION COROMANDELIANUM* (FABRICIUS) (ZYGOPTERA: COENAGRIONIDAE)

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*Received August 3, 2010 / Revised and Accepted April 3, 2011*

In central India, floating leaves of *Nymphaea nouchali* form a perfect site for landing and oviposition for *C. coromandelianum.* Experiments with *N. nouchali* leaves suggest that oviposition occurs preferentially within distinct region of the leaf lamina. Oviposition is maximal in the lateral region of the lamina (LRL) which was the most popular site over the whole period of observation and least in the petiolar region (PRL) while at the basal and apical regions (BRL & ARL) the total number of oviposition are similar to each other and intermediate between the lateral and petiolar regions. There is a direct correlation between the position of leaf laminar region used for oviposition and the day of oviposition. There is also a direct association between the day of the bouts of oviposition and the position of the leaf laminar region used for oviposition. In *C. coromandelianum*, visual and tactile cues play an important role in leaf lamina preference. It is not the toughness of the leaf lamina (thickness of the epidermis) but its submergence which is an important decisive factor for oviposition. – Scanning electron microscopic examination of the egg reveals that it is elongate and cylindrical with a pointed anterior and rounded posterior end. The egg chorion is composed of an outer, thin, lightly corrugated exochorion and an inner, thick, smooth, non-porous endochorion. The anterior end is surrounded by 5 micropylar orifices. Each orifice is semicircular and continues as a long horizontal streak on the endochorion and concludes at a bifid terminal point. This forms the entry point of the micropylar chute which penetrates the endochorion. The vitelline envelope below the endochorion is thin and smooth.

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## INTRODUCTION

The large floating leaf of *Nymphaea nouchali* has always been a suitable site for egg deposition by Zygoptera; mostly those which do not exhibit submerged oviposition (CORBET, 1999). These leaves form a perfect landing site for the ovipositing female and provide a large surface area for egg deposition and conspecific group oviposition. The large leaf also provides protection from aquatic predators (MARTENS, 1991, 1993a, 1993b; CORBET, 1999). There have been many observations regarding the preferences of oviposition plant and their parts (MOKRUSHOV & FRANTSEVICH, 1976; WAAGE, 1987; MARTENS, 1991, 1993a, 1993b, 2001).

Scanning electron microscope studies of the insect egg chorion have revealed important information of immense taxonomic and functional significance (HINTON, 1981; MARGARITIS, 1985). In Odonata, most of the fine structural studies of the egg chorion are confined to Anisoptera ( MILLER, 1987; IVEY et al., 1988; BENKLE & DUNKLE, 1990; TRUEMAN, 1990,1991; SAHLEN, 1994a,b; ANDREW & TEMBHARE, 1992, 1995, 1996, 1997; ANDREW, 2002, 2009; GAINO et al., 2008) and very few attempts have been made to study the chorion in Zygoptera, which always exhibit the endophytic mode of oviposition, using the ovipositor to insert eggs into plant material (SAHLEN, 1995; CORBET, 1999).

The present work has therefore been undertaken to study the preferential selection of the leaf laminar region for oviposition by *Ceriagrion coromandelianum* and to examine the fine structure of the egg chorion using scanning electron microscopy.

## MATERIAL AND METHODS

STUDY SPECIES – *Ceriagrion coromandelianum* is one of the most common Zygoptera in the Indian subcontinent. It flies among bushes and breeds in stagnant pools and small garden tanks, tubs and ornamental cement ponds containing submerged and/or floating vegetation. The females visit water only for reproduction and oviposition while the males can be spotted at all times around the shrubs near ovipositing sites (MITRA, 2006; ANDREW et al., 2008).

OVIPOSITION SUBSTRATE – The leaves of *Nymphaea nouchali* are large and flat, rounded or oval in shape with notched margins, and cleft almost to the centre where the petiole is attached. The leaves show many interesting adaptations to their aquatic environment. The margins are slightly rolled inwards toward the uppermost side (involute) which helps keep the blades afloat. The underside of the leaf, which is continually wet, has a strong attraction to the water and this holds the leaf flat against the water. The veins act like a structural support for the leaves. The upper leaf surface is coated with a smooth waxy cuticle, which gives it the appearance of being leathery and shiny (PLANTZAFRICA, 2010).

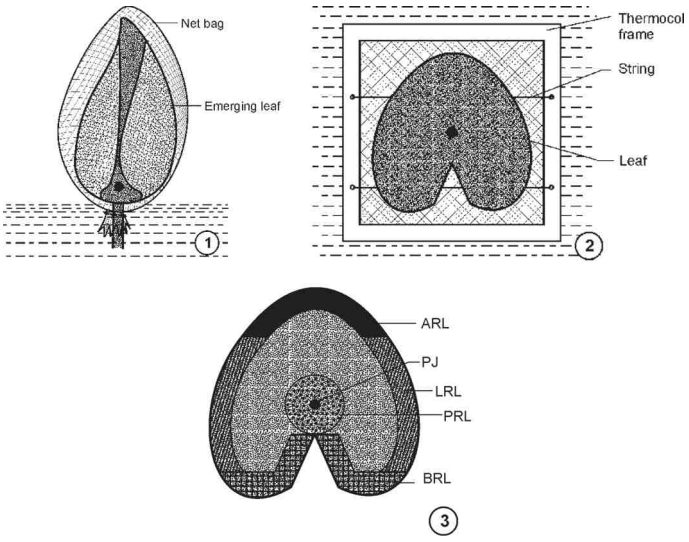
SITE – The experiments were carried out at the Botanical garden of Hislop College, Nagpur, (21°10'N, 79° 2' E) where small underground cement tubs are used to grow macrophytes. The tubs mostly contain floating (*N. nouchali* and/or *Lemna perpusilla)* and submerged (*Hydrilla verticillata*). The tubs are surrounded by bushes of flowering plants and by post-noon this area is in the shadow

of the college building. *C. coromandelianum* is found almost all around the year (except from December to February) breeding in these tubs.

EXPERIMENTAL DESIGN − Experiments were carried out in March-April 2008 and August-September 2009 to determine the preferential choice of the laminar region of the leaf for oviposition by *C. coromandelianum.* The leaf emerges out of the water upright, curled and horizontal to the water surface. The selected leaf was covered by a net-bag so that it could not be used as an ovipositing substrate by the damselflies (Fig. 1). As the leaf grows it comes to lie flat on the water surface and attains a circular or oval shape. The leaf was covered by a net attached to a square (35 cm) thermocol frame and tied by string (Fig. 2). The frame was removed for two hours (9.30-11.30 am), since the females of *C. coromandelianum* in tandem are mostly found ovipositing during these hours. The leaf rim was checked daily for deposited eggs. This continued for ten days and was repeated three times. The border of the leaf lamina was divided into four regions, the cleft basal region (BRL), the lateral region (LRL), the apical region (ARL) and the petiolar region (PRL) (Fig. 3). The largest circular tub (90 cm in diameter) in the garden containing floating leaves of *N. nouchali* and submerged *H. verticillata* was used (Figs 4-6).

SCANNING ELECTRON MICROSCOPY − Eggs were extracted from the leaf lamina, dehydrated in ethanol, transferred to acetone, air dried, mounted on stubs, gold coated and examined under the JEOL 6380A scanning electron microscope.

STATISTICAL ANALYSIS − To study the pattern of oviposition in the four sites, we combined the data for three leaves two days at a time to produce a frequency table (Tab. II). The Chi-square test was used to test any preference for a particular area of the leaf lamina, assuming that there was no association between the day of oviposition and the area chosen.

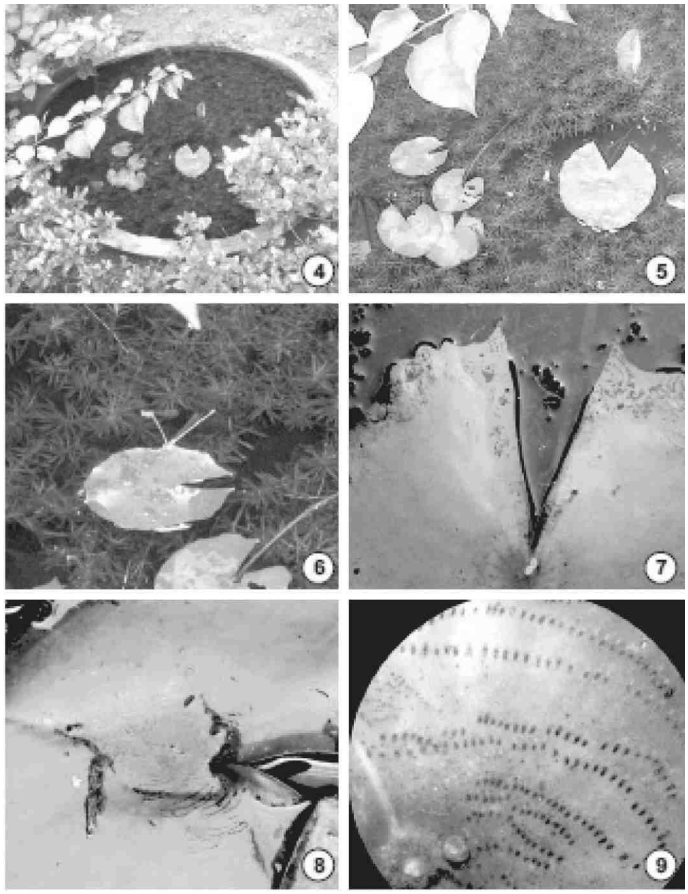



Figs 1-3. Experimental design to study the preferential selection of leaf laminar region: (1) net covering on the emerging leaf of *Nymphaea nouchali*; − (2) net covering on the completed emerged leaf of *N. nouchali*; − (3) division of the various regions of the leaf laminar region of *N. nouchali* [ARL: apical region of lamina; − BRL: basal region of lamina; − LRL: lateral region of lamina; − PJ: petiole junction; − PRL: petiolar region of lamina].

## RESULTS

### SELECTION OF LEAF LAMINAR REGION

*Ceriagrion coromandelianum* oviposits in different regions of the leaf lamina of *Nymphaea nouchali* (Figs 7-9). The oviposition pattern was observed for ten days on three leaves (Tab. I). The data was then combined for each pair of days, summing the data for all three leaves (Tab. II). The relationship between the day of oviposition and the leaf laminar region was found to be significant. Oviposition is maximal in the lateral region of the lamina (LRL) which was the most popu-




Figs 4-9. Oviposition in *Ceriagrion coromandelianum*: (4-5) the cement water tubs filled with *Hydrilla verticillata* and *Nymphaea nouchali*; – (6) ovipositing pair on the leaf of *N. nouchali*; – (7) basal laminar region of the leaf lamina with inserted eggs; – (8-9) submerged region of leaf lamina around the petiole filled with oviposited eggs.

lar site over the whole period of observation and least in the petiolar region (PRL) while at the basal and apical regions (BRL & ARL) the total number of oviposition are similar to each other and intermediate between the lateral and petiolar regions.

The maximum frequency of bouts of oviposition is found to be around the diagonal of the table (Tab. II) indicating that there is a direct correlation between the position of leaf laminar region used for oviposition and the day of oviposition. There is also a direct association between the day of the bouts of oviposition and the position of the leaf laminar region used for oviposition. Oviposition starts at the BRL followed by the LRL and continues at the ARL and PRL. Oviposition is maximum at BRL on days 1-2. Progressively, as days pass the egg-laying increases at LRL and then ARL and PRL regions of the leaf lamina.

## EGG CHORION ULTRA STRUCTURE

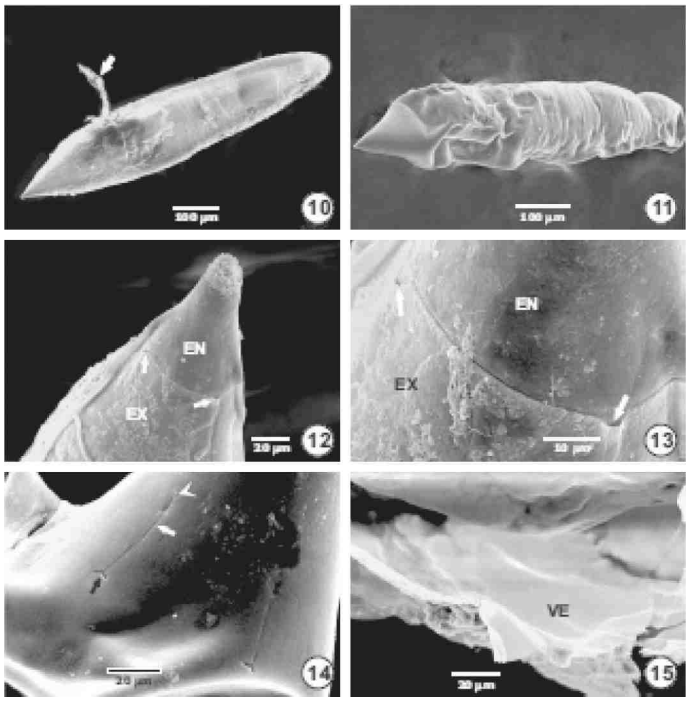
Scanning electron microscopic examination of the oviposited egg of *C. coromandelianum* reveals that

Table I

Oviposition pattern of *Ceriagrion coromandelianum* observed for ten days in different leaf laminar regions of three leaves of *Nymphaea nouchali.* – [BRL, basal region of lamina; LRL, lateral region of lamina; ARL, anterior region of lamina; PRL, petiolar region of lamina]

| Day | BRL | LRL | ARL | PRL | Total |
|---|---|---|---|---|---|
| | | Leaf 1 | | | |
| 1 3 | 1 | 0 | 0 | 4 | |
| 2 3 | 2 | 1 | 0 | 6 | |
| 3 4 | 3 | 0 | 0 | 7 | |
| 4 2 | 2 | 2 | 0 | 6 | |
| 5 0 | 4 | 2 | 0 | 6 | |
| 6 0 | 3 | 2 | 2 | 7 | |
| 7 0 | 0 | 0 | 2 | *2* | |
| 8 0 | 0 | 0 | 2 | 2 | |
| 9 0 | 0 | 1 | 1 | 2 | |
| 100 | 0 | 0 | 0 | 0 | |
| *Total* | *12* | *15* | *8* | *7* | *42* |
| | | Leaf 2 | | | |
| 1 4 | 2 | 0 | 0 | 6 | |
| 2 3 | 4 | 0 | 0 | 7 | |
| 3 2 | 4 | 1 | 0 | 7 | |
| 4 0 | 3 | 4 | 0 | 7 | |
| 5 1 | 3 | 2 | 0 | 6 | |
| 6 0 | 4 | 1 | 2 | 7 | |
| 7 0 | 0 | 2 | 3 | 5 | |
| 8 0 | 0 | 0 | 2 | 2 | |
| 9 0 | 0 | 1 | 1 | 2 | |
| 100 | 0 | 0 | 0 | 0 | |
| *Total* | *10* | *20* | *11* | *8* | *49* |
| | | Leaf 3 | | | |
| 1 2 | 3 | 0 | 0 | 5 | |
| 2 4 | 3 | 2 | 0 | 9 | |
| 3 3 | 5 | 3 | 0 | 11 | |
| 4 2 | 6 | 3 | 3 | 14 | |
| 5 1 | 2 | 1 | 2 | 6 | |
| 6 2 | 4 | 3 | 2 | 11 | |
| 7 0 | 0 | 2 | 3 | 5 | |
| 8 0 | 0 | 0 | 0 | 0 | |
| 9 0 | 0 | 1 | 1 | 2 | |
| 100 | 0 | 0 | 1 | 1 | |
| *Total* | *14* | *23* | *15* | *12* | *64* |

the egg bears a typically endophytic structure; it is elongate (980 ± 30 μm in length and 140 ± 20 μm in width at the mid region) and cylindrical, with a pointed anterior and rounded posterior end (Fig. 10). The egg chorion is composed of an outer thin (2-4 μm), lightly corrugated exochorion (EX) and an inner, thick (6-10 μm), smooth, non-porous endochorion (EN). The EX is thinner at the anterior end and easily gets detached from the EN. The EX is completely obliterated in some of the older developing eggs (Fig. 11). The pointed anterior end of the egg is surrounded by five micropylar orifices (Figs 12,13). Each orifice is semicircular (3μm) and continues as a long (35-40 μm) horizontal streak (indentation) on the EN and concludes at a bifid "V" shaped terminal point. This forms the entry point of the micropylar chute which penetrated the endochorion (Fig. 14). The




Figs 10-15. SEM micrographs of C*eriagrion coromandelianum* eggs: (10) fresh egg showing elongate cylindrical structure with rounded posterior end and pointed apical end covered with a thin peeling exochorion (arrow); – (11) eight day old egg showing completely obliterated exochorion; – (12-13) apical tip of the egg showing outer, thin, lightly corrugated exochorion (EX), inner, thick, smooth, non-porous endochorion and a pair of micropylar orifices (white arrows); – (14) the micropylar apparatus with the exochorion removed. Note the indentation on the endochorion of the micropylar orifice (white arrow), micropylar streak (white arrow) and "V" shaped terminal point (black arrow); – (15) fractured eggshell showing smooth vitelline envelope (VE).

Table II
Observed frequency of the total number of ovipositions by *Ceriagrion coromandelianum* in different leaf laminar regions of three leaves of *Nymphaea nouchali* in pairs of days. – [BRL: basal region of lamina; – LRL: lateral region of lamina; – ARL: anterior region of lamina; – PRL: petiolar region of lamina]

| Day | BRL | LRL | ARL | PRL | Total |
|---|---|---|---|---|---|
| 1-2 | 19 | 15 | 3 | 0 | 37 |
| 3-4 | 13 | 23 | 13 | 3 | 52 |
| 5-6 | 4 | 20 | 11 | 8 | 43 |
| 7-8 | 0 | 0 | 4 | 12 | 16 |
| 9-10 | 0 | 0 | 3 | 4 | 7 |
| *Total* | *36* | *58* | *34* | *27* | *155* |

micropylar marking too is erased in older eggs. The vitelline envelope lodged below the EN is smooth and thin, about 1 to 1.5 μm in thickness and devoid of any reticulations (Fig. 15).

## DISCUSSION

The present study clearly indicates that *C. coromandelianum* exhibits a distinct preferential choice of selection for oviposition in the floating leaf of *N. nouchali.*

Initially the choice of oviposition site was in the basal or lateral regions of the lamina, with a slight (but not significant) preference for the former. Between days 3 and 6 the lateral region was the main choice. Under the lower margin around the base the lamina is thicker than the apical end of the leaf. It thus provides a much better choice for egg deposition than the apical end because the eggs are completely inserted and therefore well protected. Further, the angular cleft base of the lamina is slightly curled all along its cleft border which probably scatters and reflects the sunlight in a different pattern from the rest of the laminar region, which in turn may attract the female for oviposition. MOKRUSHOV & FRANTSEVICH (1976) and WILDERMUTH (1993) reported that responses to polarized light are involved in odonate site selection for oviposition. In windy conditions, the margins (apex and lateral rim of the lamina) flap faster and disturb the oviposition pair than the basal region of the lamina which is anchored nearer to the petiole.

The lateral margin of the lamina is slightly submerged in water in a wavy pattern. This causes a change in the reflection and refraction pattern of light which may also attract females for oviposition. MARTENS (1993a, 1993b) reported that oviposition sites can be detected by the female from the wavelength composition of the light reflected from the leaves.

The anterior region of the lamina was used quite often on days 3-6, possibly because the complete leaf margin was becoming full of deposited eggs and so the female had no choice but to oviposit in the remaining apical margin of the leaf.

Later in the study (days 7-8) the petiolar region was preferred. Although CORBET (1999) reported that zygopterans prefer to oviposit along the undersurface of the floating leaf because it has a thinner epidermis and wax layer, which make it easier for the ovipositor to pierce and deposit the egg inside the plant tissue, it was the upper surface that was preferred in the present study. At this stage the female had no choice but to cut through the thick waxy upper layer and deposit the eggs around the petiole junction because this was the only area of the leaf which was always submerged underwater and had not yet been used for oviposition.

The present results demonstrate that visual and tactile cues play an important role in the region of the leaf lamina preferred for oviposition in *C. coromandelianum.* It further indicates that it is not the softness of the leaf but its submergence which is essential for oviposition in this species. MARTENS (2001), while studying the preferential oviposition sites and the discrimination between living and dead plant material by *Sympecma fusca* and *Coenagrion coerulescens*, reported that the dead wet plant tissue is nearly exclusively used for oviposition. He further suggested that odonates which do not diapause in the egg stage prefer to oviposit into dead plant tissue. In the present study, all observed ovipositing by *C. coromandelianum* took place in fresh, living leaves of *N. nouchali.*

The general shape and structure of the egg of *C. coromandelianum* is similar to other endophytic odonate eggs (SAHLEN, 1995; ANDREW & TEMBHARE, 1997; CORBET, 1999) but there are various fine structural variations. All endophytic eggs in odonates have numerous polygonal impressions of the follicle cell just below the base of the apex, which forms a loose collar-like structure, and the micropylar opening is lodged between these polygonal impressions (SAHLEN, 1994b, 1995; ANDREW & TEMBHARE, 1997). However, in *C. coromandelianum* the collar with hexagonal impressions is lacking and the micropylar structure is different from that of other zygopteran eggs (SAHLEN, 1995). Thus, in most endophytic zygopteran and anisopteran eggs, the micropylar chute penetrates across the endochorion from the micropylar orifice (SAHLEN, 1995) but in *C. coromandelianum* the chute runs along the outer surface of the endochorion and terminates at a bifid end point. The sperm penetrates the endochorion through this bifid point. Minute pores have been reported in the exochorion of *Coenagrion hastulatum* but are not found in *C. coromandelianum* and have also not been reported in studies of *Ischnura elegans, Pyrrhosoma nymphula*, and *Calopteryx virgo* (SAHLEN, 1995).

**ACKNOWLEDGEMENTS**

We wish to thank Dr R. BADARE (Dept. of Botany, Hislop College, Nagpur, India) for valuable suggestions and help in identification of plants. RJA thanks University Grants Commission, Pune, India for partial financial support under the minor research project #47-1041/09 (WRO).

**REFERENCES**

ANDREW, R.J., 2002. Egg chorionic ultrastructure of the dragonfly, Tramea virginia (Rambur) (Anisoptera: Libellulidae). *Odonatologica* 31: 171-175.

ANDREW R.J., 2009. Fine structure of the egg chorion in two anisopteran dragonflies from central India (Libellulidae). *Odonatologica* 38: 359-363.

ANDREW R.J. & D.B. TEMBHARE, 1992. Surface ultrastructure of the egg chorion in the dragonfly, Ictinogomphus rapax (Rambur) (Odonata: Gomphidae). *Int. J. Insect Morphol. Embryol.* 21: 347-350.

ANDREW, R.J. & D.B. TEMBHARE, 1995. Ultrastructural post-ovipositional changes in the chorion of the dragonfly, Zyxomma petiolatum Rambur (Odonata: Libellulidae). *Int. J. Insect Morphol. Embryol.* 24: 235-238.

ANDREW, R.J. & D.B. TEMBHARE, 1996. Surface ultrastructure of the egg chorion of Bradinopyga geminate (Rambur) and Rhyothemis variegata variegata (Linn.). *Fraseria* (NS), 3:1-5.

ANDREW, R.J. & D.B. TEMBHARE, 1997. The post-ovarian genital complex in Anax guttatus (Burmeister) (Anisoptera: Libellulidae). *Odonatologica* 26: 385-394.

ANDREW, R.J., K.A. SUBRAMANIAN & A.D. TIPLE, 2008. *A handbook of common odonates of central India.* Sth Asian Counc. Odonatol., Nagpur.

BECNEL, J.J. & S.W. DUNKLE, 1990. Evolution of micropyles in dragonfly eggs (Anisoptera). *Odonatologica* 19: 235-241.

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

GAINO, E., S. PIERSANTI & M. REBORA, 2008. Egg envelope synthesis and chorion modification after oviposition in the dragonfly Libellula depressa (Odonata, Libellulidae). *Tissue Cell* 40: 317-324.

HINTON, H.E., 1981. *Biology of insect eggs*, Vols 1-3, Pergamon Press, Oxford.

IVEY, R.K., J.C. BAILEY, B.P. STARK & D.L. LEMTZ, 1988. A preliminary report of egg chorion features in dragonflies (Anisoptera). *Odonatologica* 17: 393-399.

MARGARITIS, L.H., 1985. Structure and physiology of the eggshell. *In:* G.A. Kerkut & L.I. Gilbert, [Eds], *Comprehensive insect physiology, biochemistry and pharmacology*, Vol. 1., pp. 153-230, Pergamon Press, Oxford.

MARTENS, A., 1991. Plasticity of mate-guarding and oviposition behaviour in Zygonyx natalensis (Martin) (Anisoptera: Libellulidae). *Odonatologica* 20: 293-302.

MARTENS, A., 1993a. Influence of cospecific and plant structures on oviposition site selection in Pyrrhosoma nympula (Sulzer) (Zygoptera: Coenagrionidae). *Odonatologica* 22: 487-494.

MARTENS, A., 1993b. Field experiments on aggregation behavior and oviposition in Coenagrion puella (L.) (Zygoptera: Coenagrionidae). *Adv. Odonatol.* 6: 49-58.

MARTENS, A., 2001. Initial preference of oviposition site: discrimination between living and dead plant material in Sympecma fusca and Coenagrion caerulescens (Odonata: Lestidae, Coenagrionidae). *Eur. J. Ent*. 98: 121-123.

MILLER, P.L., 1987. Oviposition behaviour and eggshell structure in some libellulid dragonflies, with particular reference to Brachythemis lacustris (Kirby) and Orthetrum coerulescens (Fabricius) (Anisoptera). *Odonatologica* 16: 361-374.

MITRA, T.R., 2006. *Handbook of common Indian dragonflies*. Zool. Surv. India, Kolkata.

MOKRUSHOV, P.A. & L.I. FRANTSEVICH, 1976. [Visual stimuli in behaviour of dragonflies, 3: choice of setting place in Erythromma najas.]. *Vest. Zool.* 1976(4): 20-24.

PLANTZAFRICA 2010. (http://www.plantzafrica.com/plantnop/nymphnouch.htm 02/03/10).

SAHLEN, G., 1994a. Ultrastructure of the eggshell and micropylar apparatus of Somatochlora metallica (Vander L.), Orthetrum cancellatum (L.) and Sympetrum sanguineum (Mull.) (Anisoptera; Corduliidae and Libellulidae). *Odonatologica* 23: 255-269.

SAHLEN, G., 1994b. Ultrastructure of the eggshell of Aeshna juncea (L.) (Odonata; Aeshnidae). *Int. J. Insect Morphol. Embryol.* 23: 345-354.

SAHLEN, G., 1995. Transmission electron microscopy of the eggshell in five damselflies (Odonata: Coenagrionidae, Megapodagrionidae and Calopterygidae). *Odonatologica* 24: 311-318.

TRUMAN, J.W.H., 1990. Eggshells of Australian Gomphidae: plastron respiration in eggs of stream-dwelling Odonata (Anispotera). *Odonatologica* 19: 395-407.

TRUMAN, J.W.H., 1991. Egg chorionic structures in Corduliidae and Libellulidae (Anisoptera). *Odonatologica* 20: 441-452.

WAAGE, J.K., 1987. Choice and utilization of oviposition sites by female Calopteryx maculata (Odonata: Calopterygidae), 1: influence of site size and the presence of other females. *Behav. Ecol. Sociobiol.* 20: 439-449.

WILDERMUTH, H., 1993. Habitat selection and oviposition site recognition by the dragonfly Aeshna juncea (L.): an experimental approach in natural habitats (Anisoptera: Aeshnidae). *Odonatologica* 22: 27-44.

*Odonatologica 40(3): 179-190* *September 1, 2011*

# A BIODIVERSITY HOTSPOT FOR ODONATES IN MEXICO: THE HUASTECA POTOSINA, SAN LUIS POTOSÍ

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*Received August 6, 2010 / Reviewed and Accepted January 2, 2011*

The Huasteca Potosina in the state of San Luis Potosí represents the second hotspot for odon. diversity in Mexico. A total of 11 fam., 49 gen. and 126 spp. for the region are recognized. Estimated richness values using the nonparametric estimators ICE and Chao2 were 174.3 and 204.55 species respectively. The odon. diversity of the HP is surpassed in Mexico only by that of the region of Los Tuxtlas with 139 spp.

## INTRODUCTION

Tropical forests harbour the highest diversity of Odonata of the world (MAY, 1979; JURZITZA, 1981; PAULSON, 1985, 2006, KALKMAN et al., 2008). According to PAULSON (1985), some sites in the neotropics contain more than one hundred species, a situation that is unparalleled by any other temperate area of the world (see in contrast AZPILICUETA et al., 2007). In Mexico only two such hotspots has been recorded to date, the area of Los Tuxtlas in Veracruz state with approximately 139 species (GONZÁLEZ-SORIANO, 1997; and unpublished data) and more recently the area of sierra de Coalcomán in Michoacán state with 116 species (NOVELO-GUTIÉRREZ & GÓMEZ-ANAYA, 2009).

The Huasteca Potosina (HP), in the state of San Luis Potosí, is considered as a high priority hydrological region due to its high biodiversity and some types of threat according to the standards of the Comisión Nacional para el Conocimiento y Estudio de la Biodiversidad (CONABIO) (ARRIAGA et al., 2000).

From 1957 to 1962 a series of expeditions to collect dragonflies in eastern Mexico were made by George H. Beatty from Pennsylvania State University. He and his associates visited 15 sites in the HP region, and the results were presented in an unpublished paper (BEATTY & BEATTY, 1962) recording 48 species of Odonata for the area. MAYA-FLORES (1994 unpublished) recorded 42 species of Zygoptera from the surroundings of the city of Ciudad Valles. More recently ALONSO--EGUIA et al. (2002) recorded 27 species in nine localities of the state.

Here we present a list of Odonata of the HP region, based on a survey of dragonflies collected by the authors but also on literature records and museum specimens deposited in the Frost Entomological Museum, PA and in the Colección Nacional de Insectos (CNIN) from the Instituto de Biología, UNAM. The 126 species found in the area make the HP the second richest area of Odonata diversity for Mexico, surpassed only by the Los Tuxtlas area in the state of Veracruz.

## STUDY AREA

The HP is located in the so-called Confluence of the Huastecas region (CONABIO, 1988). The last area comprises portions of the states of Veracruz, San Luis Potosi, Hidalgo and Querétaro and has an extent of 27,404.85 km$^2$. It is situated in the Pánuco River basin comprising the High and the

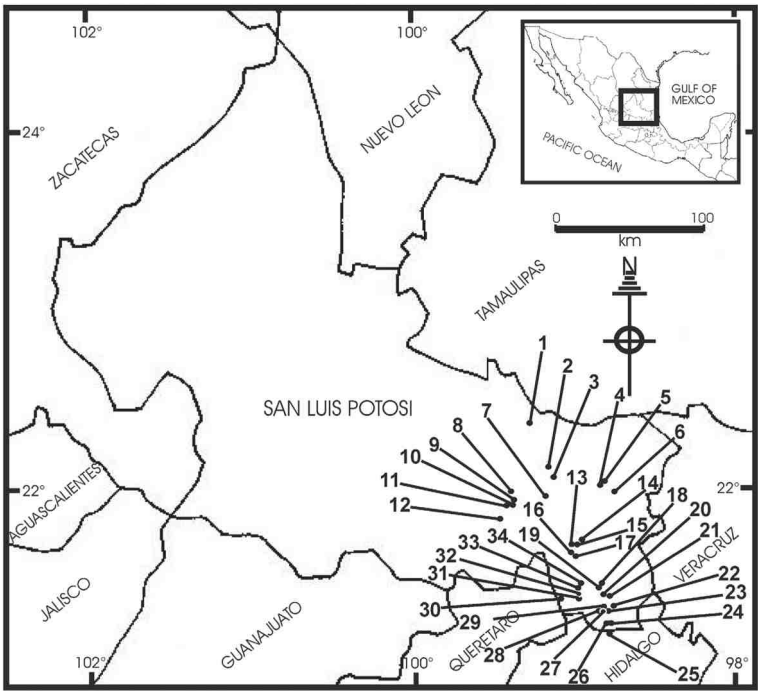


Fig. 1. Huasteca Potosina, collecting sites.

Low Pánuco basins (CARMONA-JIMÉNEZ, 1997). The Pánuco River is the fifth most important freshwater reservoir of Mexico. This basin belongs to the Gulf of Mexico slope and is located from 22°16' 48''-20°19' 48''N and 101°21' 00''-98°01'12'' W.

Most of the localities visited are located in the Low Pánuco basin beginning near Tamazunchale and extending to the coast through several tributaries (Amajac, Axtla, Moctezuma, Tempoal and

Table I
List of localities from Huasteca Potosina

| Localities | Municipality | Geographic location |
|---|---|---|
| 1. - Río El Salto | Ciudad del Maiz | 22.3877 N- 99. 2861W 1260 m asl |
| 2. - Río Micos | Ciudad Valles | 22. 1302 N- 99.1686 W 120 m asl |
| 3. - Cascada de Micos al NO Cd. Valles | Ciudad Valles | 22.0858 N- 99.1358 |
| 4. - Nacimiento del Río Florido | Ciudad Valles | 22.0350 N – 98.8541 W |
| 5. - Ejido Las Palmas | Tamuín | 22.0508 N-98.8244 W |
| 6. - Tamuín | Ciudad Valles | 21.9975 N-98.7588 W |
| 7. - Río Santa Anita | Aquismón | 21.9719 N-98.1883 140 m asl |
| 8. - Agua Buena | Tamasopo | 21.9941 N-99.3941 W |
| 9. - Balneario "Las Cascadas" N Tamasopo | Tamasopo | 21.9452 N-99.3850 W 320 m asl |
| 10. - Centro Acuícola "Tamasopo" | Tamasopo | 21.9202 N-99.3916 W |
| 11. - Puente de Dios | Tamasopo | 21.9188 N-99.4166 W 450 m asl |
| 12. - Hotel Taninul | Ciudad Valles | 21.8422 W-99.4725 W |
| 13. - Tanute, cerca de Tambaque | Aquismón | 21.6544 N-99.0372 W |
| 14. - Nacimiento del Río Coy | Ciudad Valles | 21.7191 N- 98.9683 W |
| 15. - Río Ojitipa al noroeste Palmira Viejo | Tancahuitz de Santos | 21.6858 N-99.0133 W |
| 16. - Tambaque | Aquismón | 21.6527 N-99.0358 W |
| 17. - 0.7 km de Aquismón | Aquismón | 21.6316 N-99.0094 W |
| 18. - Río Axtla | Axtla de Terrazas | 21.4613 N-98.8522 W |
| 19. - Arroyo al S Tamazunchale | Tamazuchale | 21.4511 N-98.8552 W |
| 20. - Nacimiento del Rio Choy | Ciudad Valles | 21.4108 N-98.8275 W 100 m asl |
| 21. - Río Moctezuma | Tamazunchale | 21.4047 N-98.7911 W 62 m asl |
| 22. - Arroyo en Palictla | Aquismón | 21.3452 N-98.7683 W |
| 23. - Arroyo N Tamazunchale | Tamazunchale | 21.3169 N-98.8011 W 62 m asl |
| 24. - El Sol | Tamazunchale | 21.2466 N- 98.7916 W |
| 25. - Arroyo bajo el puente de Hierro | Tamazunchale | 21.1888 N-98.7852 W |
| 26. - Parte del Río Moctezuma localizada 1.6 km al S Tamazunchale | Tamazunchale | 21.2502 N-98.8016 W 42 m asl |
| 27. - Arroyo aprox. 8 km N Tamazunchale | Tamazunchale | 21.3177 N-98.8275 W 132 m asl |
| 28. - Pequeño arroyo en barranca arbolada | Tamazunchale | 21.3175 N-98.8441 W 62 m asl |
| 29. - Arroyo cerca de la carretera 85 | Tamazunchale | 21.3338 N-98.8169 W 62 m asl |
| 30. - Al este de Xilitla | Xilitla | 21.3836 N-99.0941 W 137 m asl |
| 31. - Las Pozas de Xilitla | Xilitla | 21.3947 N-98.5277 W 600 m asl |
| 32. - La Conchita | Xilitla | 21.4088 N-98.9850 W |
| 33. - Nacimiento del Río Huichihuayán | Huehuetlán | 21.4516 N-98.9811 W 100 m asl |
| 34. - Río Huichiuayán | Huehuetlán | 21.4686 N-98.9669 W |

Table II
Families, number of species and percentage of total Odonata species from the Huasteca Potosina (N = 126)

| Families | No. of species | % total species |
|---|---|---|
| Libellulidae | 45 | 36 |
| Coenagrionidae | 34 | 26.9 |
| Gomphidae | 15 | 12 |
| Aeshnidae | 9 | 7.2 |
| Calopterygidae | 6 | 4.8 |
| Protoneuridae | 5 | 4 |
| Lestidae | 4 | 3.2 |
| Platystictidae | 3 | 2.4 |
| Pseudostigmatidae | 3 | 2.4 |
| Macromiidae | 1 | 0.8 |
| Megapodagrionidae | 1 | 0.8 |

Tampaón rivers). The altitude of these rivers is below 1500 m. Most of the localities are situated in a transect running between Xilitla and Ciudad Valles (excepting Ciudad del Maíz) (see Fig. 1 and Tab. I ). The vegetation and also the environmental and physicochemical conditions of the water of the collecting sites are relatively well known (PUIG,1991; CARMONA-JIMÉNEZ,1997; MEAVE DEL CASTILLO, 1997). The collecting sites were chosen because most of them are located in or near springs, hence show excellent water conditions.

## METHODS

Collections were made during May 1987, May 1989, June 1990, August 1999, June 2001 and July 2007, totaling 28 collecting days. Additional records were obtained from the material deposited in Colección Nacional de Insectos (CNIN, UNAM) and from the Frost Entomological Museum of the University of Pennsylvania (554 records). Additional records are from the literature (GLOYD, 1944; DAIGLE, 1991; DUNKLE, 1992; TENNESSEN, 1992; ALONSO-EGUIA et al., 2002; BEHRSTOCK, 2005; BEHRSTOCK et al., 2007). A total of 2537 records were obtained. In order to calculate the true diversity of the area an accumulation curve was projected using the program EstimateS (COLWELL, 1997). Each spot on the curve represents one collecting event.

## RESULTS

A total of 11 families, 49 genera and 126 species were recorded for the area (Tab. II). Libellulidae with 45 species was the most diverse family followed by Coenagrionidae (34), Gomphidae (15), Aeshnidae (9), Calopterygidae (6), Protoneuridae (5), Lestidae (4), Platystictidae (3), Pseudostigmatidae (3), Megapodagrionidae (1), and Macromiidae (1).

At the genus level, *Argia* was the most diverse (17 spp), followed by *Hetaerina* (6), *Micrathyria* (5), *Enallagma* (5), *Erythemis* (7), *Protoneura* (4), *Erpetogomphus* (4), *Phyllogomphoides* (4), *Brechmorhoga* (4), *Palaemnema* (3), *Ischnura* (3),*Teleba-*

*sis* (3), *Gynacantha* (3), *Dythemis* (3), *Macrothemis* (3), *Erythrodiplax* (3), *Tramea* (3), *Orthemis* (3), *Archilestes* (2), *Lestes* (2), *Mecistogaster* (2), *Anax* (2), *Aphylla* (2), *Progomphus* (2), *Libellula* (2), *Perithemis* (2) and *Tauriphila* (2). All remaining genera are represented by one species each.

The observed species (126 species) represent between 61.27- 71.83 % of the true richness of the area according with Chao2 (204 spp) and ICE (174 spp) estimates respectively. As shown in Figure 2, the accumulation curves do not reach an asymptote, probably indicating that more species could be found in the area with more collecting effort.

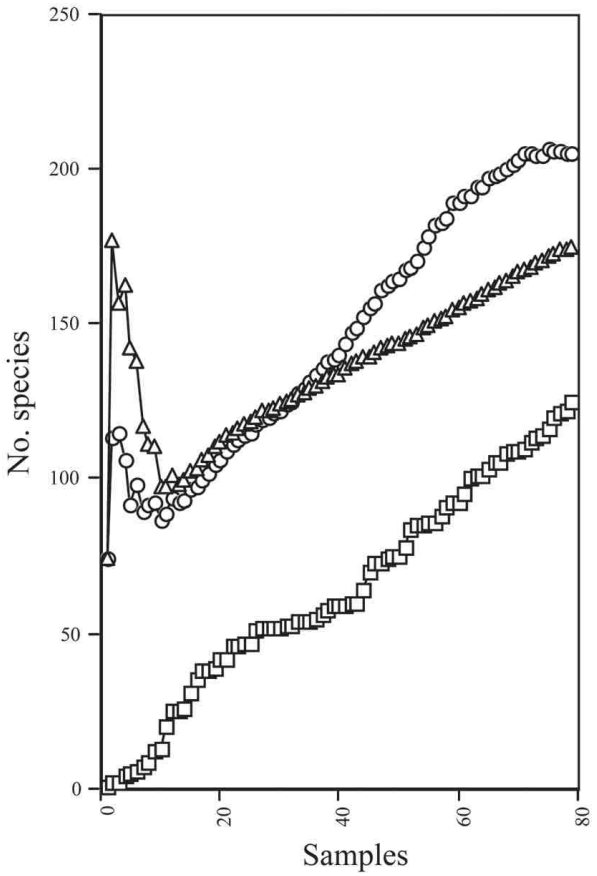


Fig. 2. Observed and estimated species accumulation curve of Odonata of Huasteca Potosina, SLP using two non-parametric estimators. – [Square: observed richness; – circle: estimated richness using Chao2; – triangles: estimated richness using ICE]

LIST OF ODONATA SPECIES FROM LA HUASTECA POTOSINA

Total 126 species; * = species not shared with Los Tuxtlas; ++ = a single female, probably of a new species.

| SPECIES | LOCALITIES |
|---|---|
| CALOPTERYGIDAE | |
| *Hetaerina americana* (Fabricius, 1798) | 1,2,3,9,20,26,33,34 |
| *H. capitalis* Selys, 1873 | 19,25,27,28 |
| *H. cruentata* (Rambur, 1842) | 27,31 |
| *H. infecta* Calvert, 1901 * | 31 |
| *H. occisa* Hagen in Selys, 1853 | 1,2,3,11,13,15,16,25,27,28,31,33,34 |
| *H. titia* (Drury, 1773) | 1,2,3,11,14,15,18,19,20,22,31,33,34 |
| LESTIDAE | |
| *Archilestes grandis* (Rambur, 1842) * | 8,11,21,23,30 |
| *A. regalis* Gloyd, 1944 | 19,28,31 |
| *Lestes forficula* Rambur, 1842 * | 20 |
| *L. tenuatus* Rambur, 1842 | 14 |
| MEGAPODAGRIONIDAE | |
| *Paraphlebia zoe* Selys, 1862 * | 19,28,31 |
| PSEUDOSTIGMATIDAE | |
| *Mecistogaster modesta* Selys, 1860 | 25,30,31 |
| *M. ornata* Rambur, 1842 | 1 |
| *Pseudostigma aberrans* Selys, 1860 | 23 |
| PLATYSTICTIDAE | |
| *Palaemnema paulicoba* Calvert, 1931 * | 1,2,3,11,14,15,33 |
| *P. paulitoyaca* Calvert, 1931 | 13,19,21,25,28,31 |
| *P.* sp. nov.* | 31 |
| PROTONEURIDAE | |
| *Neoneura amelia* Calvert, 1903 | 2,3,14,15,33 |
| *Protoneura aurantiaca* Selys, 1886 | 13,33 |
| *P. cara* Calvert, 1903 * | 1,2,3,12,14 |
| *P. corculum* Calvert, 1907 | 12 |
| *P. cupida* Calvert, 1903 | 22,25 |
| COENAGRIONIDAE | |
| *Acanthagrion quadratum* Selys, 1876 | 2,12,14,15,22,33 |
| *Apanisagrion lais* (Brauer in Selys, 1876) * | 11 |
| *Argia anceps* Garrison, 1996 | 30 |
| *A. barreti* Calvert, 1902 * | 2,8,11,14,15,21,33,34 |
| *A. calida* (Hagen, 1861) * | 15,33 |
| *A. cuprea* (Hagen, 1861) | 14,31 |
| *A. extranea* (Hagen, 1861) | 1,2,3,8,11,21,27,28,34 |
| *A. frequentula* Calvert, 1907 | 14, 15, 33 |
| *A. garrisoni* Daigle, 1991 * | 2,3,8,11,12,14,15,20,22,31,33,34 |
| *A. immunda* (Hagen, 1861) | 1,2,3,8,11,22,29 |
| *A. oculata* Hagen in Selys, 1865 | 2,8,11,13,22,28,33 |
| *A. oenea* Hagen in Selys, 1865 | 2,25,29,34 |
| *A. plana* Calvert, 1902 * | 2,11,31,32 |
| *A. pulla* Hagen in Selys, 1865 | 14,33 |
| *A. rhoadsi* Calvert, 1902 * | 1,7,8,14,15,21,22,29,33,34 |

| | |
|---|---|
| *A. sedula* (Hagen, 1861) * | 1,2,3,8,11,14,15,21,34 |
| *A. translata* Hagen in Selys, 1865 | 1,2,3,8,11,12,14,18,21,22,23,25,28,29,33,34 |
| *A. ulmeca* Calvert, 1902 | 3,8,11,14,19,28,31 |
| *A. westfalli* Garrison, 1996 * | 33 |
| *Enallagma basidens* Calvert, 1902 * | 1 |
| *E. civile* (Hagen, 1861) | 12 |
| *E. novaehispaniae* Calvert, 1907 | 1,2,7,8,15,18,22,25,33 |
| *Enallagma praevarum* (Hagen,1861) | 5 |
| *E. semicirculare* Selys, 1876 | 17 |
| *Ischnura capreolus* (Hagen, 1861) | 7 |
| *I. hastata* (Say,1839) | 6 |
| *I. posita* (Hagen, 1861) * | 8 |
| *I. ramburii* Selys, 1850 | 15,17 |
| *Leptobasis vacillans* Hagen in Selys, 1877 | 14,15, 34 |
| *Nehalennia minuta* (Selys in Sagra, 1857)* | 6 |
| *Neoerythromma cultellatum* (Selys, 1876) | 1 |
| *Telebasis filiola* (Perty, 1834) * | 6 |
| *T. levis* Garrison, 2008 | 6 |
| *T. salva* (Hagen, 1861) | 1,12 |
| AESHNIDAE | |
| *Anax amazili* (Burmeister, 1839) | 14 |
| *A. junius* (Drury, 1770) | 1 |
| *Coryphaeschna adnexa* (Hagen, 1861) | 20 |
| *Gynacantha helenga* Williamson & Williamson, 1930 * | 1,25 |
| *G. mexicana* Selys, 1868) | 14 |
| *G. nervosa* Rambur, 1842 | 14 |
| *Remartinia secreta* (Calvert, 1952) | 11 |
| *Rhionaeschna psilus* (Calvert, 1947) | 1 |
| *Triacanthagyna caribbea* Williamson, 1923 | 28 |
| GOMPHIDAE | |
| *Aphylla angustifolia* Garrison, 1986 | 7,14 |
| *A. protracta* (Hagen in Selys, 1859) | 14 |
| *Archaeogomphus furcatus* Williamson, 1923 * | 14 |
| *Erpetogomphus bothrops* Garrison, 1994* | 1,2,33 |
| *E. constrictor* Ris, 1918 * | 1,2,8,9,11,14,15,29,33 |
| *E. elaps* Selys, 1858 * | 1 |
| *E. eutainia* Calvert, 1905 | 14 |
| *Gomphus (Gomphurus) gonzalezi* Dunkle, 1992 * | 14 |
| *Phyllocycla breviphylla* Belle, 1975 | 2,14,15 |
| *Phyllogomphoides albrighti* ( Needham, 1950) * | 2,14 |
| *Phyllogomphoides* sp * (++) | 7 |
| *P. duodentatus* Donnelly, 1979 | 2,8,14,15 |
| *P. suasus* (Selys, 1859) | 1,3,8,11,19,25,28,29,33,34 |
| *Progomphus amarillus* Tennessen, 1992* | 12 |
| *P. clendoni* Calvert, 1905 | 1,2,33 |
| MACROMIIDAE | |
| *Macromia annulata* Hagen, 1861 * | 2 |
| LIBELLULIDAE | |
| *Brachymesia furcata* (Hagen, 1861) | 12 |

| | |
|---|---|
| *Brechmorhoga mendax* (Hagen, 1861) * | 3 |
| *B. nubecula* (Rambur, 1842) | 31 |
| *B. praecox praecox* Hagen, 1861 | 2,7,11,13,15,31 |
| *B. vivax* Calvert, 1906 | 2,3,20,22,31,32,33 |
| *Cannaphila insularis* (Carpenter, 1897) | 1,7,11,20 |
| *Dythemis multipunctata* Kirby, 1894 | 1,2,3,8,11,12,13,14,20,22,23,25,28,29,33,34 |
| *D. nigrescens* Calvert, 1899 * | 1,2,3,7,9,14,15,18,33,34 |
| *D. sterilis* Hagen, 1861 | 1,2,3,7,11,14,15,23,31,33 |
| *Elasmothemis aliciae* Gonzalez & Novelo, 2006 | 1,14,33 |
| *Erythemis attala* (Selys in Sagra, 1857) | 28 |
| *Erythemis haematogastra* (Burmeister, 1839) | 9 |
| *E. mithroides* (Brauer, 1900) * | 1,2,8 |
| *E. peruviana* (Rambur, 1842) | 14 |
| *E. plebeja* (Burmeister, 1839) | 2,14,15,22,33 |
| *E. simplicicollis* (Say, 1839) * | 14 |
| *E. vesiculosa* (Fabricius, 1775) | 1,2,3,14,15,20,25,34 |
| *Erythrodiplax fervida* (Erichson, 1848) | 17 |
| *E. fusca* (Rambur, 1842) | 1,7,14,15,21,22 |
| *E. umbrata* (Linnaeus, 1758) | 2,11,14,15,33,34 |
| *Libellula croceipennis* Selys, 1868 * | 1,2,3,11 |
| *L. herculea* Karsch, 1889 | 3 |
| *Macrothemis imitans leucozona* Ris, 1913 * | 1,25 |
| *M. inequiunguis* Calvert, 1895 | 7,14,33 |
| *M. pseudimitans* Calvert, 1898 | 9,11,23,27,31,33 |
| *Miathyria marcella* (Selys in Sagra, 1857) | 1 |
| *Micrathyria aequalis* (Hagen, 1861) | 1,17 |
| *M. debilis* (Hagen, 1861) * | 10,12 |
| *M. didyma* (Selys in Sagra, 1857) | 7,12,14,15 |
| *M. hagenii* Kirby, 1890 | 1, 12 |
| *Micrathyria dissocians* Calvert, 1906 | 16 |
| *Orthemis discolor* (Burmeister, 1839) | 2,3,7 |
| *O. ferruginea* (Fabricius, 1775) | 1,2,14,15,20 |
| *O. levis* Calvert, 1906 * | 9 |
| *Pantala flavescens* (Fabricius, 1798) | 2 |
| *Perithemis domitia* (Drury, 1773) | 2,3,12,14,33 |
| *P. mooma* Kirby, 1889 | 17,22 |
| *Pseudoleon superbus* (Hagen, 1861) | 1,7,8,11,22,24,25 |
| *Tauriphila argo* (Hagen, 1869) * | 14 |
| *T. azteca* Calvert, 1906 | 15 |
| *Tholymis citrina* Hagen, 1867 | 33 |
| *Tramea abdominalis* (Rambur, 1842) | 1 |
| *T. calverti* Muttkowski, 1910 | 6 |
| *T. lacerata* Hagen, 1861 | 17 |
| *T. onusta* Hagen, 1861 | 1,2 |

## DISCUSSION

The high diversity found at the HP (126 spp.) makes this region the second hotspot (sensu PAULSON, 1985) for odonate diversity in Mexico. The number of species in this area is higher than other neotropical sites so far recorded in Mexico as sierra de Coalcomán, Michoacán (116 spp, NOVELO-GUTIÉRREZ & GÓMEZ-ANAYA, 2009), Chamela, Jalisco (72 spp, GONZÁLEZ-SORIANO et al., 2004), Calkmul, Campeche (71 spp, E. González-Soriano, unpublished data), and Sian Ka'an, Quintana Roo (47 spp, NOVELO-GUTIÉRREZ, 1988).

In comparison with other neotropical hotspots, the HP diversity is remarkable. For example Barro Colorado has a total of 90 species (MAY, 1979), Parque Nacional Iguazú, Argentina, 106 species (JURZITZA, 1981) and the Peruvian regions of Pakitza (117 species), Iquitos (123) and Tambopata (177) respectively (PAULSON, 1985, 2006; LOUTON et al., 1996). However, more recent collections brought the total at one site (Explorer's Inn) in the Tambopata area to 186 species (KALKMAN et al, 2008 and D. Paulson, 2008 pers. com.).

The number of species here is less than those reported for Los Tuxtlas (LT), another humid tropical area of Mexico located farther south (18°10'-18°45'N and 94°42'- 95°27'W), with 139 species (GONZÁLEZ-SORIANO, 1997 and unpublished data).

Differences in species richness among the latter two regions seem to be due to two factors. The first is that most aquatic habitats visited in HP are lotic, while in LT many lentic habitats were surveyed. This could explain why we recorded more Libellulidae and Aeshnidae in LT than in HP. Secondly, some groups of rain forest odonates [e.g., Perilestidae (*Perissolestes*) and Polythoridae (*Cora*)] seem to reach their northern distributional limit in LT and hence do not reach HP. Others, although not strictly linked to the tropical rainforest, are more speciose there (e. g., Megapodagrionidae, Pseudostigmatidae and Platystictidae). At present the limit of the tropical rain forest in Mexico is situated around the region of Los Tuxtlas (DIRZO & MIRANDA, 1991).

Of the 125 species of HP, 87 (69.6%) are shared with LT. The species not shared with LT are shown above in the list. Of the 50 genera found at HP, 45 (90%) are shared with LT. The genera not shared with LT are: *Apanisagrion*, *Nehalennia, Archaegomphus, Gomphus* and *Macromia*.

The following neotropical species seem to reach their northern limit on the east slope of Mexico at the HP: *Hetaerina infecta*, *H. capitalis* (Calopterygidae); *Palaemnema paulitoyaca* (Platystictidae); *Protoneura aurantiaca*, *P. cupida* (Protoneuridae); *Gynacantha helenga* (Aeshnidae*); Archaegomphus furcatus*, *Phyllogomphoides duodentatus* (Gomphidae); *Brechmorhoga nubecula*, *Elasmothemis aliciae* and *Libellula herculea* (Libellulidae)

On the other hand, *M. annulata* (Macromiidae) seems to have its southern limit in this area.

Two taxa seem to be endemic to this area: an undescribed species of *Palaemnema* (Platystictidae) collected near the locality of Xilitla and *Progomphus amarillus* (Gomphidae) a recently described species collected at a sulphur stream in Taninul (TENNESSEN, 1992). One quasi-endemic species is *Gomphus (Gomphurus) gonzalezi* which has also a disjunct population in southern Texas (DUNKLE, 1992)

The following 9 species were new records for the state: *Protoneura corculum*, *Enallagma basidens*, *Triacanthagyna caribbea*, *Archaeogomphus furcatus*, *Brachymesia furcata*, *Macrothemis imitans*, *Orthemis discolor*, *Perithemis mooma* and *Tauriphila argo.*

Six species recorded by BEATTY & BEATTY (1962, unpubl.) were not found during our recent collections: *Hetaerina capitalis*, *Pseudostigma aberrans*, *Enallagma basidens*, *Anax junius*, *Triacanthagyna caribbea* and *Micrathyria hagenii.* Finally tropical warm areas harbor the greatest odonate diversity in Mexico. As an example the Huasteca Potosina and Los Tuxtlas hotspots harbor in common 177 species (50.7% of Mexican odonate diversity recently estimated in 349 species) (GONZÁLEZ-SORIANO & NOVELO-GUTIÉRREZ, 2007). To see in perspective the high biodiversity found in the HP, four small collecting points of only some hundred square meters (Nacimiento Rio Huichihuayán, Río El Salto, Río Micos and Nacimiento del Río Coy) each have between 32-43 spp., more than the maximal number of odonates recorded in a rather larger area (10 × 10 km) considered as a temperate hotspot (AZPILICUETA et al., 2007).

**ACKNOWLEDGEMENTS**

We want to acknowledge K.C. KIM and specially John R. GREHAN for hosting EGS during his visit to the Frost Entomological Museum at Penn. State University. Dr DENNIS PAULSON kindly read the manuscript and his comments are very appreciated. To HELGA C.P. BARBA-MEDINA, ELIZABETH DIAZ but specially FELIPE VILLEGAS for the help in the elaboration of the map.

**REFERENCES**

ALONSO-EGUÍA L.P., E. GONZÁLEZ-SORIANO & P.J. GUTIÉRREZ-YURRITA, 2002. Listado y distribución de los odonatos de la cuenca del Río Moctezuma, centro-occidente de México (Insecta-Odonata). *Folia ent. mex.*41(3): 347-357.

ARRIAGA C.L., V. AGUILAR-SIERRA & J. ALCOCER-DURAND, 2000. *Aguas continentales y diversidad biológica de México*. Comisión Nacional para el Conocimiento y Estudio de la Biodiversida (CONABIO), Mexico.

AZPILICUETA, A.M., C. REY RAÑO, F. DOCAMPO B., X.C. REY MUÑIZ & A. CORDERO RIVERA, 2007. A preliminary study of biodiversity hotspots for odonates in Galicia, NW Spain. *Odonatologica* 36(1): 1-12.

BEATTY, G.H. & A.F. BEATTY, 1962. *Odonata collecting in México, 1957-1962*. [Unpublished manuscript]

BEHRSTOCK, R.A., 2005. New state records of Odonata for eastern Mexico. *Argia* 17(1): 13-15.

BEHRSTOCK, R.A., M. DOBBS, S. DUNKLE & M. OVERTON, 2007. Additional records of

Odonata from Tamaulipas, San Luis Potosí, Hidalgo, and Querétaro States, Mexico. *Argia* 19(3): 30-33.

CARMONA-JIMÉNEZ, J., 1997. *Estudio florístico (taxonómico-ecológico-biogeográfico) de las rodofitas de agua dulce en la región central de México*. Doctoral Thesis, Facultad de Ciencias, UNAM.

COLWELL, R.K., 1997. User´s guide to estimates 5. Statistical estimation of species richness and shared species from sample. Website: *viceroy.eeb.edulestimates*.

DAIGLE, J.J., 1991. Argia garrisoni spec. nov., from Mexico (Zygoptera: Coenagrionidae). *Odonatologica* 20(3): 337-342.

DIRZO, R. & A. MIRANDA, 1991. El límite boreal de la selva tropical húmeda en el continente americano. Contracción de la vegetación y solución de una controversia. *Interciencia* 16(5): 240.247.

DUNKLE, S.W., 1992. Gomphus (Gomphurus) gonzalezi spec. nov., a new dragonfly from Texas and Mexico (Anisoptera: Gomphidae). *Odonatologica* 21(1): 79-84.

GLOYD, L.K., 1944. A new species of Archilestes from Mexico (Odonata: Lestinae). *Occ. Pap. Mus. Zool. Univ. Mich.* 483(4): 1-4.

GONZÁLEZ-SORIANO, E., 1997. Odonata. *In*: E. González Soriano, R. Dirzo & R.C. Vogt, [Eds], *Historia natural de Los Tuxtlas*, pp. 245-255, Inst. Biol., UNAM, México.

GONZÁLEZ-SORIANO, E., O. DELGADO-HERNÁNDEZ & G.L. HARP, 2004. Libélulas de la Estación de Biología Chamela (Insecta: Odonata). *In*: A.N. García-Aldrete & R. Ayala, [Eds], *Artrópodos de Chamela*, Inst. Biol., UNAM, Mexico.

GONZÁLEZ-SORIANO, E. & R. NOVELO-GUTIÉRREZ, 1996. Odonata. *In*: Llorente-Bousquets, J., A.N. García-Aldrete & E. Gonzalez-Soriano, [Eds], *Biodiversidad, taxonomía y biogeografía de artrópodos de México: hacia una síntesis de su conocimiento*, pp. 147-168, Inst. Biol., UNAM, Mexico.

GONZÁLEZ-SORIANO, E. & R. NOVELO-GUTIÉRREZ, 2007. Odonata of Mexico revisited. *In*: B.K. TYAGI, [Ed.], *Odonata*: *biology of dragonflies*, pp. 105-136, Scient. Publishers (India).

JURZITZA, G., 1981. Lista provisional de los odonatos del Parque nacional Iguazú, Provincia de Misiones, República Argentina. *Notul. odonatol.* 1: 117-118.

KALKMAN, V.J., V. CLAUSNITZER, K.-D.B. DIJKSTRA, A.G. ORR, D.R. PAULSON & J. VAN TOL, 2008. Global diversity of dragonflies (Odonata) in freshwater. *Hidrobiologia* 595: 351-363.

LOUTON, J.A., R.W. GARRISON & O.S. FLINT, 1996. The Odonata of Parque Nacional Manu, Madre de Dios, Peru: natural history, species richness and comparisons with other Peruvian sites. *In*: D.E. Wilson & A. Sandoval, [Eds], *Manu, The biodiversity of southeastern Peru*, pp. 431-449, Smithsonian Instn, Washington, D.C.

MAY, M.L., 1979. Lista preliminar de nombre y clave para identificar a los Odonata (caballitos) de la Isla de Barro Colorado. *Cuadernos Cienc.*, Panama 1: 1-50. 2 pls excl.

MAYA-FLORES, A., 1994. *Estudio preliminar del suborden Zygoptera (Insecta: Odonata) de la región de Ciudad Valles, San Luis Potosí*. Bachelor Thesis, ENEP, Iztacala.

MEAVE DEL CASTILLO, M.E., 1997. *Taxonomía y distribución de las especies Cladophorales (Chlorophyta) de La Huasteca.* Tesis doctoral, Fac. Cienc., UNAM.

NOVELO-GUTIERREZ, R., 1988. Los odonatos de la Reserva de Sian Ka'an, Quintana Roo, México (Insecta:Odonata). *In*: D. Navarro & J.G. Robinson, [Eds], *Diversidad biológica de la Reserva de la Biósfera de Sian Ka'an, Quintana Roo, México*, pp. 257-273, CIQRO & Program Stud. Trop. Conserv.

NOVELO-GUTIERREZ, R. & J.A. GOMEZ-ANAYA, 2009. A comparative study of Odonata (Insecta) assemblages along an altitudinal gradient in the sierra de Coalcomán Mountains, Michoacán, México. *Biodiv. Conserv.* 18: 679-698.

PAULSON, D.R., 1985. Odonata of the Tambopata Reserved Zone, Madre de Dios, Perú. *Revta*

*peru. Ent.* 27: 9-14.
PAULSON, D.R., 2006. The importance of forest to neotropical dragonflies. *In*: A. Cordero, [Ed.], *Forest and dragonflies*, pp. 79-101, Fourth WDA Int. Symp. Odonatol., Pontevedra.
PUIG, H., 1991. *Vegetación de la Huasteca ( México): estudio fitogeográfico y ecológico*. Inst. Ecol. Centre d'études mexicaines et centramericaines.
TENNESSEN, K.J., 1992. Progomphus amarillus spec.nov., from eastern Mexico (Anisoptera: Gomphidae). *Odonatologica* 21(2): 247-252.

*Odonatologica 40(3): 191-202* *September 1, 2011*

# MORPHOLOGICAL CHARACTERS OF *EPIOPHLEBIA LAIDLAWI* TILLYARD LARVAE, WITH NOTES ON THE HABITAT AND DISTRIBUTION OF THE SPECIES IN NEPAL ("ANISOZYGOPTERA": EPIOPHLEBIIDAE)

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*Received July 1, 2010 / Revised and Accepted February 24, 2011*

Based on 78 specimens recorded from 14 forest streams at the elevations between 1800 and 2850 m a.s.l. in central Nepal, 9 larval instars are described and illustrated. *E. laidlawi* is for the first time documented from the Sim and Indrawati watersheds. The habitats are described and clearly indicated that the sp. is widespread but has a restricted range. The protection of the habitats is essential for its conservation.

## INTRODUCTION

Anisozygoptera dragonflies were common in the Mesozoic era (MALZ & SCHRÖDER, 1979; TRUEMAN & ROWE, 2001). Two extant species (Epiophlebiidae) are still known in the world today. *Epiophlebia superstes* and *E. laidlawi* occur, respectively, in Japan and in the Himalayan region including Nepal. They are considered classical "living fossils". *E. laidlawi* was originally described by TILLYARD (1921) from Darjeeling Himalaya.

Anisozygoptera have more than 30 Mesozoic genera. They show combined features of Anisoptera and Zygoptera and are regarded as ancestors or the stem group of the Anisoptera, a theory which is strongly supported by their earlier fossil presence. According to BECHLY (1999), the Triassic *Italophlebia paganoniae* and *I. gervasuttii* (Isophlebioptera: Isophlebioidea) are the oldest known stem group

representatives of Anisoptera. The formerly well-represented Anisozygoptera became nearly extinct in the Cretaceous/Tertiary. NEL & JARZEMBOWSKI (1996) describe remarkable dragonflies from the non-marine Lower Cretaceous of southern England, belonging to four Anisozygoptera families. Among them *Mesoepiophlebia bexleyi* is the oldest and the first record of the relict extant family Epiophlebiidae.

The Himalayan *E. laidlawi* is a freshwater indicator of river ecosystem health. The species was categorized by IUCN as Vulnerable in 1983, 1986, 1988, 1990, 1994, and 1996 and as Near Threatened in 2010 (IUCN, 2010). Previous studies have reported *E. laidlawi* at the Tamar river near the village of Chitre in July 1963 (ASAHINA, 1963); at the Shivapuri mountains in May 1979 (TANI & MIYATAKE, 1979), in May 1981 (ASAHINA, 1982), in June 1987 (MAHATO, 1993) and in December 1988 (SAVILLE, 1990); from the headwater of Bhote Koshi near Phelping in 1996 (SHARMA & OFENBÖCK, 1996) and in May 1997 (BUTLER, 1997); and at the Dudhkoshi river catchment (Bihla Khola, Phakding Khola and Kahrte Khola) in March and April 1994 (SHARMA & OFENBÖCK, 1996). The present study investigated 44 forest streams ranging from 900 to 3200 m above sea level in central Nepal. In this paper, the identifying characters of different larval instars are illustrated and their habitats and associated macroinvertebrate assemblages are described.

## MATERIAL AND METHODS

STUDY AREA – We sampled at 44 forest streams in central Nepal within the Sim (Daman, Makwanpur district), the Bagmati (Shivapuri Nagarjun National Park), and the Indrawati (Sindhupalchowk district) watersheds that lie in the Himalayan broadleaf mixed forest, and Eastern Himalayan subalpine conifer forest (Fig. 1).

METHODS – The fieldwork was conducted in different time intervals between 2006 and 2009. The streams were categorized using the protocols of STRAHLER (1957) and HARTMANN et al. (2010). Qualitative sampling was carried out from different micro habitats (10 sub-samples per site) within a 100 m river stretch by using hand nets having a mesh size of 1 mm and 0.5 mm. The body length of all *Epiophlebia* specimens was measured with the help of a field binocular. Males and females were distinguished by the presence or absence of the ovipositor.

The *E. laidlawi* specimens were collected from the Sim watershed (R.D.T. Shah, D.N. Shah & H. Nesemann leg.) November 2006-2007, the Indrawati watershed (Chittara: R.D.T. Shah, D.N. Shah & H. Nesemann leg.; Helambu: D.N. Shah leg.) December 2007-March 2008, and the Bagmati watershed (D.N. Shah leg.) November 2008-April 2009-December 2009. Samples were then transferred into plastic containers and preserved in 4% formaldehyde for a week to harden the benthos. In the laboratory, the samples were washed carefully, using hand nets with a mesh size of 0.5 mm, transferred into a white enameled tray with water, and the animals sorted from the sediments. The animals were identified to the family/genus level for most Insecta and the genus/species level for non-insects (NESEMANN et al. 2007). The specimens were kept in 70% alcohol for further preservation.

One specimen from each size class has been drawn by H. Nesemann (Fig. 2 a-i). The original drawings are stored in the collection of the Hindu Kush Himalayan Benthological Society (HKH BENSO) in Kathmandu, Nepal.

The relative abundance of each taxon was estimated from field observations (also verified after

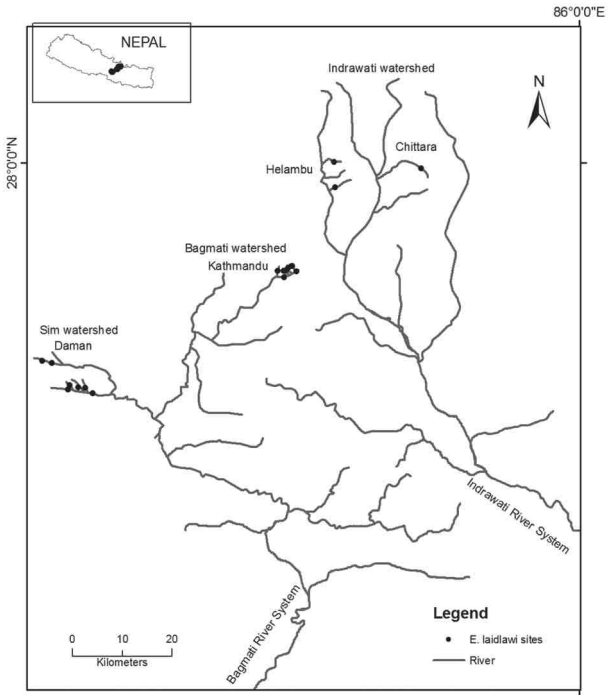


Fig. 1. Map showing the watershed of the study area. Sim watershed Daman, Makwanpur district), Bagmati watershed (Shivapuri, Kathmandu district), and Indrawati watershed (Helambu and Chittara, Sindhupalchowk district) are the major habitats for *E. laidlawi.*

sorting and identification in the laboratory) and then classified into five abundance classes according to MASON (1981) and CHAPMAN (1992). The ecological quality class was calculated using the Average Score per Taxon (ASPT) Value. The revised transformation from SHARMA et al. (2009) was used. The calculation procedure using the ASPT value is described in detail by SHARMA et al. (2009) and OFENBÖCK et al. (2010).

## RESULTS

All the studied streams belong to stream orders 1 to 4, i.e., head water streams to medium-sized rivers and were characterized by a good ecological quality class with no to minimal anthropogenic impacts. The habitat substrates were mostly hygropetric to mesolithal except in the Simbhanyjang Khola, which was dominated by psammal, pelal, and detrial substrates.

*E. laidlawi* was recorded in Simbhnajyang Khola with abundance class 1 whereas in the Sim Khola and its three left tributaries with an abundance class 2. Similarly, the species was recorded at one site of the Bagmati River main stream, two sites at the main stream of Nagmati (a tributary of the Bagmati) downstream to Dhap, and at four tributaries of the Nagmati forest streams with an abundance class 1. In Indrawati watershed, the species was recorded at two forest streams of the Helambu at the villages of Parachin and Thimbu, headwaters of the Melam-

chi River, and the Chittara stream (Sindhupalchowk), a tributary of the Indrawati River with abundance class 1.

The new discovery of populations in the Sim watershed, i.e., granite mountain streams of the Mahabharat range (NESEMANN et al., 2008) is one of the odonatological highlights, since *E. laidlawi* was previously known only from very few localities close to the high mountain range of the Himalayas. In total, 58 specimens from streams of the Sim watershed, 9 specimens from streams of the Indrawati watershed, and 11 specimens from streams of the Bagmati watershed are recorded. Their size ranges from 3 to 29 mm. Nine developmental stages are distinguished based on morphological characters and different colour patterns on the dorsal side. They represent the different instars which are separated by moulting. The largest four instars (Fig. 2 f-i) are already known and have been extensively described by ASAHINA (1961a, 1961b). Male and female individuals can be separated by the presence of an ovipositor. This is only possible for larvae larger than 8 mm body length. The larval lengths for the Sim watershed, Indrawati watershed, and Bagmati watershed populations are given in Figures 3, 4, and 5, respectively. The larvae of larger size form clear stages which correspond to distinct instars.

The common associated macroinvertebrates are Baetidae, Leptophlebiidae, Heptageniidae (Ephemeroptera); Perlidae, Nemouridae, Peltoperlidae (Plecoptera); Hydropsychidae, Philopotamidae, Lepidostomatidae, Polycentropodidae,

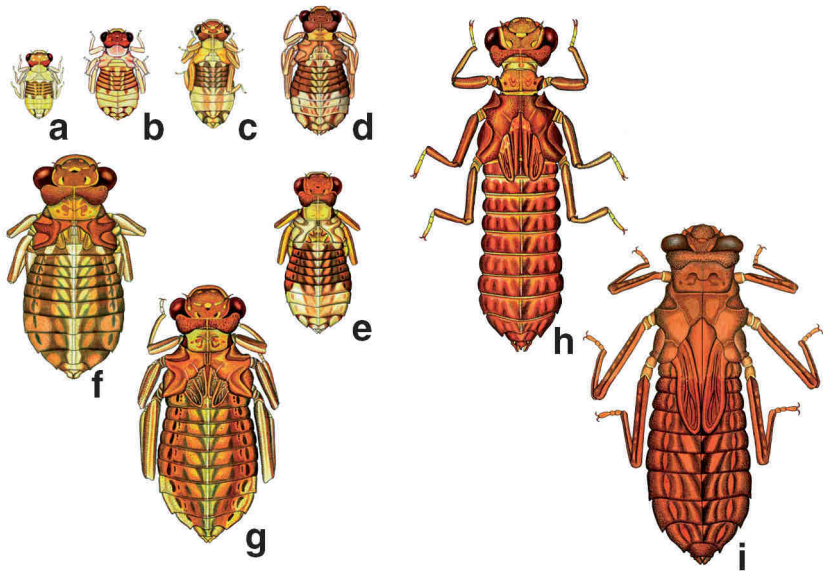


Fig. 2. Hand-drawn *Epiophlebia laidlawi* individuals from each instar developmental stages from Sim Khola and Simbhanyjang Khola (Fig. 2 a-g & i), Helambu (Fig. 2 h).

Limnephilidae, Rhyacophilidae (Trichoptera); Gomphidae, Aeshnidae, Corduligastridae (Odonata); Scirtidae, Elmidae (Coleoptera); Chironomidae (not red), Simuliidae, (Dipetra). The diversity of benthic macroinvertebrates in the *E. laidlawi* habitat varied from 20 taxa at the lower stream of Sim Bhanjyang Khola to 42 taxa at the first tributary of Sim Khola, Daman.

## BRIEF CHARACTERS OF THE LARVAL DEVELOPMENTAL STAGES

The description is based on the specimens from Sim- and Indrawati watershed.

(a) The length of four specimens varied between 3.0 -3.1 mm. Abdominal segments 2-5 were dark colored on the dorsal side with lighter paramedian longitudinal fields. Abdominal segments 1 and 6-8 had a light yellow appearance.

(b) The length of twelve specimens varied between 3.8-4.6 mm. There was no visible external wing sheath. Abdominal segments 2-5 were dark colored on the dorsal side with lighter paramedian fields. Abdominal segments 1 and 6-8 had a light yellow appearance.

(c) The length of two specimens varied between 5.1-5.5 mm. There was no external wing sheath visible. Abdominal segments 2-5 were dark

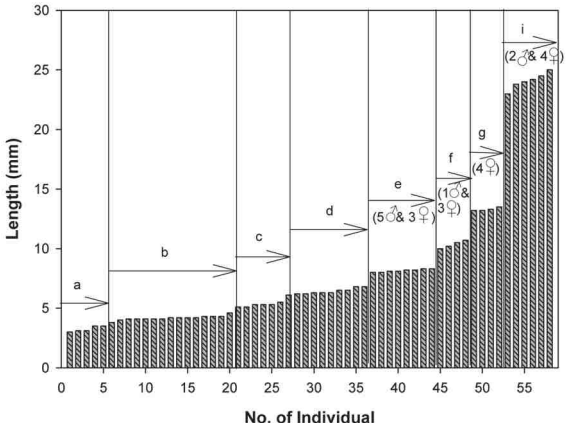


Fig. 3. Length frequency of the *Epiophlebia laidlawi* population from Sim watershed. The letter above the arrow represents the instar stage.

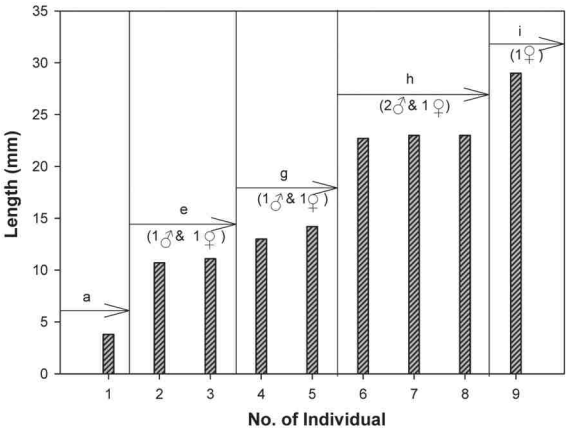


Fig. 4. Length frequency of the *Epiophlebia laidlawi* population from the Indrawati watershed. The letter above the arrow represents the instar stage.

colored on the dorsal side with a broad lighter median field. Abdominal segments 1 and 6-8 had a light yellowish-brown appearance.

(d) The length of five specimens varied between 6.2-6.8 mm. Abdominal segments 2-5 were dark colored with similar metameric patterns on the dorsal abdominal segments. The fore wing and hind wing sheaths were short and stout on the second and third thoracal segments.

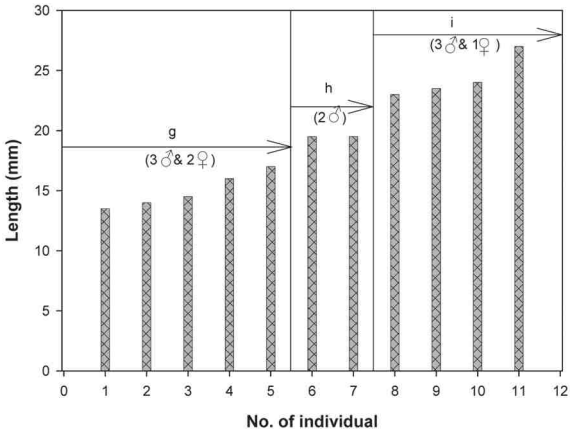


Fig. 5. Length frequency of the *Epiophlebia laidlawi* population from the Bagmati watershed. The letter above the arrow represents the instar stage.

(e) The length of eight specimens (5♂, 3♀) varied between 8.0-8.3 mm. Abdominal segments 2-5 were dark colored and bore similar metameric patterns on the dorsal side. Abdominal segments 1 and 6 had dark lateral and paramedian zones interrupted by light yellow zones. The fore wing sheath length reached and covered the segmental border between the third thoracic segment and the first abdominal segment.

(f) The length of four specimens (1♂, 3♀) varied between 10.0-10.7 mm. The hind wing sheath extended beyond the first half of the first abdominal segment. The general color of abdominal segments 7-9 was lighter than other segments.

(g) The length of five specimens (5♀) varied between 13.2-13.5 mm. Abdominal segments 1-6 were dark colored and bore dark metameric patterns on the dorsal side. Abdominal segments 7-9 were slightly lighter with a yellow orange pattern on the sides. The hind wing sheath extended to the end of the first abdominal segment.

(h) The length of the three extended specimens (2♂, 1♀) varied between 22.7-23.0 mm. All abdominal segments were dark reddish brown and bore metameric patterns on the dorsal side. The wings extended beyond the distal end of the second abdominal segment.

(i) The length of seven specimens (2♂, 5♀) varied between 23.0-25.0 mm; one extended specimen was 29.0 mm long. All abdominal segments were dark brown and bore similar metameric patterns on the dorsal side. The hind wing sheath extended beyond the distal end of the fourth abdominal segment. The general color appearance can be blackish due to iron cover.

## HABITATS OF *EPIOPHLEBIA LAIDLAWI*

**Sim watershed**: The two forest streams investigated, the Sim Khola and the Simbhanyjang Khola in Daman, are densely forested (Fig. 6). The northern slope of the Mahabharat hills is dominated by blue pine (*Pinus wallichiana*), forming a natural monoculture together with alder (*Alnus nepalensis*) along the water courses. The southern slope is covered with mixed broadleaf forest of brown oak (*Quercus semecarpifolia*). The area is the largest Paleozoic Granite island of Nepal. The headwaters are naturally very poor in calcium carbonate, so that only a very few shell-bearing mollusks can occupy the upper reaches of the streams. The mineral habitat was mainly dominated by megalithal, macrolithal, and mesolithal with moss cover (Fig. 7). All the sites were shaded at the zenith by 40% (mid-day) on average except at one site of the Simbhanjyang Khola which had no shading (Fig. 8). The water depth ranged from 0.10 m to 0.45 m and stream width from 0.30 m to 1.50 m, respectively, while water velocity ranged from 0.10 m/sec to 0.30 m/sec. The average water temperature during sampling was 11ºC.

**Indrawati watershed**: The upper section of Indrawati watershed, namely the Chittara and the Helambu (Sindhupalchowk district), are densely forested by oak trees, rhododendron, etc. The mineral composition in the Chittara was dominated by megalithal and macrolithal. The shading at the zenith on the stream was estimated at 80%. The average water depth and stream width were 0.60 m and 6 m, respectively. The water velocity was rapid (>0.50 m/s). The surrounding area was covered with snow to a depth of 0.50 m and water temperature was 8ºC during the sampling. In the Helambu, the substrates mainly consisted of macrolithal

Fig. 6. The forested Mahabharat Range. View from Daman to the southeast at 2560 m a.s.l. Hill tops in the watershed of Sim Khola and Simbhanyjang Khola. The northern slope is dominated by *Pinus wallichiana*, whereas the southern part has mainly *Quercus semecarpifolia* forests.

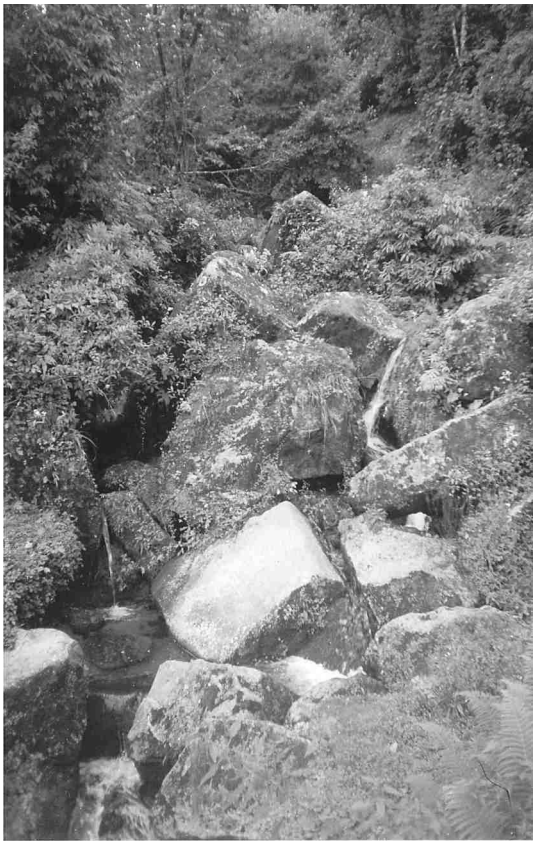

Fig. 7. Lotic habitat of Simbhanyjang Khola with a natural gigalithal substrate, structurally rich streambed with riffles and small water falls. Here the youngest instar larvae of *Epiophlebia laidlawi* were discovered for the first time in November 2006.

and mesolithal. The shading at the zenith on the stream was estimated at 20%. Average water depth was 0.20 m, stream width 1.50 m, and the water velocity was 0.10 m/sec. The water temperature was 10.5ºC.

**Bagmati watershed**: The Shivapuri mountains are dominated by the Schima-Castanopsis association, with chir pine stands on southern dry ridges and is associated with alder, wild Himalayan cherry, cherry, *Engelhardia,* and ring-cupped oak along streams. The mineral habitat was dominated by megalithal, macrolithal, and mesolithal. About 40% shading at the zenith was estimated at all streams except in uppermost site of the Nagmati (0% shading). The water depth ranged from 0.15 m to 0.50 m, stream width from 0.50 m to 1 m, and water velocity from slow to rapid (0.10-0.40 m/s). The recorded water temperature ranged from 9ºC to 11ºC.

## DISCUSSION

While the taxonomy (ASAHINA, 1949, 1961b, 1986), life cycle including adults, terrestrial phase and egg deposition (ASAHINA, 1954; ASAHINA & EDA, 1956, 1958, 1982; TABARU, 1984; RÜPPELL & HILFERT, 1993; NARAOKA, 2006; NARAOKA & TAKAHASHI, 2007) for *E. superstes* are better known, the adult of *E. laidlawi* has not yet been studied (KAWAI & KAZUMI, 2005; OKUDAIRA et al., 2005; INOUE & SUGIMURA, 2008). The present study distinguished nine different larval developmental stages based on morphological characters and different color patterns on the dorsal side. Of these nine stages,

the largest four instars (Fig. 2 f-i) were already known and were extensively described by ASAHINA (1961a, 1961b). BROCKHAUS & HARTMANN (2009) have reported instars F1, F2, and F4 (based on ASAHINA, 1961a) from Bhutan.

The mineral composition in the *E. laidlawi* habitats was widely dominated by macrolithal and mesolithal substrates, characterized by a sequence of riffles and pools, and similar to habitats documented in earlier studies in Nepal and Bhutan (SHARMA & OFENBÖCK, 1996; BROCKHAUS & HARTMANN, 2009). Some sites with hygropetric surface were also observed. In addition, we found one specimen in psammal and pelal habitat, covered by detrital substrates, upstream of the Simbhanyjang Khola (Fig. 8). The sites are pristine mountain streams with no to minimal anthropogenic impacts along and across the streams/rivers. All the sites had a good water quality class according to the ecological water quality classification, similar to the earlier findings (SHARMA & OFENBÖCK, 1996; BROCKHAUS & HARTMANN, 2009).

Fig. 8: Lentic pool habitat of the Simbhanyjang Khola with natural psammal, pelal, and detrial substrates, a structurally rich stream bed with shallow runs and riffles, the lithal substrate is densely covered by aquatic mosses. Here large forms of the holarctic peaclam, *Pisidium casertanum*, were discovered for the first time in September 2006.

The present study documented *E. laidlawi* at streams of the Sim watershed (Sim Khola and Simbhanyjang Khola, Daman), the Indrawati watershed (Helambu, the villages of Parachin and Thimbu, and the Chittara stream; Sindhupalchowk), and the Bagmati watershed (Bagmati and Nagmati River). Previous studies have reported *E. laidlawi* from various localities. The first known *E. laidlawi* from Nepal was recorded at the Tamar River near the village of Chitre in July 1963 (ASAHINA, 1963). The species has been reported frequently from the Shivapuri mountains (TANI & MIYATAKE, 1979; ASAHINA, 1982; SAVILLE, 1990; MAHATO,

1993). Similarly, *E. laidlawi* has been reported from the headwater of the Bhote Koshi near Phelping (SHARMA & OFENBÖCK, 1996; BUTLER, 1997) and from the Dudhkoshi river catchment (SHARMA & OFENBÖCK, 1996). *E. laidlawi* was only known from limited localities of Nepal and India and has recently been reported for the first time from Bhutan (BROCKHAUS & HARTMANN, 2009) as well as from new localities in Nepal (NESEMANN et al., 2008). Therefore, the distribution as known at present reaches from the central Himalaya and its foothills in Nepal to the eastern Himalayan region in Bhutan.

## CONCLUSION

The morphological development of *E. laidlawi* can be clearly demarcated into nine developmental stages. The young larvae differ markedly in dorsal color, having dark pigmentation only on abdominal segments 2 to 5 and 9. Large larvae have a generally brownish or nearly blackish appearance with a dorsal metameric pattern on the abdomen. Distinguishing male and female individuals by the presence of an ovipositor is only possible for larvae with at least an 8 mm body length. The larvae are limited to the natural upper regions of slow to fast running forest streams. Small larvae prefer rapids and riffles with an embedded stream bottom; they are highly pollution-sensitive and live only in the Epirhithron to Metarhithron-type of biocoenotic zone. The discovery of the new locality of *E. laidlawi* from central Nepal has increased the known distribution range of the species. However, the construction of trails and roads, access to tourism, cattle grazing and scattered settlements at the headwater streams may lead to the destruction of its habitats. Among the study sites, only the Bagmati watershed (Shivapuri Nagarjun National Park) is protected under the National Park and Wildlife Conservation Act 2029. Despite the high abundance of *E. laidlawi* at the Sim Khola and its tributaries, the Sim watershed has not yet been prioritized for conservation efforts, which may be a threat to the existing available habitats.

**ACKNOWLEDGEMENTS**

We want to thank Dr BASTIAAN KIAUTA for assistance with literature and review of the manuscript. We would also like to express our deepest appreciation to Ms SARAH McGEE (www.scientific-english.de) for the proofreading of the manuscript and Mr MATHIAS KUEMMERLEN for his constructive comments on the draft version.

**REFERENCES**

ASAHINA, S., 1949. On some archaic structures retained in Epiophlebia superstes (Odonata: Anisozygoptera). *Mushi* 19: 49-51.

ASAHINA, S., 1954. On the life-history of Epiophlebia superstes (Odonata, Anisozygoptera). *Proc. 8th. int. Congr. Ent.*, Stockholm, pp. 1-5.

ASAHINA, S., 1961a. Is Epiophlepia laidlawi Tillyard (Odonata, Anisozygoptera) a good species? *Int. Revue ges. Hydrobiol.* 46: 441-446.

ASAHINA, S., 1961b. The taxonomic characteristics of the Himalayan Epiophlebia-Larva (Insecta, Odonata). *Proc. Japan Acad.* 37: 42.

ASAHINA, S., 1963. Description of the possible adult dragonfly of Epiophlebia laidlawi from the Himalayas. *Tombo* 6: 18-20.

ASAHINA, S., 1982. Survey of the relict dragonfly Epiophlebia laidlawi Tillyard in Nepal, May 1981. *Rep. Odon. Specialist Gr. Int. Un. Conserv. Nat.* 1: 1-6.

ASAHINA, S., 1986. Centennial of the capture of Epiophlebia superstes. *Tombo* 24: 2-4.

ASAHINA, S. & S. EDA, 1956. Resting female of Epiophlebia superstes Selys. *Kontyu* 24: 1.

ASAHINA, S. & S. EDA, 1958. A female Epiophlebia superstes laying eggs (Odonata, Epiophlebiidae). *Kontyu* 26: 1.

ASAHINA, S. & S. EDA, 1982. Further observations on bryophyte oviposition by Epiophlebia superstes. *Tombo* 25: 2-6.

BECHLY, G., 1999. *Phylogeny and systematics of fossil dragonflies (Insecta: Odonatoptera) with special reference to some Mesozoic outcrops*. Ph.D Thesis, Univ. Tübingen, Tübingen.

BROCKHAUS, T. & A. HARTMANN, 2009. New records of Epiophlebia laidlawi Tillyard in Bhutan, with notes on its biology, ecology, distribution, zoogeography and threat status (Anisozygoptera: Epiophlebiidae). *Odonatologica* 38: 203-215.

BUTLER, S.G., 1997. Notes on collection and transportation of live Epiophlebia laidlawi Tillyard larvae (Anisozygoptera: Epiophlebiidae). *Notul. odonatol.* 4: 147-148.

CHAPMAN, D., 1992. *Water quality assessment: a guide to the use of biota, sediments and water in environmental monitoring*. Chapman & Hall, London.

HARTMANN, A., O. MOOG & I. STUBAUER, 2010. "HKH screening": a field bio-assessment to evaluate the ecological status of streams in the Hindu Kush-Himalayan region. *Hydrobiologia* 651: 25-37.

INOUE, K. & M. SUGIMURA, 2008. Vivid life of dragonflies in high vision camera including the whole life history of the living fossil Epiophelebia superstes. *Abstr. Pap. 18th int. Symp. Odonatol.*, Nagpur.

IUCN, 2010. http://www.iucnredlist.org/apps/redlist/search.

KAWAI, T. & T. KAZUMI, 2005. *Aquatic insects of Japan: manual with keys and illustrations.* Tokai Univ. Press, Tokyo.

MALZ, H. & H. SCHRÖDER, 1979. Fossile Libellen – biologisch betrachtet. *Kleine Senckenberg-Reihe* 9: 1-46.

MAHATO, M., 1993. Epiophlebia laidlawi, a living ghost. *Selysia* 22: 2.

MASON, C.F., 1981. *Biology of freshwater pollution*. Longman, Harlow.

NARAOKA, H., 2006. Landing of Epiophlebia superstes (Sel.) larvae on snow-covered slopes (Epiophlebioptera: Epiophlebiidae). *Notul. odonatol.* 6: 92-93.

NARAOKA, H. & K. TAKAHASHI, 2007. The landing from the water and the terrestrial period before emergence of the final instar larvae of Ephiophlebia superstes Selys (Anisoptera: Epiophlebiidae). *Tombo* 49: 15-21.

NEL, A. & E.A. JARZEMBOWSKI, 1996. Description and revision of the dragonflies ('Anisozygoptera') from the Lower Cretaceous of England (Odonata: Stenophlebiidae, Campterophlebiidae?, Epiophlebiidae, Euthemistidae). *Cretaceous Res.* 17: 87-96.

NESEMANN, H., R.D.T. SHAH, D.N. SHAH & S. SHARMA, 2008. Morphological development of Epiophlebia laidlawi, a relict Himalyan dragonfly, *Abstr. Pap. 18th int. Symp. Odonatol.*, Nagpur, p. 43.

NESEMANN, H., S. SHARMA, G. SHARMA, S.N. KHANAL, B. PRADHAN, D.N. SHAH, & R.D. TACHAMO, 2007. *Aquatic invertebrates of the Ganga river system*, 1: *Mollusca, Annelida, Crustacea (in part)*. Hasko Nesemann, Kathmandu, ISBN 978-99946-2-674-8.

OFENBÖCK, T., O. MOOG, S. SHARMA & T. KORTE, 2010. Development of the HKHbios: a new biotic score to assess the river quality in the Hindu Kush-Himalaya. *Hydrobiologia* 651: 39-58.

OKUDAIRA, M., M. SUGIMURA, S. ISHIDA, K. KOJIMA, K. ISHIDA, & T. AOKI, 2005. *Dragonflies of the Japanese Archipelago in color*. Hokkaido Univ. Press.

RÜPPELL, G. & D. HILFERT, 1993. The flight of the relict dragonfly Epiophlebia superstes (Selys) in comparision with the modern Odonata (Anisozygoptera: Epiophlebiidae). *Odonatologica* 22: 295-309.

SAVILLE, N., 1990. Survey of the status of Epiophlebia laidlawi (Tillyard) in the Shivapur Watershed and Wildlife Reserve, 1998. *Rep. Cambridge, ent. Expd. Nepal* 1998; 31-35.

SHARMA, S., O. MOOG, H. NESEMANN & B. PRADHAN, 2009. Application of Nepalese Biotic Score and its extension for river water quality management in central Himalaya. *Symposium on "Environment energy and water in Nepal: recent researches and direction for future"*, pp. 1-10, Kathmandu.

SHARMA, S. & T. OFENBÖCK, 1996. New discoveries of Epiophlebia laidlawi Tillyard, 1921 in the Nepal Himalaya (Odonata, Anisozygoptera: Epiophlebiidae). *Opusc. zool. flumin.* 150: 1-11.

STRAHLER, A.N. 1957. Quantitative analysis of watershed geomorphology. *Trans. Am. Geophys. Un.* 8: 913-920.

TABARU, N., 1984. Larval development of Epiophlebia superstes in Kyushu. *Tombo* 27: 27-31.

TANI, K. & Y. MIYATAKE, 1979. The discovery of Epiophlebia laidlawi Tillyard, 1921 in the Kathmandu valley, Nepal (Anisozygoptera: Epiophlebiidae). *Odonatologica* 8: 329-332.

TILLYARD, R.J., 1921. On an anisozygopterous larva from the Himalayas (order Odonata). *Rec. Indian Mus.* 22: 93-109, pl. 13 excl.

TRUEMAN, J.W.H & R.J. ROWE, 2001. Odonata: dragonflies and damselflies. Version 01 January 2001. *http://tolweb.org/Odonatal8266/2001.01.01 in The Tree of Life Web Project, http://tolweb.org/.*

*Odonatologica 40(3): 203-225* *September 1, 2011*

# UPDATED CHECKLIST OF THE ODONATA KNOWN FROM COLOMBIA

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*Received September 2, 2010 / Revised and Accepted January 31, 2011*

The checklist includes 335 spp., of which 98 spp. are added to the latest figure published, while 21 previously listed spp. are removed from the list since they were based on unverifiable records. The number of spp. hitherto known from Colombia is low if compared to that from some other S American countries, such as Brazil (660 spp.), Venezuela (487) and Peru (368). A summary of the exploration of odon. diversity in Colombia is provided.

## INTRODUCTION

A recent publication (PAULSON, 2004), revealed that little progress regarding the knowledge of odonate diversity in Colombia has been made since the compilation by SANTOS (1981) showing that during the last 30 years only eleven new species have been described from Colombia (VON ELLENRIEDER, 2008; GARRISON, 2009).

Many facts contribute to Colombia being considered a "terra incognita" (see PAULSON, 2004) when it comes to odonate taxonomy, such as the scarcity of taxonomy students, the reduced fund support to activities related to insect conservation, the presence of illegal armed groups in many areas of the country that poses obstacles to recording of general biodiversity, as well as the loss of reference material, such as the Navás types which were lodged in Spanish museums and later destroyed as a consequence of violent conflicts in that country (A. Cordero, pers. comm.). In addition, some taxa are not documented by reference material in local museums, representing one of the most serious limitations for solving the national collection's taxonomical problems. All these elements are a sign of the crisis that taxonomy is currently experiencing worldwide (AGNARSSON &

KUNTNER, 2007; CRISCI, 2006; WHEELER, 2004), which is intensified in the "Third-World" countries such as Colombia (PAULSON, 2004).

Colombia orogenic features triggered high endemism in some zones which have been declared hotspots (MYERS et al., 2000), turning Colombia into one of the priority countries for biodiversity conservation. This applies to dragonflies as well because a large part of Colombia remains unexplored, and 35 of the 335 species here recorded are endemic to paramos, various basins, and to isolated mountain systems such as the Chiribiquete, Macarena, Sierra Nevada de Santa Marta, and the Perija mountain ranges.

Data were obtained from material deposited in national collections, of which 75% has been studied by specialists, which allowed us to exclude species whose existence in the country is doubtful. Other sources of information include the website of the Slater Museum (http://www.pugetsound.edu/x7039.xml) compiled by PAULSON (2009), and the inventory published by SANTOS (1981). Species are listed alphabetically by family, following DAVIES & TOBIN (1984, 1985) and BRIDGES (1993), cross-referenced to bibliography, and the statements on their distribution by province, and the acronym of the collections where specimens are deposited, are provided.

The current list includes 335 species, referable to 90 genera in 14 families (Fig. 1); 98 species are added to the last published number (see PAULSON, 2004), and from these four are new and as yet undescribed.

The records compiled in this work are mostly based on material identified by Jürg De Marmels, Rosser Garrison, Natalia von Ellenrieder, Carlos Esquivel, and Dennis Paulson.

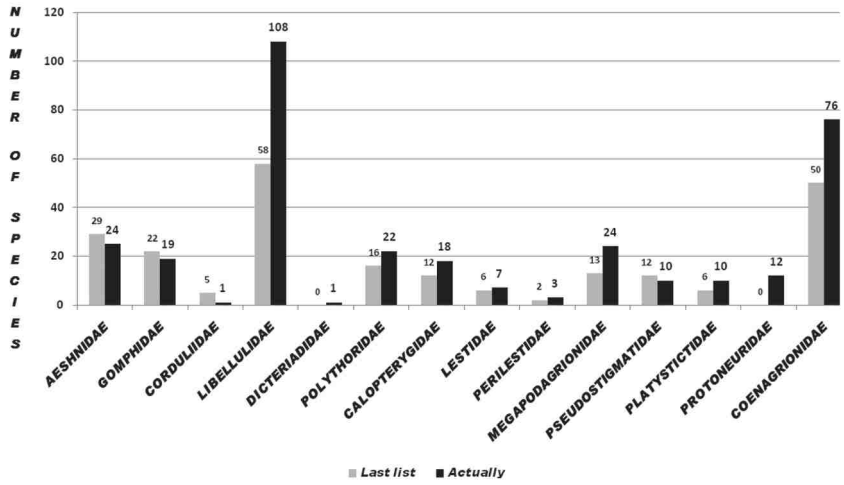


Fig. 1. Histogram showing the odonate proportional diversity per family, comparing the list of SANTOS (1981) and the present list.

ACRONYMS USED FOR COLLECTIONS

ABMM: Angelo B.M. Machado collection, Belo Horizonte, Minas Gerais, Brazil
AMNH: American Museum Natural History, New York, USA.
ANDES: Entomologic Collection University of the ANDES, Bogotá, Colombia.
ANSP: Academy of Natural Sciences. Philadelphia, Pennsylvania, USA.
BMNH: The Natural History Museum, London, United Kingdom.
CUIC: Cornell University, Ithaca, New York, USA
DRPC: Dennis R. Paulson personal collection, Seattle, Washington, USA.
FSCA: Florida State Collection of Arthropods, Gainesville, Florida, USA.
ICN: Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá D.C.
IRSNB: Institut Royal des Sciences Naturelles de Belgique, Bruxelles, Belgium.
MCZ: Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA.
MEUV: Museo de Entomología de la Universidad del Valle, Cali, Colombia.
MIZA: Museo del Instituto de Zoología Agrícola, Maracay, Venezuela.
MNHN: Muséum National d'Histoire Naturelle, Paris, France
MEFLG: Museo Entomológico Francisco Luis Gallego, Universidad Nacional de Colombia, Medellín, Colombia.
MNHP: Princeton University. Princeton, New Jersey, USA.
MUNZ: Massey University, Palmerston North, New Zealand.
NMW: Naturhistorisches Museum Wien, Wien, Austria.
RWG: Rosser W. Garrison personal collection, Sacramento, California, USA.
SMF: Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt-am-Main, Germany.
TWD: Thomas W. Donnelly personal collection, Binghamton, New York, USA.
UARC: Universidad del Atlantico Región Caribe.
UMMZ: University of Michigan, Museum of Zoology, Ann Arbor, Michigan, USA.
USNM: National Museum of Natural History, Washington, D.C., USA.

ACRONYMS USED FOR COLOMBIAN DEPARTMENTS

Amazonas (Am), Antioquia (An), Atlántico (At), Bolívar (Bo), Boyacá (By), Caldas (Cl), Caquetá (Ca), Casanare (Cn), Cauca (Cc), Cesar (Ce), Córdoba (Co), Cundinamarca (Cu), Chocó (Ch), Guainía (Gu), Guaviare (Gv), Huila (Hu), Ll (Llanos Orientales), Magdalena (Ma), Meta (Me), Nariño (Na), Norte de Santander (NS), Quindío (Qu), Putumayo (Pu), Risaralda (Ri), San Andrés (SA), Santander (St), Sucre (Su), Tolima (To), Valle (Vl), Vaupes (Vp) and Vichada (Vi).

## SPECIES EXCLUDED FROM THE COLOMBIAN CHECKLIST

The following 21 species were previously registered for Colombia but are not included in the present list because they were based on unverifiable records:

- *Acanthagrion gracile* (Rambur, 1842), listed by STEINMANN (1997) and HECKMAN (2006) but the record could not be verified and is considered here incorrect.
- *Amphipteryx agrioides* Selys, 1853, listed by RIS (1918); according to GONZÁLEZ-SORIANO & VON ELLENRIEDER (2009), the material collected by Funck originated from northern Mexico rather than from Colombia.
- *Argia extranea* (Hagen, 1861), listed by RIS (1918); according to R.W. Garrison (pers. comm.),

this species reaches its southernmost limit at the Istmus of Tehuantepec in Mexico.

- *Argia funcki* (Selys, 1854), listed by STEINMANN (1997) and HECKMAN (2006) but it could not be verified and is considered here incorrect. According to von ELLENRIEDER AND GARRISON (2007) the reports from South America may have resulted from errors on museum labels.
- *Argia insipida* Hagen in Selys, 1865, listed by STEINMANN (1997) and HECKMAN (2006) but the record could not be verified and is considered here incorrect.
- *Argia oenea* Hagen in Selys, 1865, listed by Ris (1918); according to GARRISON (1994) *Argia oenea* does not extend into South America, being known only as far south as Panamá.
- *Argia pocomana* Calvert, 1907, listed by STEINMANN (1997), HECKMAN (2006), and PAULSON (2009) but it could not be verified and is considered here incorrect.
- *Erythrodiplax melanorubra* Borror, 1942, listed by HECKMAN (2006) but it could not be verified and is considered here incorrect.
- *Forcepsioneura sancta* (Hagen in Selys, 1860), listed by STEINMANN (1997), HECKMAN (2006), and PAULSON (2009) but it could not be verified and is considered here incorrect. All the species of this genus are limited to eastern Brazil (MACHADO, 2009).
- *Hetaerina majuscula* Selys, 1853, listed by RIS (1918); according to GONZÁLEZ-SORIANO & VON ELLENRIEDER (2009), the material collected by Funck originated from northern Mexico rather than from Colombia..
- *Libellula croceipennis* (Selys, 1868), listed by HECKMAN (2006) but it could not be verified and is considered here incorrect. It is possible that the data comes from RIS (1910) whose material was collected by Funk. Nevertheless, as it happened to other localities provided by Funk it is likely that the material originated from northern Mexico rather than from Colombia (GONZÁLEZ--SORIANO & VON ELLENRIEDER, 2009).
- *Mnesarete ephippium* Garrison, 2006, listed by HECKMAN (2006) but it could not be verified and is considered here incorrect. GARRISON (2006) gives Ecuador and Peru as the distribution range for this species.
- *Mnesarete hauxwelli* (Selys, 1869), listed by STEINMANN (1997) and PAULSON (2009) but the record could not be verified and is considered here incorrect. GARRISON (2006) gives Ecuador and Perú as the distribution range for this species. It is probable that the record is based on FRASER (1946) who mentioned it from Colombia. Nevertheless, GARRISON (2006) stated that the illustration of the cerci of *Mnesarete hauxwelli* that Fraser provides does not correspond to this species but to *Mnesarete fulgida* (Selys, 1879).
- *Perithemis intensa* Kirby, 1889, listed by HECKMAN (2006) but it could not be verified and is considered here incorrect.
- *Philogenia berenice* Higgings, 1901, listed by STEINMANN (1997) but it could not be verified and is considered here incorrect.
- *Polythore aurora* (Selys, 1879), listed by STEINMANN (1997) but it could not be verified and is considered here incorrect.
- *Polythore lamerceda* Bick & Bick, 1985, listed by STEINMANN (1997) but it could not be verified and is considered here incorrect.
- *Polythore picta* (Rambur, 1842), listed by STEINMANN (1997) and HECKMAN (2006) but it could not be verified and is considered here incorrect.
- *Polythore vittata* (Selys, 1869), listed by STEINMANN (1997) but it could not be verified and is considered here incorrect.
- *Teinopodagrion vilorianum* De Marmels, 2001, listed by HECKMAN (2006) but it could not be verified and is considered here incorrect.
- *Telebasis carmesina* Calvert, 1909, listed by STEINMANN (1997) but it could not be verified and is considered here incorrect.

## UPDATED LIST OF ODONATA FROM COLOMBIA

### Z y g o p t e r a [10 fam, 41 gen., 183 spp.]

DICTERIADIDAE [1 gen., 1 sp.]

*Heliocharis amazona* Selys, 1853: Cu, Me, RIS (1918), ICN

POLYTHORIDAE [4 gen., 22 spp.]

*Cora aurea* Ris, 1918: RIS (1918)

*Cora confusa* Kennedy, 1940: Ch, ANDES

*Cora chiribiquete* Zloty & Pritchard, 2001: Ca, ZLOTY & PRITCHARD (2001), USNM

*Cora inca* Selys, 1873: Am, To, RIS (1918), BICK & BICK (1990), RWG

*Cora klenei* Karsch, 1891: Vl, BICK & BICK (1990), DRPC

*Cora lugubris* Navás, 1934: Cl, Ri, BICK & BICK (1990), MEFLG, UARC

*Cora marina* Selys, 1868: An, Cu, RIS (1918), BICK & BICK (1990), FSCA

*Cora modesta* Selys, 1869: Cu, Vl, RIS (1918), BICK & BICK (1990), FSCA

*Cora terminalis* MacLachlan, 1878: SCHMIDT (1942), GARRISON et al. (2003)

*Cora xanthostoma* Ris, 1918: Me, RIS (1918), BICK & BICK (1990), ANDES, UARC

*Euthore fasciata fasciata* (Hagen *in* Selys, 1853): By, Cn, Cc, Cu, Me, RIS (1918), BICK & BICK (1992), ANSP, FSCA, MCZ, MUNZ, RWG, UARC, UMMZ

*Euthore fasciata fastigiata* (Selys, 1859): Am, Cu, Me, RIS (1918), BICK & BICK (1992), ANSP, BMNH, FSCA, IRSNB, MCZ, UMMZ

*Euthore fassli* Ris, 1914: Am, RIS (1918), BICK & BICK (1992), SMF

*Euthore hyalina* (Selys, 1853): By, Cu, RIS (1918), BICK & BICK (1992), ANSP, BMNH, FSCA, UMMZ

*Euthore leroii* Ris, 1918: Cl, To, RIS (1918); BICK & BICK (1992), SMF, UMMZ

*Miocora peraltica* Calvert, 1917: GARRISON et al. (2003), UMMZ

*Polythore beata* (McLachlan, 1869): Ca, BICK & BICK (1986)

*Polythore concinna* (McLachlan, 1881): Pu, KIMMINS (1970), BICK & BICK (1986), BMNH, IRSNB, UARC

*Polythore derivata* (McLachlan, 1881): Ca, Pu, BICK & BICK (1985, 1986), USNM, UARC

*Polythore gigantea* (Selys, 1853): An, Ch, Cu, Ri, To, RIS (1918), BICK & BICK (1985, 1986), AMNH, MEFLG, USNM, UARC

*Polythore mutata* (McLachlan, 1881): Pu, BICK & BICK (1986), UARC

*Polythore procera* (Selys, 1869): An, By, Cu, Me, RIS (1918), BICK & BICK (1985, 1986), SÁNCHEZ (2006), ANDES, DRPC, UARC, UMMZ, USNM

CALOPTERYGIDAE [3 gen., 18 spp.]

*Hetaerina aurora* Ris, 1918: An, Ma, Ri, RIS (1918), GARRISON (1990), UARC

*Hetaerina caja caja* (Drury, 1773): Ch, Me, To, RIS (1918), GARRISON (1990), ANDES, UARC

*Hetaerina capitalis* Selys, 1873: An, By, Cu, Ma, St, Vl, RIS (1918), GARRISON (1990), URRUTIA (2005), MEUV

*Hetaerina cruentata* (Rambur, 1842): By, Cu, Cc, Ma, Qu, To, Vl, Ri, RIS (1918), GARRISON (1990), PÉREZ (2003), URRUTIA (2005), DE MARMELS (2006), ANDES, MEFLG, MEUV, MIZA, UARC

*Hetaerina duplex* Selys, 1869: By, Cu, Cn, Me, RIS (1918), GARRISON (1990), ANDES, ICN, UARC

*Hetaerina fuscoguttata* Selys, 1878: Ch, Ma, Vl, GARRISON (1990), PÉREZ (2003), URRUTIA (2005), ANDES, MEUV, UARC

*Hetaerina laesa* Hagen *in* Selys, 1853: GARRISON (1990)

*Hetaerina miniata* Selys, 1879: Ch, PÉREZ et al. (2007), ANDES, UARC

*Hetaerina occisa* Hagen *in* Selys, 1853: An, At, Bo, By, Cu, Ma, Me, Vl, NAVÁS (1935), GARRISON (1990), PÉREZ (2003), URRUTIA (2005), PALACINO (2009a), ANDES, ICN, MEUV, UARC

*Hetaerina proxima* Selys, 1853: Cu, GARRISON (1990)

*Hetaerina sanguinea* Selys, 1853: Me, RIS (1918), GARRISON (1990)

*Hetaerina sempronia* Hagen *in* Selys, 1853: Cu, RIS (1918), GARRISON (1990)

*Hetaerina simplex* Selys, 1853: Me, DUNKLE (1981)

*Hetaerina vulnerata* Hagen *in* Selys, 1853: Cu, GARRISON (1990), UMMZ

*Mnesarete drepane* Garrison, 2006: GARRISON (2006)

*Mnesarete fulgida* (Selys, 1879): Ca, GARRISON (2006) reported this species for the Amazon Department, but the locality mentioned is the river Mesay, which is located in the northern region of Araracuara and corresponds to Caquetá Department], UARC

*Mnesarete metallica* (Selys, 1869): Pu, Ri, KIMMINS (1966), GARRISON (2006), BMNH

*Ormenophlebia imperatrix* (McLachlan, 1878): Me, RIS (1918), GARRISON (2006)

LESTIDAE [2 gen., 7 spp.]

*Archilestes grandis* (Rambur, 1842): Cu, Ma, St, Vl, RIS (1918), GARRISON (1982), PÉREZ (2003), URRUTIA (2005), ANDES, ICN, MEFLG, MEUV, UARC

*Archilestes* sp.: Ch, UARC

*Lestes apollinaris* Navás, 1934: By, Cu, ANDES, UARC.

*Lestes forficula* Rambur, 1842: Ma, Qu, Vl, PÉREZ, (2003), URRUTIA (2005), MEUV, MIZA, UARC
*Lestes henshawi* Calvert, 1907: Cu, Vl, RIS (1918), URRUTIA (2005), MEUV
*Lestes sternalis* Navás, 1930: Cu, ANDES
*Lestes tenuatus* Rambur, 1842: Ma, Vl, At, RIS (1918), URRUTIA (2005), MEUV, UARC

PERILESTIDAE [2 gen., 3 spp.]
*Perilestes kahli* Williamson & Williamson, 1924: Me, UARC
*Perissolestes magdalenae* (Williamson & Williamson, 1924): Am, GARRISON et al. (2003)
*Perissolestes remotus* (Williamson & Williamson, 1924): Ch, At, GARRISON et al. (2003), PÉREZ et al. (2007), ANDES, UARC

MEGAPODAGRIONIDAE [5 gen., 24 spp.]
*Heteragrion aequatoriale* Selys, 1886: Cu, Ch, RIS (1918), WILLIAMSON (1919B), GARRISON (1999), VON ELLENRIEDER & GARRISON (2007), ANDES
*Heteragrion breweri* De Marmels, 1989: Me, ANDES, IRSNB, UARC
*Heteragrion calendulum* Williamson, 1919: An, WILLIAMSON (1919B), GARRISON et al. (2003), UMMZ
*Heteragrion erythrogastrum* Selys, 1886: An, Ch, Vl, URRUTIA (2005), PÉREZ et al. (2007), ANDES, MEUV, UARC, UMMZ
*Heteragrion mitratum* Williamson, 1919: An, To, WILLIAMSON (1919B), GARRISON et al. (2003), UMMZ
*Heteragrion peregrinum* Williamson, 1919: An, WILLIAMSON (1919B), GARRISON et al. (2003), UMMZ
*Heteropodagrion superbum* Ris, 1918: Vl, Ris (1918), GARRISON & VON ELLENRIEDER (2005), DRPC, RWG, UARC
*Mesagrion leucorrhinum* Selys, 1885: Cu, An, By, Me, RIS (1918), NAVÁS (1935), GARRISON & VON ELLENRIEDER (2005), VON ELLENRIEDER & GARRISON (2007), ANDES, BMNH, UARC, UMMZ
*Philogenia cassandra* Hagen *in* Selys, 1862: Cu, RIS (1918), BICK & BICK (1988)
*Philogenia cristalina* Calvert, 1924: An, Ch, BICK & BICK (1988), GARRISON et al. (2003), PÉREZ et al. (2007), ANDES
*Philogenia ebona* Dunkle, 1986: Ch, DUNKLE (1986), BICK & BICK (1988)
*Philogenia helena* Hagen, 1869: By, Cu, RIS (1918), BICK & BICK (1988)
*Philogenia raphaella* Selys,1886: Cu, RIS (1918), BICK & BICK (1988)
*Philogenia sucra* Dunkle, 1986: Su, DUNKLE (1986) USNM
*Teinopodagrion caquetanum* De Marmels, 2001: Ca, DE MARMELS (2001), PÉREZ (2007), ANDES, UARC, USNM

*Teinopodagrion curtum* (Selys, 1886): Am, DE MARMELS (2001), UMMZ
*Teinopodagrion epidrum* De Marmels, 2001 Me, collected in Villavicencio, district La Vanguardia, on road to Calvario. Specimen compared with paratype male by R.W. Garrison (pers. comm.) and apparently conspecific.
*Teinopodagrion macropus* (Selys, 1862): Ca, Me, DE MARMELS (2001), UMMZ
*Teinopodagrion mercenarium* (Hagen, 1869): An, Cu, To, RIS (1918), DE MARMELS (2001), UMMZ
*Teinopodagrion muzanum* (Navás, 1934): By, DE MARMELS (2001), MNHN
*Teinopodagrion oscillans* (Selys, 1862): By, Cu, Ris (1918), DE MARMELS (2001), UMMZ
*Teinopodagrion temporale* (Selys, 1862): Ca, Cu, To, NAVÁS (1935), UMMZ
*Teinopodagrion vallenatum* De Marmels, 2001: Ma, DE MARMELS (2001), GARRISON et al. (2003), PÉREZ (2007), UARC, UMMZ
*Teinopodagrion venale* (Hagen in Selys, 1862): DE MARMELS (2001), UMMZ

PSEUDOSTIGMATIDAE [5 gen., 10 spp.]
*Anomisma abnorme* McLachlan, 1877: Am, Vp, RWG (von Ellenrieder pers. comm.)
*Mecistogaster j. jocaste* Hagen, 1869: By, Me, Na, RIS (1918), UARC
*Mecistogaster jocaste vicentius* Ris, 1918: Cu, Me, RIS (1918)
*Mecistogaster linearis infumata* Fraser, 1946: Ch, ANDES, UARC
*Mecistogaster l. linearis* (Fabricius, 1776): By, Cu, Me, RIS (1918)
*Mecistogaster modesta iphigenia* Selys, 1886: By, RIS (1918), DE MARMELS (1990)
*Mecistogaster o. ornata* Rambur, 1842: By, Me, Vl, Ma, At, RIS (1918), URRUTIA (2005), ANDES, MEUV, UARC
*Megaloprepus caerulatus* (Drury, 1782): By, Ch, Cu, Me, To, Vl, RIS (1918), URRUTIA (2005), PÉREZ et al. (2007), PALACINO (2009a), ANDES, ICN, MEFLG, MEUV, UARC
*Microstigma rotundatum* Selys, 1860: Me, RIS (1918), UARC
*Pseudostigma accedens* Selys, 1860 An, MEFLG

PLATYSTICTIDAE [1 gen., 10 spp.]
*Palaemnema apicalis* Navás, 1924: Bo, CALVERT (1931)
*Palaemnema brucei* Calvert, 1931: CALVERT (1931), GARRISON et al. (2003), UMMZ, UARC
*Palaemnema carmelita* Ris, 1918: RIS (1918)
*Palaemnema clementia* Selys, 1886: Ma, RIS (1918), PÉREZ (2003), UARC
*Palaemnema croceicauda* Calvert, 1931: Pu, CALVERT (1931), GARRISON et al. (2003), UMMZ
*Palaemnema dentata* Donnelly, 1992: At, Ch, PÉREZ et al. (2007), ANDES,

UARC
*Palaemnema edmondi* Calvert, 1931: CALVERT (1931), GARRISON et al. (2003), UMMZ
*Palaemnema joanetta* Kennedy, 1940: Vl, URRUTIA (2005), MEUV
*Palaemnema mutans* Calvert, 1931: Ch, ANDES
*Palaemnema nathalia* Selys, 1886: Ch, ANDES

PROTONEURIDAE [5 gen., 12 spp.]
*Drepanoneura donnellyi* von Ellenrieder & Garrison, 2008: An, To, VON ELLENRIEDER & GARRISON (2008a), RWG, TWD, UMMZ, USNM
*Drepanoneura flinti* von Ellenrieder & Garrison, 2008: Ca, VON ELLENRIEDER & GARRISON (2008a), RWG, USNM [Reported from Puerto Abeja which is not in the Amazon Department as erroneously indicated in that paper but in Caquetá Department]
*Epipleoneura metallica* Rácenis, 1955: To, ANDES, UARC
*Neoneura bilinearis* Selys, 1860: An, Ma, Qu, WILLIAMSON (1918a), GARRISON (1999), MIZA, UARC
*Neoneura amelia* Calvert, 1903: Vl, URRUTIA (2005), MEUV
*Neoneura esthera* Williamson, 1917: An, Ma, To, WILLIAMSON (1918a), GARRISON (1999), ANDES, UARC
*Neoneura myrthea* Williamson, 1917: GARRISON (1999)
*Neoneura sylvatica* Hagen in Selys, 1886: Me, ANDES, UARC
*Protoneura amatoria* Calvert, 1907: Ch, To, PÉREZ et al. (2007), ANDES, UARC
*Protoneura cara* Calvert, 1903: Vl, URRUTIA (2005), MEUV
*Psaironeura remissa* (Calvert, 1903): Ch, Ma, Vl, URRUTIA (2005), PÉREZ et al. (2007), ANDES, MEUV, UARC
*Psaironeura* sp.: Ch, UARC

COENAGRIONIDAE [13 gen., 76 spp.]
*Acanthagrion abunae* Leonard, 1977: Me, ROJAS & SÁNCHEZ (2009), ANDES, UARC
*Acanthagrion apicale* Selys, 1876: Me, UARC
*Acanthagrion adustum* Williamson, 1916: Me, ROJAS & SÁNCHEZ (2009), ANDES, UARC
*Acanthagrion ascendens* Calvert, 1909: By, Ma, RIS (1918), LEONARD (1977)
*Acanthagrion floridense* Fraser, 1946: KIMMINS (1966), LEONARD (1977), BMNH
*Acanthagrion fluviatile* (De Marmels, 1984): Ma, DE MARMELS (1984)
*Acanthagrion inexpectum* Leonard, 1977: Cu, ROJAS & SÁNCHEZ (2009), ICN, UARC
*Acanthagrion kennedii* Williamson, 1916: Vl, URRUTIA (2005), MEUV

*Acanthagrion minutum* Leonard, 1977: Me, ROJAS & SÁNCHEZ (2009), ICN
*Acanthagrion obsoletum* (Förster, 1914): Me, RIS (1918), LEONARD (1977)
*Acanthagrion peruvianum* Leonard, 1977: Me, ROJAS & SÁNCHEZ (2009), ANDES, ICN, UARC
*Acanthagrion trilobatum* Leonard, 1977: By, Co, Ch, Ma, Qu, Ri, To, LEONARD (1977), GARRISON et al. (2003), PÉREZ (2003), PÉREZ et al. (2007), ANDES, MIZA, UARC, UMMZ
*Acanthagrion vidua* Selys, 1876: Cu, Me, LEONARD (1977), ROJAS & SÁNCHEZ (2009), ANDES, UARC
*Acanthagrion viridescens* Leonard, 1977: Me, ROJAS & SÁNCHEZ (2009), ICN
*Acanthagrion williamsoni* Leonard, 1977: Cc, Me, To, LEONARD (1977), GARRISON et al. (2003), UARC, UMMZ
*Acanthagrion yungarum* Ris, 1918: Me, RIS (1918)
*Acanthallagma strohmi* Williamson & Williamson, 1924: ANDES, UARC
*Argia adamsi* Calvert, 1902: Ch, To, ANDES, UARC
*Argia cupraurea* Calvert, 1902: Ch, Me, PÉREZ et al. (2007), ANDES, UARC
*Argia cuprea* (Hagen, 1861): Cu, Me, To, Vl, RIS (1918), URRUTIA (2005), ANDES, MEUV, UARC
*Argia difficilis* Selys, 1865: By, Cu, Ma, Me, RIS (1918)
*Argia dives* Förster, 1914 Me, ICN
*Argia fissa* Selys, 1865: By, Cu, Qu, Vl, RIS (1918), URRUTIA (2005), ANDES, MEUV, MIZA, UARC
*Argia gerhardi* Calvert, 1909: Cu, Me, RIS (1918), NAVÁS (1935), GARRISON et al. (2003), UMMZ
*Argia indicatrix* Calvert, 1902: By, Ch, Cu, Vl, RIS (1918), KIMMINS (1966), GARRISON et al. (2003), PÉREZ et al. (2007), ANDES, BMNH, UARC, UMMZ
*Argia infrequentula* Fraser, 1946: Ri, KIMMINS (1966), BMNH
*Argia jocosa* Hagen *in* Selys, 1865: RIS (1918)
*Argia kokama* Calvert, 1909: Ri, KIMMINS (1966), BMNH
*Argia medullaris* Hagen *in* Selys, 1865: Cu, GARRISON et al. (2003), UARC, UMMZ
*Argia oculata* Hagen *in* Selys, 1865: At, Cu, Ch, Ma, To, RIS (1918), PÉREZ (2003), ANDES, UARC
*Argia orichalcea* Hagen *in* Selys, 1865: Ma, RIS (1918), PÉREZ (2003), UARC
*Argia pulla* Hagen *in* Selys, 1865: At, By, Ca, Cu, Ch, Ma, Me, Qu, To, PÉREZ (2003) ANDES, MIZA, UARC
*Argia talamanca* Calvert, 1907: Ma, Me, RIS (1918), PÉREZ (2003), UARC
*Argia translata* Hagen *in* Selys, 1865: Ch, Ma, To, RIS (1918), NAVÁS (1935), PÉREZ (2003), ANDES, UARC
*Argia variabilis* Selys, 1865: Cc, Cu, To, Vl, RIS (1918), URRUTIA (2005), MEUV
*Argia variata* Navás, 1935: GARRISON et al. (2003)

*Argia variegata* Förster, 1914: Ri, KIMMINS (1966), BMNH
*Enallagma civile* (Hagen, 1861): By, Cu, RIS (1918), ANDES, UARC
*Enallagma novaehispaniae* Calvert, 1907: Ma, To, RIS (1918), PÉREZ (2003), ANDES, UARC
*Enallagma praevarum* (Hagen, 1861): Vl, URRUTIA (2005), MEUV
*Homeoura chelifera* (Selys, 1876): An, VON ELLENRIEDER (2008), RWG, UARC
*Homeoura obrieni* von Ellenrieder, 2008: Bo, Ma, Ch, VON ELLENRIEDER (2008), UMMZ
*Ischnura capreolus* (Hagen, 1861): At, Bo, Ce, Co, Cu, Ch, Ma, To, RIS (1918), ANDES, UARC
*Ischnura cruzi* De Marmels, 1987: Cu, VELÁSQUEZ et al. (2009), ANDES, UARC
*Ischnura denticollis* (Burmeister, 1839): Vl, URRUTIA (2005), MEUV
*Ischnura chingaza* Realpe, 2010: Cu, REALPE (2010), ANDES
*Ischnura cyane* Realpe, 2010: By, Cu, REALPE (2010), ANDES
*Ischnura hastata* (Say, 1840): Ch, PÉREZ et al. (2007), ANDES, UARC
*Ischnura indivisa* (Ris, 1918): By, Cu, Qu, RIS (1918), DE MARMELS (2006), MIZA
*Ischnura ramburii* (Selys, 1850): At, Ce, Co, Cu, Ma, Qu, To, Vl, RIS (1918), PÉREZ (2003), URRUTIA (2005), DE MARMELS (2006), ANDES, MEUV, MIZA, UARC
*Leptobasis buchholzi* (Rácenis, 1959): Bo, DONNELLY (1967), GARRISON & VON ELLENRIEDER (2010), RWG
*Leptobasis vacillans* Hagen *in* Selys, 1877: An, Ch, Vl, GARRISON & VON ELLENRIEDER (2010), TWD, RWG
*Mesamphiagrion demarmelsi* (Cruz, 1986): Cu, CRUZ (1986), VON ELLENRIEDER & GARRISON (2008b), ANDES, RWG, UARC
*Mesamphiagrion laterale* (Selys, 1876): By, Cc, Cu, St, RIS (1918), VON ELLENRIEDER & GARRISON (2008b), ANDES, BMNH, FSCA, MNHN, RWG, TWD, UARC, UMMZ
*Mesamphiagrion occultum* (Ris, 1918): Cu, RIS (1918), VON ELLENRIEDER & GARRISON (2008b), ANDES, RWG, UARC
*Mesamphiagrion ovigerum* (Calvert, 1909): By, Cu, RIS (1918), VON ELLENRIEDER & GARRISON (2008b), DRPC, MCZ, MNHP
*Mesamphiagrion risi* (De Marmels, 1997): Cu, Vl, VON ELLENRIEDER & GARRISON (2008b), ANDES, UARC
*Mesamphiagrion tamaense* (De Marmels, 1988): By, VON ELLENRIEDER & GARRISON (2008b), ANDES, RWG
*Metaleptobasis bicornis* (Selys, 1877): RIS (1918)
*Metaleptobasis foreli* Ris, 1918: RIS (1918)
*Metaleptobasis westfalli* Cumming, 1954: At, UARC

*Metaleptobasis* sp.: Ch, UARC
*Neoerythromma cultellatum* (Hagen *in* Selys, 1876): At, Me, UARC.
*Oreiallagma oreas* (Ris, 1918): RIS (1918), VON ELLENRIEDER & GARRISON (2008b)
*Oxyagrion miniopsis* Selys, 1876: Cu, RIS (1918), ANDES, UARC
*Telebasis corallina* (Selys, 1876): Me, To, ANDES
*Telebasis digiticollis* Calvert, 1902: Ch, RIS (1918), ANDES
*Telebasis farcimentum* Garrison, 2009: Vl, Qu, GARRISON (2009), FSCA, TWD, MIZA
*Telebasis filiola* (Perty, 1834): At, Bo, Ma, Vl, RIS (1918), BICK & BICK (1995), PÉREZ (2003), URRUTIA (2005), GARRISON (2009), ANDES, MEUV, UARC, RWG
*Telebasis garrisoni* Bick & Bick, 1995: An, Ma, St, BICK & BICK (1995), GARRISON et al. (2003), GARRISON (2009), RWG
*Telebasis garleppi* Ris, 1918: Vl, GARRISON (2009), TWD
*Telebasis griffinii* (Martin, 1896): An, Bo, Ce, Co, BICK & BICK (1995), GARRISON(2009), ANDES, FSCA, RWG, SWD, UARC, UMMZ
*Telebasis isthmica* Calvert, 1902: BICK & BICK (1995), GARRISON (2009)
*Telebasis salva* (Hagen, 1861): At, Bo, Cu, Ma, Qu, Vl, RIS (1918), BICK & BICK (1995), URRUTIA (2005), DE MARMELS (2006), GARRISON (2009), ANDES, MEUV, MIZA, RWG, UARC
*Telebasis versicolor* Fraser, 1946: Pu, Ri, KIMMINS (1966), BICK & BICK (1995), GARRISON (2009), BMNH
*Telebasis williamsoni* Garrison, 2009: GARRISON, (2009), Bo, By, Ce, Co, Ma, Me, ABMM, ICN, RWG, UMMZ

## A n i s o p t e r a [4 fam, 49 gen., 152 spp.]

### AESHNIDAE [9 gen., 24 spp.]

*Allopetalia pustulosa* Selys, 1873: By, Cu, Ma, RIS (1918), PALACINO (2009b), ICN, UARC
*Anax amazili* (Burmeister, 1839): At, Cl, Cu, Qu, To, Vl, RIS (1918), DE MARMELS (2006), PALACINO (2009b), MIZA
*Anax concolor* Brauer, 1865: At, ANDES
*Andaeschna rufipes* (Ris, 1918): RIS (1918)
*Coryphaeschna adnexa* (Hagen, 1861): At, Bo, By, Qu, Me, RIS (1918), HINCKS (1934), PALACINO (2009b), DE MARMELS (2006), ANDES, ICN, MIZA
*Coryphaeschna viriditas* Calvert, 1952: At, Bo, Cu, Me, To, PALACINO (2009b), ICN
*Gynacantha jessei* Williamson, 1923: An, WILLIAMSON (1923), GARRISON et al. (2003), UMMZ
*Gynacantha membranalis* Karsch, 1891: Am, At, Ch, Me, RIS (1918), WILLIAM-

SON (1923), HINCKS (1934), PÉREZ et al. (2007), PALACINO (2009b), ICN, ANDES

*Gynacantha mexicana* Selys, 1868: Bo, Ch, Ma, Vl, WILLIAMSON (1923), PALACINO (2009b), ANDES, ICN, UARC

*Gynacantha nervosa* Rambur, 1842: An, Bo, Cu, Ch, Ma, To, RIS (1918), WILLIAMSON (1923), HINCKS (1934), PÉREZ (2003), PALACINO (2009b), ANDES, MEFLG, UARC

*Gynacantha remartinia* Navás, 1934: Me, To, NAVÁS (1935)

*Gynacantha tenuis* Martin, 1909: An, WILLIAMSON (1923), DE MARMELS (2006)

*Remartinia l. luteipennis* (Burmeister, 1839): Ma, Me, Qu, RIS (1918), CALVERT (1956), DE MARMELS (2006), MIZA

*Rhionaeschna brevicercia* (Muzón & von Ellenrieder, 2001): Cu, St, VON ELLENRIEDER (2003), IRSNB, UMMZ

*Rhionaeschna cornigera* (Brauer, 1865): By, Cu, Ch, Hu, Ma, NS, Ri,To, RIS (1918), VON ELLENRIEDER (2003), PÉREZ (2003), PALACINO (2009a,b), ICN, NMW, UARC, UMMZ

*Rhionaeschna intricata* (Martin, 1908): By, Ma, St, PALACINO (2009b), ICN

*Rhionaeschna joannisi* (Martin, 1897): Cc, VON ELLENRIEDER (2003)

*Rhionaeschna marchali* (Rambur, 1842): Bo, By, Cc, Ce, Cl, Cu, Ch, Hu, Ma, Me, NS, St, To, Vl, RIS (1918), NAVÁS (1935), VON ELLENRIEDER (2003), PÉREZ (2003), PALACINO (2009a,b), DRPC, ICN, IRSNB, UARC, USNM

*Rhionaeschna planaltica* (Calvert, 1952): VON ELLENRIEDER (2003)

*Staurophlebia reticulata* (Burmeister, 1839): HINCKS (1934), ANDES

*Triacanthagyna caribbea* Williamson, 1923: An, Bo, Ma, WILLIAMSON (1923), VON ELLENRIEDER & GARRISON (2003), RWG, UMMZ, USNM

*Triacanthagyna ditzleri* Williamson, 1923: An, WILLIAMSON (1923), HINCKS (1934), VON ELLENRIEDER & GARRISON (2003), RWG, UMMZ, USNM

*Triacanthagyna septima* (Selys *in* Sagra, 1857): At, Bo, Co, Ma, Ll, RIS (1918), WILLIAMSON (1923), DUNKLE (1981), PÉREZ (2003), VON ELLENRIEDER & GARRISON (2003), PALACINO (2009b), ICN, UARC, USNM

*Triacanthagyna trifida* (Rambur, 1842): RIS (1918), WILLIAMSON (1923)

GOMPHIDAE [9 gen., 19 spp.]

*Agriogomphus jessei* (Williamson, 1918): An, WILLIAMSON (1918b), UARC, UMMZ

*Agriogomphus sylvicola* Selys, 1869: Ma, WILLIAMSON (1918c), UMMZ

*Aphylla molossus* Selys, 1869: Cu, To, ANDES

*Aphylla tenuis* Selys, 1859: Ch, RIS (1918)

*Archaeogomphus furcatus* Williamson, 1923: Ma, PÉREZ (2003), UARC

*Archaeogomphus hamatus* (Williamson, 1918): Ma, WILLIAMSON (1919a),

GARRISON et al. (2003), UMMZ
*Desmogomphus paucinervis* (Selys, 1873): Gu, GARRISON et al. (2006), PALACINO (2009b), ICN
*Epigomphus obtusus* Selys, 1869: RIS (1918)
*Epigomphus pechumani* Belle, 1970: BELLE (1970), CUIC
*Erpetogomphus sabaleticus* Williamson, 1918: An, Ma, To, WILLIAMSON (1918b), GARRISON (1994), PÉREZ (2003), UARC, UMMZ
*Phyllocycla anduzei* (Needham, 1943): BELLE (1970), SMF
*Phyllocycla volsella* (Calvert, 1905): Cu, Me, Qu, DE MARMELS (2006), PALACINO (2009b), ICN, MIZA
*Phyllogomphoides cornutifrons* (Needham, 1944): By, ANDES
*Phyllogomphoides insignatus* Donnelly, 1979 An, MEFLG
*Phyllogomphoides semicircularis* (Selys, 1854): Ma, PÉREZ (2003), UARC
*Progomphus abbreviatus* Belle, 1973: Cc, Ma, GARRISON et al. (2003), PÉREZ (2003), UARC, UMMZ
*Progomphus incurvatus bivittatus* De Marmels, 1991: Ma, PÉREZ (2003), UARC
*Progomphus phyllochromus* Ris, 1918: Ma, PÉREZ (2003), UARC
*Progomphus pygmaeus* Selys, 1873: Bo, Ma, Qu, RIS (1918), WILLIAMSON (1920), PÉREZ (2003), DE MARMELS (2006), MIZA, UARC, UMMZ

CORDULIIDAE [1 gen., 1 sp.]
*Neocordulia batesi* (Selys, 1871): Ch, PÉREZ et al. (2007), ANDES, UARC

LIBELLULIDAE [30 gen., 108 spp.]
*Anatya guttata* (Erichson, 1848): At, Bo, By, Cn, Ch, Co, Me, St, To, RIS (1918), PALACINO (2009b), ANDES, MEFLG, UARC
*Brachymesia furcata* (Hagen, 1861): At, ANDES, UARC
*Brachymesia herbida* (Gundlach, 1889): At, By, Ce, Co, Ma, Me, RIS (1918), PALACINO (2009b), ANDES, ICN, MEFLG, UARC
*Brechmorhoga flavopunctata* (Martin, 1897): RIS (1918)
*Brechmorhoga nubecula* (Rambur, 1842): Ch, Ma, CALVERT (1906, 1909), PÉREZ (2003), ANDES, UARC
*Brechmorhoga pertinax* (Hagen, 1861): RIS (1919)
*Brechmorhoga praecox* (Hagen, 1861): Ma, Me, CALVERT (1898, 1909), RIS (1918), PÉREZ (2003), ANDES, UARC
*Brechmorhoga rapax* Calvert, 1898: Ma, Me, RIS (1918), NAVÁS (1935), PÉREZ (2003), ANDES, UARC
*Brechmorhoga vivax* Calvert, 1906: Qu, DE MARMELS (2006), MIZA
*Cannaphila mortoni* Donnelly, 1992: Ch, PÉREZ et al. (2007), ANDES, UARC
*Cannaphila vibex* (Hagen, 1861): By, Cu, Ma, Me, Qu, Ri, Vl, CALVERT (1909), RIS (1918), PÉREZ (2003), DE MARMELS (2006), PALACINO (2009a,b),

ICN, MEFLG, MIZA, UARC
*Dasythemis esmeralda* Ris, 1910: Ca, Me, Ri, SCHMIDT (1942), PALACINO (2009b)
*Diastatops intensa* Montgomery, 1940: ANDES, UARC
*Diastatops obscura* (Fabricius, 1775): Me, ANDES, UARC
*Dythemis multipunctata* Kirby, 1894: Cn, Cu, Ma, Me, RIS (1918), PÉREZ (2003), PALACINO (2009b), ANDES, ICN, MEFLG, UARC
*Dythemis sterilis* Hagen, 1861: At, Bo, By, Cl, Cu, Ma, To, CALVERT (1906, 1909), RIS (1918), PÉREZ (2003), PALACINO (2009a,b), ANDES, ICN, UARC
*Elasmothemis cannacrioides* (Calvert, 1906): By, Ch, Ma, To, RIS (1918), PÉREZ (2003), PALACINO (2009b), ANDES, ICN, UARC
*Elga leptostyla* Ris, 1909: ANDES, UARC
*Erythemis attala* (Selys *in* Sagra 1857): At, Cu, RIS (1918), PÉREZ (2003), ANDES, UARC
*Erythemis carmelita* Williamson, 1923: Ma, At, WILLIAMSON (1923), UMMZ, UARC
*Erythemis credula* (Hagen, 1861): Am, Ch, Me, RIS (1918); PÉREZ et al. (2007); PALACINO (2009b), ANDES, UARC
*Erythemis haematogastra* (Burmeister, 1839): At, Bo, By, Ce, Co, Gv, At, Ch, Me, RIS (1918); PALACINO (2009b), ICN, UARC
*Erythemis mithroides* (Brauer, 1900): At, Ch, RIS (1918), PALACINO (2009b), ANDES, UARC
*Erythemis peruviana* (Rambur, 1842): Am, At, Bo, By, Cc, Ce, Co, Ch, Cu, Me, St, To, Vl, RIS (1918), NAVÁS (1935), PALACINO (2009b), ANDES, ICN, MEFLG
*Erythemis plebeja* (Burmeister, 1839): At, Bo, Co, Ma, Me, Qu, RIS (1918), PÉREZ (2003), DE MARMELS (2006), PALACINO (2009b), ICN, MIZA, UARC
*Erythemis vesiculosa* (Fabricius, 1775): Am, At, Bo, Ce, Co, Cl, Cn, Cu, Ch, Hu, Ma, Me, Qu, SA, Su, To, Vl, RIS (1918), PÉREZ (2003), DE MARMELS (2006), PALACINO (2009b), ANDES, ICN, MEFLG, MIZA, UARC
*Erythemis* sp.: At, UARC
*Erythrodiplax abjecta* (Rambur, 1842): Am, By, Cl, Cu, Ma, Me, St, Vl, RIS (1918), BORROR (1942), PAULSON (2003), PÉREZ (2003), PALACINO (2009b), ANDES, ICN, UARC
*Erythrodiplax andagoya* Borror, 1942: An, Ch, Vl, BORROR (1942), GARRISON et al. (2003), PÉREZ et al. (2007), ANDES, UARC, UMMZ
*Erythrodiplax attenuata* (Kirby, 1889): Am, Me, PALACINO (2009b), ICN
*Erythrodiplax basalis* (Kirby, 1897): Am, An, Co, Ch, Ma, Pu, Vl, RIS (1918), ANDES, UARC
*Erythrodiplax b. berenice* (Drury, 1773): Bo, PALACINO (2009b), ICN

*Erythrodiplax berenice naeva* (Hagen, 1861): Bo, Ma, BORROR (1942),
*Erythrodiplax castanea* (Burmeister, 1839): Am, An, Bo, Ch, Me, Pu, Vl, RIS (1918), BORROR (1942), PÉREZ et al. (2007), PALACINO (2009b), ANDES, ICN, UARC
*Erythrodiplax cauca* Borror, 1942: Cc, Qu, BORROR (1942), PAULSON (2003), DE MARMELS (2006), ANDES, MIZA, UMMZ
*Erythrodiplax connata* (Burmeister, 1839): By, Ca, Cc, Ch, Me, BORROR (1942), PÉREZ et al. (2007), ANDES, UARC
*Erythrodiplax famula* (Erichson, 1848): Me, RIS (1918)
*Erythrodiplax fervida* (Erichson, 1848): An, At, Bo, By, Ca, Ce, Co, Ch, Ma, Su, BORROR (1942), PÉREZ (2003), PALACINO (2009b), ICN, UARC
*Erythrodiplax funerea* (Hagen, 1861): Ma, Na, Vl, RIS (1918), PALACINO (2009b), ICN
*Erythrodiplax fusca* (Rambur, 1842): Am, An, Bo, By, CC, Cu, Ch, Ma, Me, Qu, Ri, St, To, Vl, RIS (1918), BORROR (1942), PÉREZ (2003), DE MARMELS (2006), PALACINO (2009b), ANDES, ICN, MIZA, UARC
*Erythrodiplax ines* Ris, 1911: An, BORROR (1942)
*Erythrodiplax juliana* Ris, 1911: An, BORROR (1942)
*Erythrodiplax kimminsi* Borror, 1942: An, By, Co, Ch, Ma, Me, Pu, St, BORROR (1942), PALACINO (2009b), ANDES, ICN, UARC
*Erythrodiplax lativittata* Borror, 1942: An, Ch, PÉREZ et al. (2007), ANDES, UARC
*Erythrodiplax minuscula* (Rambur, 1842): Me, RIS (1918)
*Erythrodiplax ochracea* (Burmeister, 1839): Ch, Ma, RIS (1918)
*Erythrodiplax paraguayensis* (Förster, 1905): To, ANDES, UARC
*Erythrodiplax umbrata* (Linnaeus, 1758): Am, An, At, Bo, Ca, Cc, Ce, Cl, Cn, Co, Cu, Ch, Ma, Me, Na, Qu, St, Su, To, Vc, Vl, RIS (1918), DE MARMELS (2006), PALACINO (2009b), ANDES, ICN, MEFLG, MIZA, UARC
*Erythrodiplax unimaculata* (De Geer, 1773): Ca, Me, RIS (1918), BORROR (1942), PALACINO (2009b), ICN
*Erythrodiplax venusta* (Kirby, 1897): Me, RIS (1918)
*Gynothemis pumila* (Karsch, 1890): Me, CALVERT (1909), RIS (1913)
*Idiataphe amazonica* (Kirby, 1889): At, ANDES, UARC
*Idiataphe longipes* (Hagen, 1861): Ch, KIRBY (1889), PÉREZ et al. (2007), ANDES, UARC
*Libellula herculea* Karsch, 1889: By, Cc, Ma, Me, Qu, Ri, Vl, CALVERT (1909), RIS (1918), PÉREZ (2003), DE MARMELS (2006), PALACINO (2009a,b), ANDES, ICN, MEFLG, MIZA, UARC
*Macrothemis fallax* May, 1998: Ma, PÉREZ (2003), UARC
*Macrothemis hahneli* Ris, 1913: Pu, RIS (1918), ANDES
*Macrothemis hemichlora* (Burmeister, 1839): At, Ma, Me, CALVERT (1898, 1906, 1909), RIS (1918)

*Macrothemis imitans leucozona* Ris, 1913: Ch, Qu, DE MARMELS (2006), ANDES, MIZA
*Macrothemis inacuta* Calvert, 1898: Ch, ANDES
*Macrothemis inequiunguis* Calvert, 1895: Ch, CALVERT (1906, 1909), ANDES
*Macrothemis musiva* Calvert, 1898: Me, CALVERT (1898, 1906, 1909), RIS (1918)
*Macrothemis pseudimitans* Calvert, 1898: Cu, Ma, RIS (1918), PÉREZ (2003)
*Macrothemis tessellata* (Burmeister, 1839): RIS (1918)
*Miathyria marcella* (Selys in Sagra 1857): At, Bo, Ce, Co, Ch, Ma, Su, To, Vl, CALVERT (1906, 1909), RIS (1918), PALACINO (2009b), ANDES, ICN, UARC
*Miathyria simplex* (Rambur, 1842): At, Bo, Ma, PÉREZ (2003), PALACINO (2009b), ICN, UARC
*Micrathyria aequalis* (Hagen, 1861): At, Cu, Ma, Qu, St, To, RIS (1918), PÉREZ (2003), DE MARMELS (2006), ANDES, MIZA, UARC
*Micrathyria dictynna* Ris, 1919: At, Ch, PÉREZ et al. (2007), ANDES, UARC
*Micrathyria didyma* (Selys *in* Sagra 1857): Bo, Cu, St, RIS (1918),
*Micrathyria eximia* Kirby, 1897: RIS (1918)
*Micrathyria laevigata* Calvert, 1909: RIS (1918)
*Micrathyria mengeri* Ris, 1919: An, DUNKLE (1995)
*Micrathyria ocellata* Martin, 1897: At, UARC
*Micrathyria pseudeximia* Westfall, 1992: Me, UARC
*Micrathyria spuria* (Selys, 1900): RIS (1918), ANDES, UARC
*Micrathyria tibialis* Kirby, 1897: By, Bo, Ce, Co, Me, PALACINO (2009b), ICN, UARC
*Nephepeltia flavifrons* (Karsch, 1889): Bo, By, Ca, Co, Me, St, Su, RIS (1918), PALACINO (2009b), ANDES, ICN, UARC
*Nephepeltia phryne* (Perty, 1834): Ch, PÉREZ et al. (2007), ANDES, UARC
*Oligoclada heliophila* Borror, 1931: Ma, GARRISON et al. (2003), UMMZ
*Oligoclada umbricola* Borror, 1931: St, PALACINO (2009b), ICN
*Orthemis attenuata* (Erichson, 1848): Ma, VON ELLENRIEDER (2009), RWG
*Orthemis aequilibris* Calvert, 1909: Me, RIS (1918)
*Orthemis biolleyi* Calvert, 1906: Bo, By, Me, RIS (1918), PALACINO (2009b), ICN
*Orthemis cultriformis* Calvert, 1899: Am, Ch, Me, St, RIS (1918), PÉREZ et al. (2007), PALACINO (2009b), ANDES, ICN, UARC
*Orthemis discolor* (Burmeister, 1839): Am, At, By, Cu, Ch, Gu, Ma, Me, Qu, Ri, St, To, CALVERT (1909), PÉREZ (2003), DE MARMELS (2006), PALACINO (2009a, 2009b), ANDES, ICN, MIZA, UARC
*Pantala flavescens* (Fabricius, 1798): At, Ce, Cn, Cu, Ch, Ma, Me, NS, Qu, St, To, Vc, Vl, CALVERT (1906, 1909), RIS (1918), PÉREZ (2003), DE MARMELS

(2006), PALACINO (2009b), ANDES, ICN, MEFLG, MIZA, UARC
*Pantala hymenaea* (Say, 1840): Bo, Cu, Ch, Ma, Me, To, CALVERT (1906, 1909), RIS (1918), PALACINO (2009b), ICN, UARC
*Perithemis domitia* (Drury, 1773): Bo, Ch, Ma, To, RIS (1918, 1930), PÉREZ (2003), ANDES, UARC
*Perithemis electra* Ris, 1930: Ch, Ma, RIS (1930), ANDES, UARC
*Perithemis lais* (Perty, 1834): Co, Ch, Ma, Me, RIS (1930), PALACINO (2009b), ANDES, ICN, UARC
*Perithemis mooma* Kirby, 1889: At, Bo, By, Co, Cu, Ma, Me, Na, Qu, To, RIS (1930), PÉREZ (2003), DE MARMELS (2006), PALACINO (2009a), ANDES, ICN, MIZA, UARC
*Perithemis tenera* (Say, 1840): Ch, PÉREZ et al. (2007), ANDES
*Planiplax phoenicura* Ris, 1912: At, ANDES, UARC
*Rhodopygia cardinalis* (Erichson, 1848): Ca, Me, BELLE (1998), PALACINO (2009b), ANDES, ICN, UARC
*Sympetrum gilvum* (Selys, 1884): By, Cc, Cu, Ma, Vl, PÉREZ (2003), PALACINO (2009b), ANDES, ICN, UARC
*Sympetrum illotum* (Hagen, 1861): By, RIS (1918)
*Tauriphila australis* (Hagen, 1867): At, Bo, Cu, Ma, CALVERT (1906, 1909), RIS (1918), PALACINO (2009b), ICN
*Tholymis citrina* Hagen, 1867: Am, At, Ch, Co, Ma, Me, To, CALVERT (1906), RIS (1918), DUNKLE (1981), PÉREZ (2003), PALACINO (2009b), ANDES, ICN, UARC
*Tramea abdominalis* (Rambur, 1842): RIS (1913), ANDES, UARC,
*Tramea binotata* (Rambur, 1842): Ch, Vl, RIS (1918), PÉREZ et al. (2007), ANDES, UARC
*Tramea calverti* Muttkowski, 1910: At, Bo, Cl, Cu, Ch, Ma, Me, Qu, Su, PÉREZ (2003), DE MARMELS (2006), MIZA
*Tramea cophysa* Hagen, 1867: Me, CALVERT (1906, 1909), RIS (1918), ANDES
*Tramea rustica* De Marmels & Rácenis, 1982: Ma, Me, To, DE MARMELS & RÁCENIS (1982), PALACINO (2009b).
*Uracis fastigiata* (Burmeister, 1839): Am, Ch, Me, Na, St, Ris (1918), Pérez et al. (2007), PALACINO (2009b), ANDES, ICN, MEFLG, UARC
*Uracis imbuta* (Burmeister, 1839): Am, Bo, By, Ca, Cl, Cn, Co, Cu, Ch, Gu, Gv, Me, Pu, Ri, St, To, Vl, RIS (1918), PÉREZ et al. (2007), PALACINO (2009a, 2009b), ANDES, ICN, MEFLG, UARC
*Uracis infumata* (Rambur, 1842): Am, Ca, PALACINO (2009b), ICN
*Uracis siemensi* Kirby, 1897: PALACINO (2009b), ICN
*Zenithoptera fasciata* (Linnaeus, 1758): Ca, Co, Ch, Me, St, RIS (1918), PÉREZ et al. (2007), PALACINO (2009b), ANDES, MEFLG
*Zenithoptera viola* Ris, 1910: Co, PALACINO (2009b), ICN

## COMMENTS ON THE LIST

Fifty percent of the species reported from the country were registered between 1898 and 1928 for the first time (Fig. 2), largely by NAVÁS (1935) and the Williamson brothers as a result of their expedition with the University of Michigan to Colombia (see WILLIAMSON 1918a, 1918b, 1918c, 1919a, 1919b, 1920, 1923). Almost 70 years later work on odonates from Colombia was resumed, and during the last 20 years there has been a significant increase in taxonomic studies by Colombian researchers, although unfortunately most have not been published yet.

A comprehensive review of the collections deposited in academic institutions in Colombia from key regions of the country may lead us to quickly recognize a much larger number of species for the country.

The best known regions regarding the Odonata diversity in Colombia include the departments of Atlantico, Bolivar, and Magdalena in the Caribbean region, and the departments of Cundinamarca, Boyacá, and Meta in the Andean region. However, it is necessary to increase sampling in other regions such as the departments of Guainia, Vaupes, and Guaviare, which are completely unexplored as regards to odonates, and where many undescribed species may be found. We make a special call to study these regions strategically, emphasizing taxonomic studies in national parks and nature reserves.

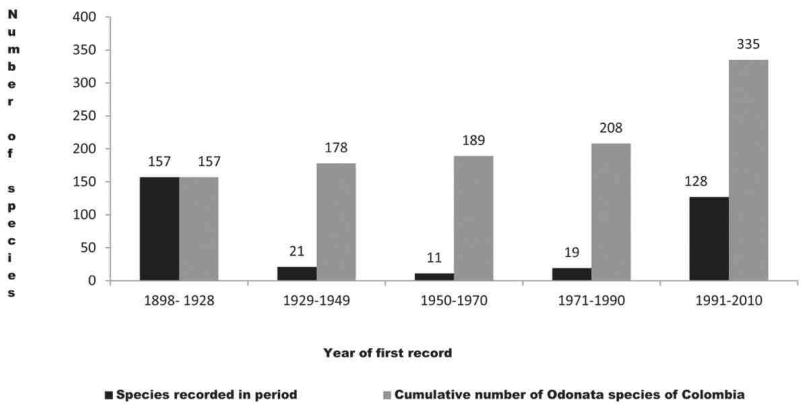


Fig. 2. Histogram showing the number of Odonata species known to occur in Colombia in the periods of thirty and twenty years.

**ACKNOWLEDGEMENTS**

We express our sincere gratitude to NATALIA VON ELLENRIEDER, JÜRG DE MARMELS and ROSSER W. GARRISON, for contributing with their valuable experience to the taxonomic study of neotropical odonates and for their scientific support in the preparation of this paper. To ENRIQUE GONZALEZ-SORIANO and NANCY C. ROJAS for their contributions. Thanks also go to all Colombian odonatologists and enthusiastic colleagues who shared their species data and to Natalia von Ellenrieder for her corrections and suggestions editing this manuscript.

**REFERENCES**

AGNARSSON, I. & M. KUNTNER, 2007. Taxonomy in a changing world: seeking solutions for a science in crisis. *Syst. Biol.* 56(3): 531-539.

BELLE, J., 1970. Studies on South American Gomphidae (Odonata). *Stud. Fauna Suriname*. 11(43): 1-158.

BELLE, J., 1998. Synopsis of the neotropical genus Rhodopygia. *Zool. Meded.* Leiden 72: 1-13.

BICK, G.H. & J.C. BICK, 1985. A revision of the Picta group of Polythore, with a description of a new species, P. lamerceda spec. nov., from Peru (Zygoptera: Polythoridae). *Odonatologica* 14(1): 1-28.

BICK, G.H. & J.C. BICK, 1986. The genus Polythore exclusive of the Picta group (Zygoptera: Polythoridae). *Odonatologica* 15(3): 245-273.

BICK, G.H. & J.C. BICK, 1988. A review of males of the genus Philogenia, with descriptions of the five new species from South America (Zygoptera: Megapodagrionidae). *Odonatologica* 17(1): 9-32.

BICK, G.H. & J.C. BICK, 1990. A revision of the neotropical genus Cora Selys, 1853 (Zygoptera: Polythoridae). *Odonatologica* 19(2): 117-143.

BICK, G.H. & J.C. BICK, 1992. A study of family Polythoridae, with details on the genus Euthore Selys, 1869 (Zygoptera). *Odonatologica* 21(3): 275-288.

BICK, G.H. & J.C. BICK, 1995. A review of the genus Telebasis with descriptions of eight new species (Zygoptera: Coenagrionidae). *Odonatologica* 24(1): 11-44.

BORROR, D.J., 1942. A revision of the Libelluline genus Erythrodiplax (Odonata). *Contr. Zool. Ent. Ohio St. Univ.* 4: xv+286 pp.

BRIDGES, C.A., 1993. *Catalogue of the familiy-group, genus-group and species-group names of the Odonata of the world* [2nd edn]. C.A. Bridges, Urbana, Ill.

CALVERT, P.P., 1898. The odonate genus Macrothemis and its allies. *Proc. Boston Soc. nat. Hist*. 28: 301-332.

CALVERT, P.P., 1906. The 'Biologia Centrali-Americana' *Ent. News* 17: 213-308.

CALVERT, P.P., 1909. Contributions to a knowledge of the Odonata of the neotropical region, exclusive of Mexico and Central America. *Ann. Carnegie Mus*. 6: 73-281.

CALVERT, P.P., 1931. The generic characters and the species of Palaemnema (Odonata: Agrionidae). *Trans. Am. ent. Soc.* 57: 1-111.

CALVERT, P.P., 1956. The neotropical species of the subgenus Aeshna sensu Selysii 1883 (Odonata). *Mem. Am. ent. Soc.* 15: 1-251.

CRISCI, J.V., 2006. One-dimensional systematist: perils in a time of steady progress. *Syst. Bot.* 31(1): 217-221.

CRUZ, L.F., 1986. Contribución a los estudios taxonómicos de Odonata - Zygoptera de Colombia: descripción de una nueva especie de Cianallagma [*sic*] (Odonata: Coenagrionidae). *Caldasia* 14(68-70): 743-747.

DAVIES, D.A.L. & P. TOBIN, 1984. The dragonflies of the world: a systematic list of the extant species of Odonata, Vol. 1: Zygoptera, Anisozygoptera. *S.I.O. rapid Comm.* (Suppl.) 3: 1-127.

DAVIES, D.A.L. & P. TOBIN, 1985. The dragonflies of the world: A systematic list of the extant species of Odonata, Vol. 2: Anisoptera. *S.I.O. rapid Comm.* (Suppl.) 5: 1-151.

DE MARMELS, J., 1984. Oxyagrion fluviatile sp. n. from Venezuela, with notes on Oxyagrion cardinale Fraser (Odonata: Coenagrionidae). *Boln. Ent. Venez.* (N.S.) 3(3): 21-28.

DE MARMELS, J., 1990. Hallazgo de Odonata nuevos para Venezuela o poco conocidos. 6. *Boln. Ent. Venez.* (N.S.) 5(20): 193-195.

DE MARMELS, J., 2001. *Revision of Megapodagrion (Selys, 1886) (Insecta, Odonata: Megapodagrionidae)*. Diss. Univ. Zürich.

DE MARMELS, J., 2006. Una pequeña colección de libélulas (Odonata) de Colombia. *Entomotropica* 21(1): 69-71.

DE MARMELS, J. & J. RÁCENIS., 1982. An analysis of the Cophysa-group of Tramea Hagen, with descriptions of two new species (Anisoptera: Libellulidae). *Odonatologica* 11(2): 109-128.

DONNELLY, T.W., 1967. The discovery of Chrysobasis in central America, with the description of a new species (Odonata: Coenagrionidae). *Fla. Ent*. 50(1): 47-52.

DUNKLE, S.W., 1981. Dunkle and Knopf blitz Ecuador and Colombia. *Selysia* 10(1): 5-6.

DUNKLE, S.W., 1986. Four new species of Philogenia damselflies from Ecuador and Colombia (Zygoptera: Megapodagrionidae). *Odonatologica* 15: 43-50.

DUNKLE, S.W., 1995. Geographical variation in Micrathyria mengeri Ris, with a description of M. mengeri watsoni ssp. nov. (Anisoptera: Libellulidae). *Odonatologica* 24(1): 45-51.

FRASER, F.C. 1946. Notes on Amazonian Odonata in the Leeds Museum. *Trans. R. ent. Soc.* 96(2): 11-46.

GARRISON, R.W., 1982. Archilestes neblina, a new damselfly from Costa Rica, with comments on the variability of A. latzalatus Donnelly (Odonata: Lestidae). *Occ. Pap. Mus. Zool. Univ. Mich.* 702: 1-12.

GARRISON, R.W., 1990. A synopsis of the genus Hetaerina with descriptions of four new species (Odonata: Calopterygidae). *Trans. Am. ent. Soc.* 116(1): 175-260.

GARRISON, R. W., 1994. A revision of the New World genus Erpetogomphus Hagen in Selys (Odonata: Gomphidae). *Tijdschr. Ent.* 137: 173-269.

GARRISON, R.W., 1999. The genus Neoneura, with keys and description of a new species, Neoneura jurzitzai spec.nov. (Zygoptera: Protoneuridae). *Odonatologica* 28(4): 343-375.

GARRISON, R.W., 2006. A synopsis of the genera Mnesarete Cowley, Bryoplathanon gen. nov., and Ormenoplebia gen. nov. (Odonata: Calopterygidae). *Contr. Sci*, Los Angeles 506: 1-84.

GARRISON, R.W., 2009. A synopsis of the genus Telebasis Odonata: Coenagrionidae). *Int. J. Odonatol.* 12(1): 1-121.

GARRISON, R.W., N. VON ELLENRIEDER & M.F. O'BRIEN, 2003. An annotated list of the name-bearing types of species-group names in Odonata preserved in the University of Michigan Museum of Zoology. *Occ. Pap. Mus. Zool. Univ. Mich*. 736: 1-73.

GARRISON, R.W. & N. VON ELLENRIEDER, 2005. Neuragrion mysticum (Odonata: Megapodagrionidae) demystified. *Can. Ent.* 137: 169-173.

GARRISON, R.W. & N. VON ELLENRIEDER, 2010. Redefinition of Leptobasis Selys with the synonymy of Chrysobasis Rácenis and description of L. mauffrayi sp. nov. from Peru (Odonata: Coenagrionidae). *Zootaxa*, 2438: 1-36.

GONZÁLEZ-SORIANO, E. & N. VON ELLENRIEDER, 2009. What is Amphipteryx agrioides Selys 1853 (Odonata: Amphipterygidae)?. *Zootaxa* 2074: 61-64.

HECKMAN, C.W., 2008. *Encyclopedia of South American aquatic insects: Odonata- Zygoptera. Illustrated keys to known families, genera, and species in South America.* Springer, Dordrecht.

HINCKS, W.D., 1934. Odonata (Paraneuroptera) from Peru and Colombia. *Ent. Rec. J. Var.* 46: 77-81.

KIMMINS, D.E., 1966. A list of the Odonata types described by F.C. Fraser, now in the British Museum (Natural History). *Bull. Brit. Mus. nat. Hist.* (Ent.) 18(6): 173-228.

KIMMINS, D.E., 1970. A list of the type-specimens of Odonata in the British Museum (Natural History), 3. *Bull. Brit. Mus. nat. Hist.* (Ent.) 24: 173-205.

KIRBY, W.F., 1889. A revision of the subfamily Libellulinae, with descriptions of new genera and species. *Trans. zool. Soc. Lond.* 12: 249-348.

LEONARD, J.W., 1977. A Revisionary study of the genus Acanthagrion (Odonata: Zygoptera). *Misc. Publ. Mus. Zool. Univ. Mich.* 153: 1-173.

MACHADO, A.B.M., 2009 Studies on neotropical Protoneuridae, 21: the status of Amazoneura Machado, 2004 (Odonata: Protoneuridae). *Lundiana* 9(1): 53-56.

MYERS, N., R.A. MITTERMEIER, G.A.B. DA FONSECA & J. KENT, 2000. Biodiversity hotspots for conservation priorities. *Nature, Lond.* 403: 853-858.

NAVÁS, L., 1935. Odonatos de Colombia. *Boln Soc. ent. Esp*. 17(1-3): 33-38.

PALACINO, F., 2009a. Odonata. *In*: G. Amat, [Ed.], *Biodiversidad regional: Santa María (Boyacá)*. Guía de Campo: artrópodos: arácnidos, miriápodos, crustáceos, insectos. Guías de Campo No. 5, 30 pp., Inst. Cienc. Nat., Univ. Nac. Colombia, Bogotá.

PALACINO, F., 2009b. Dragonflies (Odonata: Anisoptera) of the collection of the Instituto de Ciencias Naturales, Universidad Nacional de Colombia. *Boln Mus. Ent. Univ. Valle* 10(1): 37-41.

PAULSON, D.R., 2003. Comments on the Erythrodiplax connata (Burmeister, 1839) group, with the elevation of E. fusca (Rambur, 1842), E. minuscula (Rambur, 1842), and E. basifusca (Calvert, 1895) to full species (Anisoptera: Libellulidae). *Bull. Am. Odonatol.* 6(4): 101-110.

PAULSON, D.R. 2004. Critical species of Odonata in the Neotropics. *Int. J. Odonatol*. 7: 163-188.

PAULSON, D.R., 2009. South American Odonata. List of the Odonata of South America, by country. Available from: <http://www.ups.edu/x7039.xml> (Accessed 14/08/2009).

PÉREZ, L.A., 2003. *Estudio biotaxonómico de los odonatos (Insecta: Odonata Fabricius, 1793) del distrito de Santa Marta (Magdalena-Colombia)*. Trab. Grado, Univ. Magdalena, Santa Marta, Colombia.

PÉREZ, L.A., 2007. The larvae of Teinopodagrion caquetanum De Marmels and T. vallenatum De Marmels (Zygoptera: Megapodagrionidae). *Odonatologica* 36(3): 307- 313.

PÉREZ, L., D. MONROY & E. REALPE, 2007. Local assemblage patterns of odonates in central Chocó, colombian pacific. *In*: B.K. Tyagi, [Ed.], *Odonata: biology of dragonflies*. Scientific Publishers, Jodhpur, pp. 183-199.

REALPE, E., 2010. Two new species of the genus Ischnura Charpentier from Colombia, with a key to the regional species (Zygoptera: Coenagrionidae). *Odonatologica* 39(2):121-131.

RIS, F., 1910. Libellulinen monographisch bearbeitet, 1. *Collns zool. Edm. de Selys Longchamps* 10: 121-244, col. Pl. 2 excl.

RIS, F., 1913. Libellulinen monographisch bearbeitet, 7. *Collns zool. Edm. de Selys Longchamps* 15: 837-964.

RIS, F., 1918. Libellen (Odonata) aus der Region der amerikanischen Kordilleren von Costa Rica bis Catamarca. *Arch. Naturg*. (A) 9: 1-197.

RIS, F., 1930. A revision of the libelluline genus Perithemis (Odonata). *Misc. Publ. Mus. Zool. Univ. Mich.* 21: 1-50.

ROJAS, N.C. & M. SÁNCHEZ, 2009. New records of Acanthagrion (Odonata: Coenagrionidae) from Colombia. *Bull. Am. Odonatol.* 11(1): 17-19.

SÁNCHEZ, M., 2006. *Estructura de la población de Polythore procera (Odonata: Polythoridae) residente en la quebrada "La Catira", en la vereda Monterredondo (Guayabetal-Cundinamarca)*. Trab. Grado, Depto Cienc. Biol., Univ. Andes, Bogotá.

SANTOS, N.D., 1981. Odonata. *In*: S.H. Hurlbert et al., [Eds], *Aquatic biota of tropical South America*, 1, pp. 64-85, San Diego St. Univ., San Diego.

SCHMIDT, E., 1942. Odonata, nebst Bemerkungen über die Anomisma und Chalcopteryx des Amazonas Gebietes, pp. 225-276. *In*: E. Titschak, [Ed.]. *Beiträge zur Fauna Perus nach der Ausbeute*

*der Hamburger Südperu Expedition 1936*, Bd 2, pp. 225-276, Fischer, Jena.
STEINMANN, H., 1997. *World catalogue of Odonata.* Vols 1 & 2, Tierreich 110 & 111, de Gruyter, Berlin.
URRUTIA, M.X., 2005. Riqueza de species de Odonata (Zigoptera) [*sic*] por unidades fisiográficas en el departamento del Valle del Cauca. *Boln. Mus. Ent. Univ. Valle* 6(2): 30-36.
VELÁSQUEZ, N., K. BAUTISTA, M. GUEVARA, D. RAMÍREZ, E. L.A. PÉREZ-GUTIÉRREZ, 2009. Larval development and growth ratio in Ischnura cruzi De Marmels, with description of last larval instar (Zygoptera: Coenagrionidae). *Odonatologica* 38(1): 29-38.
VON ELLENRIEDER, N., 2003. A synopsis of the neotropical species of "Aeshna" Fabricius: the genus Rhionaeschna Förster (Odonata: Aeshnidae).*Tijdschr. Ent.* 146: 67-207.
VON ELLENRIEDER, N., 2008. Revalidation of Argentagrion and redefinition of Homeoura, with the description of H. obrieni n. sp. (Odonata: Coenagrionidae). *Revta. Soc. ent. argent.* 67(1/2): 81-106.
VON ELLENRIEDER, N., 2009. Five new species of Orthemis from South America (Odonata: Libellulidae). *Int. J. Odonatol.* 12(2): 347-381.
VON ELLENRIEDER, N. & R.W. GARRISON, 2003. A synopsis of the genus Triacanthagyna (Odonata: Aeshnidae). *Int. J. Odonatol.* 6 (2): 147-184.
VON ELLENRIEDER, N. & R.W. GARRISON, 2007. Untangling some taxonomic riddles on damselfly genera (Zygoptera) from the Neotropical region. *Int. Dragonfly Fund Rep.* 11: 1-34.
VON ELLENRIEDER, N. & R.W. GARRISON, 2008a. Drepanoneura gen. nov. for Epipleoneura letitia and Protoneura peruviensis, with descriptions of eight new Protoneuridae from South America (Odonata: Protoneuridae). *Zootaxa* 1842: 1-34.
VON ELLENRIEDER, N. & R.W. GARRISON, 2008b. Oreiallagma gen. nov. with a redefinition of Cyanallagma Kennedy 1920 and Mesamphiagrion Kennedy 1920, and the description of M. dunklei sp. nov. and M. ecuatoriale sp. nov. from Ecuador (Odonata: Coenagrionidae). *Zootaxa* 1805: 1-51.
WHEELER, Q.D., 2004. Taxonomic triage and the poverty of phylogeny. *Philos. Trans. R. Soc. Lond.* (B) 359: 571-583.
WILLIAMSON, E.B., 1918a. A collecting trip to Colombia, South America. *Misc. Publ. Mus. Zool. Univ. Mich.* 3: 1-24.
WILLIAMSON, E.B., 1918b. Results of the University of Michigan Williamson Expedition to Colombia, 1916-1917, 1: two interesting new Colombian gomphines (Odonata). *Occ. Pap. Mus. Zool. Univ. Mich.* 52: 1-14.
WILLIAMSON, E.B., 1918c. Results of the University of Michigan Williamson Expedition to Colombia, 1916-1917, 2: a new species of Agriogomphus (Odonata). *Occ. Pap. Mus. Zool. Univ. Mich.* 59: 1-18.
WILLIAMSON, E.B., 1919a. Results of the University of Michigan Williamson Expedition to Colombia, 1916-1917, 3: Archaeogomphus, a new genus of dragonflies (Odonata). *Occ. Pap. Mus. Zool. Univ. Mich.* 63:1-8.
WILLIAMSON, E.B., 1919b. Results of the University of Michigan Williamson Expedition to Colombia, 1916-1917, 4: notes on species of the genus Heteragrion Selys with descriptions of new species (Odonata). *Occ. Pap. Mus. Zool. Univ. Mich.* 68: 1-88.
WILLIAMSON, E.B., 1920. Results of the University of Michigan Williamson Expedition to Colombia, 1916-1917, 5: notes on a few species of Progomphus (Odonata). *Occ. Pap. Mus. Zool. Univ. Mich.* 77: 1-18.
WILLIAMSON, E.B., 1923. Notes on American species of Triacanthagyna and Gynacantha. *Misc. Publ. Mus. Zool. Univ. Mich.* 9: 1-80.
ZLOTY, J. & G. PRITCHARD, 2001. Cora chiribiquete spec. nov., a new damselfly species from Colombia (Zygoptera: Polythoridae). *Odonatologica* 30(2): 227-232.

*Odonatologica 40(3): 227-249* *September 1, 2011*

# THE GENERA OF THE AFROTROPICAL "AESHNINI": *AFROAESCHNA* GEN. NOV., *PINHEYSCHNA* GEN. NOV. AND *ZOSTERAESCHNA* GEN. NOV., WITH THE DESCRIPTION OF *PINHEYSCHNA WATERSTONI* SPEC. NOV. (ANISOPTERA: AESHNIDAE)

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*Received February 14, 2011 / Reviewed and Accepted March 14, 2011*

The generic names *Afroaeschna, Pinheyschna* and *Zosteraeschna* are introduced for 3 groups of Afrotropical dragonfly species, traditionally assigned to the paraphyletic taxon *Aeshna*. The phylogenetic relationships of these monophyla which are not immediately related to each other are discussed. The Ethiopian populations of *Pinheyschna* gen. n. are described and characterized as a new sp. (*Pinheyschna waterstoni*). *Zosteraeschna ellioti* (Kirby, 1896) and *Z. usambarica* (Förster, 1906) are regarded as distinct species. Only synonymy, information on status (if feasible) and distribution are given for the remaining species of the group, and a preliminary key to the adults of all but one species is presented.

## INTRODUCTION

After the last transfer of American species into the huge and hierarchically differentiated monophyletic taxon *Rhionaeschna* Förster (VON ELLENRIEDER, 2003) about 40 species remained in the traditional genus *Aeshna* Fabricius, 1775. There are no traits synapomorphically characterizing the members of this assemblage (PETERS, 1987; VON ELLENRIEDER, 2003) which encompasses such disparate species as *Aeshna isosceles* (Müller), *A. petalura* (Martin), *A. scotias* Pinhey and *A. williamsoniana* Calvert. Thus, even with the removal of the *Rhionaeschna* species, *Aeshna* is a paraphyletic construct. Nonetheless there are several monophyletic units included with the genus, for instance around the Pal-

aearctic generotype *A. grandis* (L.).

The same paraphyletic status applies to the few *Aeshna* species, distributed in the Afrotropical region (PINHEY, 1961, 1962, 1964, 1981a, 1984; CLAUSNITZER & PETERS, 2003). Although they are geographically well-separated from the bulk of the "Aeshnini" (sensu BRIDGES, 1994) in the Holarctic, Neotropical and Oriental regions, thus appearing as a zoogeographically bounded complex, the Afrotropical "Aeshnini"do not appear to be monophyletic as a whole.

The first author was repeatedly asked by V. Clausnitzer and K.-D.B. Dijkstra to finally describe an *Aeshna* taxon from Ethiopia for which he already fixed the type material in the ZMHU and BMNH years ago. Honouring this request, we feel obliged to offer the results of extended studies on the Afrotropical "Aeshnini", in order to avoid assigning the new species to an obsolete taxon. These studies resulted in the recognition of the mentioned taxon as a new species and in the founding of new genera for three not closely inter-related groups of Afrotropical *Aeshna* species.

## MATERIAL AND METHODS

The terminology used for the description of body pattern and wing venation largely follows PETERS & THEISCHINGER (2007).

Measurements are given in millimetres (mm).

The following abbreviations are used for material depositories:

| | |
|---|---|
| BMNH | British Museum (Natural History), London, England |
| MRAC | Musee Royal de l'Afrique Centrale, Tervuren, Belgium |
| MSNG | Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy |
| MZUF | Museo Zoologico "La Specola", Firenze, Italy |
| NHRS | Naturhistoriska Riksmuseet, Stockholm, Sweden |
| NMBZ | Natural History Museum of Zimbabwe, Bulawayo, Zimbabwe |
| RMNH | Nationaal Natuurhistorisch Museum „Naturalis", Leiden, The Netherlands |
| UMMZ | University of Michigan Museum of Zoology, Ann Arbor, USA |
| ZFMK | Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany |
| ZMHU | Zoologisches Museum der Humboldt Universität, Berlin, Germany. |

Abbreviations for common morphological terms: Ax: antenodal cross-veins, Ax1: first Ax from base, Fw: forewing(s), Hw: hindwing(s), Pt: pterostigma, Px: postnodal cross-veins, S1-S10: first – tenth abdominal segment.

The term cerci is used for male superior anal appendages, the term epiproct for male inferior anal appendage. The gender symbols (♂ for male, ♀ for female) are used when appropriate.

## THE MONOPHYLETIC TAXA OF THE AFROTROPICAL SPECIES FORMERLY PLACED IN *AESHNA*

The African "*Aeshna*" species south of the Tropic of Cancer constitute three units, which each have a special set of characters. Among odonatologists one has been known as the "*Aeshna rileyi* group" and a second as the "*Aeshna ellioti* group". *Aeshna scotias* belongs to neither group. It has a number of ancestral

traits and some autapomorphies which in their combination have not been found in other aeshnine taxa, *Aeshna* s. str. included. To recognise these disparities, it is desirable to create a new genus for each group.

## *AESHNA SCOTIAS*

As already pointed out above, the particularity of the species reflecting its isolated phylogenetic position should be marked by the allocation of the generic name *Afroaeschna* gen. nov.

## *AFROAESCHNA* GEN. NOV.

E t y m o l o g y. – The prefix "Afro" is chosen in order to accentuate the Afrotropical distribution of this puzzling taxon.

Type species: *Aeshna scotias* PINHEY, 1952.

Species: *Afroaeschna scotias* (Pinhey).

DIAGNOSIS. – A fairly large dragonfly: total length 77-98 mm (male), 78-86 mm (female); Fw 49-53 mm (male), 53-56 mm (female). The most remarkable diagnostic characters are:

- eyes green
- incisura lateralis (posterior border of eye) well marked
- occiput small with posterior border concave
- all thoracic and abdominal stripes and spots green
- wing venation black
- high number of Ax and Px (19-24 and 14-16 in Fw)
- IR2 fork nearly symmetrical, in some specimens with 1-2 irregular inserted cells at level of branching (Fig. 9)
- MA-RP3/4 anastomosis badly marked (Fig. 9)
- one paranal cell (Fig. 9)
- anal loop with 3 rows of cells (Fig. 9)
- anal triangle 2-celled with the crossvein in posterior half (Fig. 4)
- membranule short (Fig. 4)
- auricles with 3-6 denticles
- cerci without ventrobasal tubercle, the elevated posterior portion of its dorsal crest with 3-6 denticles, apical portion of blades with deep insertion (Fig. 27)
- larvae with claw-like curved and sharply pointed labial palps and distinct paraglossae (Fig. 5 in CHELMICK, 2001) and with spiniform (single-pointed) epiproct.

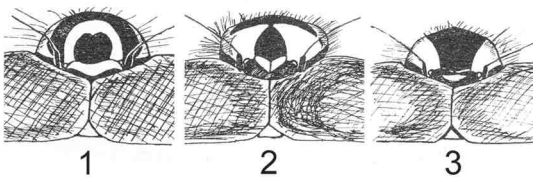
DISCUSSION, DISTRIBUTION, HABITAT AND ECOLOGY. – As *Afroaeschna* is monotypic these accounts are presented below, under *Afroaeschna scotias*.

## *AFROAESCHNA SCOTIAS* (PINHEY) COMB. NOV.

Figures 4, 9, 23, 27

*Aeshna scotias* PINHEY, 1952: 14 [Type: Kamengo Forest, Uganda, BMNH].
*Aeshna wittei* FRASER, 1955: 15 [Type: Kaziba, DRC, MRAC], new synonymy.

DISTRIBUTION. – In contrast with the south-north extended distribution of *Pinheyschna, Zosteraeschna* and *Anaciaeschna triangulifera* throughout eastern Africa, *Afroaeschna scotias* is concentrated in the equatorial region and not only in its eastern part but also in the west. Its occurrence in west Africa was quite unpredictable: Southwest province of Cameroon (VICK, 1999; CHELMICK, 2001); Fernando Po (= Bioko) (5 specimens collected by W. Hartwig in 1962/63, not mentioned by PINHEY (1971)), in ZFMK. Until now no other "Aeshnini" has been reported from West Africa. In the eastern African tropics *A. scotias* is known from several places: Uganda: Kamengo and Matuma Forest (Terra typica) 20-30 miles W of Kampala (PINHEY, 1952, 1961) and Butolo Forest (1 ♀ in NMBZ); Tanzania: Mpanda distr., Sitebi (1 ♂ coll. Kieland in NMBZ); Congo: Katanga, Upemba Nat. Park, Kaziba and Kalumengongo (T. t. of *A. wittei*); Zambia: Ikelenge distr., N. Mwinilunga, Isombo River (*A. wittei*, see PINHEY, 1981b). In general, the distribution of *A. scotias* is known quite inadequately, even in East Africa where the species, confined to shaded mountain streams, should exist in many more places. Its occurrence in the southern edgings of the Congo basin and in Gabon, due to the poor odonatological knowledge about these vast territories, cannot be ruled out. On the other hand its absence there could indicate a Cameroon highlands/Albertina rift disjunction as is known from other dragonfly species. Anyhow, at the present *A. scotias* is known from two disjunct regions on both sides of the Congo basin. On the Albertina Rift stretching from Uganda to NW Zambia, it overlaps with *Pinheyschna* and *Zosteraeschna,* and on the Cameroon highlands it is the only Aeshnini species.



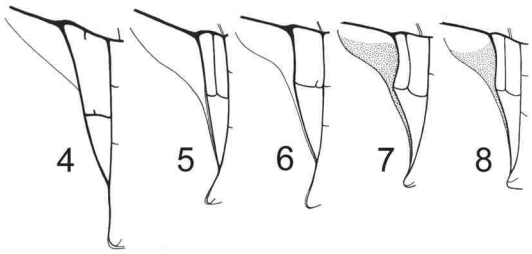

Figs 1-3. Top of frons (modified from PINHEY, 1951): (1) *Pinheyschna subpupillata*; – (2) *Zosteraeschna minuscula*; – (3) *Z. usambarica* (as *ellioti*).

HABITATS AND ECOLOGY. – Deeply shaded calm streams with moderate current. Lotic; ovipositing in dead wood or vegetation lying in the water. Larvae have been found among roots of branches hanging in the water.

DISCUSSION. – *Aeshna wittei* Fraser, 1955, with only 4 specimens known (see PINHEY, 1981b) is identical with *Afroaeschna scotias.* This conclusion, made from the study of specimens clearly identified as *A. scotias* and the detailed redescription of *A. wittei* by PINHEY (1981b), and agreed to by K.-D. DIJK-

STRA who saw the holotypes of both, seems to be the most acceptable hypothesis.

*Afroaeschna scotias* is the most enigmatic taxon of all Afrotropical hawkers. It is fairly "rich" in ancestral character states, and none of the few advanced expressions of traits unites the species with *Pinheyschna, Zosteraeschna* or *Anaciaeschna* Selys. The apomorphic state of a narrow 2-celled anal triangle and of 3 rows of cells in the discoidal field as well as a single paranal cell (instead of 2) has been brought about in a number of aeshnid taxa. Denticles on the dorsal crest of the cerci are met with in some species of *Aeshna* s. str. (*crenata, eremita, osiliensis, serrata* etc.). But with these taxa *A. scotias* does not share any other apomorphy. Supposedly only two characters seem to represent unambiguous autapomorphies: the claw-like bending and tapering of the larval labial palps (unknown to us from other Aeshnini) and the far-going reduction of pale/bright abdominal spots in the adults. Anterodorsal, medio- and posterodorsal spots are totally missing and the anterolateral ones are diminished to small antero-carinal lines. Reduction of abdominal spots, where not caused by rufinism (the potential of species to produce individuals more or less uniformly brown with little blue instead of green, yellow and blue marked with black) as for instance to different degrees in *Andaeschna* De Marmels*, Amphiaeschna* Selys*,* or *"Aeshna" isoceles*, has taken place also in *Aeshna grandis*, *Anax speratus* Hagen and *Remartinia* Navas. But reductions seldom can be discussed seriously as indications of synapomorphy, at last concerning the abdominal pattern or spots. Totally inadequate for systematic analysis, of course, are the numerous and conspicuous ancestral character states like green eyes, large incisura lateralis, short membranule, large number of auricle teeth, unforked larval epiproct and others. *Afroaeschna scotias* is not included in the comprehensive cladistic analysis of VON ELLENRIEDER (2003).Thus the determination of the phylogenetic position of the species remains a challenge for future research.




Figs 4-8. Anal triangle and mebranule of left Hw, male, ventral view: (4) *Afroaeschna scotias* (from Fernando Po); – (5) *Pinheyschna rileyi*; – (6) *P. waterstoni*; – (7) *Zosteraeschna usambarica*; – (8) *Z. minuscula*.

## THE "*AESHNA RILEYI* GROUP"

*Aeshna rileyi,* the first Afrotropical species described of the genus, serves as the generotype of a complex of related species which is introduced as *Pinheyschna* gen. nov.

## *PINHEYSCHNA* GEN. NOV.

E t y m o l o g y. – The name is coined in honour of the late Elliot Charles Gordon P i n h e y for his extensive and fruitful investigations of the Afrotropical dragonfly fauna. It is a composite of Pinhey and Aeschna. The gender of the name is feminine.

Type species: *Aeschna Rileyi* CALVERT, 1892.

Species: *Pinheyschna meruensis* (Sjöstedt), *P. moori* (Pinhey), *P. rileyi* (Calvert), *P. subpupillata* (McLachlan), *P. waterstoni* sp. n., *P. yemenensis* (Waterston).

DIAGNOSIS. – All *Pinheyschna* species share the following apomorphies:

- ocellus- (eye) like rounded stem of the "T-spot" (on top of frons) surrounded by a pale ring and potentially thinly connected with the cross-bar of that spot (Figs 1, 32)
- extended (down-running) membranule and shortened anal triangle (Figs 5, 6)
- postero-ventrad protruding male genital lobe (Figs 13, 14)
- abdomen with dorsal and lateral pairs of bright intersegmental spots (repeated in *Basiaeschna* Selys, *Aeshna umbrosa* Walker and some species of *Anax* Leach.

Characters of some diagnostic value: females somewhat larger than males; eyes green (not blue); abdominal sternum 1 without tubercle; S2 dorsally without uninterrupted crossing ridge; auricles with 2-4 teeth; crossveins in basal portion of wings yellow (not black); IR2-fork symmetrical; anal triangle 2-3-celled, with apical cell longer than the basal one(s), and CuP ("anal crossing") usually situated in front of it (Figs 5, 6); membranule not distinctly two-coloured; cerci strongly hooked; larval epiproct bifid with apical cleft longer than wide. Additionally peculiarities of the male secondary genitalia (Figs 19-22) may be of systematic value.

DISTRIBUTION. – Yemen, Ethiopia, Kenya, Tanzania, Uganda, Zimbabwe, Cape.

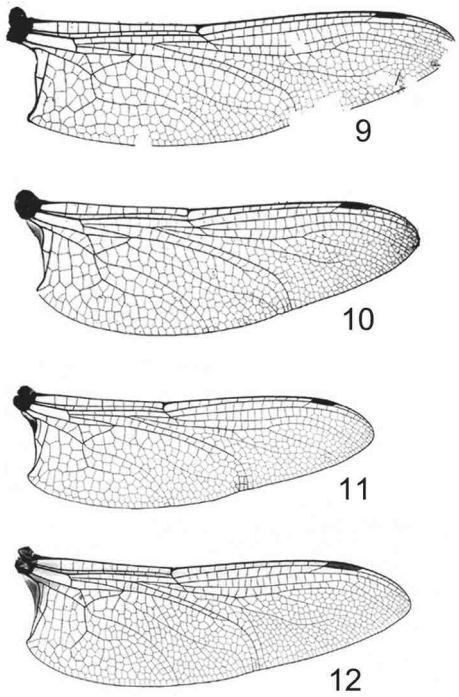
The six species of this monophylum form, according to venation density, shape of the extended male genital lobe and to the proportions of the larval anal pyramid, two species groups, a northern and a predominantly southern one with one species somehow suspended in between. The more northerly distributed group, termed *P. meruensis* group for the remainder of this paper, includes *P. meruensis* (CLAUSNITZER & PETERS, 2003), *P. yemenensis* (WATERSTON, 1985), the Ethiopian species described below and possibly *P. moori*. Its diagnostic characters include more open venation, in male a rather short, triangular genital lobe with apex pointed, and cerci without sub-basal inferior hump, and in the larvae a not particularly short and wide anal pyramid. The group of the southern species, termed *P. rileyi* group for the remainder of this paper, includes *P. rileyi* and *P. subpupillata* and possibly *P. moori.* It is characterized by denser venation, in male by a more or less funnel-like process of the genital lobe and a sub-basal inferior hump on the cerci, and in the larvae by a very short and broad anal

pyramid (SAMWAYS, CARCHINI & DI DOMENICO, 1993).

HABITAT AND ECOLOGY. – *Pinheyschna,* as compared to *Afroaeschna* and *Zosteraeschna*, favours more open country including highlands without forest. The habitats are fast-flowing, rocky open streams with limited shading. Lotic; oviposits in steep gravel banks, dead wood or bankside vegetation. Larvae among silt, gravel and pebbles under rocks in rapid stream sections.

DISCUSSION. – The first and third of the above listed autapomorphies are unique among the "Aeshnini".

The relatives and finally the sister group of of *Pinheyschna* have to be searched for among "Aeshnini" bearing an advanced type of hamular apparatus (to be characterized elsewhere) combined with an extended membranule. A "down-running" membranule which is the apomorphic counterpart of the short one, characterizes not only the taxa more or less closely related to *Zosteraeschna* (see next paragraph) but also *Adversaeschna* Watson, *Oreaeschna* Lieftinck, *Anax*, "*Aeshna*" *isoceles*, *mixta* Latreille and *affinis* Vander Linden. In nearly all these groupings with *Pinheyschna* included, the extended membranule is associated with some other apomorphic trends [diminishing incisura lateralis and number of auricle teeth, expression of MA-RP3/4 anastomosis and presence of Rspl2 (Fig. 12)]. The only exception from this picture is "*Aeshna*" *isoceles*. But all the just listed advanced states may have been produced independently more than once in the evolutionary history of the taxa. Therefore the determination of the phylogenetic position of *Pinheyschna* in the first place depends on the phylogenetic evaluation of the combined character states. At the present we can only draw one preliminary conclusion: none of the mentioned taxa is the sister group of *Pinheyschna*. In a comprehensive cladistic analysis by VON ELLENRIEDER (2003), however, "*Aeshna" rileyi* + *subpupillata*, both assigned to *Pinheyschna* gen. n. in this paper, emerged as the sister group of *Rhionaeschna*.




Figs 9-12. Right Hw of males: (9) *Afroaeschna scotias*; – (10) *Pinheyschna rileyi*; – (11) *Zosteraeschna usambarica*; – (12) *Anaciaeschna jaspidea.*

## *PINHEYSCHNA MERUENSIS* (SJÖSTEDT) COMB. NOV.

Figure 19

*Aeshna meruensis* SJÖSTEDT, 1909: 32 [Type: Mt Meru, Tanzania NHRS].

STATUS. – The species specific distinctness of *P. meruensis* and *P. yemenensis* is unquestionable, as well as the sympatry of *P. meruensis* and *P. rileyi* (CLAUSNITZER & PETERS, 2003; DIJKSTRA & CLAUSNITZER, 2005).

DISTRIBUTION. – Kenya, Tanzania and Uganda; ?Sudan, Angola (PINHEY, 1975).

## *PINHEYSCHNA MOORI* (PINHEY) COMB. NOV.

*Aeshna moori* PINHEY, 1981: 64 [Type: Ikelenge, Zambia, NMBZ].

STATUS. – According to K.-D.B. Dijkstra, the holotype is in fairly good condition, only the abdominal markings are indiscernible. It is apparently a dark species, the synthorax is dark save three complete but narrow stripes on each side. The frontal mark is clearly preserved and although the extreme tip of the left lobe is lost, the tapering and strongly curved genital lobes do not represent a distortion or aberration. Combined with the dimensions stated, this indicates that *P. moori* is a good species. Hw 48.5 mm, Abd 54.8 (50.1 without appendages), Fw Pt 4.0, Hw Pt 3.9 mm. The allotype is more stained, but clearly shows a frontal mark like the holotype and is also large. Hw 52.8 mm, Abd 52.7 without appendages, Fw Pt 4.6, Hw Pt 4.1 mm.

DISTRIBUTION. – Zambia; known only from Kamankundju River and Isomo River in North Mwinilunga.

DISCUSSION. – *P. moori* is known only from a single poorly preserved male and a female from NW Zambia. According to PINHEY (1981b) it is near *P. rileyi* but the male has the genital lobes tapering to a fine, well-curved point, and the T-mark on the frons is not ocellate but a typical T with thick stem, although his note that the "stem [is] slightly more swollen near base and edged with yellow" suggests some similarity to a *rileyi*-type T-mark. The genital lobe, large size (Hw given as 49 mm), relatively short Pt (given as 3 mm) and appearance of the appendages (see also PINHEY, 1984) would have suggested that this specimen is close to *P. meruensis*, although the well-curved genital lobe is a feature of *P. yemenensis* and *P. waterstoni* spec. nov. PINHEY (1981b) may not have thought of *P. meruensis*, because he considered it synonymous with *P. rileyi* (see PINHEY, 1963). Anyway the position of *P. moori* will have to be re-assessed when more material is at hand.

## *PINHEYSCHNA RILEYI* (CALVERT) COMB. NOV.

Figures 5, 10, 22

*Aeschna Rileyi* CALVERT, 1892: 164 [Type: Kilimanjaro, N.E. Tanzania].
*Aeshna rileyi raphaeli* PINHEY, 1964: 112 [Type: Ikelenge, Zambia, NMBZ].
*Aeshna rileyi* form (or subspecies) *raphaeli* PINHEY, 1964 – PINHEY (1984: 28).

PINHEY (1984) downgraded his *P. raphaeli* to a form and supposed sympatry of both, *rileyi* and *raphaeli,* in eastern Zimbabwe. It appears that only a thorough revision of the widely scattered collection material may be able to answer the question about the status of *raphaeli* (see also the distribution map of *P. subpupillata* in TARBOTON & TARBOTON (2002) and the quotation of the latter species for Mozambique by CLAUSNITZER (2001).

DISTRIBUTION. – Kenya to Zimbabwe; ?Sudan; Angola (PINHEY, 1975).

## *PINHEYSCHNA SUBPUPILLATA* (MCLACHLAN) COMB. NOV.

Figure 1

*Aeschna subpupillata* McLACHLAN, 1896: 422 [Type: South Africa, BMNH].

STATUS. – PINHEY (1981b) confirmed the species status of *P. subpupillata* and *P. rileyi.*

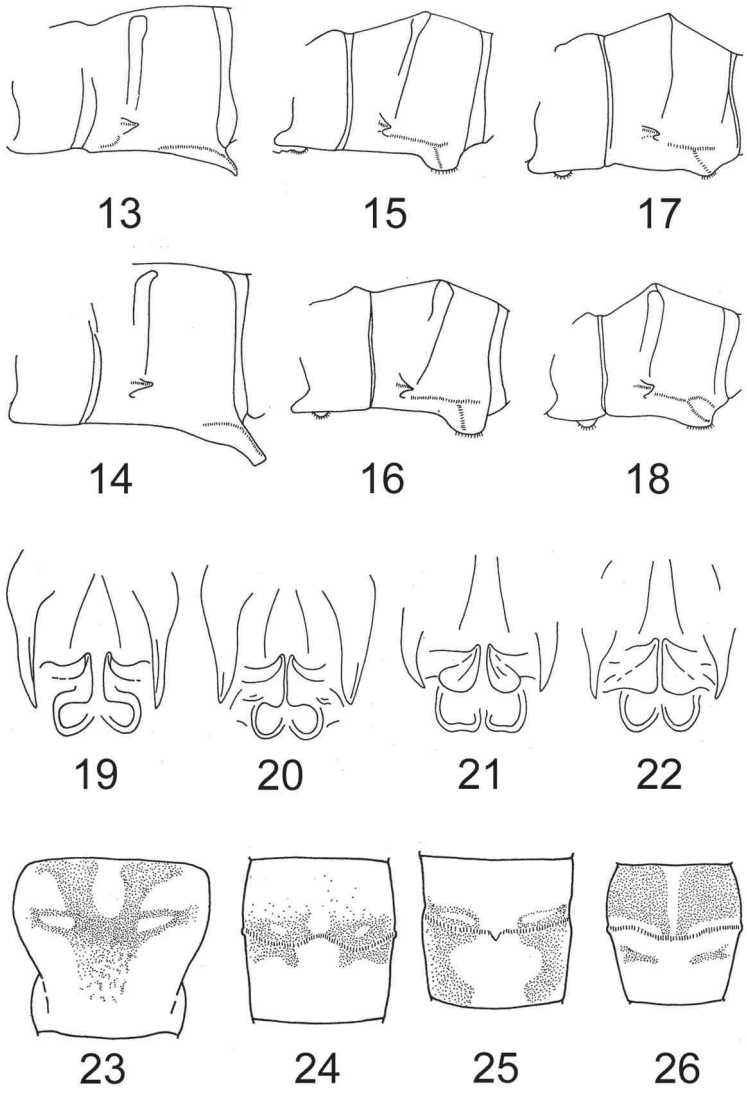
DISTRIBUTION. – Zimbabwe to Cape.

## *PINHEYSCHNA WATERSTONI* SP. NOV.

Figures 6, 13, 20, 28, 31, 32

*Aeschna Rileyi* nec CALVERT, 1892 – CALVERT (1896: 632).
*Aeschna Ragazii* Selys [Type: Shoa, Ethiopia, MCSN] – CALVERT (1896: 632), nomen nudum.
*Aeshna ragazzi* Selys – PINHEY (1962: 191), nomen nudum.
*Aeshna meruensis waterstoni* TELFER, 1992: 127 – CLAUSNITZER & DIJKSTRA (2005: 121), nomen nudum.
*Aeshna* sp. – CLAUSNITZER & PETERS (2003: 11).
*Aeshna* cf. *yemenensis* WATERSTON, 1985 - CLAUSNITZER & DIJKSTRA (2005: 121).

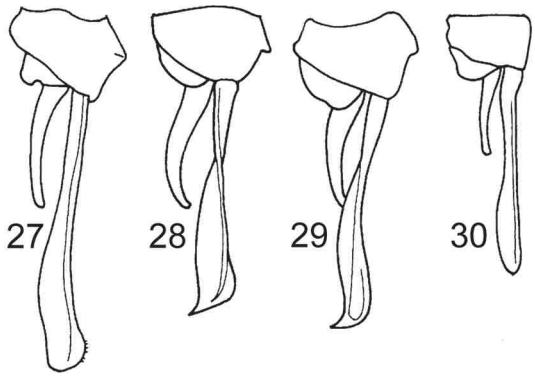
M a t e r i a l. – **Holotype** ♂: Ethiopia, Antoto, north of Addis Abeba, V-1907, Kostlan, S. (with an original blue handwritten label "Abessynia Antoto V. 07 Kostlan, S.") (ZMHU). – **Paratypes**: 1 ♀, Sciotalit, 116. Luglis 1887, Non rari (MSNG); 1 ♀, Abyssinia near Djem-Djem Forest alt. 8000 ft, 20-IX-1926, I. Omer. Cooper (this specimen with an additional label added by A.R. WATERSTON in 1977: "Not *A. rileyi* CALV. but n. sp. near *meruensis* and *yemenensis* MS female"); 1 ♂, C. Abyssinia, Managascha, 26-V-1914, O. Kovacs leg.; 1 ♂, C. Abyssinia, Maraquo, 20-VIII-1914, O. Kovacs leg.; 1 ♂, R. (or ?L.) Tana, 13-V-1915, O. Kovacs leg. (all BMNH). 1 ♂, Akaki River, 2500 m (Addis), 23-IV-1971, Carfi; Nr. 2075 [*Aeshna rileyi* Calvert)] det. Carfi (MZUF). 1 ♂, Ethiopia, Debre Libanos, 12-III-2004, V. Clausnitzer & K.-D.B. Dijkstra leg.; 1 ♀, Ethiopia, 15 km S of Sashemene, Wondo Genet,




Figs 13-26. (Figs 13-18) S1 and S2 of males, lateral view, with the outline of the ventral tubercle on sternum 1 (where present), the auricle and the genital lobe: (13) *Pinheyschna waterstoni*; – (14) *P. subpupillata*; – (15) *Zosteraeschna minuscula*; – (16) *Z. usambarica*; – (17) *Anaciaeschna triangulifera*; – (18) *Rhionaeschna marchali*. – (Figs 19-22) Anterior hamuli and spines of the anterior lamina, male, ventro-posterior aspect: (19) *Pinheyschna meruensis*; – (20) *P. waterstoni* (holotype); – (21) *P. yemenensis*; – (22) *P. rileyi*. – (Figs 23-26) Ridge (girdle, carina) across abdominal tergum 2, dorsal: – (23) *Afroaeschna scotias* (ridge absent); – (24) *Zosteraeschna ellioti*; – (25) *Anaciaeschna jaspidea*; – (26) *Rhionaeschna elsia.*

1650 m a.s.l., 7º05'N/38º36.77'E, 30-III-2004, V. Clausnitzer & K.D.B. Dijkstra leg.; 2 final instar exuviae (♀), Ethiopia, Nekemte, 15-III-2004, V. Clausnitzer & K.-D.B. Dijkstra leg.; 5 final instar exuviae (1 ♂, 4 ♀), Ethiopia, Wondo Genet, 30-III-2004, V. Clausnitzer & K.-D.B. Dijkstra leg. (all in RMNH).

E t y m o l o g y. – The species is named in honour of the late Andrew Roger W a t e r s t o n for his merits in the investigation of the south-Arabian odonate fauna, including his description of *P. yemenensis*.




Figs 27-30. S10, cerci and epiproct, male, lateral view: (27) *Afroaeschna scotias*; – (28) *Pinheyschna waterstoni*; – (29) *P. yemenensis*; – (30) *Zosteraeschna ellioti.*

MALE (**Holotype**). – Colours faded; tips of right Fw and Hw missing.

H e a d. – Outer (posterior) eye margin with badly indicated incisura lateralis. Antennae 6-segmented. Top of frons with subpupillate black mark, connected thinly with the dark anterior border of frons (as in Fig. 9).

T h o r a x. – Bright synthoracic stripes with nearly parallel borders, antehumeral stripes not as bright as lateral stripes. Legs more brownish than black.

Wings. Nodal formula 12 . 17/18 . 13 (Fw), 13 . 12/12 . 13 (Hw); IR2 fork at level 3 postnodal cells proximal to Pt, symmetrical, with 3 rows of cells; forking of MA in front of the well developed "aeshnine groove" with branches of nearly equal thickness; discoidal triangles with 5 cells in Fw and 4 cells in Hw (basal cells divided); anal triangle 2-celled, occupying the inner border of the wing for about 2/3 of its length (Fig. 6); anal loop with 9/11 cells in 3 rows.

A b d o m e n. – A cross-extended spot, covered with hairs and low blackish denticles, in the anterior portion of sternum 1; dorsum 2 flat (not crossed by a ridge); laminar spines and anterior hamuli as in Figure 20; a complete set of bright spots on terga 3-8: the broad anterodorsals posteriorly extended to the intersegmental carina, laterally broadly connected with the anterolaterals, the paired mediodorsalia triangular in shape and not bluish but yellow, the pair of posterodorsals not connected with the posterolaterals and the latter not contacting the mediolaterals; intersegmental rings with pairs of bright dorsal and lateral spots; S10 with a small mid-dorsal hump; cerci (Fig. 28) and ventral portions of abdomen more brownish than black.

M e a s u r e m e n t s. – Total length 66.0; Hw 43.5; abdomen 43.5; Pt of Fw 3.3; cerci 6.1; width of head 11.6.

Overall colouration and colour pattern (brown to black with largely pale greyish to greenish blue elements and some small yellow markings) of the live insect can be seen in Figure 32; little variational deviation from the basic description as given

for the holotype and from the photo has been found.

FEMALE (**Paratype** (allotype) from Djem-Djem Forest). – Wings with nodal formula 12 . 18/17 . 11 (Fw) and ? . 11/12 . 12 (Hw).

Measurements. – Hw 45.1; Pt 3.3.

From the available (only old) material can be detected that the female much agrees in all details with *A. meruensis*.

LARVA. – Prementum nearly twice as long as its greatest width, just surpasses posterior side of mesocoxa; labial palps without bristles, lobe evenly wide with apex round to truncate; antennae generally 7-segmented; femora with two pale rings; lateral spines on S5-9, that on 5 tiny; ovipositor reaching just beyond end of S9; anal pyramid not particularly short and stout, fairly smooth, with paraprocts about 4 times as long as wide. Total length 37.0-41.0 mm

DISTRIBUTION. – *Pinheyschna waterstoni* is known to occur in the Ethiopian Highlands and mountain chains at elevations between 1650 and 2500 m. Some information is now available from Tesfaye Kebede (Addis Abeba) on the localities where the stored last century specimens have been taken: Antoto (=Entoto) is located halfway between Addis Abeba and Debre Markos; Djem-Djem Forest (=Gemgem) means forested river valley some 50 km north of Gima; Maraquo (=Maraki or Marequo) is a site in the Gojam Province near Debre Markos; the Akaki River flows through Addis Abeba; Wondo Genet lies south of Lake Awasha (250 km S Addis Abeba) and Nekemte in the province Welega (230 km W Addis Abeba). "Managascha" and Sciotalit" remain undeciphered (Scioa is the Italian version of the central province Shoa = Shewa).

As a mountain species, *P. waterstoni* is separated from its congeners in Uganda/ Kenya (*P. meruensis*) and Yemen (*P. yemenensis*) by large stretches of low-level savannas and even desert, not to mention the Red Sea. An isolated population of *Pinheyschna* identified by LONGFIELD (1936) as *Aeshna rileyi*, occurs at Jebel Marra in the South Darfur Province of Sudan, some 1,400 km west of the Ethiopian Highlands. The presence of this taxon at Jebel Marra was confirmed by HAPPOLD (1966) and DUMONT (1988). Whether or not the population (documented by 3 specimens in BMNH) belongs to *P. waterstoni* remains to be seen.

HABITAT AND ECOLOGY. – The larvae live in running water (brooks, streams).

DISCUSSION. – This species has a long bibliographic history. CALVERT (1896) described a female from Ethiopia in MSNG, which he assumed to be *P. rileyi*, labelled "*Aeschna Ragazzii*, Selys typus! ♀". However, by origin and description this female must pertain to *P. waterstoni*. Because CALVERT (1896) considered *ragazzii* as synonym of *rileyi*, the name *ragazzii* CALVERT, 1896 is unavailable (ICZN 1999: article 11.6). PINHEY (1962) lists it under *P. rileyi* as "*Aeshna ragazzi* SELYS (ined.; nom. nud.)". TELFER (1992), CLAUSNITZER & PETERS (2003) and CLAUSNITZER & DIJKSTRA (2005) discussed the species as *A.*

*meruensis waterstoni*, an unnamed *Aeshna* species and *A.* cf. *yemenensis* respectively. Lacking a description, the name *waterstoni* TELFER, 1992 is unavailable (ICZN 1999: article 13.1.1).

In both sexes of *P. waterstoni* the length of the Pt does not exceed 7.5% of Hw length (as opposed to 8.0-9.6% in individuals of the *P. rileyi* group) and the abdomen is relatively shorter [95.0-103.0% of Hw length (as opposed to 103.0-107.0%)]. In the males of *P. waterstoni* the anal triangle is 2-celled (with single 3-celled exceptions) as opposed to 3-celled, rarely 2-celled, in the *P. rileyi* group, and the genital lobes are not only downwardly extended, but also sharply pointed (Fig. 13).

The males of *P. waterstoni* differ from *P. meruensis* by the shape of the genital lobe (see Fig. 1 in CLAUSNITZER & PETERS, 2003). Differences between the females are still unknown.

Both sexes of *P. waterstoni* differ from *P. yemenensis* by the yellowish brown postgenae (black in *yemenensis*), the males by the predominantly 2-celled anal triangle and the abruptly (instead of gradually) rising dorsal crest of the cerci and their somewhat broader blade (Fig. 28). Cell- and crossvein-counts in different fields of the wings showed a somewhat denser venation in *P. waterstoni* and *P. meruensis* than in *P. yemenensis.* Also the hamular folds appear more roundish in *P. waterstoni* and *P. meruensis* than in *P. yemenensis* (Figs 19-21).

In summary, the small but nevertheless consistent differences between the adults of *P. waterstoni* and *P. yemenensis* are hardly or not at all detectable between *P. waterstoni* and *P. meruensis*. In the shape of the male genital lobe, however *P. waterstoni* strongly differs from *P. meruensis*, but is indistinguishable from *P.*

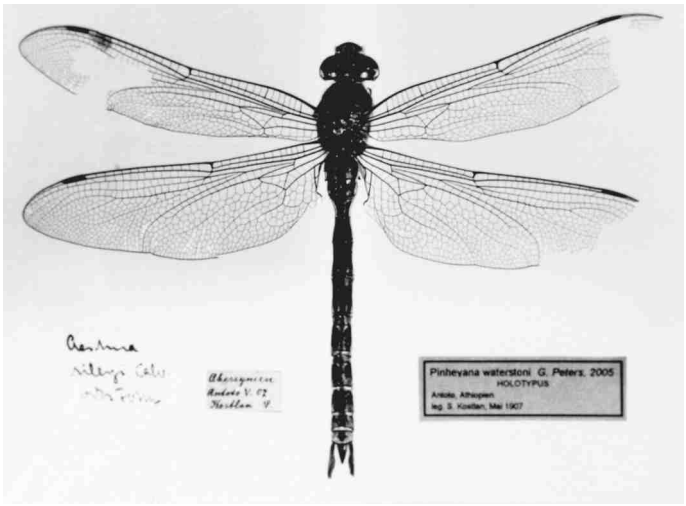



Fig. 31. Holotype male of *Pinheyschna waterstoni.*

Fig. 32. Live male of *Pinheyschna waterstoni* (Photo K.-D.B. Dijkstra).

*yemenensis*. Following the "biological species" hypothesis as defined by MAYR (1942) and acknowledging the close morphological affinities, *P. waterstoni* could be described as a subspecies of *P. meruensis*, which by chance achieved the same shape of male genital lobe as found in *P. yemenensis*. But there are some serious arguments not to proceed along this concept. Leaving aside the poorly known *P. moori*, the distribution ranges of the *Pinheyschna* taxa follow each other from South to North: *subpupillata – rileyi – meruensis – waterstoni – yemenensis*. But this chain is not in accord with subsequent changes of character states in the same, or in opposite, direction. The ancestral (plesiomorphic) 3-celled state of anal triangle is retained by the southern species and in remote north-eastern *P. yemenensis* but not by the taxa situated between them (*P. meruensis* and *P. waterstoni*). Examples of return from the advanced 2-celled state to the 3-celled state (excluding atavism) are not known to us. But the tendency to produce 2-celled triangles in species usually bearing 3-celled ones can be found in different aeshnine taxa, for instance even in some *P. rileyi* specimens.

To the 3-celled condition of the anal triangle another "groundplan" character of the hypothetical *Pinheyschna* stem species can be added: the down-curved tip of the genital lobe (secondarily tube-like widened in the males of the *rileyi* group). If so, the down-turned extension of the genital lobe in *P. yemenensis* and *P. waterstoni* should be regarded as the plesiomorphic state, changed by *P. meruensis*, the sister species of *P. waterstoni*, apomorphically into a posteriorly directed pointed tip.

The opposite point of view, considering the contour of the genital lobe in *P. meruensis* as the ancestral state and thus as a groundplan character, fails, because this scenario would imply an even twofold return ("reversal") of an advanced anal triangle to the more ancestral type (in *rileyi*/*subpupillata* and in *yemenensis*) and because it would ignore a sister-species relationship between *P. meruensis* and

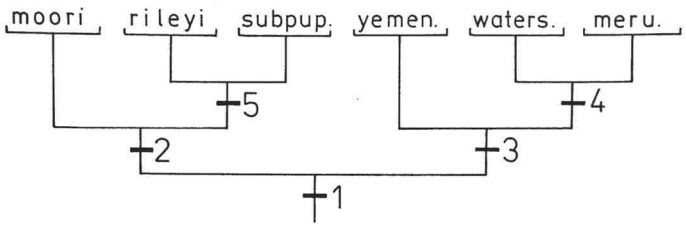



Fig. 33. Phylogram of *Pinheyschna* (autapomorphies of species omitted): 1: stem of T-spot ocellate, postero-ventrad protruding genital lobe (males); – 2: Pt longer than 7.9% of Hw length; – 3: male genital lobe funnel-like, abdomen as long as, or shorter than, Hw; – 4: male anal triangle predominantly 2-celled; – 5: antehumeral stripes shortened, epiproct (male) shortened.

*P. waterstoni*. And last not least, it would be impossible to explain the contradiction between the *meruensis*-like characters of *P. waterstoni* and the *yemenensis*-like shape of its genital lobe.

Thus, it appears an acceptable hypothesis on the phylogenetic relationships of the *Pinheyschna* species (if *P. moori* is included in the *P. rileyi* group) that the *Pinheyschna* stem species by splitting produced the stem species of *rileyi/subpup-illata* (+ *moori*) and of *P. yemenensis*. Then the *yemenensis* stem species gave rise to *P. yemenensis* at one side and to the stem species of *waterstoni/meruensis* to the other (Fig. 33).

### *PINHEYSCHNA YEMENENSIS* (WATERSTON) COMB. NOV.

Figures 21, 29

*Aeshna yemenensis* WATERSTON, 1985: 461 [Type: Al 'Asr, Yemen, BMNH].

DISTRIBUTION. – Yemen.

## THE "*AESHNA ELLIOTI* GROUP"

Three species of this third group of Afrotropical "*Aeshna*" species are very closely related, constituting a monophylum which is introduced as *Zosteraeschna* gen. nov.

### *ZOSTERAESCHNA* GEN. NOV.

E t y m o l o g y. – The prefix "Zostera", proposed by K.-D.B. Dijkstra (in litt.), points to the ring-like ornamental ridge, crossing in both sexes abdominal tergum 2 in its middle.

Type species: *Aeshna ellioti* KIRBY, 1896.
Species: *Zosteraeschna ellioti* (Kirby), *Z. minuscula* (McLachlan), *Z. usambarica* (Förster).

DIAGNOSIS. – Compared with *Afroaeschna* and *Pinheyschna*, the members of *Zosteraeschna* seem to be united by the following synapomorphies:

- Rspl2 usually well expressed (Fig. 11)
- apical cell of anal triangle "opened" posteriad to the anal angle of Hw (Figs 7, 8)
- membranule distinctly bicoloured (half white, half black) (Figs 7, 8)
- ridge across the middle of abdominal tergum 2 with central ornament (Fig. 24)
- angulated posterior part of male genital lobe markedly projecting ventrally (Figs 15, 16)
- number of auricle denticles reduced to 2
- S10 of male without distinct mid-dorsal tooth (Fig. 30)
- cerci along their central axis slanted inwardly (in lateral view the outer border of the blades appears as their upper border (Fig. 30))

Discriminating traits of uncertain phylogenetic orientation are:

- cerci without basoventral projection (only badly expressed rugosity present) (Fig. 30)
- larval labial palps and their movable hook with fine bristles (CHELMICK, 2001).

DISTRIBUTION. – Ethiopia, Tanzania, Kenya, Namibia, South Africa (except for Namibia within the range of *Pinheyschna*).

HABITAT AND ECOLOGY. – Variably shaded ponds, swamps, lakes and calm sections of streams with little or no current. Lentic; oviposition takes place in aquatic and riparian vegetation. Larvae probably live among detritus.

DISCUSSION. – By the majority of the listed advanced character states *Zosteraeschna* appears synapomorphically connected with aeshnine and anactine genera distributed outside of Africa. Among the taxa bearing a long membranule reaching the tornus, the ridge across the middle of abdominal tergum 2 is exposed not only in *Zosteraeschna*, but also found in all species of *Anaciaeschna*, *Andaeschna* and *Rhionaeschna* (in the sense of VON ELLENRIEDER, 2003). This ornamental carina is unique in Aeshnidae sensu PETERS & THEISCHINGER (2007) and therefore in all probability represents a synapomorphy of the four genera. The mid-dorsal tooth (cone, tubercle) on S10 of males is present in all species of *Rhionaeschna* and *Anaciaeschna* but, as in *Zosteraeschna*, it is missing also in *Andaeschna* (DE MARMELS, 1994).

The apomorphic trend "widening of anal triangle down to tornus" is broadly dispersed among taxa with long membranule. In parallel with *Zosteraeschna* it is realised in the *Neureclipa* Navas subgroup of *Rhionaeschna*, in *Andaeschna* and *Anaciaeschna* (most strikingly in *A. martini* Selys) and even in "*Aeshna" isoceles*.

The reduction of the number of auricle denticles to 2 has been achieved not only by *Zosteraeschna, Rhionaeschna* (except *Marmaraeschna* Calvert), *Andae-*

*schna* and *Anaciaeschna*, but is found also in *Pinheyschna*, *Adversaeschna* and *Oreaeschna*.

Additionally a usually well expressed Rspl2 (Figs 15-18) connects the first four of the just mentioned taxa.

*Zosteraeschna* is linked geographically with *Anaciaeschna* through the Afrotropical species *A. triangulifera* McLachlan. The collections of NHRS and of MSNG each contain a female of *A. triangulifera*, misidentified by Sjöstedt, respectively Nielsen, as *Aeshna ellioti*. Some similarities in eye diameter (eyes are not globular in *A. triangulifera*), colouration (large bright spots on S8-10; black and white tinted membranule) and in wing venation may produce identification difficulties. But all the otherwise highly individually characterized *Anaciaeschna* species differ from *Zosteraeschna* at least in four apomorphic traits partly shown in Figure 12: strongly slanting Ax1 in Fw, asymmetrical IR2-forking (as in *Andaeschna*), RP2-bulging and predominant existence of a prolonged cell (instead of two smaller ones) distal the MA-RP3/4 anastomosis.

With *Rhionaeschna* the *Zosteraeschna* species share the down-projected posterior borders of the genital lobes (Figs 15, 16, 18). But the more extensively and differently built genital lobes of *Pinheyschna* males seem to represent the advanced state in the evolution of these structures. If so, the similarities in the shape of genital lobes between *Zosteraeschna* and *Rhionaeschna* can be interpreted as symplesiomorphies.

From *Rhionaeschna* the *Zosteraeschna* species differ by the absence of a tubercle on the first abdominal sternum (VON ELLENRIEDER, 2003). Only *Z. minuscula* instead of a tubercle bears a slightly elevated central spot densely covered with small spinules.

The differences between *Andaeschna* and *Zosteraeschna* are striking. Reduction of the T-spot on the frons, uni-coloured body, rounded anal angle of Hw with widely opened anal triangle in male and asymmetrical IR2-fork with IR2b branching off posteriad represent advanced character states of *Andaeschna*, against which *Zosteraeschna* holds an ancestral position. The males of both genera agree in the reduction of the mid-dorsal tooth on S10 and in the very long cerci which (except in *A. rufipes* Ris) are simply constructed.

Among the above listed apomorphies, the absence of a tooth (tubercle) on S10, notwithstanding its parallel reduction in *Andaeschna,* seems to be the only obvious autapomorphy of *Zosteraeschna*. Its presence has to be interpreted as a "groundplan character" of the Aeshnini+Anactini+Polycanthagini sensu DAVIES & TOBIN (1985), but including *Oplonaeschna* Selys and *Basiaeschna* Selys. Besides *Zosteraeschna* and *Andaeschna* there is only a small number of taxa with the status "tooth missing": *Anax*, the 7 species of the *cyanea*-group of *Aeshna* (*constricta, cyanea, palmata, persephone, petalura, umbrosa, walkeri*) and the closely related genera *Castoraeschna* Calvert, *Remartinia* Navas and *Coryphaeschna* Williamson. Badly detectable remnants of the tubercle are retained in some *Anax*

species, in *Castoraeschna coronata* (Ris) and even in one of the *Zosteraeschna* species (*ellioti*). In order to accentuate the value of this character the following remark should be added: Where present in the Gynacanthidae and Panbrachytronoda sensu PETERS & THEISCHINGER (2007), the tooth is not situated in the anterior half of the segment but in its rear portion, frequently just in front of its posterior border (*Epiaeschna* Hagen, *Tetracanthagyna* Selys, some *Gynacantha* Rambur and *Heliaeschna* Selys, *Telephlebia* Selys, *Antipodophlebia* Fraser, *Austrophlebia* Tillyard and the majority of species of *Austroaeschna* Selys). The deviating position of the cone and its rareness and scattered distribution call for non-homology and multiple origin of the trait among "ancestral" aeshnids.

Finishing with the comments on *Zosteraeschna* we repeat the main points: *Zosteraeschna* is a monophyletic taxon. Together with *Anaciaeschna, Andaeschna* and *Rhionaeschna* it appears to us to constitute a higher ranked monophylum based on the synapomorphy of an ornamental cross-bar on abdominal tergum 2 and a number of more or less shared apomorphic trends. In the elaborate cladogram of VON ELLENRIEDER (2003), however, "*Aeshna" ellioti*, assigned to *Zosteraeschn*a in this paper, is nested together with *Anaciaeschna*, *Andaeschna* and some other "*Aeshna"* species in a monophylum representing the sister group of *Rhionaeschna*+("*Aeshna" rileyi*+ *subpupillata*). As the sister-taxon of "*Aeshna ellioti"* emerges "*Aeshna" mixta* (to which most probably "*Aeshna" affinis* can be added).

## *ZOSTERAESCHNA ELLIOTI* (KIRBY) COMB. NOV.

Figures 24, 30

*Aeschna Ellioti* KIRBY, 1896: 124 [Type: Ruwenzori, BMNH].

STATUS. – Since PINHEY (1956) *Aeschna usambarica* generally was included in *Aeschna ellioti* as a distinct subspecies. Return to species rank is proposed for *A. usambarica* below, under *Zosteraeschna usambarica*.

DISTRIBUTION. – North Tanzania (Kilimandjaro) to eastern Congo and Ethiopia.

DISCUSSION. – See under *Zosteraeschna usambarica*.

## *ZOSTERAESCHNA MINUSCULA* McLACHLAN COMB. NOV.

Figures 2, 8

*Aeschna minuscula* McLACHLAN, 1896: 421 [Type: Cape of Good Hope, South Africa, BMNH].
*Aeschna dolabrata* KARSCH, 1899: 48 [Type: Cape of Good Hope, South Africa, ZMHB].

DISTRIBUTION. – South Africa (except north-eastern and north-western) and Namibia.

## *ZOSTERAESCHNA USAMBARICA* (FÖRSTER) COMB. NOV., STAT.

Figures 3, 11, 16

*Aeschna usambarica* FÖRSTER, 1906: 48 [Type: Nguelo, Tanzania, UMMZ].

STATUS. – Since PINHEY (1956) *Aeschna usambarica* generally was considered as a subspecies of *Aeschna ellioti*. For the reasons discussed in the following we consider *Zosteraeschna ellioti* and *Z. usambarica* as two distinct species.

DISTRIBUTION. – South Kenya (Taita Hills) to north-eastern South Africa.

DISCUSSION. – None of the authors dealing with *Zosteraeschna ellioti* and its assumed subspecies *usambarica* seems to have had difficulties with the allocation of a certain specimen to one or the other of the two. *Z. usambarica* is distributed from the northern provinces of South Africa through Zimbabwe, Zambia and Malawi to the northeast of Tanzania (Usambara Mts) and the southeast of Kenya. *Z. ellioti* is known to occur in northern Tanzania, the most eastern parts of Congo, in Kenya, Uganda and Ethiopia. Nothing is known about the existence of *Zosteraeschna* in the mountain chains between the northern shores of Lake Nyasa (Nyika Plateau: *Z. usambarica*) and Lake Kiwu (*Z. ellioti*), including the mountain ranges on both sides of Lake Tanganyika. Whether or not (and to what extent) one or both species bridge this enormous distance along the western branch of the Rift Valley, remains to be explored.

As pointed out under *Zosteraeschna*, the *Z. ellioti* males retained a remnant of the mid-dorsal tooth on S10, but *Z. usambarica* and *Z. minuscula* did not. Additionaly *Z. usambarica* differs from *Z. ellioti* in colour markings and wing venation. The antehumeral stripes in *ellioti* are parallel sided, but wedge-shaped, with wider upper ends, in *usambarica*. Meso- and metepimeral stripes are also wider in *usambarica*: 14.6 and 17.4% of head diameter against 12.3 and 14.7% in *ellioti*. The white coloured portion of the membranule usually takes 1/3 of its area in *ellioti* and ½ in *usambarica*. *Z. usambarica* is characterised by a markedly denser venation: 15.0 Fw Ax against 14.0 in *ellioti* (14.4 in *minuscula*); cells along RP3/4 in Hw 23.3 against 20.9 (22.4 in *minuscula*); double cells between MP and CuA 6.7 against 4.4 in males and 9.4 against 6.8 in females (5.4 in both sexes of *minuscula*). All differences between the mean values are statistically significant. The proportions of the discoidal triangle differ between both species: in *usambarica* the Hw triangle reaches only 84% (females) and 88% (males) of the Fw triangle length against 90-92% in *ellioti*. The Hw triangle (exposed to Hw length) is distinctly narrower in *usambarica* (5.7% in males, 6.2% in females) than in *ellioti* (6.5% and 7.0%). These data have been sampled and calculated from 30 specimens of *Z. usambarica* and 11 of *Z. ellioti* as follows: *Z. usambarica*: Transvaal (3); Vumba Mts, Zimbabwe (2); Nyika Plateau, Malawi (8); Uluguru Mts, Tanzania (2); Usambara Mts, Tanzania (11); Taita Hills to the west of Voi, Kenya (4). *Z. ellioti*: north of Lake Kiwu (Sabinio), Congo (1); Kilimanjaro (Kibonoto),

Tanzania (2); Mt Elgon Nat. Park, Kenya (5); Saiwa Swamp (east of Mt Elgon), Kenya (1); Prov. Shewa (= Shoa), Ethiopia (2).

Considering the points made in the above discussion, it appears reasonable to accept *Z. ellioti* and *Z. usambarica* as distinct species. Notwithstanding allopatry and morphological similarity, both taxa are distinguished by integrated complexes of traits in colour markings, venation and proportions. This integrity of characters reveals the nature of a closed propagating community, meaning the nature of an independent evolutionary species (CLAUSNITZER & PETERS, 2003; PETERS, 1998). Hybrids of the two may occur, but no gradually deviating "intermediates" which usually exist in the transgression zones of subspecies. SJÖSTEDT (1909) collected typical *Z. ellioti* individuals on the slopes of Kilimanjaro, whereas Viola Clausnitzer took "normal" *Z. usambarica* at the adjoining Taita Hills in southeastern Kenya. On the other hand large distances seem not to have caused differences between the *ellioti* populations of Uganda/Kenya and Ethiopia. It should be added that the allopatry between *Z. ellioti* and *Z. usambarica* in east Africa (CLAUSNITZER, 1999) is repeated in the south of the continent by *Z. usambarica* and *Z. minuscula* which are morphologically quite different from each other (PINHEY, 1951; TARBOTON & TARBOTON, 2002).

It has to be pointed out here that what is presented under *Aeshna ellioti* in two popular books on the dragonflies of South Africa (TARBOTON & TARBOTON, 2002; SAMWAYS, 2008) has to be referred to *Z. usambarica*.

## KEY TO THE ADULTS OF THE SPECIES OF *AFROAESCHNA*, *PINHEYSCHNA* AND *ZOSTERAESCHNA* (*P. moori* not included)

1 Top of frons with stem of black T-mark incomplete, circular and surrounded by a pale ring (Fig. 1). Male: genital lobe long and/or pointed, without denticles (Figs 13, 14); S10 with well-developed mid-dorsal tooth; tips of cerci with down-curved point (Figs 28, 29) ..... ***Pinheyschna*** 4

– Top of frons with stem of black T-mark complete, rectangular or triangular, or with black stout pentagon, no pale ring (Figs 2, 3). Male: genital lobe short and rounded, denticulate (Figs 15, 16); S10 with or without mid-dorsal tooth; apex of cerci flat or rounded (Figs 27, 30) ..... 2

2 Large species (Hw >45 mm); membranule evenly pale grey; S2 dorsally without transverse girdle (Fig. 23). Male: anal triangle 2-celled (Fig. 4); anal loop of 3 cell-rows (Fig. 9); auricles with 3-6 denticles; S10 with well-developed mid-dorsal tooth; cerci with apex thickened, rounded, dorsally bearing large denticles (Fig. 27) ..... ***Afroaeschna scotias***

– Smaller species (Hw <45 mm); membranule blackish with strongly contrasting white base (Figs 7, 8); S2 prominently raised dorsally along transverse suture, forming a girdle (Fig. 24). Male: anal triangle 3-celled (Figs 7, 8); anal loop of 2 rows of cells (Fig. 11); auricles with 2 denticles.; S10 without mid-dorsal tooth; cerci with apex flat, pointed, without denticles (Fig. 30) ..... ..... ***Zosteraeschna*** 8

4 Membranule dark, basal half distinctly white. Pt 3.5-4.0 mm, 8.0-9.6% of Hw length; abdomen 103-107% of Hw length. Male: anal triangle mostly 3-celled (Fig. 5), rarely 2-celled; genital lobe long and curved, apex rounded or truncate (Fig. 14) ..... ***P. rileyi*-group** 5

– Membranule grey, almost without white at base. Pt 2.5-3.3 mm, 7.5-7.8% of Hw length; abdomen 95-103% of Hw length. Male: anal triangle mostly 2-celled, rarely 3-celled (Fig. 6); genital lobe

short and triangular, apex pointed (Fig. 13) ..... ***P. meruensis*-group** 6
5 Space between lateral synthoracic stripes all dark; costa brown, venation quite uniformly dark. Male genital lobe rather straight ..... ***rileyi***
– Space between lateral thoracic stripes black with pale marking near Fw base; costa pale yellow and many cross-veins near base yellow, including those in triangles. Male genital lobe distinctly curved (Fig. 14) ..... ***subpupillata***
6 From Kenya, Tanzania, Uganda, possibly Sudan and Angola. Male genital lobe straight ..... ..... ***meruensis***
– From Ethiopia or Yemen. Male genital lobe curved, with apex twisted downwards .....7
7 From Ethiopia. Postgenae predominantly yellowish brown. Male: anal triangle mostly 2-celled (Fig. 6), rarely 3-celled; dorsal ridge abruptly rising posteriorly from plain of cerci (Fig. 28) ..... ..... ***waterstoni***
– From Yemen. Postgenae back. Male: anal triangle mostly 3-celled, rarely 2-celled; dorsal ridge of cerci rising gradually (Fig. 29) ..... ***yemenensis***
8 Top of frons with distinct black T-mark made up of cross-bar and triangular stem (Fig. 2); antehumeral stripes narrow and parallel to each other; costa yellow; pale latero-basal spots of S4-7 larger than apical spots ..... ***minuscula***
– Top of frons with solid black pentagon (Fig. 3); antehumeral stripes wider, converging dorsally; costa dark brown; latero-basal pale spots of S4-7 smaller than apical spots, or absent ..... 9
9 From Tanzania to eastern Congo and Ethiopia. Antehumeral stripes parallel sided; pale lateral thoracic stripes narrow, space between them mor than twice as wide as one stripe ..... ***ellioti***
– From south Kenya to north-eastern South Africa. Antehumeral stripes wedge-shaped, with dorsal end much wider than ventral end; lateral thoracic stripes broad, space between them less than twice as wide as one stripe ..... ***usambarica***

## CONCLUDING REMARKS

No matter what the results of further, most particularly molecular, research will be, already now it is obvious that Africa produced endemic supra-specific groups of "Aeshnini". This conclusion has some zoogeographical implications which previously were not traceable due to the camouflaging use of the traditional name *Aeshna* for the "Aeshnini" of the Afrotropical region. But for as long as the phylogenetic relationships of *Pinheyschna, Zosteraeschna* and *Afroaeschna* are not more firmly elucidated, nothing definite can be said about their zoogeographic connections. The absence of immediate relationships between the three sympatric taxa may refer to a relatively long period of independent evolutionary history. Anyway, besides all suggestions and speculations, the three new aeshnid genera add another enigma terminating in the question: What happened to the African odonate fauna during the Tertiary, keeping in mind the scarcity of endemic monophyla and the absence of Gomphaeschnidae and Panbrachytronoda sensu PETERS & THEISCHINGER (2007)?

**ACKNOWLEDGEMENTS**

We are very grateful to Dr VIOLA CLAUSNITZER and Dr KLAAS-DOUWE B. DIJKSTRA for the encouragement to compile this paper in order to enrol the necessary new taxic names, pro-

viding invaluable information including unpublished details and for the loan of valuable and rare specimens. For the last reason we are also indebted to Dr DAVID GOODGER (London) and to Dr FRANK KOCH (Berlin) who during his journeys through southeast and South Africa enriched the collections of the ZMHU by more than a dozen specimens to the advantage of this publication. Mrs VERA HEINRICH (Berlin) is thanked for drawing up the figures from sketches of the first author and for the preparation of the photographs.

## REFERENCES

BRIDGES, C.A., 1994. *Catalogue of the family-group, genus-group and species-group names of the Odonata of the world* (3rd edn). Bridges, Urbana/III.

CALVERT, P.P., 1892. Preliminary notes on some African Odonata. *Trans. Am. ent. Soc.* 19: 161-164.

CALVERT, P.P., 1896. On the odonate Aeshna rileyi. *Annali Mus. civ. Stor. nat. "Giacomo Doria", Genova* 2(16): 631-632.

CLAUSNITZER, V., 1999. A ckecklist of the dragonflies (Odonata) of Kenya. *Afr. J. Ecol.* 17: 400-418.

CLAUSNITZER, V., 2001. Notes on the species diversity of east African Odonata, with a checklist of species. *Odonatologica* 30(1): 49-66.

CLAUSNITZER, V. & K.-D.B. DIJKSTRA, 2005. The dragonflies (Odonata) of Ethiopia, with notes on the status of its endemic taxa and the description of a new one. *Ent. Z. Stuttgart* 115(3): 117-130.

CLAUSNITZER, V. & G. PETERS, 2003. Identity and distribution of the little known Aeshna meruensis (Odonata: Aeshnidae). *Int. J. Odonatol.* 6(1): 9-16.

CHELMICK, D.G., 2001. Larvae of the genus Aeshna Fabricius in Africa south of the Sahara (Anisoptera: Aeshnidae). *Odonatologica* 30(1): 39-47.

DAVIES, D.A. & P. TOBIN, 1985. *The dragonflies of the world: a systematic list of the extant species of Odonata*, Vol. 2: *Anisoptera.* Societas Internationalis Odonatologica, Utrecht.

DE MARMELS, J., 1994. A new genus of Aeshnini (Odonata: Aeshnidae) from the Andes, with description of a new species. *Ent. scand.* 25(4): 427-438.

DUMONT, H.J., 1988. On the composition and palaeoecological significance of the Odonate fauna of Darfur, western Sudan. *Odonatologica* 17(4): 385-392.

FÖRSTER, F., 1906. Die Libellulidengattungen von Afrika und Madagaskar. *Jber. mannheim. Ver. Naturk.* 71/72: 1-67.

FRASER, F.C., 1955. Odonata. *Parc National De L'Upemba* 38: 1-34.

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE, 1999. *International Code of Zoological Nomenclature*, [4th edn]. Int. Trust Zool. Nomencl., London.

KARSCH, F., 1899. Neue Odonaten aus Ost- und Südafrika mit Einschluss des Seengebietes. *Ent. Nachr.* 25: 369-382.

KIRBY, W.F., 1896. On a new dragonfly captured by Mr. Scott Elliot in East Africa. *Ann. Mag. nat. Hist.* 6(17): 124-125.

LONGFIELD, C., 1936. Studies on African Odonata, with synonymy and descriptions of new species and subspecies. *Trans. R. ent. Soc. Lond*. 85: 467-498.

MAYR, E., 1942. *Systematics and the origin of species from the viewpoint of a zoologist.* Columbia Univ. Press, New York.

McLACHLAN, R., 1896. On some Odonata of the subfamily Aeschnina. *Ann. Mag. nat. Hist.* 6(17): 409-425.

MILLER, P.L., 1993. Some dragonflies of the Budongo forest, western Uganda (Odonata). *Opusc. zool. flumin*. 102: 1-12.

PETERS, G., 1987. *Die Edellibellen Europas*. Neue Brehm-Bücherei, Nr. 585, Ziemsen, Wittenberg-

Lutherstadt.
PETERS, G., 1998. Der „Point of no return“ im Speziationsprozeß. *Zool. Abh. staatl. Mus. Tierk. Dresden* 50(Suppl. 6): 69-76.
PETERS, G. & G. THEISCHINGER, 2007. Die gondwanischen Aeshniden Australiens (Odonata: Telephlebiidae und Brachytronidae). *Denisia* 20: 517-574.
PINHEY, E.C.G., 1951. The dragonflies of Southern Africa. *Mem. Transv. Mus.* 5: xvi + 335 pp.
PINHEY, E., 1952. Three new species of Odonata from Eastern Africa. *Occ. Pap. Coryndon Mus.* 3: 13-16.
PINHEY, E., 1956. Some dragonflies of East and Central Africa and a rarity from Mauritius. *Occ. Pap. Coryndon Mus.* 4: 17-41.
PINHEY, E., 1959. Notes on African Odonata nymphs. *J. ent. Soc. Sth Afr.* 22: 469-488.
PINHEY, E.C.G., 1961. *A survey of the dragonflies (Order Odonata) of Eastern Africa*. Brit. Mus. (Nat. Hist.) London.
PINHEY, E.C.G., 1962. A descriptive catalogue of the Odonata of the African continent, pts 1, 2. *Publcoes cult. Co. Diam. Angola* 59: 1-322.
PINHEY, E., 1963. Some anomalous types of African Odonata and the description of a new species. *J. ent. Soc. sth Afr.* 26: 146-160.
PINHEY, E.C.G., 1964. Dragonflies (Odonata) of the Angola-Congo borders of Rhodesia. *Publcoes cult. Co. Diam. Angola* 63: 95-130.
PINHEY, E.C.G., 1971. Odonata of Fernando Po Island and of neighbouring Cameroons Territory. *J. ent. Soc. sth Afr.* 34(2): 215-230.
PINHEY, E., 1975. A collection of Odonata from Angola. *Arnoldia, Rhodesia* 7(23): 1-16.
PINHEY, E.C.G., 1981a. Checklist of the Odonata of Mocambique. *Occ. Pap. natl Mus. Monum. Rhod. (nat. Sci.)* 6(8): 555-632.
PINHEY, E.C.G., 1981b. Two interesting species of Aeshna Fabricius from Zambia (Odonata: Aeshnidae). *Arnoldia, Zimbabwe* 9(4): 61-68.
PINHEY, E.C.G., 1984. A checklist of the Odonata of Zimbabwe and Zambia. *Smithersia* 3: 11-64.
SAMWAYS, M.J., 2008. *Dragonflies and damselflies of South Africa.* Pensoft Publishers, Sofia.
SAMWAYS, M.J., G. CARCHINI & M. DI DOMENICO, 1993. The last instar larvae of the southern African endemics Aeshna minuscula McLachlan, 1896 and A. subpupillata McLachlan, 1896 (Anisoptera: Aeshnidae). *Odonatologica* 22(1): 83-88.
SJÖSTEDT, Y., 1909. *Wissenschaftliche Ergebnisse der Schwedischen Zoologischen Expedition nach dem Kilimandjaro, dem Meru und den umgebenden Massaisteppen Deutsch-Ostafrikas 1905-1906 (14. Pseudoneuroptera, I: Odonata)*. Palmquists Aktiebolag, Stockholm.
TARBOTON, W. & M. TARBOTON, 2002. *A fieldguide to the dragonflies of South Africa*. Tarboton, Johannesburg.
TELFER, M.G.,1992. A collection of dragonflies and damselflies (Odonata) from Nechisar National Park. *In*: J.W. Duckworth, M.I. Evans, R.J. Safford, M.G. Telfer, R.J. Timmins & C. Zewdie, [Eds], *A survey of Nechisar National park, Ethiopia*, pp. 126-129. International Council for Bird Preservation Study Report 50, Cambridge.
VICK, G.S., 1999. A checklist of the Odonata of the South-west province of Cameroon, with the description of Phyllogomphus corbetae spec. nov. (Anisoptera: Gomphidae). *Odonatologica* 28(3): 219-256.
VON ELLENRIEDER, N., 2002. A phylogenetic analysis of the extant Aeshnidae (Odonata: Anisoptera). *Syst. Ent.* 27: 437-467.
VON ELLENRIEDER, N., 2003. A Synopsis of the Neotropical species of “Aeshna” Fabricius: the genus Rhionaeschna Förster (Odonata: Aeshnidae). *Tijdschr. Ent.* 146: 67-207.
WATERSTON, A.R, 1985. Insects of southern Arabia. Odonata from the Yemen and Saudi Arabia. *Fauna Saudi Arabia* 6: 451-472.

*Odonatologica 40(3): 251-254* *September 1, 2011*

**SHORT COMMUNICATIONS**

# FIRST RECORD OF *RHODISCHNURA NURSEI* (MORTON) FROM IRAN (ZYGOPTERA: COENAGRIONIDAE)

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*Received February 11, 2011 / Reviewed and Accepted April 2, 2011*

*R. nursei* is for the first time reported from the South of Iran, a considerable widening of the range of this rather ill-known sp. towards the West, and redefining its geographical range as West-Oriental and rather typical of semi-arid climates. The nearest certified record from Pakistan is situated some 1000 km NE of the locations in Iran, but it can be supposed that numerous populations live in the gap. The specimens, collected in Rudan and Ziarat Ali, Hormozgan province, S Iran, lived along the grassy shores of 2 slow-flowing rivers, a habitat that is also typical of the sp. further East. A ♀ found at Sarbaz, Beluchistan, confirms that this small and inconspicuous sp. may be widespread in suitable biotopes of southern and eastern Iran, and probably in the West of Pakistan as well.

## INTRODUCTION

HEIDARI & DUMONT (2002) published an analysis of the biogeographical composition of the Iranian dragonfly fauna, and found a sizeable fraction of oriental species to be present. They also predicted that in the South and the East of the country, even more oriental species could be expected to reach Iran (see DUMONT & HEIDARI, 1996, 1998 for examples in *Ischnura* and *Pseudagrion*). Here, we confirm this expectation and add one further such species, *Rhodischnura nursei* (Morton, 1907), to the fauna of Iran.

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## MATERIAL AND METHODS

All adult specimens were collected using a semicircular aerial net from the top of grasses in a wetland close to a wide and shallow river with slow water flow. Some of the captured specimens were preserved in 80% ethyl alcohol; others were transferred to the laboratory in small envelopes and prepared for mounting using acetone for 30 minutes. GPS data were recorded for each location.

## RESULTS

Eight *Rhodischnura nursei* specimens (7 males, 1 female) were collected on 20 and 21 June 2010, and seven specimens (5 males, 2 females) on 10 and 11 November 2010 by the first author from two localities in Hormozgan province, southern Iran. One of these locations is situated near Bandar Abbas (27°17'N, 56°20'E) and the other in Rudan area at a place called Ziarat-ali (27°44'N, 57°13'E). The localities are rivers with reduced flow, bordered by grasses and sedges (Fig. 1), between which the damselflies were seen flying. Re-examination of all small *Ischnura*'s collected by the senior author at Sarbaz, Baluchistan-Seistan province, 28 April 1995, revealed that the specimen used for DNA analysis was in fact also a *Rhodischnura nursei* female, therefore the species is now known from at least three localities in Iran.

Fig. 1. Riverine biotope near Bandar Abbas where *Rhodischnura nursei* was collected.

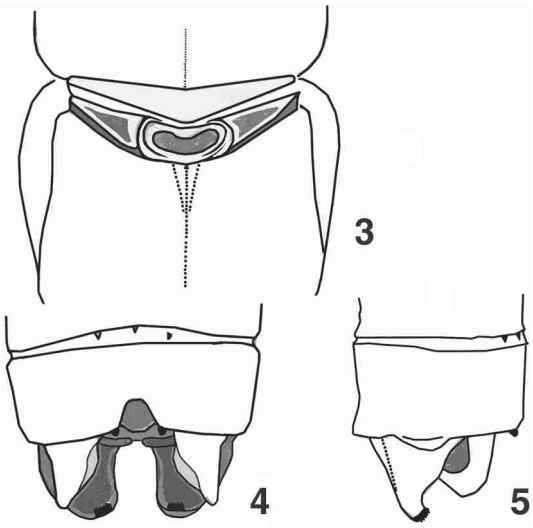
## DISCUSSION

*R. nursei* is similar to most members of the genus *Ischnura* in wing venation and in most other respects except that it has no postocular spots and that males have a short abdomen, slightly widened at the end, with the apex of segment 10 not erect but broadly invaginated. The pterostigma in the fore wing is larger than in the hind wing and reddish in colour (MORTON, 1907; FRASER, 1933; LAIDLAW, 1916, 1919) (Fig. 2). The male appendages are comparatively simple, rather uniformly light brownish in colour, the upper pair squarish-conical and shorter than the tenth abdominal segment, the lower pair somewhat longer, hollowed out, somewhat wrapped around the superior appendages, and crowned with a broad,

black apical tooth (Figs 4-5). The females have a well developed vulvar spine; the hind rime of the pronotum is triangular, and the laminae mesostigmales are triangular and only slightly hollowed out (Fig. 3).

Fig. 2. *Rhodischnura nursei*, male, Bandar Abbas, 10 November 2010.

In the field, the male of this extremely small species is identified at once by the characteristic zonation of the abdomen, which is tricoloured in a typical "Belgian" or "German" flag pattern, viz. red, yellow, and black on the dorsum and sides (Fig. 2). Specimens of our Bandar-Abbas collections, possibly representing two generations, varied somewhat in colour: males in the June collection had some yellow on the first and second abdominal segments instead of reddish, as in Indian and Pakistani specimens described by MORTON (1907), LAIDLAW (1916) and FRASER (1933). But a comparison with series of specimens in the collection of HJD (from Jaipur and Asan Lake near Dehra Dun, India, March 1999) showed that morphologically there was no difference with Iranian examples. As to the environment in which it was found, the Jaipur samples were collected from stagnant pools near a river, with abundant grasses that provided shelter for the damselflies, exactly the same type of environment as in Iran.




Figs 3-5. *Rhodischnura nursei,* Bandar Abbas, Iran: (3) female pronotum and laminae mesostigmales; – (4) male terminalia, dorsal view; – (5) same, lateral view.

One male specimen from the Bandar Abbas collection and one female from Sarbaz were subjected by the senior author (HJD, Belgium) to a molecular investigation, details of which will be given in a paper on broader relationships within oriental *Ischnura*. However, the sequence of a portion of the COI mitochondrial gene unequivocally revealed that Indian and both Iranian examples are identi-

cal taxa. Moreover, there is ground to doubt the validity of the genus *Rhodischnura*, and a return to *Ischnura* will have to be considered.

This species was to date believed to be limited to India and Pakistan (FRASER, 1933; BOSE & MITRA, 1975; KHALIQ & YOUSUF, 1993), where it occurs predominantly in the drier parts of the country. In India, its range seems to be restricted to the plains of the North and centre of the country; it has not been found in the East and South, does not occur in mountain areas, and does not seem to extend to Nepal and to Bangladesh. Its favourite environment appears to be rivers in semi-arid climate areas. Not surprisingly, it has therefore been cited from many stations in Pakistan (KHALIQ & YOUSUF, 1993). Records are available from as far West as the environs of Karachi and from the "Makran coast". The latter is the closest to Iran currently available, but cannot be exactly placed, so that the range extension is at minimum 1000 kilometers West. Our record of this taxon in Iran brings the total number of Odonata species known from the country to 97 (HEIDARI & DUMONT, 2002; KALKMAN, 2006), and there is no reason why not even more oriental species should be expected in the future. Yet, it is unclear now where the northern and western boundaries of the range of *nursei* should ultimately be drawn.

## REFERENCES

BOSE, G. & T.R. MITRA, 1975. The Odonate fauna of Rajasthan. *Rec. zool. Surv. India* 71: 1-11.

DUMONT, H.J. & H. HEIDARI, 1996. On a collection of spring Odonata from Iran, with the description of Coenagrion australocaspicum n. sp. *Bull. Annls Soc. roy. Belge Ent.* 132: 63-78.

DUMONT, H.J. & H. HEIDARI, 1998. The genus Pseudagrion (Insecta: Odonata) in Iran. *Int. J. Odonatol.* 1: 159-163.

FRASER, F.C., 1920. Notes on Indian dragonflies, 1: a description of the dimorphic females of Rhodischnura nursei Morton. *Rec. Indian Mus.* 19(2): 31-33.

FRASER, F.C., 1933. *The fauna of British India, including Ceylon and Burma*, Vol. 1. Taylor & Francis, London.

HEIDARI, H. & H.J. DUMONT, 2002. An annotated check-list of the Odonata of Iran. *Zool. Middle East* 26: 133-150.

KALKMAN, V.J., 2006. Key to the dragonflies of Turkey, including species known from Greece, Bulgaria, Lebanon, Syria, the Trans-Caucasus and Iran. *Brachytron* 10: 3-82.

KHALIQ, A. & M. YOUSUF, 1993. Coenagrionidae (Zygoptera: Odonata) of Pakistan, 3: subfamily Ischnurinae. *Pakistan J. Zool.* 25: 329-336.

LAIDLAW, F.F., 1916. Notes on Indian Odonata. *Rec. Indian Mus.* 12(4): 131-132.

LAIDLAW, F.F., 1919. A list of the dragonflies recorded from the Indian Empire with special reference to the collection of the Indian Museum, 2: the family Agrionidae, B: the legions Argia and Agrion. *Rec. Indian. Mus.* 16: 169-195.

MORTON, K.J., 1907. Odonata collected by Lt. Colonel Nurse, chiefly in north western India. *Trans. ent. Soc. Lond.* 1907: 303-308.

# ODONATOLOGICAL ABSTRACTS

## 2000

(18424) BROWN, J.M., M.A. McPEEK & M.L. MAY, 2000. A phylogenetic perspective on habitat shifts and diversity in the North American Enallagma damselflies. *Syst. Biol.* 49(4): 697-712. – (Second Author: Dept Biol. Sci., Dartmouth Coll., Hanover, NH 03755, USA).
Community ecologists are increasingly aware that the regional history of taxon diversification can have an important influence on community structure. Likewise, systematists recognize that ecological context can have an important influence on the processes of speciation and extinction that create patterns of descent. Here, a phylogenetic analysis is presented of radiation of 33 N Amer. Enallagma spp., which have been well studied ecologically, to elucidate the evolutionary mechanisms that have contributed to differences in diversity between larval habitats (lakes with and without fish predators). Analysis of molecular variation in 842 bp of the mitochondrial cytochrome oxidase I and II subunit and of the intervening Leu-rRNA and 38 morphological characters resulted in 3 well-defined clades that are only partially congruent with previous phylogenetic hypotheses. Molecular and morphological data partitions were significantly incongruent ($p < 0.01$). Lack of haplotype monophyly within sp. and small amounts of sequence divergence (< 1%) between related spp. in 3 of the 4 clades suggest that recent, and parallel, speciation has been an important source of community diversity. Reconstruction of habitat preference over the phylogeny suggests that the greater species diversity in fish-containing lake habitats reflects the recency of shifts into the fishless lake habit, although a difference in speciation or extinction rates between the 2 habitats is difficult to exclude as an additional mechanism.

(18425) KOURIE, J.I. & A.A. SHORTHOUSE, 2000. Properties of cytotoxic peptide-formed ion channels. *Am. J. Physiol. Cell Physiol.* 278: C1063-C1087. – (Membrane Transport Gr., Dept Chem., Austr. Natn. Univ., Canberra, ACT-0200, AU).
A review paper. – A number of insect orders have been found to produce antimicrobial peptides, collectively known as insect defensins. The defensin isolated from Odon. (Aeshna) is very similar to the scorpion defensin. These 2 are shorter than defensins in the more "modern" insect orders; see S. Cociancich et al., 1993, *J. biol. Chem.* 268: 19239-19245.

(18426) MARDEN, J.H. & B. HOWAN, 2000. Growth, differential survival and shifting sex ration of free-living Libellula pulchella (Odonata: Libellulidae) dragonflies during adult maturation. *Ann. ent. Soc. Am.* 93(3): 452-458. – (208 Mueller Lab., Dept Biol., Pennsylvania St. Univ., University Park, PA 16802, USA).
A mark-recapture study was performed to determine rates of change in body mass during maturation of adult free-living L. pulchella. Captured, weighed, marked, and released were 444 individuals (278 ♀, 166 ♂) that were 0-5 d old, including 261 that had emerged on the day of initial capture. On subsequent days, 87 individuals were recaptured at least once, and 6 were recaptured more than once. Nearly all new emergents (mean mass = 272 mg) that were recaptured after 1 or 2 d had lost mass (mean change = -29 mg), whereas most individuals recaptured after ≥ 3 days had gained mass (mean change = 109 mg; mean rate = 18 mg/d). Individuals that were heavier at emergence were much more

likely to gain mass and to be recaptured at ages > 1 or 2 d, thus suggesting differential survivorship based on size at emergence. Average growth rates of gainers were as high as 57 mg/d over a 5-d period. The sex ratio of newly emerged adults was heavily biased toward ♀♀ (61%), but ♂♂ were significantly larger at emergence, were more successful at gaining mass, and the sex ratio of individuals that ultimately gained mass did not differ significantly from 1 : 1. New emergents had empty guts and minimal fat, and changes in fat and water content explained very little of the average decrease in body mass observed for most new emergents. Overall, data suggest that L. pulchella faces severe energy stress during early adult maturation, which strongly affects its demography.

## 2001

(18427) ELDER, J.-F. & C. MOUQUET, [Eds], 2001. Les invertébrés des dunes d'Hatainville-Baubigny. *Bull. Gretia* (Suppl) 2001: 1-19, 4 App. + 2 pls excl. − (c/o Gretia, 65 rue de Saint Brieuc, F-35042 Rennes cedex).
Includes a list of 9 odon. spp.; − dépt la Manche, France.

(18428) FOSSATI, O., J.-G. WASSON, C. HÉRY, G. SALINAS & R. MARIN, 2001. Impact of sediment releases on water chemistry and macroinvertebrate communities in clear water Andean streams (Bolivia). *Arch Hydrobiol.* 151(1): 33-50. − (First Author: Inst. Rech. Dev., IRD, Ecol. Hydrosyst. Fluv., Univ. Lyon-I, 43 Bd du 11-novembre-1918, F-69622 Villeurbanne).
The impact, due to road construction, was studied in the Bolivian Amazonian basin, part of the High Rio Madeira basin. Data on mean densities/$m^2$ are stated family-wise for Gomphidae and Libellulidae, but with respect to the expected and observed effects of sediment addition, the odon. are considered non-contributive.

## 2002

(18429) FOURCASSIÉ, V. & P.S. OLIVEIRA, 2002. Foraging ecology of the giant Amazonian ant Dinoponera gigantea (Hymenoptera, Formicidae, Ponerinae): activity schedule, diet and spatial foraging patterns. *J. nat. Hist.* 36: 2211-2227. − (First Author: Lab. Ethol. & Psychol. Anim., Univ. Paul Sabatier, 118 rte Narbonne, F-31062 Toulouse Cedex-4).
Field work was conducted during Dec. 1999 (end of dry season) in a secondary rainforest near Paragominas (Pará, N. Brazil). Live odon. are listed among the food items collected by workers.

(18430) HORECKÝ, J., E. STUCHLIK, P. CHVOJKA, P. BITUŠIK, M. LIŠKA, P. PŠENÁKOVÁ & J. ŠPAČEK, 2002. Effects of acid atmospheric deposition on chemistry and benthic macroinvertebrates of forest streams in the Brdy Mts (Czech Republic). *Acta Soc. zool. behem.* 66: 189-203. − (First Author: Dept Hydrobiol., Charles Univ., Vinicna 7, CZ-128-44 Praha-2).
A Cordulegaster boltonii larva is recorded from the Voldušský brook.

(18431) KETENCHIEV, H.A., S.G. KOZ'MINOV & T.H. GOGUZOKOV, 2002. Nasekomye Sredizemnomor'ya [Insects of the Mediterranean], 1: Odonata, Diptera: Syrphidae. Kabardino-Balkarskiy St. Univ., Nal'chik. 107 pp. ISBN none. (Russ.).
An overview of biogeography of the genera of the Mediterranean Biogeographic Region (Europe, Asia, Africa).

(18432) PÉTILLON, J. & F. DUSOULIER, 2002. Liste commentée d'invertébrés récoltés dans le basin rennais en 200/2001. *Lombric à Brac* 46: 16-25. − (First Author: 111 Boulvd d'Europe, F-29200 Brest).
Ischnura elegans is listed from a locality in the Rennes area, France.

(18433) REIMCHEN, T.E. & P. NOSIL, 2002. Temporal variation in divergent selection on spine number in threespine stickleback. *Evolution* 56(12): 2472-2483. − (Dept Biol., Univ. Victoria, P.O. Box 3020, Victoria, BC, V8W 3N5, CA).
More than 20.000 stickleback (Gasterosteus aculeatus) individuals were collected (1970-1987) from Boulton Lake (Queen Charlotte Islands, Canada) and were scored for the multiple meristic and metric characters, incl. numbers of dorsal pelvic and anal spines. The fish suffer in winter mostly from avian predation, but in summer sticklebacks move to a benthic niche, where odon. predation is more common. Consequently, there is a selection for increased spine number in winter, whereas a selection

for decreased spine number is apparent during the summers season. – (See also *OA* 3133).

(18434) WILLIGALLA, C., 2002. Die Libellenfauna im Erweiterungsgebiet der Rieselfelder Münster. *Jber. biol. Stn Rieselfelder Münster* 5: 68-76. – (Brock 45, D-48346 Ostbevern).
A description of the fauna (30 spp.), with annotations on Erythromma najas, E. viridulum and Ischnura pumilio; – Münster, North Rhine-Westphalia, Germany.

(18435) ZHANG, Y.-C., B. LIU, Z.-M. ZHENG & L. LI, 2002. DNA extraction and RAPD-PCR of insect specimens preserved with different methods. *Acta ent. sin.* 45(5): 693-695. (Chin., with Engl. s.). – (Coll. Life Sci., Shaanxi Normal Univ., Xian-710062, China).
Genome DNA was extracted and amplified using the polymerase chain reaction and arbitrary primers from 7 insect spp., incl. Crocothemis servilia. The results suggest that with respect to DNA extraction, oven-dried specimens and those preserved in alcohol are better than naturally dried specimens. DNA extraction using the CTAB method was easier and more economic than other methods.

(18436) ZUELLIG, R.R., B.C. KONDRATIEFF & H.A. RHODES, 2002. Benthos recovery after an episodic sediment release into a Colorado Rocky Mountain river. *West. N. Am. Naturalist* 62(1): 59-72. – (First Author: Dept Fish. & Wldl. Biol., Colorado St. Univ., Fort Collins, CO 80523, USA).
During late Sept. 1996, approx. 7000 $m^3$ of clay- to gravel-sized sediment was flushed into the North Fork Cache la Pondre river. Ca 9.6 km of river was partially or completely affected. The densities of Zygoptera (July 1997) and Ophiogomphus severus (Aug. 1997) are stated; – Larimer co., Colorado, USA).

## 2003

(18437) BASS, D., 2003. A survey of freshwater macroinvertebrates in Tobago. *J. Trinidad Tobago Fld Naturalists' Club* 2003: 64-69. – (Biol. Dept, Univ. Central Oklahoma, Edmond, OK 73034,, USA).
5 taxa of odon. larvae are listed (mostly on gen. level) from the island of Tobago (SE Caribbean basin).

(18438) CANO-VILLEGAS, F.J., 2003. Aportación al conocimiento de la fauna de odonatos (Insecta: Odonata) en una cuenca fluvial del rio Fuengirola (Málaga, sur de España). *Boln SAE* 7: 7-15. (With Engl. s.). – (Area Zool., Depto Sistemas Fisicos Quimicos Naturales, Univ. P. de Olavide, ES-41013 Sevilla).
A biogeographic analysis is presented of 20 spp. occurring in the Fuengirola river basin, S Spain. The number of African faunal elements is particularly high.

(18439) CANO-VILLEGAS, F.J., 2003. Una rara libélula amenazada peligra al exluirse de Natura 2000 una cuenca malagueña. *Quercus* 212: 53. – (Area Zool., Depto Sistemas Fisicos Quimicos Naturales, Univ. P. de Olavide, ES-41013 Sevilla).
Oxygastra curtisii.

(18440) GILBERT, G., G. TYLER & K.W. SMITH, 2003. Nestling diet and fish preference of bitterns Botaurus stellaris in Britain. *Ardea* 91(1): 35-44. – (Royal Soc. Prot. Birds, The Lodge, Sandy, Berfordshire, SG19 2DL, UK).
The samples from nestlings were examined during visits to bittern nests made at 9 sites in England, but for reasons of confidentiality these are not named. Adult and larval libellulids were found among the food items.

(18441) GLASER, F., F. MUNGENAST & H. SONNTAG, 2003. Bewässerungsteiche als Lebensräume für Amphibien und Libellen am Beispiel der Trams bei Landeck (Tirol, Österreich): Artenbestand, naturschutzfachliche Bedeutung, Schutz und Erhaltung. *Ber. naturw.-med. Ver. Innsbruck* 90: 165-205. – (First Author: Tech. Büro Biol., Gabelsbergerstr. 41, A-6020 Innsbruck).
25 odon. spp. are listed from the ponds on a highland terrace near Innsbruck (Austria), alt. 850-1100 m a.s.l. Data on their phenology and Red List status are provided, and details on the local occurrence of each sp. are outlined.

(18442) SANE, S.P., 2003. The aerodynamics of insect flight. *J. exp. Biol.* 206: 4191-4208. – (Dept Biol., Univ. Washington, Seattle, WA 98195, USA).
A review paper.

(18443) VALLADOLID, M. & M. PRZYBYLSKI, 2003. Feeding ecology of Cobitis paludica and Cobitis calderoni in central Spain. *Folia biol.*, Krakow

51 (Suppl.): 135-141. – (First Author: Dept Biodiv. & Evol. Biol., Natn Mus. Nat. Hist., c. Jose Gutierrez Abascal 2, ES-28006 Madrid).
7 odon. taxa are recorded from the Lozoya river (Madrid, Spain), where odon. occurred in the diet of C. paludica.

(18444) VALTONEN, P., 2003. Sambian sudenkorennoista. – [On a small collection of Zambian dragonflies]. *Diamina* 2003: 28-33. (Finn.). – (Kaukolankuja 2, FIN-36200 Kangasala).
The records are presented of 34 spp., collected (2001) from 3 localities (Ndola, Nsobe and Luapula) in Zambia.

## 2004

(18445) GIBBS, K.E., B. BRADEEN & D. BOLAND, 2004. Spatial and temporal segregation among six species of coexisting Ophiogomphus (Odonata: Gomphidae) in the Aroostook river, Maine. *NEast. Nat.* 11(3): 295-312. – (First Author: 588 Kennebec Rd, Hampden, ME 04444, USA).
Spatial and temporal segregation of coexisting Ophiogomphus anomalus, O. aspersus, O. carolus, O. howei, O. mainensis and O. rupinsulensis were studied in a 137.7 km reach of the Aroostook river in northern Maine. Collections of exuviae showed that O. mainensis was most abundant and dominated the assemblage at sites in the upper reaches of the study area and was in low numbers and percent of total Ophiogomphus at sites in the lower reaches of the study area. O. rupinsulensis was most abundant and dominated the assemblage at sites in the lower reaches of the study area but was absent or in low numbers and percent of total Ophiogomphus at sites in the upper reaches. O. anomalus and O. carolus were present at all sites and O. anomalus was generally more abundant and made up a higher percent of the total Ophiogomphus spp. than O. carolus. O. howei and O. aspersus were present at only a few sites in low abundance and percent of the total Ophiogomphus. Several Ophiogomphus spp. coexisted as larvae in 0.20 $m^2$ areas of the substrate. There was little evidene of temporal segregation among the six species. All species had short seasonal emergence periods in June. Diel emergence was during the morning and early afternoon. Timing of seasonal and diel emergence either differed little or not al all among the six species. Spp. that could be identified in all larval stages (O. mainensis, O. anomalus, and O. howei) were present in a wide range of instars on all sampling dates (May to Oct.) suggesting overlapping generations and multivoltine life histories. In all 6 spp., some larvae remained in the final instar for almost a year before emerging as adults.

(18446) KOMPOSCH, B., H. BRUNNER & W.E. HOLZINGER, 2004. Wiederfund der Zwerglibelle (Nehalennia speciosa) und weitere bemerkenswerte Libellen-Nachweise aus Kärntner Mooren (Insecta: Odonata). *Carinthia* (II) 194/114: 495-502. (With Engl. s.). – (Inst. Faunistik u. Tierökol., Bergmanngasse 22, A-8010 Graz).
A small N. speciosa population at Egelsee, S of Millstätter Lake, Carinthia (Austria) is brought on record (June 2003) and 15 other noteworthy odon. spp. are reported from various Carinthian peat bogs.

(18447) MANTEL, S.K., M. SALAS & D. DUDGEON, 2004. Foodweb structure in a tropical Asian forest stream. *Jl N. Am. benthol. Soc.* 23(4): 728-755. – (First Author: Unilever Cent. Environ. Water Quality, Inst. Water Res., Rhodes Univ., P.O. Box 94, Grahamstown, SA).
A food web based on the gut contents of consumers (incl. odon.) in pools of Tai Po Kau Forest Stream (Hong Kong) indicated the importance of periphyton and fine organic particles. Stable isotope analysis of consumer tissues was undertaken to confirm the results. Animal parts composed most of the gut contents (50-92%) of Euphaea decorata, but 10-50% in its diet was coarse particulate organic matter. There were fewer prey taxa in the guts of E. decorata in pools compared to its diet in riffles of the same stream.

(18448) TOFILSKI, A., 2004. DrawWing, a program for numerical description of insect wings. *J. Insect Sci.* 2004, 5 pp. Available online: *Insectscience.org/4.17*. – (Bee Res. Dept, Agric. Univ., 29-Listopada 52, PO-31-425 Krakow).
A tool is presented that enables automatic identification of vein junctions. Aeshna juncea wing is used as an example.

## 2005

(18449) ACUÑA, V., I. MUÑOZ, A. GIORGI, M. OMELLA, F. SABATER & S. SABATER, 2005.

Drought and postdrought cycles in an intermittent Mediterranean stream: structural and functional aspects. *Jl N. Am. benthol. Soc.* 24(4): 919-933. – (Second Author: Dept Ecol., Fac. Biol., Univ. Barcelona, Avinguda Diagonal 645, ES-08028 Barcelona).
The study was conducted at the Furosos stream (alt. 150 m) near Barcelona, NE Spain. When the stream dried out, isolated pools were formed where the increase in macroinvertebrate density peaked. One of the consequences was the increase of predation pressure of Cordulegaster sp. in the isolated pools.

(18450) AMEILIA ZULIYANTI, S., M.R. CHE SALMAH & A.A[BU] HASSAN, 2005. The diversity of Odonata in relation to ecosystem and land use in northern Peninsular Malaysia. *J. Ilmiah Pertanian Kultura* 40(2): 106-112. (With Malay s.). – (First Author: Dept Pest & Disease, Fac. Agric., USU, Medan-20155, Malaysia).
Odon. larvae (35 spp. listed) were sampled from 16 tributaries of the Kerian river (Sept. 1998-May 1999), covering wet and dry seasons. The distribution of genera was significantly different in the 2 seasons. Scores of biological indices and indicator species, based on selected chemical properties, are listed. There is a strong correlation between generic diversity and dissolved oxygen and nitrate in wet season, and temperature and conductivity in dry season.

(18451) BARKOV, D.V., 2005. [Importance of the Baikalian amphipod Gmelinoides fasciatus (Stebb.) in the macrozoobenthos structure of the Valaam Lake (Ladoga Lake)]. *Issledovano v Rossii* [*Investigated in Russia*] 2005: 820-833 (Russ.); http//zhurnal.ape.relarn.ru/articles/2005/079.pdf – (Author: Inst. Ozerovedeniya, RAN, Sevast'yanova 9, RUS-196105 Sankt-Peterburg).
Platycnemis pennipes, Coenagrion concinum, C. hastulatum and Sympetrum flaveolum are recorded.

(18452) BORISOV, S.N., 2005. Distribution and habitat characteristics of Ophiogomphus reductus Calvert, 1898 (Odonata, Gomphidae). *Euroasian ent. J.* 4(4): 273-278. (Russ., with Engl. s.). – (Inst. Anim. Syst. & Ecol., Russ. Acad. Sci., Frunse 11, RUS-630091 Novosibirsk).
O. reductus is endemic to central Asian mountains, where it breeds in silty rivers, influenced by melting snow. In the lowlands, the larvae inhabit irrigation channels, hence their distribution there is subject to the development of irrigation systems.

(18453) DITTRICH, S. & L. DITTRICH, 2005. *Lexicon der Tiersymbole. Tiere als Sinnbilder in der Malerei des 14.-17. Jahrhunderts.* [2nd revised edn]. Imhof, Petersberg. 672 pp. Hardcover (24.5 × 30.5 cm). ISBN 3-937251-18-9. – (Publishers: Stettiner Str. 25, D-36100 Peterberg).
Some works of art that are assumed to use dragonflies as a symbol of the soul (metamorphosis from the aquatic larva to the aerial insect; cf. also *OA* 8888) and of malignity (predatory life) are described and commented upon.

(18454) OTT, J., 2005. Klimaänderung: auch ein Thema und Problem für den Biodiversitätschutz im Grenzüberschreitenden Biosphärenreservat Vosges du Nord und Pfälzerwald? *Annls scient. Réserve Biosphère transfrontière Vosges Nord-Pfälzerwald* 12: 127-142. (With Fr. & Engl. s's). – (L.U.P.O., Friedhofstr. 28, D-67705 Trippstadt).
In the very recent past, climate change appears one of the main factors which in future will lead to further massive losses of spp. and habitat as well as to disruptions and changes affecting the latter. Here, a brief review of the latest literature on this problem is presented and reference is made to Coenagrion hastulatum, Somatochlora arctica and Leucorrhinia dubia.

(18455) PACKAUSKAS, R.J., 2005. *Hudsonian Emerald dragonfly (Somatochlora hudsonica): a technical conservation assessment*. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project. 38 pp. – (Author: Dept Biol. Sci., Fort Hays St. Univ., 600 Park St., Hays, KS 67601, USA).
The assessment is addressing the biology of this sp. throughout its range in the Rocky Mountain Region (Region 2 of the United States Forest Service) and was produced as part of the Species Conservation Project. Its goal is to provide a thorough discussion of the biology, ecology, conservation status and management of the sp.

(18456) SCHMIDT, C., 2005. *Pflege und Bewirtschaftung von Ausgewählten Gräben im LSG „Nassau und Elbwiesen bei Brockwitz" unter besonderer*

*Berücksichtigung der Libellenfauna*. Diplomarbeit, Hochschule für Technik und Wirtschaft, Dresden. vii + 78 pp., App. excl. – (Author: Louisenstr. 45, D-01099 Dresden).
A detailed study on the management of selected ditches in the protected area of "Nassau und Elbwiesen", Brockwitz, Saxony (Germany). Among the 22 recorded spp., Calopteryx virgo, Lestes barbarus, Coenagrion ornatum, Orthetrum brunneum, O. coerulescens, Sympetrum flaveolum and S. pedemontanum are of particular regional interest.

(18457) SCHEVEN, J., 2005. *Bernstein-Einschlüsse: eine untergangene Welt bezeugt die Schöpfung. Erinnerungen an die Welt vor der Sintflut*. Kuratorium Lebendige Vorwelt, Hofheim a. T. 160 pp. Hardcover (21.3 × 30,0 cm). ISBN none. – (Available free from the Publishers: Postfach 40, D-65711 Hofheim a. T.).
A picture book, with excellent col. phot. of arthropod (mostly insect) fossils from Baltic and Dominican Amber. The explanatory text is brief and written from the point of view of the ideology of creationism (deny of evolution and the age of the Earth, etc.). A single zygopteran is presented on p. 100; the name of the sp. and the provenance are not stated. – The Author is a graduated biologist and a recognized Amber palaeontologist.

## 2006

(18458) ELLWANGER, G., K. BURBACH, R. MAUERSBERGER, J. OTT, F.-J. SCHIEL & F. SUHLING, 2006. Libellen (Odonata). *Ber. LandAmt. NatSchutz Sachsen-Anhalt* (Sonderh.) 2006(2): 121-139. – (First Author: Cäsariusstr. 1/B, D-53173 Bonn).
A detailed presentation of the criterions for the status assessment of Coenagrion mercuriale, Sympecma paedisca, Aeshna viridis, Gomphus flavipes, Ophiogomphus cecilia, Leucorrhinia albifrons, L. caudalis and L. pectoralis.

(18459) MEURGEY, F., [Ed.], 2006. *Les odonates des départements et collectivités d'Outre-mer français. Bilan des activités de Groupe Odonatologique Outre-mer, 1999-2005*. Soc. Fr. Odonatol., Bois-d'Arcy. iv + 139 pp. ISBN 2950729169. (With Engl. s. on cover p. 4). – (Editor: Mus. Hist. Nat., rue Voltaire 12, F-44000 Nantes; – Publishers: SFO, rue Lamartine 7, F-78390 Bois-d'Arcy).
*Dommanget, J.-L.*: Préface (pp. 3-4); – *Dommanget, J.-L. & M. Mashaal*: L'Outre-mer français (pp. 5-10); – *Meurgey, F.*: Premier bilan des activités du Groupe Odonatologique Outre-mer (pp. 11-28); – Listes des odonates des départements et collectivités d'Outre-mer (pp. 29-55); – Clé de determination actualisée des odonates de Guadeloupe et de Martinique (pp. 57-72); – *Papazian, M. & S. Couteyen*: Clé de determination des odonates de la Réunion (pp. 73-77); – *Anonymous*: Liste des odonates de France métropolitaine et des départements et collectivités d'Outre-mer (pp. 79-92); – *Bibliographie par zone géographique* (pp. 93-104); – *Bibliographie des descriptions originales* (pp. 105-126); – *Liste des membres du Groupe Odonatologique Outre-mer* (pp. 127-128); – *Liste des structures environnementales* (pp. 129-132); – *Glossaire* (pp. 133-134).

(18460) XU, J., C. ZHAO, Y. ZHANG & Y. ZHANG, 2006. Effect of flapping trajectories on the dragonfly aerodynamics. *Chin. Sci. Bull.* 51(7): 777-784. – (First Author: Micro Energy System Lab., Guangzhou Inst. Energy Conversion, Chin. Acad. Sci., Guangzhou-510640, China).
The effects of translational, figure eight and double-figure-eight flapping trajectories on the dragonfly aerodynamics were numerically studied by solving the Navier-Stokes equations. There is a common characteristic regarding the lift/drag force coefficients that the downstroke flapping provides the lift forces while the upstroke flapping creates the thrust forces for different flapping trajectories. The maximum lift force coefficient exceeds five for the translational trajectory. It is greater than six for the figure-eight and double-figure-eight flapping trajectories, which is sufficiently larger than unity under the steady state flight condition. The ellipse and double-figure-eight flapping trajectories yield the decrease of the lift force, while the figure-eight flapping trajectory yields higher lift force as well as the thrust force than the translational flapping one. During the insect flight, the wing flapping status should be changed instantaneously to satisfy various requirements. Study of the flapping trajectories on the insect aerodynamics is helpful for the design of the Micro-air-vehicles (MAVs).

## 2007

(18461) AGUDELO-ZAMORA, H.D., J.N. LÓPEZ-MACIAS & C.L. SÁNCHEZ-PÁEZ, 2007.

Hábitos alimentarios de la arawana (Osteoglossum bicirrhosum Vandelli, 1829) en el alto rio Putumayo, area del Parque Nacional Naturel La Paya, Putumayo, Colombia. *Acta biol. par.*, Curitiba 36(1/2): 91-101. (With Engl. s.). − (Fac. Administración Recursos Costeros & Marinos, Univ. Santiago de Cali, Santiago de Cali, Colombia).
This fish is omnivorous, mostly piscivorous. Stomach contents of 247 individuals of various sizes (220-820 mm) were examined. The odon. were also found in these, but the quantity and the names of taxa are not stated.

(18462) BENGEN, E. & C. RITZAU, 2007. *Es tanzt die schöne Libelle. Libellen zwischen Weser und Ems mit Photos von Josef Johanning*. Isensee Verlag, Oldenburg. 110 pp., 41 col. pls incl. Softcover (19.5 × 22.5 cm). ISBN 978-3-89995-450-5. Price: euro 14.-- net. − (Publishers: Haarenstr. 20, D-26122 Oldenburg).
Portraits of 41 spp., accompanied by an anthology of dragonfly poems. For each sp., the adult phenology, habitat, local status and the regional distribution are stated along with the locality and date of the photograph. − In its scope, the book is unique in odonatological literature.

(18463) DE MARMELS, J., 2007. Reportes de Odonata nuevos para Venezuela. *Entomotropica* 22(1): 45-47. (With Span. s.). − (Mus. Inst. Zool. Agric., Fac. Agron., niv. Central Venezuela, Apdo 4579, Maracay 2101-A, Venezuela).
Neoneura rufithorax, Phyllocycla pegasus, Aeschnosoma elegans and Brechmorhoga flavopunctata are added to, and 5 spp. are deleted from the Venezuelan list.

(18464) GERAEDS, R.P.G., 2007. Golden-ringed dragonfly [Cordulegaster boltonii] along the Venbeek brook. *Natuurh. Maandbl.* 96(1): 17-18. (Dutch, with Engl. s.). − (Bergstraat 70, NL-6131 AW Sittard).
Recently, C. boltonii adults were observed along the Venbeek brook, probably representing the 4th subpopulation of this sp. in the Meinweg National Park, the Netherlands.

(18465) HERMANS, J.T., 2007. The Golden-ringed dragonfly [Cordulegaster boltonii] at the Meinweg National Park. *Natuurh. Maandbl.* 96(6): 165-169. (Dutch, with Engl. s.). − (Hertestraat 21, NL-6067 ER Linne).
The C. boltonii habitats in the Park (Limburg, the Netherlands) are described. Calopteryx virgo and Orthetrum coerulescens are the most characteristic accompanying spp.

(18466) KADOYA, T. & I. WASHITANI, 2007. An adaptive management scheme for wetland restoration incorporating participatory monitoring into scientific predictions using dragonflies as an indicator taxon. *Global envir. Res.* 11: 179-185. − (Inst. Agric. & Life Sci., Univ. Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo, 113-8657, JA).
An adaptive management scheme for wetland restoration is proposed, using data collected by citizens. The potential advantages of such a scheme are assessed, using a wetland restoration project conducted in a small floodplain area along the Matsuura river in Kyushu, Japan. For the case study, data provided by amateur naturalists on odon. distribution patterns on eco-regional scale and biological characteristics, such as behaviour and habitat preferences, were compiled. Based on this information, a species recovery trajectory at the wetland restoration site is predicted. By monitoring species recovery in order to test the prediction, it is demonstrated that odon. colonization at the restored site could be predicted using species prevalence on the regional scale, based on the nestedness rule. The data collected by the amateur naturalists were essential in making this prediction, which emphasizes the importance of citizen participation in the proposed scheme.

(18467) KASANGAKI, A., L.J. CHAPMAN & J. BALIRWA, 2007. Land use and the ecology of benthic macroinvertebrate assemblages of high-altitude rainforest streams in Uganda. *Freshw. Biol.* 2007: 17 pp.; − DOI: 10.1111/j.1365.2427.2007.01925.x − (First Author: Inst. Trop. Forest Conserv., Mbarara Univ. Sci. & Technol., P.O. Box 44, Kabale, Uganda).
The study was conducted in the Bwindi Impenetrable National Park; 8 odon. taxa are listed at the fam. level only.

(18468) SEQUEIROS SAN ROMAN, L., J.J. BASTERO MONSERRAT & H. DE LA CAMPA MARTINEZ, 2007. El Homenaje a Linneo de 1907 en Zaragoza: un suglo más tarde. *Naturaleza aragonesa* 18: 4-13. − (First Author: Fac. Teologia

de Granada, Campus Universitario de la Cartuja s/n, A.C. 2002, ES-18080 Granada).
Includes biographic notes on Longinos Navas (1858-1937).

(18469) VALTONEN, P., 2007. Sudenkorennot aihekeräilyn kohteena. – [Dragonflies as object of thematic philately]. *Postari* 2007(6): 6-7. (Finn.). – (Kaukolankuja 2, FIN-36200 Kangasala).
The article is directed at young philatelists and includes some general information on dragonflies and an outline of the history of dragonfly postal stamps, including the illustrations of some of these. (See also *OA* 18485)

(18470) VAN SCHAIK, V.A., 2007. The Yellow-spotted emerald [Somatochlora flavomaculata] along the Venbeek brook: situation in 2005 and 2006 and an overview of the accompanying dragonfly fauna. *Natuurh. Maandbl.* 96(7): 198-201. (Dutch, with Engl. s.). – (First Author: St. Luciaweg 20, NL-6075 EK Herkenbosch).
The 2005 and 2006 S. flavomaculata records are listed and the habitats described. The sp. is accompanied by 28 other odon. spp. (a list is provided), incl. Calopteryx virgo, Brachytron pratense and Cordulegaster boltonii; – Limburg, the Netherlands.

(18471) ZHOU, C.-F., 2007. The bracing and fusing pattern of longitudinal veins at base in living mayflies (Insecta: Ephemeroptera). *Acta ent. sin.* 50(1): 51-56. (With Chin. s.). – (Jiangsu Key Lab. Bioresour. Technol., Coll. Life Sci., Nanjing Normal Univ., Nanjing-210097, China).
Includes a discussion on interrelationships among Ephemeroptera, Odon. and Neoptera.

## 2008

(18472) GERAEDS, R.P.G., 2008. Larvae of the Golden-ringed dragonfly [Cordulegaster boltonii] in the Rode Beek brook (Meinweg National Park). *Natuurh. Maandbl.* 97(6): 129-132. (Dutch, with Engl. s.). – (Bergstraat 70, NL-6131 AW Sittard).
The Meinweg National Park hosts the largest C. boltonii population in the Netherlands. In Oct. 2007, the Rode Beek was surveyed. The recorded larvae ranged in age from 1 to 4 or 5 yr.

(18473) PHILLIPS, I.D., D. PARKER & G. McMASTER, 2008. Aquatic invertebrate fauna of a northeastern prairie stream: range extensions and water quality characteristics. *West. N. Am. Nat.* 68(2): 173-185. – (First Author: Stewardship Div., Saskatchewan Watershed Authority, 330-350 3rd Ave North, Saskatoon, SK, S7K 2H6, CA).
Includes a list of 28 odon. spp. from 5 study sites in the Pipestone Creek and its tributaries, SE Saskatchewan, Canada.

(18474) SCHÄFER, O., 2008. *Die Maler Robert als Vorläufer heutiger Ökotheologie*. Fondation Collection Robert, Biel-Bienne. 28 pp. ISBN 978-2-8399-0441-4. – (Publishers: Postfach 1056, CH-2501 Biel-Bienne).
Includes an assessment of the work of P.-A. Robert and reproductions of 2 of his dragonfly paintings (adult Erythromma najas, larva Onychogomphus uncatus).

## 2009

(18475) ADEYEMI, S.O., L.A. ADIKWU, P.M. AKOMBU & J.T. IYELA, 2009. Survey of zooplankton and macroinvertebrates of Gbedikere lake, Bassa, Kogy state, Nigeria. *Int. J. Lakes Rivers* 2(1): 37-44. – (First Author: Dept boil. Sci., Benue St. Univ., Makurdi, Nigeria).
In macroinvertebrate samples, 29.07% of individuals were referable to Odon. (Zygoptera 16.74%, Anisoptera 12.33%). The names of lower taxa are not stated.

(18476) CATLING, P.M., 2009. Dragonflies (Odonata) emerging from brackish pools in saltmarshes of Gaspé (Quebec). *Can. Fld Nat.* 123: 176-177. – (170 Sanford Ave, Ottawa, ON, K2 0E9, CA).
Enallagma hageni, Lestes disjunctus, Sympetrum costiferum, S. danae, S. internum and S. obtrusum were observed emerging from brackish pools with an overall salinity range of 6.0-17.3 ppt in 3 saltmarshes. Lestes congener, Libellula quadrimaculata and spp. of Sympetrum were prominent among the larvae in these pools.

(18477) DÉVAI, G., M. MISKOLCZI, T. JAKAB & Z. MÜLLER, 2009. The dragonfly fauna (Insecta: Odonata) of the landscape Badrogköz (Hungary). *Thaiszia* 19(Suppl. 1): 365-388. – (First Author: Agrion 2000 BT., Zelizy Dánniel u. 18, HU-4033 Debrecen).

The region is situated within the Great Hungarian Plain, between the Tisza and the Bodrog rivers. 51 odon. spp. are known to occur there, representing 78.5% of the Hungarian fauna. The Hungarian checklist (65 spp.) is provided and the composition of the Bodrogköz fauna is biogeographically analysed.

(18478) GRAND, D., 2009. Les libellules et le réchauffement climatique. *Revue scient. Bourgogne--Nature* 9/10 (Invert. aquat.: espèc. patrimoniales, ordinaries & invasives): 124-133. − (Impasse de la Voûte, F-69270 Saint-Romain-au-Mont-d'Or).
As thermophilic organisms, odon. are very sensitive to the change of climate. Since 1950, the arrival of a number of afrotropical spp. to the Iberian peninsula was documented. One of these, Trithemis annulata, reached also S France. In addition, many of the European resident southern spp. are expanding their ranges northwards. The examples are analysed and mapped, and the phenomenon is discussed. A comprehensive bibliography on the subject is appended.

(18479) MAIOLINI, B. & M. CAROLLI, 2009. Odonata in Trentino (NE Italy): historical and recent data. *Studi trentini Sci. nat.* 84: 11-18 (With Ital. s.). − (Sez. Zool. Invert. & Idrobiol., Mus. Trentino Sci. Nat., via Calepina 14, I-38122 Trento).
A commented list of 64 spp. ever recorded from Trentino (Italy), of which 24 spp. were collected. recently.

(18480) PHILLIPS, I.D., R.D. VINEBROOKE & M.A. TURNER, 2009. Experimental reintroduction of the crayfish species Orconectes virilis into formerly acidified Lake 302S (Experimental Lakes Area, Canada). *Can. J. Fish aquat. Sci.* 66: 1892-1902. (With Fr. s.). − (First Author: Saskatchewan Watershed Authority, Stewardship Div., Science, Information & Monitoring Unit, 101.108 Research Dr., Saskatoon, SK, S7N 343, CA).
O. virilis strongly suppressed the total abundance of Aeshna larvae by negatively affecting the larger individuals. However, Aeshna densities were significantly elevated in the enclosures relative to the crayfish-less controls because of the increase in small individuals. Similarly, the smaller Enallagma larvae were also more abundant in the presence of crayfish. It is suggested that size-selective predation by crayfish on larger odon. relieved smaller odon. from competition and cannibalism.

(18481) PHOENIX, J. & W. HENTSCHEL, 2009. Die Hochmoore um Prebuz/Frühbuss, Rolava/Sauersach und Jeleni/Hirschenstand (Erzgebirge), bedeutende Lebensräume für moorgebundene Libellenarten. *Sb. oblast. Muz. Moste* (Prir.) 31: 31-42. (With Engl. & Czech s's). − (First Author: Goethestr. 22, D-01924 Königstein).
From the rised bogs in the western Krušné Hory (= Erzgebirge, Iron Mts), Czech Republic, Aeshna subarctica elisabethae, Somatochlora alpestris and S. arctica are recorded for the first time.

(18482) RUFFONI, A. & N. VARANGUIN, 2009. Étude sur la repartition de l'Agrion de mercure (Coenagrion mercuriale) et de l'Agrion orné (Coenagrion ornatum) sur le territoire du Contrat territorial des grands lacs du Morvan (Odonata, Zygoptera, Coenagrionidae). *Revue scient. Bourgogne--Nature* 9/10 (Invert. aquat.: espèc. patrimoniales, ordinaries & invasives): 57-66. − (Soc. Hist. Nat. Autun, Maison du Parc, F-58230 Saint-Brisson).
The distribution of the 2 spp. in central Morvan, Bourgogne (France) is outlined and mapped, and ecological features and altitudes of their habitats are described.

(18483) SAMWAYS, M.J. & N.J. SHARRATT, 2009. Recovery of endemic dragonflies after removal of invasive alien trees. *Conserv. Biol.* 24(1): 267-277. − (Dept Conserv. Biol. & Ent., Univ. Stellenbosch, P.B. XI, Matieland-7602, SA).
Because dragonflies are very sensitive to alien trees, their response to large-scale restoration of riparian corridors is here assessed. 3 types of disturbance regime are compared: alien invaded, cleared of alien vegetation, and natural vegetation (control), and data are recorded on 22 environmental variables. The most significant variables in determining dragonfly assemblages were percentage of bank cover and tree canopy cover, which indicates the importance of vegetation architecture for these dragonflies. This finding suggests that it is important to restore appropriate marginal vegetation and sunlight conditions. Recovery of dragonfly assemblages after the clearing of alien trees was substantial. Species richness and abundance at restored sites matched those at control sites. Dragonfly assemblage patterns reflected vegetation succession. Thus, initially eurytopic, widespread spp. were the main beneficiaries of the removal of alien trees, and stenotopic, endemic spp. appeared after indigenous vegetation

recovered over time. Important indicator spp. were the 2 national endemics (Allocnemis leucosticta and Pseudagrion furcigerum) which, along with vegetation type, can be used to monitor return of overall integrity of riparian ecology and to make management decisions. Endemic spp. as a whole responded positively to restoration, which suggests that indigenous vegetation recovery has major benefits for irreplaceable and widespread generalist spp.

(18484) TISSOT, B. & J.-L. LAMBERT, 2009. Les odonates de lac de Remoray et de la vallée du Drugeon. *Revue scient. Bourgogne-Nature* 9/10 (Invert. aquat.: espèc. patrimoniales, ordinaires & invasives): 119-123. – (Authors' postal addresses not stated).
A review of the highlights in the odon. fauna (58 spp.) of the Drugeon valley (56 spp.) and of the Lac de Remoray Nature Reserve (47 spp.), Franche-Comté, France.

(18485) VALTONEN, P., 2009. Keräilyn vahva vire jatkuu: Taantuma ei näy posimerkkikaupassa. – [Dragonflies as object of thematic philately]. *Keräilyuutiset* 2009(5): 20-21. (Finn.). – (Kaukolankuja 2, FIN-36200 Kangasala).
The text is similar to that of the paper listed in *OA* 18469, but the article is directed at adult philatelists and the reproductions of postal stamps are in colour.

(18486) VALTONEN, P., 2009. Litokorenoto, Epitheca bimaculata ei olekaan kadonnut Ahvenanmaalta. – [Epitheca bimaculata did not disappear from the Åland islands]. *Diamina* 2009: 6-7. (Finn.). (Kaukolankuja 2, FIN-36200 Kangasala).
During the past 90 yr, E. bimaculata was reported only once from Åland. On 25-VIII-2008, the Author found a broken piece of its abdomen at the small lake, Möträsk, which is probably the same locality from where the sp. was recorded over 90 yr ago (Finström, Pettböle, Finland).

(18487) VARANGUIN, N. & A. RUFFONI, 2009. Ophiogomphus ceclia et Gomphus flavipes, deux espèces d'odonates bourguignons protégés: état des lieux et perspectives en Bourgogne. *Revue scient. Bourgogne-Nature* 9/10 (Invert. aquat.: espèc. patrimoniales, ordinaries & invasives): 118. – (Soc. Hist. Nat. Autun, Maison du Parc, F-58230 Saint-Brisson).
On the status of the 2 spp. in Bourgogne, France.

(18488) VEBER, T., J. KOTTA, V. LAURINGSON & I. KOTTA, 2009. Influence of the local abiotic environment, weather and regional nutrient loading on macrobenthic invertebrate feeding groups in a shallow brackish water ecosystem. *Oceanologia* 51(4): 541-559. – (Second Author: Estonian Marine Inst., Univ. Tartu, Mäealuse 10a, EE-12618 Tallinn).
The study evaluates the extent to which depth, sediment type, exposure to waves and coastal slope inclination modulate the relationships between regional nutrient loading, weather patterns and the species composition and dominance structure of macroinvertebrate feeding groups in a brackish water ecosystem of the Baltic Sea. Odon. are considered under "carnivores", their abundance, biomass and occurrence are order-wise stated, but no other details on the order are specifically provided.

## 2010

(18489) ABILHOA, V., J.R.S. VITULE & H. BORNATOWSKI, 2010. Feeding ecology of Rivulus luelingi (Aplocheiloidei: Rivulidae) in a Coastal Atantic Forest stream, southern Brazil. *Neotrop. Ichthyol.* 8(4): 813-818. – (Mus. Hist. Nat., Rua B. Conceicão 407, BR-82810-080 Curitiba, Paraná).
Libellulid larvae are reported among the food items of this predominantly entomophagous killifish from a black water stream in Guaratuba (Apr. 2003-Jan. 2004).

(18490) BEDJANIČ, M., 2010. *Kačji pastirji (Odonata): priprava izhodišč za monitoring in vzdrževanje habitatov na območju naravnega rezervata Škocijanski zatok*. – [*Dragonflies (Odonata): preparation of starting points for monitoring and habitat management in the area of the Škocianski Zatok Nature Reserve*]. Prepared for the Slovenian Ornithological Soc. (Tržaška 2, SI-1000 Ljubljana). 55 pp. (Slovene). – (Author: Kolodvorska 21/B, SI-2310 Slovenska Bistrica).
An overview of the fauna (37 spp.) of the Reserve (Bertoška Bonifika, nr Koper/Capodistria, NW Istria, Slovenia) is presented and 10 spp. of particular conservation importance are considered in detail. Of interest is the co-occurrence of Lestes parvidens and L. viridis. Suggestions for habitat management are outlined and the bibliography on the odon.

fauna of the Reserve is provided. Col. phot. of all spp. are appended.

(18491) *The BLUE BILL*. Quarterly journal of the Kingston Field Naturalists (ISSN 0382-5655), Vol. 57 (2010), Nos 3 (Sept.), 4 (Dec.). – (Kingston Field Naturalists, P.O. Box 831, Kingston, ON, K7L 4X6, CA).
[Odonatol. articles]: [No. 3]: *Seymour, C.*: July 23 KEN field trip to the Cataraqui Trail at McGilvrey Rd (p. 67); – *Robertson, A.*: Kingston Field Naturalists bioblitz 2010 (pp. 68-75); – [No. 4]: *Hennige, K.*: Odonate sightings and yearly list 2010 (pp. 105-108).

(18492) CONZE, K.-J. & N. GRÖNHAGEN, 2010. *Rote Liste und Artenverzeichnis der Libellen ( Odonata) in Nordrhein-Westfalen*. Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen. 3 pp. – (First Author: Listerstr. 13, D-45147 Essen).
This is the 4th edn of the Red List, showing the situation in April 2010; – Northrhine-Westphalia (Germany).

(18493) DAMM, S., B. SCHIERWATER & H. HADRYS, 2010. An integrative approach to species diversity in odonates: from character-based DNA barcoding to ecology. *Mol. Ecol.* 19: 3881-3893. – (First Author: ITZ, Ecol. & Evol., TiHo Hannover, Bünteweg 17/D, D-30559 Hannover).
Modern taxonomy requires an analytical approach incorporating all lines of evidence into decision-making. Such an approach can enhance both species identification and species discovery. The character-based DNA barcode method provides a molecular data set that can be incorporated into classical taxonomic data such that the discovery of new species can be made in an analytical framework that includes multiple sources of data. Here such a corroborative framework in a dragonfly model system that permits the discovery of 2 new, but visually cryptic spp. is illustrated. In the African dragonfly genus Trithemis, 3 distinct genetic clusters can be detected which could not be identified by using classical taxonomic characters. In order to test the hypothesis of 2 new spp., DNA-barcodes from different sequence markers (ND1 and COI) were combined with morphological, ecological and biogeographic data sets. Phylogenetic analyses and incorporation of all data sets into a scheme called taxonomic circle highly supports the hypothesis of 2 new spp. This case study suggests an analytical approach to modern taxonomy that integrates data sets from different disciplines, thereby increasing the ease and reliability of both species discovery and species assignment. The 2 new Trithemis spp. are here neither formally described nor named.

(18494) DEUTSCHMANN, U., […], W. ZESSIN & […] [11 joint authors], 2010. Erfassung und Bewertung der Insektenfauna im FFH-Gebiet „Wald- und Moorlandschaft um den Röggeliner See" bei Dechow, Mecklenburg (Lepidoptera, Coleoptera, Heteroptera, Orthoptera, Odonata). *Virgo/MittBl. ent. Ver. Mecklenburg* 13(2): 4-35. – (c/o Dr W. Zessin, Lange Str. 9, D-19230 Jasnitz).
Includes an annotated list of 19 odon. spp. from the Röggeliner Lake area near Dechow (Mecklenburg, Germany).

(18495) FRANK, M., 2010. Nachweis der Zierlichen Moosjungfer (Leucorrhinia caudalis Charpentier, 1840) im Landkreis Nordwest-Mecklenburg. *Virgo/MittBl. ent. Ver. Mecklenburg* 13(2): 71-72. – (Traubenmühle 5A, D-55268 Nieder-Olm).
A L. caudalis breeding site in a forest lake NE of Kleekamp (Mecklenburg, Germany) is described and the odon. fauna of the locality (15 spp., incl. L. pectoralis) is listed.

(18496) FRANK, M., 2010. Zum Vorkommen der Feuerlibelle (Crocothemis erythraea [Brullé]) in Nordwest-Mecklenburg im fünften Jahr nach der Erstfeststellung dort. *Virgo/MittBl. ent. Ver. Mecklenburg* 13(2): 72-74. – (Traubenmühle 5A, D-55268 Nieder-Olm).
Also during the 5th yr after ist discovery at the Schönberg carp pond, the presence of C. erythraea could be photographically documented there, meaning that the population is more than a temporary one; – NW Mecklenburg (Germany).

(18497) GAL, M., 2010. *The fauna of dragonflies at oxbow lakes and gravel pits around Petišovci and its singnificance for conservation of nature*. Graduation thesis, Univ. Ljubljana. xii+107 pp. (Slovene, with Engl. s.). – (c/o Dr R. Verovnik, Dept Biol., Univ. Ljubljana, Večna pot 111, SI-1000 Ljubljana).
The fauna (39 spp.) of 5 oxbow lakes of the Mura river (31 spp.) and 5 adjcent, man-made gravel pits at different stages of succession (32 spp.) (Prekmur-

je, NE Slovenia) is analysed and the assemblages of the 2 types of habitats are compared. In 1997, 31 odon. spp. were evidenced from the surroundings of Petiševci, whereas the present field work was conducted during 2008-2009, therefore some discussion on the possible recent faunal changes could also be included. The impact and damage caused by fishermen are emphasized, and some management suggestions are provided.

(18498) GERAEDS, R.P.G., 2010. Habitat and development of larvae of the club-tailed dragonfly [Gomphus vulgatissimus] in the river Roer. *Natuurh. Maandbl.* 99(11): 249-255. (Dutch, with Engl. s.). – (Bergstraat 70, NL-6131 AW Sittard).
Most larvae were found within a distance of 0.5-1.0 m from the bank (max. 5.0 m), mostly in mixed substrates, dominated by a combination of silt and detritus. The distribution of instars during hibernation suggests that in the Roer river the larval development requires 3 yr, meaning that most of the larvae hibernate successfully in F-4, F-2 and F-0 instars.

(18499) GRAND, D., 2010. Deux siècles d'étude de libellules en Rhône-alpes (Insecta, Odonata). *Bull. Soc. linn. Lyon* (Hors-Ser.) 2: 23-29. – (Impasse de la Voûte, F-69270 Saint-Romain-au-Mont-d'Or).
In the Rhône-Alpes region (France), 62 pp. were known up to 1960 and additional 21 spp. were recorded since that yr. The region is influenced by the mediterranean, atlantic and alpine climates, harbouring a great variety of odon. habitats in consequence of which the biodiversity is high. An overview of the latter is presented and commented upon in this paper.

(18500) GRZEDZICKA, E., 2010. Habitat preferences of the dragonflies from chosen area of Świetokrzyskie mountains and Suchedniów plateau with its conservation abilites [sic!]. *Wiad. ent.* 29(Suppl.): 123-128. (Pol., with Engl. s.). – (Inst. Ochrony Przyrody, PAN, Mickiewicz 33, PO-31-120 Kraków).
Records of 35 spp. from 7 localities; – Poland.

(18501) GUPTA, M. & A. PALIWAL, 2010. Role of aquatic insects in the Yamuna river (district Firozabad) related to physico-chemical parameters. *Adv. Biores.* 1(1): 70-73. – (Dept Zool., Ganjdunwara P.G. Coll., Ganjdunwara, Kamshiram Nagar, Uttar Pradesh-207242, India).
5 (common) odon. spp. are brought on record; – India.

(18502) HERTZOG, M., 2010. Beobachtung eines Frisch geschlüpften Weibchens von Boyeria irene am Seerhein (Odonata: Aeshnidae). *Arbeitsgruppe Bodenseeufer: Thema des Monats November 2010*, 3 pp. – (Rebhaldenstr. 19, CH-8596 Scherzingen).
A teneral B. irene ♀ was photographically documented on 17-VIII-2007 at Seerhein nr Gottlieben (canton Thurgau, Switzerland). This is the first record of its breeding in the Lake Constance area.

(18503) HIPPKE, M., 2010. Bemerkenswerte entomologische Beobachtungen in Mecklenburg-Vorpommern (2010): Odonata (Libellen). *Virgo/MittBl. ent. Ver. Mecklenburg* 13(2): 70. – (Wiesenring 29, D-19370 Parchim).
Records of Erythromma viridulum, Aeshna affinis, A. subarctica, Anax parthenope and Leucorrhinia caudalis; – Mecklenburg (Germany).

(18504) *IDF-REPORT*. Newsletter of the International Dragonfly Fund. ISSN 1435-3393, Vol. 31 (2010). – (c/o M. Schorr, Schulstr. 7/B, D-54314 Zerf).
*Martynov, A.V.*: The Odonata fauna of the basin of the river Severskyi Donets in its middle current (eastern Ukraine) (pp. 1-41).

(18505) KAROLINSKIY, E.O. & V.M. GRAMA, 2010. New finds of dragonflies (Odonata) in Kharkiv region. *Vest. Zool.* 44(6): 524. (Ukr., with Engl. title). – (Authors' addresses not stated).
Records of 9 spp.; Kharkov, the Ukraine.

(18506) KERBIRIOU, C., B. BARGAIN, I. LE VIOL & S. PAVOINE, 2010. Diet and fuelling of the globally threatened aquatic warbler at autumn migration stopover as compared with two congeners. *Anim. Conserv.* 2010, 10 pp.; – DOI: 10.1111/j.1469-1759.2010.00424.x – (First Author: Conserv. Espèces, Mus. Natn. Hist. Nat., rue Buffon 55, F-75005 Paris).
The diet composition of Acrocephalus paludicola, observed at migration stopover sites (Audierne marsh, W France), is based on large-sized prey, such as Odon., Orthoptera and Lepidoptera. The odon. represent 8.4% in its feces, whereas they amount

to 0.9 and 0.6% in A. schoenobaenus and A. scirpaceus, respectively.

(18507) KERN, D., 2010. *Fliegende Edelsteine. Libellen im Landkreis Diepholz*. MW-Verlag-Weyhe, Weyhe. 156 pp. Hardcover (24.7 × 21.4 cm). ISBN 978-3-9812556-3-8. Price: euro 16.- net. – (Publishers: D-28844 Weyhe, or Stift. Naturschutz im Landkreis Diepholz, D-49356 Diepholz).
An attractive book on 57 spp, in the district of Diepholz, S of Bremen (Germany). For each sp. the information is presented on habitat, regional distribution, duration of life cycle, adult phenology, threats and on the required conservation measures.

(18508) KETENCHIEV, H.A. & A.V. TIHONOVA, 2010. Troficheskie svyazi strekoz (Odonata) v biocenozah central'nogo Kavkaza. – [Trophic relationships of dragonflies (Odonata) in the biocenoses of central Caucasus]. *Aktual. Probl. gumanit. estest. Nauk* 2010(12): 36-38. (Russ.). – (Authors' addresses not stated).
A graphic presentation of the role of Odon. as predators, prey and parasite hosts.

(18509) KIPPING, J., 2010. The dragonflies and damselflies of Botswana: an annotated checklist with notes on distribution, phenology, habitats and Red List status of the species (Insecta: Odonata). *Mauritiana* 21: 126-204. (With Germ. s.). – (Albrecht-Dürer-Weg 8, D-04425 Taucha/Leipzig).
An updated checklist of 127 spp. (incl. 21 not previously recorded spp.) is presented. Annotations are provided on the spp. where appropriate. Distribution patterns in different freshwater ecoregions are discussed.

(18510) KLIMASZYK, P. & D. HEYMANN, 2010. Vertical distribution of benthic macroinvertebrates in a meromictic lake (Lake Czarne, Drawienski National Park). *Oceanol. Hydrob. Stud.* 39(4): 99-106. – (First Author: Dept Water Prot., Univ. A. Mickiewicz, Umultowka 89, PO-61-615 Poznan).
Somatochlora metallica and Sympetrum sp. larvae were recorded at the depth of 0.5 m, and those of Pyrrhosoma nymphula, Coenagrion sp. and Ischnura sp. at 0.5-5.0 m; – Poland.

(18511) LÓPEZ SALMERÓN, A. & L. MENDOZA-CUENCA, 2010. Efecto del parasitismo por ácaros acuáticos en la adecuación de Argia sp. (Odonata: Coenagrionidae). *Biológicas* 12(2): 122-128. (With Engl. s.). – (Authors' postal addresses not stated).
The study was conducted in the vicinity of San Miguel del Monte (Mexico). Although Argia ♀♀ are bigger than ♂♂, mites attack ♂♂ with higher intensity. The mite parasitism reduces individual ♂ survival and ♂ and ♀ mating success. The bigger ♂♂ are less attacked, have a higher survival and obtain a higher number of matings.

(18512) MABRY, C. & C. DETTMAN, 2010. Odonata richness and abundance in relation to vegetation structure in restored and native wetlands of the prairie pothole region, USA. *Ecol. Restor.* 28(4): 475-484. – (Dept Nat. Resour. Ecol. & Mngmt, Iowa St. Univ., 339 Science II, Ames, IA 50011-3221, USA).
Over the past couple of decades, 2,200,000 ha of wetlands and grasslands have been restored in the prairie pothole region, USA. However, many restored and remnant wetlands in the region are dominated by the invasive plant spp., Phalaris arundinacea and Typha spp., which form dense monotypic stands. These restorations are usually evaluated as habitat for waterfowl and other birds; however, there is a need to evaluate their success for invertebrates. Odon. are ideal organisms to include in the evaluations of restored wetland habitat quality for both ecological and practical reasons. To examine the association between vegetation structure and odon. assemblages in shoreline vegetation of prairie pothole wetlands, odon. richness and abundance in dense, monotypic stands were compared to that of vegetation with diverse vertical structure, and the use of these 2 different habitats by odon. sp. classified as "of conservation concern" in Iowa was observed. Odon. species richness was substantially greater in the mixed-structure vegetation than in monotypic stands. A similar trend was found in spp. with a "vulnerable" or "uncommon" conservation status. The number of occurrences of spp. of conservation concern was 4 times greater in mixed than in monotypic vegetation. A comparison of these data to those collected in the 1990s for one monotypic vegetation site further supported this conclusion. Many odon. spp. are targets for conservation and can readily benefit from wetland restoration and reconstruction if the sites are managed for proper vegetation structure.

(18513) MANTEL, S.K., N.W.J. MULLER & D.A. HUGHES, 2010. Ecological impacts of small dams on South African rivers, 2: biotic response: abundance and composition of macroinvertebrate communities. *Water SA* 36(3): 361-370. – (First Author: Unilever Cent. Environ. Water Quality, Inst. Water Res., Rhodes Univ., P.O. Box 94, Grahamstown, SA).
The paper investigates the cumulative impacts of small dams on invertebrate communities in the Western Cape and Mpumalanga (Sth Africa). 6 odon. fam. are family-wise considered. Alterations of a river's flow regime through the building of dams can lead to impacts on animal and plant communities. A downward trend was recorded in the abundance of Gomphidae and Libellulidae spp. In gomphids, the altered hydraulics, reduced habitat diversity and decreased availability of sediment for burrowing are likely to be responsible for this.

(18514) MARINOV, M., 2010. *Spatial modelling of dragonfly habitats in New Zealand (Odonata: Insecta)*. Diss. Master Appl. Sci., Lincoln Univ., NZ. vi + 68 pp. – (Author: 7/160 Rossall St., Merivale, Christchurch-8014, NZ).
Out of the 17 (10 endemic) spp. occurring in New Zealand, 14 spp. have been selected for this analysis. Their biological features and ecological requirements were considered in preparing a working habitat assessment methodology Habitat models were developed using ArcGIS 9.2 software. Multistep spatial analysis was carried out to reclassify the layers containing the important information on the land topology representing crucial elements in the Odon. spp. habitats. The final outputs are individual species maps where the New Zealand territory is marked with 4 different colour classes corresponding to the ranks of importance that each area is considered to have for individual species. The models are named "probabilistic" in that they reveal the areas where the ecological demands of the species are approached at a maximum level. However, they should not be used as distribution maps. Probabilistic models are contrasted against "deterministic" models used in other Odonata habitat models. The strengths and weaknesses are discussed and some important conclusions and recommendations are described and suggested.

(18515) MORENO, J.L., D.G. ANGELER & J. DE LAS HERAS, 2010. Seasonal dynamics of macroinvertebrate communities in a semiarid saline spring stream with contrasting environmental conditions. *Acuat. Ecol.* 44: 177-193. – (First Author: Reg. Cent. Water Research, CREA, Univ. Castilla-La Mancha, Crtra de Las Peñas, km 3, ES-02071 Albacete).
The seasonal changes in structure of the macroinvertebrate community in the permanent saline spring stream, the Reventión Rambla (SE Spain), are quantified. The upstream site showed more stable environmental conditions than the downstream section studied. Coenagrion mercuriale and Orthetrum brunneum were restricted to the upstream, Ishnura elegans and Crocothemis erythraea occurred in both sections.

(18516) *ODONATOLOGICAL ABSTRACT SERVICE* (ISSN 1438-0269), No. 29 (Oct. 2010), 56 pp. – (Distributor: M. Schorr, Schulstr. 7/B, D-54314 Zerf).
Abstract Nos 9237-9592.

(18517) OTT, J., 2010. Bemerkungen zum Vorkommen von Aeshna affinis Vander Linden, 1820, Somatochlora arctica (Zetterstedt, 1840) und Crocothemis erythraea (Brullé, 1832) (Insecta: Odonata: Aeshnidae, Corduliidae, Libellulidae) in Woogen des Biosphärenreservates Pfälzerwald-Vosges du Nord. *Fauna Flora Rheinland-Pfalz* 11(4): 1291-1310. (With Engl. s.). – L.U.P.O., Friedhofstr. 28, D-67705 Trippstadt).
The current status of the 3 spp. in the German part of the Biosphere Reserve "Palatinate Forest – Northern Vosges" is assessed. Whereas S. arctica has a single but stable population, the other 2 spp. show a remarkable expansion in higher altitudes and also in waters of the centre of the dense forest. C. erythraea appears indigenous even in an acid moorland water (pH 5).

(18518) OTT, J., 2010. Zur aktuellen Situation der Moorlibellen im „Pfälzerwald": wie lange können sie sich in Zeiten des Klimawandels noch halten? *Annls scient. Réserve Biosphère transfrontière Vosges Nord-Pfälzerwald* 15: 123-139. (With Fr. & Engl. s's). – (L.U.P.O., Friedhofstr. 28, D-67705 Trippstadt).
In view of the current change of climate, the situation of moor dragonflies and their recently significantly shrinking habitats in the German part of the Pfälzerwald-Vosges du Nord Biosphere Reserve is analysed.

(18519) PÉREZ-BILBAO, A., A.I. ALONSO & J. GARRIDO, 2010. Phenology of aquatic insects in a protected wetland (Natura 2000 network) in northwestern Spain. *Limnetica* 29(2): 379-386. (With Span. s.). − (Dept Ecol. & Anim. Biol., Univ. Vigo, ES-36310 Vigo).
The aim of this study was to gather new data on the life cycle phenologies of several aquatic insect spp. in the "Gándaras de Budiño" protected wetland. All 7 odon. spp. had univoltine or semivoltine life cycles. Important is the presence of Coenagrion mercuriale, a sp. listed in the Habitats Directive.

(18520) POINAR, G., Jr, G. BECHLY & R. BUCKLEY, 2010. First record of Odonata and a new subfamily of damselflies from Early Cretaceous Burmese amber. *Palaeodiversity* 3: 15-22. (With Germ. s.). − (First Author: Dept Zool., Oregon St. Univ., Corvallis, OR 97331, USA).
Palaeodisparoneura burmanica gen. n., sp. n. (Platycnemididae: Palaeodisparoneurinae sfam. n.) is described and illustrated, based on a ♂ from Hokawng Valley, SW of Maingkwam, Kachin state, Burma. This fossil taxon is tentatively considered as sistergroup of recent Disparoneurinae.

(18521) REDING, S., 2010. *Oshtemo Township parks: natural features inventory*. Kalamazoo Nature Cent., Oshtemo/ MI, USA. 25 pp., maps tabs & Apps excl. − (Address not provided).
Includes a list of 34 odon. taxa (mostly on species level) from Flesher Field Park and a list of 10 odon. spp. from Oshtemo Township Park (Kalamazoo co., SW Michigan, USA).

(18522) SABAGH, L.T., V.L. FERREIRA & C.F.D. ROCHA, 2010. Living together, sometimes feeding in a similar way: the case of the syntopic hylid frogs Hypsiboas raniceps and Scinax acuminatus (Amura: Hylidae) in the Pantanal of Miranda, Mato Grosso do Sul state, Brazil. *Braz. J. Biol.* 70(4): 955-959. (With Port. s.). − (First Author: Lab. Ecol. Vertebrados, Depto Ecol., UERJ, Rua San Francisco Xavier 524, BR-20550-019 Rio de Janeiro, RJ).
The diet of the 2 frog spp. is very similar, but only H. raniceps feeds also on odon.

(18523) SAMWAYS, M.J., P.M. HITCHINS, O. BOURQUIN & J. HENWOOD, 2010. Restoration of a tropical island: Cousine Island, Seychelles. *Biodiv. Conserv.* 19: 425-434. − (First Author: Dept Conserv. Ecol. & Ent., Stellenbosh Univ., Matieland-7612, SA).
Includes a reference to the now lost Ceriagrion glabrum and Diplacodes trivialis, which were not originally native to Cousine, as it had no open water. They only appeared on the island once artificial ponds for the tortoises had been established.

(18524) SCHMIDT, E., 2010. Aktuelles zu Sympetrum striolatum im Münsterland (Odonata: Libellulidae). *Virgo/MittBl. ent. Ver. Mecklenburg* 13(2): 59-62. − (Coesfelder Str. 230, D-48247 Dülmen).
On the occurrence of S. striolatum and S. vulgatum in the area of Dülmen (Westmünsterland, Germany) in view of the annual variation of weather conditions. In the past 2 decades, the earliest emergence of the 2 spp. was recorded on 17-V-1993 and 10-VI-1993, respectively. The features for sight identification of the 2 spp. in the field are stated.

(18525) SCHMIDT, E.G., 2010. Zur Odonatenfauna einer renaturierten Autobahn-Sandentnahmestelle (A 43 bei Haltern) im Westmünsterland. *Virgo/MittBl. ent. Ver. Mecklenburg* 13(1): 47-54. − (Coesfelder Str. 230, D-48247 Dülmen).
A commented list and analysis of the odon. fauna (29 spp.) of a highway sandpit nr Haltern (Rhineland-Westphalia, Germany).

(18526) SIESA, M.E., 2010. *Freshwater communities and biological invasions: Odonata, Amphibia and Procambarus clarkii*. Tesi di Dottorato. Univ. Milano. 144 pp. (With Ital. s.).
The processes occurring during the early stages of the P. clarkia (Crustacea) invasion in freshwater habitats are analysed based on the survey of 148 wetlands in Lombardy (N Italy). The impact on odon. communities (17 Zygoptera and 25 Anisoptera spp.) is outlined and discussed.

(18527) TRAPERO-QUINTANA, A., B. REYES-TUR & J. MATEU-AREBALO, 2010. Distancia sobre el agua durante la emergencia en larvas de Odonata para tres cuerpos dulceacuicolas de Cuba oriental. *Dugesiana* 17(2): 103-111. (With Engl. s.). − (Depto Biol., Univ. Oriente, Patricio Lumumba s/n, CU-90500 Santiago de Cuba).
The vertical distance of the position of exuviae above the water surface was recorded at 3 localities in the province of Santiago de Cuba (Cuba).

Generally, the anisopteran exuviae were located at greater heights than those of the Zygoptera, and the emergence of ♀♀ took place at a higher location than that of ♂♂. The distance of the emergence site from the bank is not considered.

(18528) VALLEJO, V.A. & J. LEDEZMA, 2010. Dragonflies (Odonata: Anisoptera) of the entomological collection of Noel Kempff Mercado Natural History Museum, Danta Cruz de la Sierra, Bolivia. *Kempffiana* 6(2): 40-47. (Span., with Engl. s.). – (First Author: Lab. Zool. & Ecol. Acuática, Univ. Los Andes, Bogotá, Colombia).
An annotated list is presented of 149 spp. from Colombia.

(18529) ZAWAL, A. & S. CZCHOROWSKI, 2010. Dragonflies (Odonata) and caddisflies (Trichoptera) of water reservoirs in the suburban landscape of Świnoujście (Northwest Poland). *Natura montenegrina* 9(3): 481-488. – (First Author: Dept Invert. Zool. & Limnol., Univ. Szczecin, Waska 13, PO-71-415 Szczecin).
3 communities of Odon. (10 spp.)-Trich. (8 spp.) larvae are differentiated and described from 5 periodical water reservoirs. Faunal similarities among the reservoirs only partly corresponded to habitat diversity and the reservoir types, which might indicate that species composition depends also on colonization processes that are well described by the model of ecological islands.

(18530) ZESSIN, W., 2010. Der Dobbertiner Jura (Lias epsilon, Mecklenburg) und seine Bedeutung für die Paläontologie. *Virgo/MittBl. ent. Ver. Mecklenburg* 13(1): 4-9. – (Lange Str. 9, D-19230 Jasnitz).
A brief outline of the history of exploration of this important locality of (also) fossil Odon. (Mecklenburg, Germany), with emphasis of its importance for insect paleontology. It includes a portrait of its discoverer, F.E. Geinitz (1854-?), and a field phot. of the Russian entomopaleontologist A.P. Rasnitsyn.

(18531) ZESSIN, W. & R. LUDWIG, 2010. Die Libellen auf dem Gebiet der Gemeinde Rostow-Kraak, Landkreis Ludwigslust, Mecklenburg. *Virgo/MittBl. ent. Ver. Mecklenburg* 13(1): 32-37. – (First Author: Lange Str. 9, D-19230 Jasnitz).
Annotated list of 27 spp.; – Mecklenburg, Germany.

## 2011

(18532) ALY, M.Z.Y., I.E.E. MOHAMED & S.M. BAKRY, 2011. Study on the prey preference of some aquatic insects for different snails under the laboratory conditions. *Egypt. Acad. J. biol. Sci.* 4(1): 91-101. (With Arab. s.). – (Address incomplete: Zool. Dept Ent., Fac. Sci., Quena, South Valley Univ., Egypt).
2 Belostomatidae spp. (Heteroptera) and Ischnura pumilio, Anax imperator and Crocothemis erythraea larvae were active predators on the harmful snails: Bulinus truncates, Melanoides tuberculata, Biomphalaria alexandrina and Cleopatra bulimoides. Although the non-choice laboratory experiment does not give the guarantee that the predator may attack and feed upon the concerned prey in nature, it is suggested that these odon. spp. could be reared in large numbers and then released in the breeding places of snails in order to achieve the biological control of these pests.

(18533) AWENG-EH RAK, ISMID-SAID & MAKETAB-MOHAMED, 2011. Effects of land use on benthic macroinvertebrate assemblages at three rivers in Endau catchment area, Kluang, Johor, Malaysia. *J. appl. Sci. envir. Sanit.* 6(2): 97-103. – (First Author: Fac. Agro Industry & Natur. Resour., Univ. Malaysia, Kelantan, Malaysia).
7 odon. gen. are listed from 3 different land use areas, viz. agriculture (palm oil), logging and urban.

(18534) BARBOSA DE OLIVEIRA, J.M., Jr, N.S. PINTO, L. JUEN & L.B. CALVÃO, 2011. Morphological variations of characters in Erythrodiplax fusca (Odonata: Libellulidae). *Goiânia* 7(12): 8 pp. (Port., with Engl. s.). – (First Author: Ecol. & Conserv., Univ. Estado Mato Grosso, Campus de Nova Xavantina-MT, Brazil).
Specimens were collected from 4 different vegetation types in 9 Brazilian states, and the variation in body length and in wing length and width was statistically examined. A significant variation was found in these features, but more work is required in order to ascertain whether the differences are significantly related to the different vegetation types of the respective habitats.

(18535) BEISEL, J.-N., M.-C. PELTRE & P. USSEGLIO-POLATERA, 2011. *Einfluss der Salzbelastung auf die aquatische Biozenöse der Mosel*.

Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes, Univ. Metz. 62 pp. – (UFR Sciences Fundamentales et Appliquées, Univ. Metz, Campus Bridoux, 8 rue du Général Delestraint, F-57070 Metz).
This is a study on the impact of the salinity load on aquatic communities in the Mosel river. It contains a single passing reference to the odon.

(18536) [BORKENSTEIN, A.], 2011. Spontane Bilder geflügelter Edelsteine am Gartenteich. Ausstellung: Schrtenser Fotografin Angelika Borkenstein zeigt im Bürgerhaus Aufnahmen von Libellen. *Wilhemshavener Ztg*, issue of 16 Feb. 2011.
An article in a local newspaper on A. Borkenstein's exhibit of garden pond dragonfly photos in the Community House of Schortens, with Author's portrait.

(18537) CANNINGS, R.A. & S.G. CANNINGS, 2011. Odonata (damselflies and dragonflies) of the Montane Cordillera Ecozone. *In*: G.G. Scudder & J.M. Smith, [Eds], *Assessment of species diversity in the Montane Cordillera Ecozone*, pp. 1-31, Royal Brit. Columbia Mus., Victoria. – (First Author: Royal Brit. Columbia Mus., 675 Belleville St., Victoria, BC V8W 9V2, CA; – Second Author: Canadian Wildlife Serv. 91780 Alaska Hgwy, Whitehorse, YT, Y1A 5B7, CA).
The Montane Cordillera Ecozone supports about 40% of the Canadian fauna. A checklist and systematic overview of Zygoptera and Anisoptera, their 10 fam. and 81 spp. (19 of which are listed as potentially endangered, threatened, or vulnerable), and an analysis of their biogeographic elements are presented. 28 spp. of Boreal origin (35% ) are recorded. Of these, 13 (16%) are Widespread Boreal, 9 (11%) are Southern Boreal, 4 (5%) are Northern Boreal, and 2 (3%) are Western Boreal. Transition spp. total 18 spp. (22%) and there are 12 (15%) Cordilleran spp. 9 spp. (11%) are Western, 8 (9%) are Austral, and 6 (8%) are widespread spp. according to authors' definitions. Ecozone aquatic habitats and their typical spp. are divided into 12 categories: large lakes (wave-washed shores with little vegetation), small lakes and ponds (floating, but little emergent vegetation), alkaline ponds, ephemeral ponds, cattail/bulrush marshes (including margins of lakes and ponds), sedge marshes, small peatland ponds with aquatic moss, 3 types of fens, streams and springs. Stress on dragonfly populations is discussed under the headings of draining of wetlands, flooding of wetlands, fish introductions, lakeshore modifications, livestock disturbance, hot springs development, logging, and climate change. Recommendations for inventory and taxonomic research are noted.

(18538) CHASE, B., 2011. Searching for dragons finding myself. *New York St. Conservationist* 65(6): 6. – (c/o Editor: NYSDEC, 625 Broadway, Albany, NY 12233-4502, USA).
Personal experience of a dragonfly photographer.

(18539) DO, M.C. & H. KARUBE, 2011. Nihonogomphus schorri sp. nov. from Huu Lien Nature Reserve, Lang Son province, Vietnam (Odonata: Gomphidae). *Zootaxa* 2831: 63-68. – (First Author: 409-57A, 22/20 Nguyn Cong Hoan, Hanoi, Vietnam).
The new sp. is described and illustrated. Holotype ♂: Vietnam, Lang Son prov., Huu Lien Nature Reserve, Boc stream in Lan Chau community, alt. 250 m, 9-VI-2008; deposited in Vietnam Natn. Mus. Nature, Hanoi. It is close to N. bequaerti Chao, from which it can be easily separated by the vesica spermalis structure and body markings.

(18540) DRONZIKOVA, M.V., 2011. Data on the fauna of Odonata of the Tom' river basin. *Amur. zool. J.* 3(2): 107-123. (Russ., with Engl. s.). – (Kuzbass St. Pedag. Univ., Pionersky Ave 13, Novokuznetsk-654027, Russia).
Based on collections (mostly) from Kuznetskaya depression and Gornaya Shoria moutains, data on the distribution of 48 spp. in the Tom' river basin (W Siberia) are presented: 13 spp. are added to the fauna from literature. Also reported are the collections made at Lake Teletskoe, NE Altai. Coenagrion lanceolatum is for the first time recorded from the environs of Guryevsk (Kuznetskaya depression) and Lake Teletskoe, which considerably extends its known range in the West. Anax p. parthenope, probably a southern colonist, is reported from Kemerovo prov., its steady populations existing within the city of Novokuznetsk. New data on life history of some spp. at Novokuznetsk are also provided.

(18541) HUANG, J.-P. & C.-P. LIN, 2011. Lineage--specific Late Pleistocene expansion of an endemic subtropical gossamer-wing damselfly, Euphaea Formosa, in Taiwan. *Evol. Biol.* 11: 94, 13 pp. –

http//www.biomedcentral.com/1471-2148/11/94 – (Second Author: Dept Life Sci. & Cent. Trop. Ecol. and Biodiv., Tunghai Univ., Taichung-40704, Taiwan).

Pleistocene glacial oscillations have significantly affected the historical population dynamics of temperate taxa. However, the general effects of recent climatic changes on the evolutionary history and genetic structure of extant subtropical species remain poorly understood. In the present study, phylogeographic and historical demographic analyses based on mitochondrial and nuclear DNA sequences were used. The aim was to investigate whether Pleistocene climatic cycles, paleo-drainages or mountain vicariance of Taiwan shaped the evolutionary diversification of the subtropical E. Formosa. Its populations originated in the Middle Pleistocene (0.3 Mya) and consisted of 2 evolutionarily independent lineages. It is likely that they derived from the Pleistocene paleo-drainages of northern and southern Minjiang, or alternatively by divergence within Taiwan. The ancestral North-central lineage colonized NW Taiwan first and maintained a slowly growing population throughout much of the Early to Middle Pleistocene. The ancestral widespread lineage reached central-southern Taiwan and experienced a spatial and demographic expansion into eastern Taiwan. This expansion began approximately 30,000yr ago in the Holocene interglacial period. The ancestral southern expansion into eastern Taiwan indicates that the central mountain range formed a barrier to E-W expansion. However, E. Formosa populations in the 3 major biogeographic regions (East, South, and North-Central) exhibit no significant genetic partitions, suggesting that river drainages and mountains did not form strong geographical barriers against gene flow among extant populations. The present study implies that the antiquity of E. formosa's colonization is associated with its high dispersal ability and larval tolerance to the late Pleistocene dry grasslands. The effect of late Pleistocene climatic changes on the subtropical sp. historical demography is lineage-specific, depending predominantly on its colonization history and geography. It is proposed that the Riss and Würm glaciations had a greater impact on the evolutionary diversification of subtropical insular sp. than the last glacial maximum.

(18542) KHELIFA, R., A. YOUCEFI, A. KAHL-ERRAS, A. ALFARHAN, K.A.S. AL-BASHEID & B. SAMRAOUI, 2011. L'odonatfaune (Insecta: Odonata) du basin de la Seybouse en Algerie: intérêt pour la biodiversité du Maghreb. *Revue Ecol.* (Terre Vie) 66: 55-66. (With Engl. s.). – (First Author: Lab. Rech. Zones Humides, Dept Biol., Univ. Guelma, Algeria).

An odonatol. survey of the wadi Seybouse watershed, NE Algeria, was carried out over a period of 2 yr. 35 spp. were recorded in this previously uncharted region, incl. Calopteryx exul and Trithemis kirbyi. The former sp., a Maghrebian endemic, has been rediscovered in Algeria after more than a century of apparent absence and the sp., classified as "Endangered" in the IUCN Mediterranean Red List, is represented in Algeria by only the Seybouse population. An efficient conservation plan is needed to prevent its extinction. T. kirbyi, a desert sp., has considerably extended its range northward. Anthropogenic impacts were noted for the majority of sampled stations and this pressure does not bode well for the conservation of the biodiversity of wadi Seybouse. The distribution and status of each recorded sp. are discussed.

(18543) KÖSSINGER, J., 2011. *Libellenkartierung an der Westlichen Günz*. SeminarArb. Biol., Bernhard-Strigel-Gymnasium, Memmingen. 19 pp. + 16 maps. – (Author's address unknown).

The Günz valley is situated in SW Bavaria (Germany). The Westliche Günz is one of the 2 streams forming the Günz river. Here, 13 spp. are treated, among which a strong Nehalennia speciosa population is of particular interest.

(18544) KOSTERIN, O.E., N.W. SKALON & T.N. SKALON, 2011. Interesting findings of Odonata in the Kuznetskiy Alatau Mts north-eastern foothills. *Amur zool. J.* 3(2): 124-127. (Russ., with Engl. s.). – (First Author: Inst. Cytol. & Genet., Siber. Br. Russ. Acad. Sci., Lavrentyev Ave 10, Novosibirsk-630090, Russia).

8 spp., collected on 3-VII-2010 at Lake Ishkol' (Sharypovo distr., Krasnoyarsk prov., Russia), are brought on record, wherewith the known Siberian ranges of the western Coenagrion pulchellum and Leucorrhinia albifrons are extended in the NE, and the hitherto assumed central Siberian range disjunctions in C. glaciale and L. caudalis are filled.

(18545) KŘOUPALOVA, V., J. BOJKÓVÁ, J. SCHENKOVÁ, P. PAŘIL & M. HORSÁK, 2011.

Small-scale distribution of aquatic macroinvertebrates in two spring fens with different groundwater chemistry. *Int. Revue Hydrobiol.* 96(3): 235-256. – (Dept Bot. & Zool., Fac. Sci., Masaryk Univ., Kotlářská 2, CZ-61137 Brno).
The springs are located in the W Carpathian flysch zone (Czech Republic). A calcareous fen (Bilé Potoky Nature Reserve) and a sphagnum-fen (Obidová Nature Monument) were examined. Cordulegaster boltonii occurred in the former, and Pyrrhosoma nymphula and Aeshna cyanea in the latter.

(18546) LAMPO, C., E. RISERVATO & V. LENCIONI, 2011. Contributo alla conoscenza dell'odonatofauna della Val di Ledro (Trentino). *Stud. trent. Sci. nat.* 88: 53-59. (With Engl. s.). – (Sez. Zool. Invert. & Idrobiol., Mus. Tridentiono Sci. Nat., Via Calepina 14, I-38122 Trento).
The odon. fauna (21 spp.) of 2 lakes, Lago d'Apola (16 spp.) and Lago di Ledro (9 spp.), situated in Val di Ledro, southern Trentino (Italy), is outlined and briefly discussed.

(18547) MIŇOVÁ, S., M. BALLA & S. DAVID, 2011. First record of Hemianax ephippiger (Odonata: Aeshnidae) from Slovakia. *Folia faun. slovaca* 16(1): 25-26. – (Third Author: Inst. Landscape Ecol., Slovak Acad. Sci., Akademicka 2, SK-94901 Nitra).
2 pairs in tandem are reported from the fish pond system of Senianské Ribniky, Východoslovenská Plain, nr Iňačovce (E Slovakia), alt 102 m, 23-V-2007.

(18548) NASADIUK, I.M, 2011. Structure of larvae communities of some water insects from streams within the city of Uzhgorod. *Sci. Bull. Uzhgorod Univ.* (Biol.) 30: 113-117. (Ukrain., with Engl. s.). – (Uzhgorod Natn. Univ., Voloshina 32, UKR-88000 Uzhgorod).
Within the city of Uzhgorod (the Ukraine), 4 streams of different types were investigated. Species composition, population dynamics and biomass of Ephemeroptera, Odon., Pleoptera and Chironomidae were studied. Gomphus vulgatissimus is the only odon. sp. encountered.

(18549) NEPAL TOURISM BOARD [Compilers & Publishers], 2011. *Natural treasures of Nepal*. Nepal Tourism Bd, Kathmandu. 83 pp. ISBN none. – (Publishers: Tourist Service Centre, Bhrikutimandap, P.O. Box 11018, Kathmandu, Nepal).
A concise and systematic description of the Nepalese National Parks, Wildlife Reserves, Conservation Areas, some lakes, rivers and other wetlands, including paragraphs on their respective flora and vertebrate fauna. On p. 5 reference is made to the occurrence of Epiophlebia laidlawi in the Sagarmatha (= Mt Everest) and Shivapuri Nagarjun national parks.

(18550) ORTAZ, M., R. MARTIN & A. LÓPEZ-ORTAZ, 2011. Spatial and temporal variation in diet composition of invertivore fishes in a tropical stream, Venezuela. *Revta Biol. trop.* 59(3): 1217-1231. (Span., with Engl. s.). – (Inst. Biol. Exp., Univ. Central Venezuela, Aptdo Postal 48170, Caracas-1041A, Venezuela).
The diet of 9 fish spp. from the Orituco river was examined. The odon. were represented in Creagratus bolivari, Knodus deuteronoides and Poecilia reticulata.

(18551) PINTO, N.S., J.M. BARBOSA DE OLIVEIRO, Jr, L. JUEN & L.B. CALVÃO, 2011. Sympatric occurrence of two forms of Erythrodiplax fusca (Rambur, 1842) (Odonata: Libellulidae) in Goiás, Brazil. *Goiânia* 7(12): 4 pp. (Port., with Engl. s.). – (Ecol. & Conserv., Univ. Estado Mato Grosso, Campus de Nova Xavantina-MT, Brazil).
The blue and red E. fusca forms are reported from a pond Goiás, central-western Brazil.

(18552) ROBERTS, N.W., M.L. PORTER & T.W. CRONIN, 2011. The molecular basis of mechanisms underlying polarization vision. *Phil. Trans. R. Soc.* (B) 366: 627-637. – (First Author: Sch. BiolSci., Univ. Bristol, Woodland Rd, Bristol, BS8 1UG, UK).
In a graph showing the evolutionary distribution of polarization vision in animal visual systems, the odon. are represented by Hemicordulia tau.

(18553) RONDINELI, G., L.M. GOMIERO, A.L. CARMASSI & F.M.S. BRAGA, 2011. Diet of fishes in Passo Cinco stream, Corumbatai river subbasin, São Paulo state, Brazil. *Braz. J. Biol.* 71(1): 157-167. (With Port. s.). – (First Author: Depto Produção Vegetal, Cent. Ciênc. Agrar., Univ. Fed. Espirito Santo, Alto Universitário s/n, Guararema, C.P. 16, BR-29500-000 Alegro, ES).
The food preference of 28 fish spp. is described and

classified. The odon. were represented in the stomachs of 9 spp., viz.: Astyanax scabripinnis paranae, Astyanax sp., Bryconamericius stramineus, Cetopsorhamedia iheringi, Characidium cf. zebra, Eigenmannia virescens, Imparfinis borodini, and I. mirini. The Grade of Feeding Preference (GFP) values for odon. are stated for each of these fish spp.

(18554) ROSARIO, K., M. MARINOV, D. STAINTON, S. KRABERGER, E.J. WILTSHIRE, D.A. COLLINGS, M. WALTERS, D.P. MARTIN, M. BREITBART & A. VARSANI, 2011. Dragonfly cyclovirus, a novel single-stranded DNA virus discovered in dragonflies (Odonata: Anisoptera). *J. gen. Virol.* 92: 1302-1308. − (The Second Author is an odonatologist, correspondence is requested to the Last Author; their address: Sch. Biol. Sci., Univ. Canterbury, Ilam, Christchurch-8140, NZ).
Dragonfly cyclovirus (DfCyV), a new sp. of ssDNA virus discovered using viral metagenomics in Odon., collected (Apr.-May 2010) from the isls of Tongatapu and Vava'u (Kingdom of Tonga, ca 1600 km NE of New Zealand). Metagenomic sequences of DfCyV were similar to viruses of the recently proposed genus Cyclovirus within the Circoviridae. Specific PCRs resulted in the recovery of 21 DfCyV genomes from Pantala flavescens, Tholymis tillarga and Diplacodes bipuntata. The 1741 nt DfCyV genomes share >95% nucleotide identity and are classified into 11 subtypes representing a single strain. The DfCyV genomes share 48-63% genome-wide nucleotide identity with cycloviruses identified in human faecal samples. Recombination analysis revealed 3 recombinant DfCyV genomes, suggesting that recombination plays an important role in cyclovirus evolution. Apparently, this is the first report of a circular ssDNA virus identified in insects, and the data may help elucidate evolutionary links among novel Circoviridae recently identified in animals and environmental samples.

(18555) ROWE, R.J., C. DAVIES, D. DAVIES, S.R. POHE & E.H. SIMPSON, 2011. Tramea loewii (Odonata: Libellulidae), a dragonfly newly arrived in New Zealand. *N. Z. Jl Zool.* 38(2): 189-193. − (First Author: Sch. Marine & Trop. Biol., James Cook Univ., Townsville, AU).
2 ♀ were observed at Lake Rotokawau, Northland in 2005 and 2007. Larvae found at nearby Lake Waipura in 2007 indicate the sp. had bred in New Zealand. Given appropriate climatic conditions, T. loewii may be expected to expand its range within the northern reaches of the ountry. Queensland and New Caledonia are likely sources for the New Zealand population. Morphological characters are provided to enable identification of adults and larvae in the field.

(18556) RYCHŁA, A., J. BENNDORF & P. BUCZYŃSKI, 2011. Impact of pH and conductivity on species richness and community structure of dragonflies (Odonata) in small mining lakes. *Fundam. appl. Limnol.* 179(1): 41-50. − (First Author: Dept Limnol. Stratified Lakes, Leibnitz-Inst. Freshw. Ecol. & Inland Fisheries, Alte Fischerhütte 2, D-16775 Stechlin).
Although acidification in freshwaters reduces the richness of aquatic spp. in general, odon. are less affected. However, detailed knowledge regarding the effects of very acidic (pH < 4.0) and highly conductive (> 700 µS $cm^{-1}$) water on odon. species richness and composition is still scarce. To assess this, 19 anthropogenically influenced waters with a wide range of pH (2.64-2.81) and conductivity (113-2620 µS $cm^{-1}$) were investigated in the Muskau Arch area (W Poland / E Germany). Of the 41 spp. found, 31 were autochthonous. Both total ($S_t$) and autochthonous ($S_a$) species richness correlated positively with pH and negatively with conductivity. However, the correlations for autochthonous spp. were strongly influenced by the samples from the extremely acidic (pH 2.64-2.86) and most ion-rich (conductivity > 1200 µS $cm^{-1}$) waters, where no spp. developed. The $S_a$ values from acidic waters with slightly higher pH values (between 3.0 and 4.0) did not differ significantly from those found in neutral waters. Nevertheless, spp. preferring acidic or neutral conditions, respectively, were clearly separated, showing a direct or indirect effect of pH on the community structure in the area. It is concluded that only pH values below 3.0 and conductivity above 1200 µS $cm^{-1}$ have a detrimental effect on dragonflies. Other acidic waters are suitable habitats for specialists, which do not develop in neutral waters. Thus, moderate acidification enhances the Odon. species richness of a region like the Muskau Arch area.

(18557) SCHWEIGHOFER, W., 2011. *Libellen im Bezirk Melk*. Kuratorium Bezirksk. Melk, Melk. 207 pp. Hardcover (17.5 × 24.5 cm). ISBN none. − (Publishers: Abt Karl Str. 25/A, A-3390 Melk;

– Author: Artstetten 150, A-3661 Artstetten).
A review is presented of the odon. fauna (55 spp.) of the district of Melk (Niederösterreich, Austria). For each sp. are given 2 field photographs, district map of known records and a photograph of the habitat. The provided information is organised in paragraphs on recognition of adult in the field, general range, occurrence in the district, phenology and vertical distribution, biology, adult behaviour, larva, and on the local threat. There are chapters on the important dragonfly water bodies in the district, on odon. biology and on threats and protection. The concluding part of the book provides 6 chapters on observations of particular interest (Cordulegaster, Orthetrum, Gomphidae, occurrence of southern spp. in the district, Anax ephippiger local reproduction, Sympecma fusca hibernation). – The nicely reproduced book is directed apparently at the local naturalists, but it will be of interest to professional workers as well. Author's style and the well-balanced illustrations are certainly enhancing its attractiveness and value.

(18558) SKARMEAS, N., 2011. Dragonfly counting. *Wildl. J.*, New Hampshire 2011 (May/June): 8-12. – (Author's address not stated).
On the New Hampshire Odon. Survey; USA.

(18559) TAKHELMAYUM, K. & S. GUPTA, 2011. Distribution of aquatic insects in phumodis (floating island) of Loktak Lake, Manipur, northeastern India. *J. threatened Taxa* 3(6): 1856-1861. – (First Author: Dept Ecol. & Envir. Sci., Assam Univ., Silchar, Assam-788011, India).
3 odon. gen. are listed, of which "Leucorrhinia" does not occur in India.

(18560) VAN GOSSUM, H., J. BOTS, J. VAN HEUSDEN, M. HAMMERS, K. HUYGHE & N.I. MOREHOUSE, 2011. Reflectance spectra and mating patterns support intraspecific mimicry in the colour polymorphic damselfly Ischnura elegans. *Evol. Ecol.* 25: 139-154. – (First Author: Evol. Ecol. Gr., Univ. Antwerp, Groenenborgerlaan 171, B-2020 Antwerp).
Coexistence of ♀ colour morphs in animal populations is often considered the result of sexual conflict, where polymorphic ♀♀ benefit from reduced ♂ sexual harassment. Mate-searching ♂♂ easily detect suitable partners when only one type of ♀ is present, but become challenged when multiple ♀♀ morphs coexist, which may result in frequency-dependent mate preferences. Intriguingly, in Zygoptera, one ♀ morph often closely resembles the conspecific ♂ in body coloration, which has lead to hypotheses regarding intra-specific ♂-mimicry. However, few studies have quantitatively evaluated the correspondence between colour reflectance spectra from ♂♂ and ♂-like ♀♀, relying instead on qualitative visual assessments of coloration. Here, using colour analyses of reflectance spectra, characteristics of the body coloration of ontogenetic ♂ and ♀ colour morphs of I. elegans were compared. In addition, it was evaluated whether ♂♂ appear to (1) discriminate between immature and mature ♀ colour morphs, and (2) whether ♂-like ♀♀ experience reduced ♂ mating attention and low mating frequencies as predicted from ♂-mimicry. Spectral reflectance data show that immature ♀♀ morphs differ substantially in coloration from mature individuals. Mating frequencies were much lower for immature than mature ♀ morphs. For the ♂-like ♀ morph, measures of colour were statistically indistinguishable from that of both immature and mature conspecific ♂♂. Mating frequencies of ♂-like ♀♀ were lower than those of other mature ♀ morphs under field and experimental conditions. Together, the results indicate that ♂♂ may use the observed spectral differences in mate choice decisions. Furthermore, ♂-like ♀♀ may be regarded as functional mimics that have reduced attractiveness and lowered rates of sexual harassment by mate-searching.

(18561) VILENICA, M., V. MIČETIĆ STANKOVIĆ & M. FRANKOVIĆ, 2011. Dragonfly fauna (Insecta, Odonata) in the Turopolje region (Croatia). *Natura Croat.* 20(1): 141-158. (With Croat. s.). – (First Author: Petrinje Dept, Fac. Teacher Educ., Univ. Zagreb, Trg Matic hrvatske 12, HR-44250 Petrinja).
The Turopolje fauna (35 spp.) is reviewed (S of Zagreb, central Croatia), based on the surveys conducted during 1986-2009. The holo-mediterranean faunal elements are prevailing, indicating complex Pleistocene glaciation and interglaciation processes, when the Croatian territory served as a refugium.

(18562) VON ELLENRIEDER, N., 2011. Preliminary report: dragonflies and damselflies. *Rapid biol. Assmnt Kwamalasamatu Region, Suriname Aug.-Sept. 2010*, pp. 43-46, 77-78. – (Plant Pest Diagn.

Br., California Dept Food & Agric., 3294 Meadowview Rd, CA 95832, USA).
45 gen. with 93 morphospecies are listed. 10 not named spp. in Argia (4), Epipleoneura (1), Neoneura (2), Elasmothemis (1), Macrothemis (1) and Micrathyria (1) are new for Surinam.

(18563) [WEIHRAUCH, F.] FESTL, F., 2011. Schillernde Schönheiten. *Natur Kosmos* 2011(7): 48-55. − (c/o Dr F. Weihrauch, Jägerstr. 21/A, D-85283 Wolnzach).
A day of dragonfly field work with Dr F. Weihrauch (portrait incl.), the Editor of *Libellula*, with a biographic note and the highlights of biology of some of the encountered spp.

(18564) WESSELING, M., 2011. Het gaat goed met de libellen. − [It is going well with the dragonflies]. *Trouw* 2011 (6 May): 10-11. (Dutch). − (c/o T. Termaat, De Vlinderstichting, P.O. Box 506, NL-6700 Wageningen).
An overview article in a Netherlands national daily. − Since the 1980s, much is being done on the improvement of water quality and on the restoration of running waters in the Netherlands, in consequence of which the general status of odon. fauna is significantly improving. Due to their mobility, some odon. spp. are also less affected by habitat fragmentation than, e.g. the Lepidoptera and many other organisms. It is likely, therefore, that quite some spp. are to be deleted from the Red List now in preparation. On the other hand, the status of 12 spp. continues deteriorating, incl. that of Coenagrion hastulatum, Aeshna viridis, Sympetrum flaveolum and Leucorrhinia albifrons.

(18565) WHITE, E., V. ZAREMBA & S. DIEHL, 2011. Flying jewels of New York. *New York St. Conservationist* 65(6): 2-7. − (c/o Editor: NYSDEC, 625 Broadway, Albany NY 12233-4502, USA).
General, on New York dragonflies, with photograhs. − See also *OA* 18289.

(18566) WILLIGALLA, C. & D. FARTMANN, 2011. Einfluss der Bebauung auf die Libellendiversität (Odonata) in Städten. *Treffpunkt biol. Vielfalt* 10: 145-149. − (First Author: Brock 45, D-48346 Ostbevern).
At 12 rainwater ponds in the city of Mainz (Germany), 32 odon. spp. were recorded (2006, 2008). The number of spp. occurring at a pond depended on the size of the pond and on the degree of the built-up of the area. Above 40% of urbanization within 200 m of a pond, the Zygoptera abundance was greatly reduced, while that of Anisoptera was not affected. This is explained by the circumstance that in an urbanized landscape the sources of food are insufficient and the insects require long feeding flights.

(18567) XU, Y. & W. BU, 2011. Chinese damselflies of the genus Coenagrion (Zygoptera: Coenagrionidae). *Zootaxa* 2808: 31-40. − (Coll. Envir. Sci. & Engineering, Nankai Univ., Tianjin-300071, China).
An updated review of spp. and information on their distribution in China are presented. A key to the ♂♂, including figs of the genital ligula and caudal appendages are provided. A distributional record of Coenagrion armatum is excluded from China. Coenagrion bifurcatum Zhu & Ou-yan, 2000 is assigned as a junior synonym of Coenagrion johanssoni (Wallengren, 1894). Coenagrion chusanicum Navás, 1933 is assigned as a junior synonym of Paracercion hieroglyphicum (Brauer, 1865). Coenagrion dorothea Fraser, 1924 is newly combined as Paracercion dorothea (Fraser, 1924) comb. nov. Coenagrion impar Needham, 1930 and Cercion yunnanensis Zhu & Han, 2000 are both treated as junior synonyms of Paracercion dorothea. Coenagrion holdereri (Förster, 1900) is redescribed based on fresh specimens.

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ASANA, J.J. & S. MAKINO, 1935. A comparative study of the chromosomes in the Indian dragonflies. *J. Fac. Sci. Hokkaido Univ*. (VI) 4: 67-86.

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

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

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