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Contents

Preliminary biodiversity assessment of the odonate fauna of the Takamanda Forest Reserve, Cameroon

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INTRODUCTION

Dragonflies (Odonata) are attractive insects which are ideal for biodiversity studies. They are sensitive to pollution and habitat disturbance. Their present-day distributions are the result of past geological events and climatic fluctuations. There are approximately 6500 species worldwide, classified in about 600 genera, but the African dragonfly fauna, with about 900 species and 125 genera, is generally considered to be impoverished compared with that of South-East Asia or Central and South America. This is probably caused by the long periods of aridity which occurred during the Pleistocene. Only drought-adapted species could survive in large areas of the continent. The upland mountain chain which runs into the Gulf of Guinea, receives very high rainfall; up to 1000 cm (400") in the vicinity of Mount Cameroon, and over 300 cm at Mamfe (Vick 1999) and the dry season is short (usually at least 50 mm of rain even in the driest month). The natural vegetation is evergreen 'Biafran' rainforest. During the Pleistocene when the rainforest in Africa was drastically reduced; a few areas persisted as lowland rainforest refuges. These are generally near the coast and in areas which have the heaviest rainfall now. Botanical evidence suggests that the Cameroon/Nigeria border area is one of these refugia, possibly the richest in Africa, and it was decided to investigate the dragonfly fauna to see whether this also held true for Odonata.

The Cameroon Dragonfly Project (CDP) was established in 1995 by Graham Vick and David Chelmick of England and Otto Mesumbe of Cameroon. Professor Philip Corbet is the president. It is the first long-term dragonfly project in tropical Africa. The initial concentration of effort has been in the South -West Province as this region appears to be the most important biodiversity hotspot. The objectives are to describe the fauna taxonomically and produce a species list; to produce an identification key to adults (mostly done by Graham Vick); to describe the larvae and write larval keys (mainly the work of David Chelmick); finally to identify areas of greatest conservation importance. Perhaps the most important of all is to gain the interest and cooperation of local people.

One of the most significant problems that are encountered when attempting to sample Odonata in tropical forests is that the adults on which the specific identity depends are extremely elusive, can be difficult to catch, and frequently

have behaviour patterns which mean that they only visit water rarely. Feeding and mating often take place in the tree canopy, and females only descend for oviposition. Larvae are surprisingly easy to find in the small streams and rainforest pools which the rarest species occupy. The breeding of larvae to adulthood therefore provides us with an unequivocal determination and is often the only way to build up data for larval keys. We have already produced keys to African *Anax* spp. (Chelmick 1999) and to African *Aeshna* spp. (Chelmick 2001), and descriptions of larvae of three of the most interesting damselflies (*Nubiolestes diotima*, *Stenocnemis pachystigma* and *Pentaphlebia stahli*) (Vick 1998). A provisional version of the larval key is presently being tested in the field (Chelmick, in prep) . Once keys are available it will be relatively easy for non-experts and para-taxonomists to improve odonate site databases. Breeding also provides records of species which are never seen as adults. Another method which has been very successful is the use of emergence traps which are placed over trickles and seepages in the forest; adults are discovered with the larval shucks and this provides another method of associating the two stages. The larval work has been one of the most productive aspects of the Project and it is an excellent way of involving local people who enjoy the practical side of the work and the wonder of seeing such a beautiful creature emerge from a drab aquatic 'grub' ! The CDP has also forged links with the Smithsonian, the World Wildlife Fund, Birdlife International, and Center for Reproduction of Endangered Species (San Diego).

The South-West province is a diversity 'hotspot'

The greatest priority for the conservation of Odonata in Western Africa lies in Cameroon and the adjacent parts of Nigeria, Equatorial Guinea and Gabon (Dijkstra & Vick, in press). Both the highland and lowland rainforests have an odonate diversity that is unrivalled elsewhere in Africa. This diversity seems to be especially high in the South-West Province of Cameroon, a mountainous region adjacent to the Nigerian border. The African dragonfly fauna may be less rich than that of tropical Asia and the neotropics but our recent work has discovered very high species densities in South-West Cameroon which are almost as high (Vick 1999). The total number of species which have been recorded in the province alone stands at 182; the number of forest-adapted species which have restricted ranges are particularly high, and many of the widespread species of the African savannah are absent (Vick 1999).

As more sampling takes place in the region to the west which extends from Guinea to Ghana, it appears that the odonate species richness there approaches that of South-West Cameroon; for example the richest appears to be Ivory Coast with 175 recorded species. However, these species totals are to some extent made up of a greater number of taxa which are characteristic of the African savannah (O'Neill & Paulson 2001); many of these taxa are widespread and occur over a huge area which extends from Senegal to the southern Africa.

The province also stands out from other species-rich parts of West Africa in terms of the number of phylogenetically interesting taxa present, such as those with affinities to the fauna of South America or Madagascar. It is also a centre of diversity, possibly the most important in Africa, for many forest-stream specialists such as the Calopterygidae (Vick, in prep.).
The Cameroon Dragonfly Project surveys between 1995 and 2001 have mainly focused on the areas around Mount Cameroon, Mount Kupe, the lowlands in the vicinity of Kumba, the Bakossi Highlands, and Takamanda. All of our recording has been in the South-West Province, except for a limited amount in Littoral Province on the east of Kupe. We are grateful to Jacqui Groves, Christopher Wild and Otto Mesumbe, and helpers for samples from Takamanda.

Subsets of the fauna

In South-West Cameroon there is a marked faunal break at around 700m. In the lowlands there is a rich representation of the Guineo-Congolian fauna, but a limited degree of endemism. On the other hand, there is a distinct submontane fauna above 700m which breeds in the rapid rocky-bedded streams of the forested uplands, together with associated marshes, seepages and waterfalls. Most of the phylogenetically interesting taxa which have broader geographic affinities occur above 700m in undisturbed forest. In fact, there is a characteristic suite of these species which are susceptible to disturbance and opening of the canopy; these have the potential to be used as indicators of forest quality.
Apart from the altitudinal break mentioned, there is some evidence to suggest that there may be two slightly different faunas which may be associated with distinct Pleistocene refugia (or at least parts of one refugium which have perhaps been separated in the past into two rainforest 'islands'). North of the Cross River, in Takamanda, there are interesting faunal elements which appear to be lacking to the south. The converse appears to also be true but further work is needed to establish this.

Takamanda

This area which appears to be of major importance for odonate diversity lies to the north of Mamfe and the Cross River: the contiguous region of the Takamanda - Mawne Forest Reserves (Cameroon) and the Okwangwo Division of the Cross River National Park (Nigeria). This huge area of about 1700 km^2 forms a mosaic of lowland and highland moist forest with savannah woodland. Surveying is at an earlier stage in this region and has only been carried out on the Cameroon side but initial results indicate a rich fauna, which is distinct from that further south in the Province. To date, 67 species have been recorded, compared with 182 from the province as a whole (Vick 1999).

Important relict elements in the fauna

In the province there are relict genera with tropical American affinities. *Pentaphlebia* (only three species extant in the subfamily - two species in the Cameroon and Nigeria border region and one species in the Guyana Highlands). The larvae are adapted to cling to the undersides of boulders in cold torrential streams. The species *P. stahli* occurs both north (including Takamanda) and south of the Cross River, and it is essentially the indicator species of submontane streams flowing through undisturbed forest. There is another species, *P. gamblesi*, which is only known from Obudu, Nigeria (only one specimen has ever been found) and this could be expected in higher altitude forests in Takamanda. Its larva awaits discovery and its relationships will be fascinating to discern.

Nubiolestes diotima is the only African species of a small family, the Perilestidae, which is otherwise neotropical. The discovery of its larva at Kupe and the observation of synapomorphisms has added strength to its placement in the family (Vick 1998). It has been found at Takamanda. It occurs in backwaters of submontane streams which flow through dense forest.

Genera with affinities with the Madagascar fauna are in the Megapodagrionidae: *Nesolestes* and *Neurolestes. Neurolestes* is represented by one species, *trinervis*, which appears to be relatively common in Takamanda (and less so to the south); *Nesolestes* is known from across the border in Obudu, Nigeria, and at Mount Oku in North-West Province, and could be expected in Takamanda, perhaps occurring with *Pentaphlebia gamblesi* at higher elevations than *Pentaphlebia stahli* and *Neurolestes trinervis.*

Other biogeographical puzzles occur in the area such as *Stenocnemis* a platycnemidid not closely related to any other taxon (Vick 1998) and *Tragogomphus* (three species endemic to Cameroon and Nigeria).

African demoiselles - the Calopterygidae

The South-West Province is a hotspot for calopterygid diversity. Three genera are present, and in the Province alone there are 12 species (including two 'forms' which appear to be specifically distinct) present in the genera *Umma*, *Phaon*, and *Sapho*. In contrast, sampling to date in Ghana has revealed four species, while Uganda and Kenya share two; even Congo (DRC) only has five (Clausnitzer 2001, O'Neill & Paulson 2001). Most taxa are rainforest-stream specialists. There appears to be a difference between the fauna of Takamanda, north of the Cross River, and that of the area to the south. Widespread taxa (i.e. occurring north and south of the Cross River) are *Umma mesostigma* (see below) and *Sapho orichalcea* (mostly in submontane rainforest). *Phaon iridipennis* is a common African taxon which occurs in disturbed habitat in the region. A much more localised taxon, *Phaon camerunense* occurs from Guinea

to Cameroon and it appears to be confined to lowland rainforest . Both species of *Phaon* have been found in Takamanda and the areas to the south.
In the genus *Sapho,* we have two taxa present to the south (possibly a third pending verifiaction), but to date in the Takamanda region we have only found the predominantly submontane, or cool-stream lowland species, *Sapho orichalcea*.
In the genus *Umma* we have recorded eight taxa for the SW Province. *Umma mesostigma* is the most widespread species,occurring in Takamanda, and south of the Cross River, in both submontane and lowland habitats, usually in forests, but not necessarily undisturbed. Another species *Umma longistigma* occurs in two forms which may be separate species: one form occurs to the south of the Cross River from the Bakossi mountains southwards, while another form with narrower inferior appendages occurs in Takamanda, Korup, and in adjacent parts of Nigeria. An endemic species *Umma mesumbei* occurs in submontane streams at Kupe and the Bakossi Mountians (Vick 1996). We have not found it at Takamanda.
However, current surveys have rediscovered *Umma purpurea*, described from Mamfe in 1961. The species appears to be absent to the south, but curiously it is locally common on Bioko (Brooks & Jackson 2001). *Umma puella* is another taxon which has only rarely been encountered since its discovery in 1917. The species was found near Mount Cameroon in 1979 and at several sites in Takamanda by Jackie Groves and Christopher Wild in the current study. This is an interesting species from a phylogenetic point of view as it does not fit neatly into either genus according to present definitions.
There is only one other calopterygid taxon, *Umma saphirina* known from the Rumpi Hills and adjacent areas of Nigeria.
With seven genera present, the south-west province also seems to be one of the centres of diversity for the Tetrathemistinae, a pleisiomorphic subfamily of the worldwide Libellulidae. They are not colourful like most libellulids, their colours being yellow-green and black, and the species are almost entirely confined to streams and ephemeral pools in dense rainforest. This subfamily is of great evolutionary interest as they show a striking diversity of behaviour (Clausnitzer & Lempert 1998). In the majority of libellulid species, the females oviposit in flight by dipping the tip of the abdomen into the water so that they are 'washed' off and sink to the bottom. In the tetrathemistines there is a range of oviposition strategies: species of *Tetrathemis* which breed exclusively in rainforest pools settle and oviposit epiphytically on leaves several metres above the water; *Notiothemis*, *Eothemis*, *Malgassophlebia* and *Micromacromia* which breed in rainforest streams and pools oviposit in flight on banks well above water level; species of *Allorhizucha* oviposit in flight directly into water as in the more 'modern' libellulids. The recent discovery of an apparently endemic tetrathemistine genus and species, *Mesumbethemis takamandensis*, in the

Takamanda Forest north of Mamfe illustrates the potential of this region (Vick 2000) .
Although surveying is in its preliminary stages in Takamanda, the discoveries so far indicate that the area is likely to be one of the highest importance for odonate diversity in Africa. Although clearly part of the main 'hotspot' in South-West Cameroon there is some evidence to suggest that its species composition may be different from that in the southern part of the province. As very little sampling has yet taken place above the critical 700m altitude at which most endemics would be expected, I would anticipate some exciting discoveries to be made in the future.

RESULTS

Species list from Takamanda (1997-2001)

This total species list is based upon sampling by Christopher Wild (World Wildlife Fund and later Center for Reproduction of Endangered Species, San Diego, CA, USA), Otto Mesumbe (Cameroon Dragonfly Project) and Jacqui Groves (Smithsonian Institution). I have added very brief notes on habitat requirement which may assist the reader to interpet these data. All of the information is held on a much larger database which covers all records for the South-West Province. These date back to 1880, when specimens were collected by the first German colonists, and continue to the present day. However, no surveying took place in Takamanda before 1997 and the area is virgin territory for dragonfly research.

The sites which have been surveyed in the period since 1997 are as follows:

01 Akwa Village, Mone Forest 9°29'E, 6°03'N, 98m
02 Ashunda Hill, Upper Mbulu Forest 9°35'E, 6°10'N
03 Bache (south of Takamanda Reserve) 9°18'E, 5°57'N, 200m
04 Bancho Village, Mbulu 9°35'E, 6°06'N
05 Bandolo, Mbulu,Ote 9°32'E, 6°09'N
06 Forest Stream Okpambe 9°22'E, 5°59'N
07 Kekpane Village 9°24'E, 6°06'N, 155m
08 Kekpane Camp 11 9°25'E, 6°09'N
09 Kekpane Makone stream 350m
10 Matene, (Akwoveli, Etanya, Kakwa & Yasonge streams) 400m
11 Matene Camp, Takamanda 9°21'E, 6°11'N, 170m
12 Mbu Forest, Mone Forest 9°32'E, 5°59'N
13 Mbu Village, Mone Forest 9°27'E, 6°01'N
14 Memume stream

15 Mfakwe (Mfakwe Village, Takamanda) 9°26'E, 6°04'N, 200m
16 Munaya river & Menume stream 9°18'E,5°58'N
17 Obony 1 Camp, Takamanda 9°16'E, 6°08'N, 100m
18 Obony III 9°18'E, 6°08'N, 115m
19 Okpambe/Assam 9°19'E, 6°01'N, 140m
20 Olulu Village, Mbulu 9°35'E, 6°10'N
21 Takamanda Camp 9°14'E, 6°03'N, 568m
22 Takamanda Oyi east 2000m
23 Takamanda Village 9°17'E, 6°02'N, 570m
24 Takpe Village, Takamanda 9°20'E, 6°01'N, 500m

Calopterygidae

Phaon camerunensis- very local, shady rainforest streams, mainly lowland; Sites 01,11,13,24

Phaon iridipennis - widespread open- stream species; Sites 11,13,18,24

Sapho orichalcea - rainforest streams, mainly submontane, Sites 01,02,07, 08,10,11,12,14,17,19,21

Umma longistigma (narrow inferior appendages) - rainforest streams, mainly lowland; Sites 06,07,08,10,11,13,18,19,21,23,24

Umma mesostigma - rainforest streams, range of altitudes, fairly tolerant of farmbush; Sites 05,10,17,19,21

Umma puella - occurs north of Cross River and near Mount Cameroon, rainforest streams; Sites 07,11,15,17,18,19,21

Umma purpurea - possibly two disjunct populations: north of Cross River and Bioko, rainforest streams, Sites 01,05,18,21,24

Amphipterygidae

Pentaphlebia stahli - rocky submontane streams, larvae cling to underside of rocks. Related to *Rimanella arcana* in Venezuela**;** Sites 17

Chlorocyphidae

Very colourful stream-dwellers with striking courtship behaviour which usually requires some breaks in tree canopy to provide sunny spots for displaying.

Chlorocypha cancellata - Sites 01,12,14, 21

Chlorocypha curta - Sites 14,23

Chlorocypha glauca - Sites 07,18,23

Chlorocypha rubida - Sites 11,17,23

Chlorocypha selysi - Site 09

Platycypha rufitibia - Site 23

Perilestidae

Nubiolestes diotima-very local endemic of Cameroon/Nigerian border, backwaters of streams in submontane rainforest. All other perilestids are neotropical; Site 10

Megapodagrionidae

Neurolestes trinervis- local endemic - submontane rainforests. Close to Madagascar species in genus *Nesolestes*; Sites 08,19,24

Coenagrionidae

stream-dwellers that are usually tolerant of canopy loss
Pseudagrion epiphonematicum - Sites 01,02,06,16,21
Pseudagrion flavipes - Sites 11,18
Pseudagrion melanicterum - Sites 01,05,09,15,18,24
Pseudagrion serrulatum - Site 13
Pseudagrion sjoestedti - Site 01,14,16,17
*Pseudagrion hamoni** - Site 09,23

Protoneuridae

stream dwellers, usually in rainforest
Chlorocnemis contraria - Sites 12,16,17,19,21
Chlorocnemis nigripes - Sites 10,11,16,17,18
Ellatoneura balli - Site 11
Elattoneura nigra - Site 11
Ellatoneura pruinosa - Sites 02,05,08,09,10,11,12,13,16,17,18,22
Prodasineura vittata - Sites 18,21

Platycnemididae

Mesocnemis singularis- streams and larger rivers, usually habitat tolerant; Sites 01,16,17,19
Platycnemis rufipes stream dweller, usually in rainforest; Site 24

Gomphidae

almost all are stream dwellers in rainforest
Diastatomma tricolor - Sites 17,18
Gomphidia gamblesi - Assam - reared specimen from larva; Site 19
Lestinogomphus angustus - Site 23
Paragomphus genei stream-dweller, usually habitat tolerant; Site 03
Paragomphus sp.3 - Site 12
Paragomphus sp.4 - Site 06
Tragogomphus aurivillii possibly first record since description in 1900; Site 17

Corduliidae

stream dwellers, usually in rainforest
Phyllomacromia bicrustulata - Site 18,24
Phyllomacromia caneri - Site 17,18
Phyllomacromia funicularia - Site 18

Libellulidae
very diverse habitat requirements
Allorhizucha klingi - stream dweller, tolerates partial loss of canopy ; Sites 02,05,08,11,12,13,15,18,21
Atoconeura biordinata - rapid streams associated with forested habitats; Site 21
Crocothemis erythraea -widespread, avoids rainforest; Site 16
Cyanothemis simpsoni - sluggish silty streams in rainforest; Site 06
Eothemis zygoptera - Site 07
Hadrothemis camarense - rainforest; Sites 12,17
Hadrothemis versuta - rainforest; Site 11
Hemistigma albipuncta - widespread and tolerant; Sites 02,07,18,19,23
Mesumbethemis takamandensis - described as new species and genus in 2000, known from Assam in Takamanda only, presumably breeding in rainforest streams or pools; Site 19
Micromacromia camerunensis - rainforest streams; Site 07
Notiothemis robertsi - shady rainforest pools; Site 24
Orthetrum camerunense - grassland pools and marshes; Site 05
Orthetrum chrysostigma - widespread; Sites 18,19
Orthetrum julia - widespread in secondary and disturbed rainforest; Sites 01,18,20,21,23
Orthetrum microstigma - farmbush and disturbed forest; Site 07
Orthetrum stemmale - farmbush and disturbed forest; Sites 02,11,17,
Palpopleura lucia - widespread; Sites 07,10,15,18
Pantala flavescens - widespread; Site 05
Porpacithemis sp.* - Site 11
Porpax bipunctus - possibly forest streams; Sites 07,11,21
Tetrathemis bifida - shady rainforest pools, tolerates secondary forest; Site 06
Trithemis aconita - streams often in farmbush and disturbed forest; Site 19
Trithemis arteriosa - widespread, avoiding rainforest; Sites 05,07,09,16,18,23
Trithemis dichroa - streams often in farmbush and disturbed forest; Sites 04,18
Trithemis pruinata - streams often in rainforest; Sites 05,23
Zygonyx flavicosta - rapid streams associated with forested habitats; Sites 12,13,17,18,21
Zygonyx speciosa - rapid streams associated with forested habitats; Sites 11,21

* = provisional determination - identity at present unconfirmed

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REFERENCES

Brooks, S.J. & Jackson, K.A. (2001): The Odonata of Bioko, Republic of Equatorial Guinea, with the description of fan-shaped setae on early instar Libellulid larvae.- Odonatologica 30: 29-38.

Chelmick, D.G. (1999): Larvae of the genus *Anax* in Africa (Anisoptera: Aeshnidae).- Odonatologica 28: 209-218.

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

Chelmick, D.G. (in prep): A key to the dragonfly larvae of Cameroon.

Clausnitzer, V. (2001): Notes on the species diversity of East African Odonata, with a checklist of species. - Odonatologica 30: 49-66.

Clausnitzer, V. & Lempert, J. (1998): Preliminary comparative approach of the reproductive behaviour of African Tetratheminae (sic) (Anisoptera: Libellulidae) J. Afr. Zool. 112: 103-107

Dijkstra, K.-D.B. & Vick, G.S. (2002): Afrotropical Region: Western Africa. IUCN Odonata Specialists Group: Regional Report. - Int. J. Odonatol. (in press)

O'Neill, G. & Paulson, D. (2001): An annotated list of Odonata collected in Ghana in 1997, a checklist of Ghana Odonata, and comments on West African odonate biodiversity and biogeography. - Odonatologica 30: 67-86.

Vick, G.S. (1996): *Umma mesumbei* spec. nov., with records of some other dragonfly species from the South West Province of Cameroon (Zygoptera: Calopterygidae). - Odonatologica 25: 167-178.

Vick, G.S. (1998): Notes on some damselfly larvae from Cameroon (Zygoptera: Perilestidae, Amphipterygidae, Playcnemididae). - Odonatologica 27: 87-98.

Vick, G.S. (1999): A checklist of the dragonflies of the South West Province of Cameroon with a description of a new species of the genus *Phyllogomphus* Selys, 1854. - Odonatologica 28: 219-256.

Vick, G.S. (2000): *Mesumbethemis takamandensis* gen. nov., spec.nov., a new genus and species of the Tetrathemistinae from Cameroon, with a key to the African genera of the subfamily (Anisoptera: Libellulidae). - Odonatologica 29: 225-237.

Vick, G.S. in prep. A study of the dragonflies of the South-West Province of Cameroon with a key to the regional species.

Dragonflies of East Africa

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INTRODUCTION

In 1998 and 2000 the IDF agreed to support my work on East African dragonflies, which includes i) the preparation of an identification key, ii) inventories of different areas, iii) collection of ecological data, iv) providing information for and capacity building within the countries.
This report gives an overview of what has been done and what research will be done on East African dragonflies. It is worth noting, that the activities currently include Kenya, Uganda and Tanzania and I am trying to get Ethiopia included soon. Field work in Burundi and Rwanda is not included for obvious reasons. Here scientific results are only mentioned briefly. Details will be presented in publications, which were prepared, are in preparation or will be prepared. The introduction gives a general focus on the necessity of research on African Odonates and the current endeavours.

Dragonflies belong to the most manageable tropical insect orders in terms of taxonomy and ecology, but not much attention has been paid to them in many parts of Africa over the last decades. Lucky enough this seems to change slightly, with several projects having started in different parts of Africa over the last years and with the network PHAON (Pinhey's Heritage African Odonata Network) that started in December 2000. Yet, there is an enormous gap to be filled in Africa. Whilst ecology, ethology and distribution of dragonflies of the northern hemisphere are extensively studied (Corbet 1999) the knowledge on afrotropical dragonfly species is still very scattered (e.g. Moore 1997). Nevertheless the intensive studies of Pinhey (for an overview see Agrion 2000 Vol. 4, No.2 and Odonatologica 2001 Vol. 30, No. 1) provide a good basis for research on (not only) East African dragonflies. Studies on African dragonflies not only add important features to the scientific knowledge but will also provide results for applied conservation biology. Because they are easy to collect, utilise different habitats during their lifetime and are well studied taxonomically, ecologically and ethologically when compared to other tropical invertebrates, dragonflies belong to the priority taxa for biodiversity research and as indicator species **Fehler! Textmarke nicht definiert.**. Specially in the tropics accelerating global environmental changes call for fast and sustainable indicator programmes, which provide rapid assessment opportunities and early warning systems based

on α- and β-diversity **Fehler! Textmarke nicht definiert.**. Survey and protection of East African rain forests and wetlands and the development of sustainable utilisation programmes have high priority already (e.g. **Fehler! Textmarke nicht definiert.**. Growing problems with natural resources like watersheds and forests in most of the African countries will need much more research in such systems.

What has been done:

IDENTIFICATION KEY FOR EAST AFRICAN DRAGONFLIES

The work on the key was started in 1998 with the compilation of available literature. A first text version was finished by the end of 1999 and given to several people who work on African dragonflies. This preliminary version has undergone a number of changes since its first copies were printed and more changes are still in process. These change are based on notes from other odonatologists, my own field work and on several visits to the Natural History Museum in London. Nevertheless the key is already used extensively in the field in East Africa, not only by myself, but by projects in Uganda and Tanzania and by private persons in Kenya.

INVENTORIES

From the beginning of 2000 I have spent considerable time in Kenya, mainly working in the East African Coastal Forests and in montane habitats. I selected these habitats because these forests are under severe threat, contain endemic species and in - the case of the coastal forests - a high species diversity.
The coastal forests of Kenya and Tanzania together with the Eastern Arc forests are regarded as worldwide biodiversity hotspots. Today these forests cover an area of 2,000 km² which is only 6.7 % of their original extent **Fehler! Textmarke nicht definiert.**. **Fehler! Textmarke nicht definiert.** regards the coastal forests as one of the four major Centres of Endemism in Africa. Once the East African Coastal Forests covered most of the East African coast from north Mozambique to south Somalia. Now this belt is reduced to over 250 small to very small separated forest patches, often of less than 500 ha in size **Fehler! Textmarke nicht definiert.**. These remaining forest patches have all in common that they are small and highly fragmented, have an exceptionally high degree of localised endemism, differ in structure and species composition and that they are extremely vulnerable and rapidly being degraded. Kenya's remaining coastal forests are listed as „critical sites" by the IUCN and are not adequately represented in Kenya's protected area system **Fehler! Textmarke nicht definiert.**.

In contrast to the species rich coastal habitats, the montane habitats of East Africa are surprisingly poor in species, especially in the upper areas (ericaceous and afroalpine belts). Also the montane forests (above 2000 m a.s.l.) do not burst with species but contain endemics which have evolved separately due to the isolation of most of the African volcanic massive. At least one species new to science (a gomphid) was found in this habitat.

During several field trips from April 2000 to May 2001 the following new records for Kenya were made.

Coenagrionidae
Agriocnemis gratiosa Gerstäcker, 1891 – Lake Jipe
Teinobasis sp. - Buda Forest; might be one of the known species *T. alluaudi* or *T. malawiensis*, the locality is far away from any other records of *Teinobasis*.

Gomphidae
Gomphidia quarrei confinii Pinhey, 1974 - Shimba Hills, Mzima Springs; but the Kenyan species is more melanic
Microgomphus nyassicus (Grünberg, 1902)
Microgomphus schoutedeni Fraser, 1949 - Kakamega Forest
Onychogomphus styx Pinhey, 1961 - Kakamega Forest
Paragomphus sabicus Pinhey, 1950 - Shimba Hills
Phyllogomphus ??? latifasciae - Shimba Hills, I got only females up to know.

Corduliidae
Phyllomacromia subtropicalis (Fraser, 1954) - Lake Victoria

Libellulidae
Thermochoria jeanneli Martin, 1915 - Buda Forest
Trithemis bifida Pinhey, 1970 - Shimba Hills
Paragomphus magnus Fraser, 1952 – previously only known by the holotype female collected by Pinhey in 1950 **Fehler! Textmarke nicht definiert.**. It was found in large numbers during the rainy season in the Shimba Hills.

Papers on the diversity and importance of the remaining patches of Coastal Rain Forests and on the montane dragonfly fauna are under preparation. Local checklists are prepared and will be handed to the corresponding institutions (e.g. Kenya Wildlife Service, Forest Department, National Museums of Kenya).

ECOLOGICAL DATA

Another reason to work in the East African Coastal Forest was the occurrence

of Africa's largest damselfly *Coryphagrion grandis* Morton, 1924. After unexpected difficulties to trace this species I finally I found it. Despite its size, it is very difficult to find it in the dense understories of coastal forests. Yet, it is not easy to collect data on its ecology and distribution. The latter is best done by searching for larvae in phytotelmata (tree holes), the only reproduction site of *Coryphagrion grandis*. With this method a lot of new distribution records in different coastal forest patches in Kenya were made. All the coastal forests, which are neither too disturbed or too dry, still support populations of *Coryphagrion grandis.* Due to the forest fragmentation all these populations are isolated nowadays.

Unfortunately, *Coryphagrion grandis* proved to be not territorial at all making observations on adult behaviour very difficult. I was hoping to find a similar pattern as observed for *Megaloprepus coerulatus* **Fehler! Textmarke nicht definiert.**, but instead found *Coryphagrion grandis* investing little in offspring survivorship, similar to *Mecistogaster linearis* and *M. ornata* from Central America **Fehler! Textmarke nicht definiert.**).

Adults of *Coryphagrion grandis* feed exclusively on small spiders and insects picked out of spider nets. This feeding behaviour is very similar to that described for four other species of the Pseudostigmatidae (*Mecistogaster linearis*, *M. ornata*, *Megaloprepus coerulatus* und *Pseudostigma accedens*) from Panama **Fehler! Textmarke nicht definiert.**. The long abdomen might be helping in holding the balance while hovering in front of the spider webs and picking out the food. It is not used for oviposition as previously anticipated. The female making a big loop with its long abdomen places the eggs close to her legs. Eggs are placed above the water level in the bark of the tree hole rim.

Currently papers on the larvae and the systematic position of *Coryphagrion grandis* are prepared together with Martin Lindeboom (Clausnitzer & Lindeboom 2002; in prep). Alcohol samples from isolated populations were collected and will be analysed by Heike Hadrys in her laboratory in Hannover.

Other observations on behavioural ecology included mating and oviposition behaviour of the following coastal species: *Gynacantha usambarica* Sjöstedt, 1909, *Gynacantha vesiculata* Karsch, 1891, *Hadrothemis scabrifrons* Ris, 1910, *Teinobasis* spec., *Thermochoria jeanneli* Martin, 1915. Exuviae of *Hadrothemis scabrifrons* were collected and sent to G. Carchini for description.

African dragonflies are hardly known from high altitudes (**Fehler! Textmarke nicht definiert.**, p. 624). The montane specialist *Pseudagrion bicoerulans* Martin, 1907 and the following two species were observed reproducing above 3000 m a.s.l. in the Aberdare Mts: *Aeshna ellioti ellioti* Kirby, 1896 and *Enallagma glauca* (Burmeister, 1893). Other high altitude records were made at a pool in 2915 m a.s.l. with *Sympetrum fonscolombei* (Selys, 1840) and *Orthetrum caffrum* (Burmeister, 1839). *Agriocnemis exilis* Selys, 1872 was found in 2750 m a.s.l. on Mt. Elgon in a pool in dense bamboo forest. This shows the enormous ecological plasticity of this tiny species, which inhabits swampy habitats

from sea level to the mentioned montane areas.

CAPACITY BUILDING AND COOPERATION

The Africa wide network PHAON, which is a very important step forward in African Odonatology, has already been mentioned in the introduction.
In East Africa two major projects have included dragonflies in their inventories: the inventory of the swamp "Important Bird Areas" (IBAs) in Uganda, led by Charles Williams and the project „Conservation of Montane Grasslands in the Southern Higlands of Tanzania" led by Tim Davenport. The preliminary version of my key is used and tested in both projects. During my last trip to East Africa I visited Charles Williams in Kampala, who has build up an extensive dragonfly collection from Uganda's swamp areas (unfortunately excluding forest areas). In October 2001 I planned to visit the project in South Tanzania, to have a look through the collection. Possibly, there might be money to have Tanzanian students working on small dragonfly projects in Tanzania in 2002.
In Uganda John Joseph Kisakye will start his PhD on dragonflies in several forest areas (Bwindi, Mabira, Mt. Elgon) in August 2001. The main focus will be the impact of forest fragmentation and degradation on the dragonfly communities and selected species.
Currently ICIPE is working on a cooperation with Ethiopia in which course I am trying to get funding for an Ethiopian student to do his PhD thesis on dragonflies in this country.
Information boards on local dragonflies were prepared and handed to the National Parks or Forest Reserve authorities (Visitor Centres of the Arabuko Sokoke Forest, Saiwa Swamp National Park, Mt. Elgon NP and Nairobi NP). Additionally small articles were published in the Newsletter of the „Friends of the Arabuko Sokoke Forest" and the Newsletter of the „East African Natural History Society".
For most visited protected areas species check lists are being prepared and will be sent to the Kenya Wildlife Service.

USE OF MONEY FROM IDF

The money spent by the IDF in this project was mainly used for covering costs in connection with the work on the key (visits to the Natural History Museum, London, photocopies, printing, etc.), for films and development, the production of information boards and travelling costs for the work on coastal rain forests.

PRESENTATION OF RESULTS

As already stated the identification key for East African dragonflies is in prepa-

ration and shall be finished by the end of 2002. Other manuscripts are in preparation dealing with different aspects of *Coryphagrion grandis* (description of larvae, systematic position, ecology and distribution), a comparative description of the dragonfly communities from different coastal habitats with a focus on natural forest habitats and the replacement communities, a general article of the dragonflies of the Shimba Hills NP, the description of a new Gomphid species and a new subspecies of *Pseudagrion bicoerulans*.
A few manuscripts are already finished including
Clausnitzer, V. (2001): Notes on species diversity of East African Odonates with a species checklist. Odonatologica 30:49-66.
Clausnitzer, V. (2001): Notes on *Trithemis bifida* and *Trithemis donaldsoni* (Odonata: Libellulidae). *Int. J. Odonatol.* 4: 107-117.
Clausnitzer, V. (2002): Reproductive behaviour and ecology of the dendrolimnetic *Hadrothemis scabrifrons* (Odonata: Libellulidae). *Int. J. Odonatol.* 5: 15-28.
Other forms of presentations, e.g. information boards, have been already mentioned under capacity building and cooperation.

OUTLOOK

The work on the identification key will be continued; the genera key for the Libellulidae and the keys for *Orthetrum* and *Pseudagrion* are the next things to be tackled (anybody volunteering to revise these genera is highly welcome). Detailed drawings will be done by K.D. Dijkstra (I had too many complaints concerning my own drawing abilities) and the key eventually put in a printable version end of 2002.
The work on East African Coastal Rain Forests will be continued in Tanzania from September 2001 onwards. Tanzania in general will be one focus of future studies including visits on the Eastern Arc Mountains (starting with the Udzungwas in 2001). Despite some considerably biological research in the Eastern Arc Mountains and the Serengeti plains, the Odonata have been simply neglected in most of these projects and Tanzania remains as one of the most underrepresented African countries in terms of dragonfly research.

REFERENCES

Blackmoore, S. (1996): Knowing the Earth's Biodiversity: Challenges for the Infrastructure of Systematic Biology.- Science 274: 63-64.
Burgess, N. D., et al., eds. (2000): Coastal Forests of Eastern Africa. Gland, Switzerland & Cambridge, UK, IUCN.

Clausnitzer, V. & Lindeboom, M. (2002): Natural history and description of the dendrolimnetic larva of Coryphagrion grandis (Odonata).- Int. J. Odonatol. 5: 29-44.
Corbet, P. S. (1999) : Dragonflies: Behaviour and Ecology of Odonata. London, Harley Books.
Denny, P., et al. (1992): Ugandan wetlands and their management. Conservation and Development: The sustainable use of wetland ressources. E. Maltby, P. J. Dugan and J. C. Lefeuvre. Gland, Switzerland, IUCN: 77-84.
diCastri, F., et al. (1992): Inventory and monitoring biodiversity. Biology International-Special Issue 27: 1-27.
Fincke, O. M. (1984): Giant damselflies in a tropical forest: reproductive biology of *Megaloprepus coerulatus* with notes on *Mecistogaster* (Zygoptera: Pseudostigmatidae).- Adv. Odonatol. 2: 13-27.
Fincke, O. M. (1992): Behavioural ecology of the Giant Damselflies of Barro Colorado Island, Panama. pp. 102-113 in: Quintero, D. and Aiello, A. Insects of Panama and Mesoamerica: selected studies. Oxford, Oxford University Press:.
Fincke, O. M. (1992): Interspecific competition for tree holes: Consequences for mating systems and coexistence in neotropical damselflies.- Am. Nat. 139: 80-101.
Kim, K. C. (1993): Biodiversity, conservation and inventory: why insects matter.- Biodiv. Conserv. 2: 191-214.
Kingdon, J. (1989): Island Africa. Princetown, Princetown University Press.
Moore, N. W. (1997): Dragonflies - Status Survey and Conservation Action Plan. IUCN. Gland, Switzerland and Cambridge, UD, IUCN/SSC Odonata Specialist Group.
Myers, N., et al. (2000): Biodiversity hotspots for conservation priorities.- Nature 403: 853-858.
Pinhey, E. (1961): A survey of the dragonflies of Eastern Africa. London, British Museum (Natural History).
Stork, N. E., et al., Eds. (1995): Inventorying and monitoring biodiversity. Global biodiversity assessment, Cambridge University Press.
Stuart, S. N., et al. (1990): Biodiversity in sub-saharan Africa and its islands - conservation, management and sustainable use. Gland & Cambridge, IUCN.
Vane-Wright, R. I., et al. (1991): What to protect? - Systematics and the agony of choice.- Biol. Conserv. 55: 235-254.
Wishart, M. J., et al. (1998). The increasing divide between First and Third Worlds: science, collaboration and conservation of Third World aquatic ecosystems.- Freshw. Biol. 39: 557-567

Dragonfly research in the Okavango Delta, Botswana

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INTRODUCTION

The Okavango Delta in Botswana is one of the major African wetlands. Its invertebrate fauna is poorly known although dragonflies may be considered an exception to that. At least two papers focussed on the dragonfly fauna of Botswana and the Delta in particular. Pinhey (1967) provided an overview on the dragonflies of Ngamiland including those of the Okavango Delta. Later he summarized the knowledge of the dragonflies of Botswana (Pinhey 1976) and reported on the expeditions of the Falcon College and the Peterhouse School to the Okavango region (Pinhey 1975). Thereafter, no publication explicitly considered the Odonata of the Okavango Delta and Botswana although in his checklist of the Odonata of Zimbabwe and Zambia Pinhey (1984) also referred to some species in the Okavango swamps. After Pinhey's work in this region only a few odonatologists visited the Okavango Delta on holidays but without publishing their results (Silsby, pers. comm.).
To date, 104 species are known for Botswana (Pinhey 1976), 85 of which occurring in the Okavango Delta and its immediate surroundings. Pinhey (1976) supposed the occurrence of a further 9 species in the northern part of Botswana close to the border to Zimbabwe, Zambia and Namibia.
As one of the results of a partnership between the Anhalt University and the Harry Oppenheimer Okavango Research Centre (HOORC) of the University of Botswana in Maun, Botswana, I had the opportunity to carry out studies on the dragonfly fauna in the famous Okavango Delta. During a practical course of our university between April and August 2000 first experiences with African Odonata were gathered in preparation for a planned Master thesis. I also helped a student of our university in his study about the emergence pattern of selected water insects on the HOORC study sites at West Chief's Island.
This study reports on preliminary results of this stay. Results from follow-up research stays of my Master thesis will be reported elsewhere (Kipping, in prep.).

The present study pursued the following goals:

a) Collecting faunistic data at several sites in the Delta. Sampling of adults, larvae and exuviae to obtain an overview about the dry season aspect of dragonflies in the Okavango region.
b) To proof Pinhey's assumptions of the occurrence of some species in the northern part of the Delta and the Chobe River. This will be a contribution towards a check-list of the dragonflies of Botswana.
c) To collect preliminary data and to extend the knowledge about the habitat utilization of dragonflies in the Delta. This will be the subject of further studies and the above mentioned Master thesis.

THE STUDY AREA

In north western Botswana the Okavango forms the largest inland delta of the world. The Okavango River descends from the Highland of Bié in Angola (annual rainfall between 1200 and 2000 mm). After its confluence with the Cuito River it drains a catchment of approximately 150,000 km^2. Just behind the border of Botswana at Mohembo it spreads to a fan-shaped Delta. It covers an area of approximately 22,000 km^2, 12,000 km^2 of which are more or less permanently water covered. At Shakawe the average annual inflow is $11x10^9$ m^3, direct rainfall providing an additional $5x10^9$ m^3 to the water balance of the Delta (Allanson *et al*. 1990). The narrow upper stretch of the delta is the so called Panhandle with a length of 80 km between Mohembo and Seronga. After passing the Gumare faultline the Okavango is divided into several water courses and form this vast wetland ecosystem. The Thamalakane faultline about 180 km to the south constitutes the southern border of the Delta (Figure 1). The distance between Mohembo and Maun is over 250 km, the altitudinal difference, however, is only 65 m. This extremely small slope under the prevailing semi-arid climatic conditions leads to a water loss of over 96 % of the inflow through evapotranspiration. Only 2 % of the inflow eventually reach the Thamalakane near Maun, the remaining 2 % leave as groundwater outflow (Ellery & Ellery 1997). The annual flood peak in the north reaches Mohembo around February, the peak at the southern end of the Delta at Maun by the end of July to early August. The sediment carried into the Delta is medium to fine grained sand and the inflowing water is characterized by a low content of organic matter, dissolved solids and chemical pollution. I measured a conductivity of only 38 µS in the upper Panhandle. It increased to only 111 µS in the Thamalakane River in the south. Thus, the water in the Delta is mostly very clear and pure.

The Delta can be divided into four major landscapes, i) the Panhandle, ii) the permanent swamps in the north, iii) the seasonal swamps in the south and iv) the dry landmasses that loom into the Delta from the surrounding and larger islands, e.g. Chief's Island.
The main water courses are the Thaoge in the west which is now blocked and mostly dry, the Jao and Boro in the centre and the Nqoga in the east. Blockades by papyrus and occasional earthquakes are the reasons for a permanent change in the water flow amongst the main water courses.
The Panhandle and the northern permanent swamp is characterized by a complex of lagoons, channels, back swamps, flats and islands. The vegetation at the channel margins is dominated by the giant sedge, *Cyperus papyrus*, which forms dense thickets. Underneath these thickets a layer of peat has accumulated. At the edge of the Papyrus flooded grasses are abundant. The back swamps and lagoons are dominated by floating-leaved and submerged aquatic plants, locally the channel flora may be very diverse. On dry land the channels are often accompanied by a dense and shady riverine forest which changes inland into broadleaved or acacia woodland. The seasonal swamp is mainly covered by mud-flats and swamps with floodplain communities exhibit a marked zonation of vegetation reflecting the extend and duration of flooding. Areas flooded for the longest time may have submerged or floating-leaved plant species similar to those occurring in the permanent swamp. Large areas are dominated by emergent sedges of *Cyperus articulatus*, *Schoenoplectus corymbosus* and the grass *Oryza longistaminata*. The more briefly flooded areas are characterized by the occurrence of several grass species, e.g. *Panicum repens*. Trees and shrubs are common on dry land. Islands are often covered by a wooded fringe of *Ficus verrucuclosa* and *Syzygium cordatum*, both of which are tolerant to flooding. The large islands and sandveld tongues generally consist of open shrub and woodland. In large parts *Acacia* shrubs are dominating and *Colophospermum mopane* woodland on deep soils.

FIELD WORK IN THE DELTA

The field work was carried out between 16 April and 9 August 2000. The HOORC is based in Maun, the gateway to the Delta. Maun has all the necessary facilities for field trips into the Okavango Delta, i.e. petrol stations, garages, hotels, campsites, supermarkets and banks.
We had the luck to work under excellent fieldwork conditions in the Okavango Delta. The main study site was situated at West Chief's Island on the bank of

the Boro River with adjacent floodplains. On this site the HOORC staff undertake hydrological and ecological research programmes. We were able to work in the

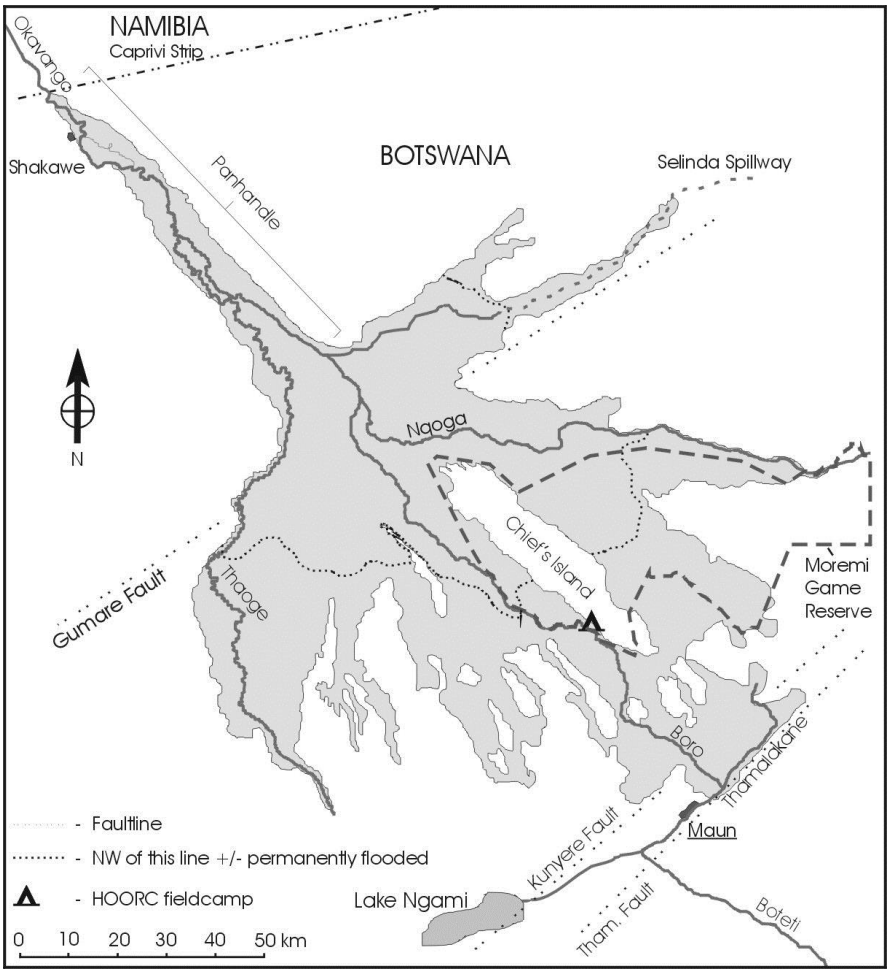

Figure 1: Map of the Okavango Delta

framework of a HOORC research permit. This was important since this stretch of the Boro is part of the Moremi Game Reserve. Without such a permit a daily park entrance fee of 120 Pula (approximately 40 €) would be due. A camp of tents in the shade of tall trees and with a lovely view over the marvellous surroundings was our home during the field trips. In 2000 exceptionally heavy rains were observed early in the year and large parts of the southern Delta were still floodedin April. It was, therefore, impossible to reach the field camp on the usual way by car. We went by boat and so had the best impression of the Delta. We took the 4x4 cars on the dry land a few kilometres north of Maun. We then switched to so called *mokoros*, simple dug-out canoes, to cross the more shallow parts and floodplains. With our almost overloaded canoes this took at least

3 hours. After reaching the deeper river Boro we again changed to a motorboat, which took us to the field camp after a further 3 hours drive. The last stage was the most impressive because we saw large amounts of water birds, herons, storks as well as giraffes, hippos and drinking elephants at the river banks. Later in the season, after drying up, we were able to use 4x4 cars for driving to the field camp. However, this solution was not less adventurous because the sandy road was often interrupted by muddy river courses in which the cars regularly got stuck. Sometimes we had to pass herds of elephants and often the large bulls chased the cars with flapping ears and trumpet sounds. The HOORC field programme enabled us to visit Chief's Island each week from Monday or Tuesday till Friday. The weekend was usually spent in Maun. Thus, I was able to study dragonflies on West Chief's Island as well as on the Boro and Thamalakane River in Maun. Furthermore, I had the opportunity to join the first AQUA-RAP excursion of Conservation International (a Conservation NGO from the USA with a branch in Botswana) to the Panhandle around Mohembo and Shakawe during the first week of June. Under the leadership of Prof. Chris Appleton (Univerrsity of Natal, R.S.A.) I was responsible for recording the dragonfly fauna of the visited sites. By this way I got very valuable insights into dragonfly communities in the northern Panhandle. They are quite different to those occurring in the seasonal swamps on Chief's Island (Table 1).

While the Panhandle and the edge of the Delta is fairly easy accessible, it is much more difficult to reach the central and more untouched parts of the Delta, as shown above. A good 4x4 car is necessary. During the flood and in the permanent swamps there is no way to travel into the delta without a boat. Travel agencies often offer *mokoro* trips into the swamps, but one should consider that this kind of canoe is very instable and not suitable for intense fieldwork. Big motorboats are safer and provide better conditions with a more extensive work range. It is possible to hire motorboats at approximately 20 €/day at some tourist lodges that offer game drives and fishing trips. Unfortunately, accommodation and service in the central Delta are fairly expensive, one night in a middle class lodge may cost up to 400 € p.p./night. Camp sites are cheaper but are mainly located at the edge of the Delta.

Another tricky problem was the presence of potentially dangerous animals in the Delta. This is obvious in the Moremi Game Reserve, but also the Wildlife Management Areas (WMA) that cover large parts of the Delta which are rich in wild animals. Our field camp was regularly visited by lions, hyenas and leopards during the night. It is, therefore, very dangerous to leave the tent during this time. The larger water bodies are the home of crocodiles and hippos, the latter ones are the most dangerous animals in the region. On one occasion we

had a collision with a hippo while driving down the Boro River by motorboat. Fortunately, the boat didn't capsize and we could continue the trip and got off the boat with not more than a fright. Near the water herds of elephants and buffalos may be encountered, without experience this can lead to serious situations. Particularly in the Panhandle large crocodiles are a problem for (not only) odonatologists and the number of serious accidents increased during the last two years. An non-experienced visitor should hire a local guide when travelling by foot into the WMAs and Moremi Game Reserve. Local guides are available at approximately 15 €/day but they are indeed a good life insurance. In addition it is a fine opportunity to learn a lot about the Delta with its animals and plants.
Altogether I spent about 60 days in the field site on West Chief's Island. Half of this time was used for my dragonfly study. One week was spent for the field trip with Conservation International to the upper Panhandle. Another week was used for travelling to the north eastern Chobe River an to the Zambezi in Zimbabwe. Remaining days were spent in Maun, doing office jobs, enjoying recreation or visiting the Thamalakane and Boro River in or nearby town.
A simple hand net was used to catch adults. At most of the sites intense searches for exuviae were carried out, if circumstances allowed them. On Chief's Island and at the rivers in and around Maun larvae were caught, using a small net with fine mesh. Those larvae were kept in small containers and tried to rear to emergence.
The identification of the collected specimens were carried out using the keys in Pinhey (1951, 1961, 1964, 1970 a, b, 1974, 1976, 1980) and the unpublished key of Vick (1997).

RESULTS

Altogether 72 species of dragonflies were brought on record, including the sampling sites on the Chobe River in north eastern Botswana and the Zambezi near Victoria Falls in Zimbabwe. In the Okavango Delta itself and the immediate surrounding 56 species were recorded. A list of the encountered species and their occurrence at certain sites are provided in Table 1.

		Chief's Island	Panhandle near Shakawe	Maun
	FAM. LESTIDAE			
1	Lestes pallidus Rambur, 1842	X		X
2	Lestes pinheyi Fraser, 1955	X		X
	FAM. PLATYCNEMIDIDAE			

3	Mesocnemis singularis Karsch, 1891		X	
	FAM. COENAGRIONIDAE			
4	Ceriagrion glabrum (Burmeister, 1839)	X	X	X
5	Ceriagrion katamborae Pinhey, 1961		X	X
6	Ceriagrion suave Ris, 1921		X	
7	Pseudagrion assegaii Pinhey, 1950	X		X
8	Pseudagrion coeleste Longfield, 1945	X		X
9	Pseudagrion deningi Pinhey, 1961	X		
10	Pseudagrion hamoni Fraser, 1955	X		
11	Pseudagrion massaicum Sjöstedt, 1909		X	
12	Pseudagrion sjoestedti jacksoni Pinhey		X	
13	Pseudagrion sublacteum pseudomassaicum Pinhey		X	X
14	Pseudagrion sudanicum rubovirid Pinhey, 1955		X	
15	Ischnura senegalensis (Rambur)	X	X	X
16	Agriocnemis exilis Selys, 1869	X	X	X
17	Agriocnemis gratiosa Gerstaecker, 1891	X		X
18	Agriocnemis ruberrima albifrons Balinsky, 1963	X		
19	Agriocnemis victoria Fraser	X		
	FAM. GOMPHIDAE			
20	Ictinogomphus ferox Rambur	X		X
21	Gomphidia guyi Pinhey, 1967	X		
22	Lestinogomphus angustus Martin, 1911		X	
23	Paragomphus genei (Selys, 1841)		X	
	FAM. AESHNIDAE			
24	Anax ephippiger (Burmeister, 1839)			X
25	Anax imperator mauricianus Rambur, 1842	X	X	X
26	Anax tristis Hagen, 1867			X
	FAM. CORDULIIDAE			
27	Phyllomacromia picta (Selys, 1871)		X	X
	FAM. LIBELLULIDAE			
28	Orthetrum brachiale (Beauvois, 1817)			X
29	Orthetrum chrysostigma (Burmeister, 1839)	X	X	X
30	Orthetrum icteromelas cinctifrons Pinhey, 1970	X		
31	Orthetrum trinacria (Selys, 1941)	X		X
32	Palpopleura deceptor (Calvert, 1899)			X
33	Palpopleura lucia (Drury, 1773)	X		X
34	Aethiothemis discrepans Lieftinck, 1969		X	
35	Hemistigma albipunctum (Rambur, 1842)	X	X	X
36	Acisoma panorpoides ascalaphoides Rambur, 1842		X	
37	Diplacodes lefebvrei (Rambur, 1842)	X	X	X
38	Diplacodes okavangoensis Pinhey, 1976	X		X
39	Crocothemis erythraea (Brullé, 1832)	X	X	X
40	Brachythemis lacustris (Kirby, 1889)		X	
41	Brachythemis leucosticta (Burmeister, 1839)	X	X	X
42	Sympetrum fonscolombii (Selys, 1840)	X		X
43	Philonomon luminans (Karsch, 1893)		X	X

44	Trithemis aequalis (Lieftinck, 1969)			x
45	Trithemis annulata (Beauvois, 1807)	x	x	x
46	Trithemis arteriosa (Burmeister, 1839)	x	x	x
47	Trithemis hecate Ris, 1921	x	x	x
48	Trithemis kirby ardens (Gerstaecker, 1891)			x
49	Trithemis monardi Ris, 1931	x		x
50	Trithemis stictica (Burmeister, 1839)	x	x	x
51	Rhyothemis semihyalina (Desjardins, 1832)	x	x	x
52	Tholymis tillarga (Fabricius, 1798)	x	x	x
53	Pantala flavescens (Fabricius, 1798)	x		x
54	Tramea basilaris (Beauvois, 1817)	x		x
55	Urothemis assignata (Selys, 1872)			x
56	Urothemis edwardsii (Selys, 1849)	x	x	x
	species total	35	28	40

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REFERENCES

Allanson, B.R., R.C. Hart, J.H. O’Keeffe & Robarts, R.D. (1990): Inland waters of Southern Africa: an ecological perspective. – Monographiae Biologicae 64: 1-458.

Conservation International (2001): Conservation International – 2000 Annual report. CI Washington

Ellery, K. & Ellery, W. (1997): Plants of the Okavango Delta – a field guide. – Tsaro Publishers, Durban.

Pinhey, E.C.G. (1951): The Dragonflies of Southern Africa. – Transvaal Museum Memoirs 5: 1-335.

Pinhey, E.C.G. (1961): Dragonflies (Odonata) of Central Africa.- Occas. papers of the Rhodes-Livingstone Museum 14: 1-97.

Pinhey, E.C.G. (1964): A revision of the African members of the genus *Pseudagrion* Selys (Odonata).- Revta entomol. Mocamb. 7: 5-196.

Pinhey, E.C.G. (1967): Odonata of Ngamiland. – Arnoldia Rhod. 3 (15): 1-17.

Pinhey, E.C.G. (1970a): Monographic study of the genus *Trithemis* Brauer

(Odonata: Libellulidae). - Mem. ent. Soc. south. Africa 11: 1-159.
Pinhey, E.C.G. (1970b): A new approach to African *Orthetrum* (Odonata). - Occas. pap. natn. Mus. Rhod. (B) 4(30): 261-321.
Pinhey, E.C.G. (1974): A revision of the African *Agriocnemis* Selys and *Mortonagrion* Fraser (Odonata: Coenagrionidae).- Occas. papers natn. Mus. Rhod. B, Nat. sci. 5 (4): 164-278.
Pinhey, E.C.G. (1976): Dragonflies (Odonata) of Botswana, with ecological notes.- Occas. pap. natn. Mus. Rhod. B, Nat.sci. 5(10): 524-601.
Pinhey, E.C.G. (1980): A revision of African *Lestidae* (Odonata).- Occas. papers Natl. Mus. Rhod B, Nat.sci. 6 (6): 327-479.
Pinhey, E.C.G. (1984): A check-list of the Odonata of Zimbabwe and Zambia.- Smithersia 3: 1-64.
Vick, G.S. (1997): Dragonflies of Cameroon – a Guide to identification. (unpubl. version)

Ground to canopy distribution of bromeliad-dwelling *Mecistogaster modesta* larvae (Odonata: Pseudostigmatidae) in a Costa Rican rainforest

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ABSTRACT

Larvae of *Mecistogaster modesta* Selys occur only in bromeliads. We quantified the vertical distribution of larvae in a Costa Rican tropical wet forest, from ground to canopy. Approximately 171 larvae per hectare are estimated to occur in this primary forest, most at intermediate heights above the ground. Only 4% were found in the canopy proper. These distributions reflect mainly spatial patterns in both the size and abundance of bromeliads, although there may also be subtle vertical differences in habitat quality. Full results are published in Melnychuk & Srivastava (2002).

BROMELIADS AS LARVAL HABITATS

Larvae of more than 38 species of Odonata are known to inhabit phytotelmata, or small volumes of water contained by plant structures such as treeholes, bromeliads, bamboo internodes, fallen fruit, leaf axils, and the occasional large pitcher plant (Corbet 1983; Kitching 2000). These species represent at least six different families within both the Zygoptera and Anisoptera suborders. However, a disproportionate number of phytotelm-inhabiting species are found within two families: Pseudostigmatidae and Coenagrionidae (Corbet 1983; Kitching 2000). Our study concerns the only pseudostigmatid species found exclusively in bromeliads, *Mecistogaster modesta* Selys. Like all pseudostigmatid species, the adults are slow-flying but remarkably agile (the family is commonly referred to as "helicopter damselflies") with exceptionally long abdomens, which presumably facilitate oviposition in bromeliads (Calvert 1911). Species occurs from Mexico to Columbia. In Costa Rica, adults have only been found in the rain-drenched forests immediately east of the Continental Divide (Hedström and Sahlén 2001). Larvae of *M. modesta* are found in tank bromeliads, that is, bromeliads whose morphology allows them collect of water and falling detritus, presumably as a means to increase nutrient uptake. In the rainforest of northwestern Costa Rica, where our research is centered, bromeliads contain a di-

verse assemblage of aquatic insects that consume the trapped detritus. In this forest, a typical medium-sized bromeliad contains over 300 individual insects representing about 15 species, all in a total water volume of ca. 200 ml! Feeding trials show that *M. modesta* larvae prey on virtually every insect species found in bromeliads.

In this study we examined the vertical distribution of *M. modesta* larvae in the rainforest, from ground to canopy. In particular we were interested in answering three questions: (1) Where do most *M. modesta* larvae occur in rainforests? In the canopy, or closer to the ground? (2) Do these patterns depend on height differences in the number of bromeliads? The size of bromeliads? Or the quality of bromeliads as larval habitats (e.g. prey abundance)? (3) Can we use this data to estimate the total number of *M. modesta* in a hectare of tropical forest?

Documenting spatial patterns in the larval abundance of *M. modesta* is an important first step to understanding the population ecology of this species, and ultimately the population's sensitivity to forest change. Until this study, very little had been published on the larval ecology of this species. By comparison, the larval ecology of several pseudostigmatid species found in treeholes is well documented (e.g. Fincke 1998; Yanoviak 1999). A detailed description of our study has been recently published (Melnychuk & Srivastava 2002), so we present only an informal summary of the main results in this report.

HOW MANY LARVAE ARE IN RAINFOREST CANOPIES?

To answer this question, we needed to first survey bromeliads from ground to canopy in forest plots. Our plots contained over a thousand bromeliads per hectare, most of which occurred close to the ground. For example, if we start counting bromeliads at ground level, by the time we are only halfway to the bottom of the canopy, we will have encountered 3/4 of the bromeliads in the forest. Furthermore, the bromeliads encountered will be larger on average than those higher up. As we will show in a minute, both of these patterns have major effects on the vertical distribution of *M. modesta* larvae.
In order to convert our bromeliad census into estimates of *M. modesta* abundance, we needed to know how many how many larvae each bromeliad contained. This required collecting 31 bromeliads from ground and canopy (the latter using single-rope climbing techniques to ascend about 20 m to the beginning of the canopy). The bromeliads were searched thoroughly for larvae as we dismantled them. Based on our field data, we developed regression models predicting larval abundance as a function of bromeliad size. Larger bromeliads contain many more larvae than smaller bromeliads. For example, a 400-ml bromeliad contains, on average, just a single larva, whereas a slightly larger 600-ml bro-

meliad will contain between 2 to 5 larvae. These predictions are given as a range, as ground bromeliads of equivalent size have slightly higher *M. modesta* abundances when we measured size as total volume or debris mass. However, there was no difference between ground and canopy bromeliads of equivalent diameter. In our bromeliad census we measured bromeliad size as diameter.
Combining all the above information, we were able to estimate total larval abundances for all vertical layers in the rainforest, including the canopy. Most of the larvae (66%) were estimated to occur in a layer which we labelled L_2 (running from 2m above the ground to halfway to the bottom of the canopy; see Fig. 1). Fewer larvae are predicted to occur in the surrounding L_1 and L_3 layers (14-15% each) and hardly any larvae may occur in the canopy itself (L_4 layer, 4%). Although the layers differed in their extent of vertical space, the same rank order was found when expressed per vertical meter.
By summing all the vertical layers together, we estimated that each hectare of rainforest at our site contains, on average, 171 ($\pm$ 65) *M. modesta* larvae.

IMPLICATIONS OF RESULTS

This study produced useful baseline statistics on larval abundance that can be compared to other localities. For example, we obtained separate funding (from W.E. Neill, UBC) to survey bromeliads in adjacent (<0.6 km) patches of secondary forest (D.S. Srivastava & M.C. Melnychuk, unpubl. results). These patches contained approximately 30x higher densities of *M. modesta* larvae than the primary forest results reported in this paper. About 50% of this difference is due to greater abundance and size of bromeliads in the secondary forest, while the remaining 50% cannot be accounted for by differences in either bromeliads or prey abundance. Such comparisons illustrate the fine-scale patchiness of larval abundance in *M. modesta*. This particular comparison also suggests that modeling the effects of forest change on *M. modesta* will be far more complicated than simply tracking bromeliad demographics.

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REFERENCES

Benzing, D.H. (2000): Bromeliaceae: profile of an adaptive radiation.- Cambridge University Press, Cambridge: 690pp.

Calvert, P.P. (1911): Studies on Costa Rican Odonata II. The habits of the plant-dwelling larva of *Mecistogaster modestus*. Entomol. News 22: 402-411.

Corbet, P.S. (1983): Odonata in phytotelmata. In: Frank, J.H. & L.P. Lounibos (eds) Phytotelmata: terrestrial plants as hosts for aquatic insect communities - Plexus, Medford, New Jersey: 29-54.

Fincke, O.M. (1998): The population ecology of *Megaloprepus caerulatus* and its effect on species assemblages in water-filled tree holes. In: Dempster, J.P. & I.F.G. McLean (eds) Insect Populations in Theory and Practice - Kluwer Academic, London: 391-416.

Hedström & Sahlen, G. (2001):

Kitching,

Melnychuk, M.C. & D.S. Srivastava (2001): Abundance and vertical distribution of a bromeliad-dwelling zygopteran larva, *Mecistogaster modesta*, in a Costa Rican rainforest (Odonata: Pseudostigmatidae).- Int. J. Odonatol. 5: 89-105.

Yanoviak, S.P. (1999): Community structure in water-filled tree holes of Panama: effects of hole height and size.- Selbyana 20: 106-115.

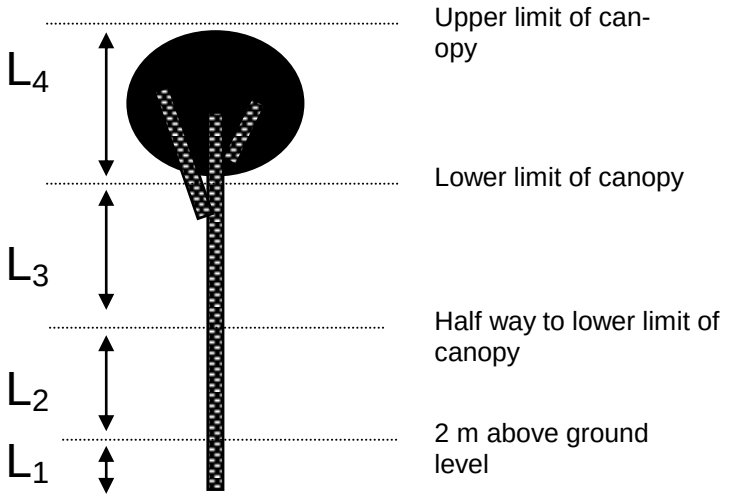

Figure 1. Four vertical height classes used in this

Förderprojekte des International Dragonfly Fund e.V.

Förder-nummer	Förder-jahr	geförderte Person bzw. Körperschaft	Fördergegenstand
1	1996	Societas Internationalis Odonatologica	Druckkostenzuschuß zur Herausgabe von zwei Nummern des Mitteilungsblattes Selysia
2	1997	Stansilav Gorb	The role of visual cues in mate recognition in the damselfly *Coenagrion puella* (L.)
3	1997	Schutzgemeinschaft Libellen in Baden-Württemberg	Pflege- und Entwicklungsplan Weberalten
4	1997	Greg O'Neill	Studies of a dragonfly biodiversity gradient in Ghana, West Africa
5	1998	Paul-Michael Brunelle	The status of *Somatochlora brevicincta* (Anisoptera, Corduliidae) in the maritime provinces, Canada
6	1998	Graham Vick	Visit of the nature reserve Mount Oku (Cameroun) by Otto Mesumbe
7	1998	Viola Clausnitzer	Identification key of East African Odonata (Text)
8	1999	Klaus Reinhardt	Untersuchungen zur Libellenfauna Ostkasachstans
9	1999	Steffen Förster	Bestimmungsschlüssel für die Libellen Mittelamerikas
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15	2000	Jens Kipping	Libellen des Harry Oppenheimer Okavango Research Centre in Maun, Botswana, Afrika: Reisekostenzuschuß
16	2000	Diane Srivastava	Are rainforest canopies important for *Mecistogaster modesta*?
17	2000	Milen Marinov	Annotated odonatological bibliography of Bulgaria
18	2000	Oleg Kosterin, V.Zaika	Dragonfly research in the Tuva-Region.
19	2001	Garcia / K.D. Dijkstra	Odonata of Ankarafantsika Forest Reserve, Madagascar
20	2001	Oleg Kosterin	Provisional revision of the genus *Enallagma*
21	2001	K.D. Dijkstra	*Oreocnemis phoenix* in Malawi
22	2002	Milen Marinov	Zuschuss zur Verteidigung der Dissertation
23	2002	Sévérin Tchibozo	Inventaire des libellules des zones humides du Sud-Bénin

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The International Dragonfly Fund (IDF) is a scientific society founded in 1996 for the improvement of odonatological science and the protection of species.

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