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DRAGONFLY (ODONATA) RECORDS OF KAKAMEGA FOREST, WESTERN KENYA, WITH NOTES ON THE ECOLOGY OF RAIN FOREST SPECIES

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ABSTRACT

A list of dragonflies recorded in Kakamega Forest, Western Kenya is presented, including ten new records for Kenya. Some of the species have their centre of distribution in West Africa. Ecological notes on different adaptation strategies of rain forest dragonflies are given, mainly focusing on visibility and flight behaviour of the males. Seasonality patterns of the observed dragonflies and distinct behavioural features of selected species, *e.g. Hadrothemis* and *Gynacantha* are described.

INTRODUCTION

Dragonflies are important indicator organisms for the condition of aquatic and terrestrial ecosystems (*e.g.* Watson *et al.*, 1982) and are commonly used in nature conservation management in Europe. Water problems in Africa (pollution, erosion, limited fresh water resources) are leading to a growing awareness of wetland conservation. First attempts to use dragonflies as indicators have been made in South Africa (Clark & Samways, 1996; Samways *et al.*, 1996). But even in South Africa, where dragonflies are comparatively well studied, a more detailed appraisal, *e.g.* of the rarity status of some dragonflies, is required (Samways, 1992). For most other African countries the database is far too small to assess dragonflies as indicators or to evaluate the rarity status. For many countries no checklists are available. For Kenya a checklist has been prepared based mainly on an inventory of museum material and publications (Clausnitzer, 2000). An inventory in the field is urgently needed.

The main focus of this study are some rain forest dragonflies of Kakamega Forest. Only very few studies have focused on African rain forest dragonflies up to now (*e.g.* Clausnitzer, 1998; Gambles, 1960; Legrand, 1977, 1979; Lempert, 1988; Miller, 1993, 1995; Robertson, 1982; Vick, 1996). These species are often heliophobic and show special adaptation to their habitat. A classification based on behaviour, habitat selection and colouring is given. The observed dragonflies include 10 new records for Kenya; 18 species are only found in Kenya in Kakamega Forest. Most of these species have their centre of distribution in West and/or Central Africa. These highly specialised dragonflies are vanishing with the rapidly growing disturbance in the last remaining rain forest patches (*e.g.* logging, charcoal production, agriculture). They are supposed to be the most threatened dragonflies, where populations vanish before being recorded (Miller, 1995; Moore, 1997).

STUDY AREA

Kakamega Forest is situated in West-Kenya near the border with Uganda (0°8'-0°24'N; 34°20'-34°33'E), at altitudes of 1,500–1,700 m a.s.l. It covers about 240 km². The temperature varies between a mean max. of 27°C and a mean min. of 15°C. The annual rainfall is more than 2,000 mm with the major wet season from April to November.

The eastern border of the forest is the Nandi Escarpment (2,200 m), which extends from the Cherangani Mountains in the North to the Mau Escarpment in the South. To the south-west, Lake Victoria forms another natural border, into which all streams crossing Kakamega Forest flow.

Kakamega Forest is the remnant of what used to be once a vast rain forest in the Pleistocene 1.8–0.5 million years ago. The lowland rain forests of West and Central Africa were connected to the highland rain forests of Uganda, expanding into today's Kenya. About 10,000 years ago these forests shrank because of increasing aridity. In Kenya only the areas in Western Kenya remained covered with highland rain forest. There has been considerable human encroachment over the last 300 years so that Kakamega Forest is now the last remaining highland rain forest in Kenya. It has the highest biodiversity of any forest in Kenya. Many plants and animals occur nowhere else in Kenya, and show the former connection to Central Africa (Lockwood, 1995; KIFCON, 1994). Kakamega Forest is listed as a priority forest for biodiversity conservation (Wass *et al.*, 1995).

Between 1965 and 1991 the area covered with indigenous rain forest decreased by 50 % (KIFCON, 1994). Burning, pastoral activities, clearing and charcoal burning have converted the forest into a patchwork of indigenous forest patches, glades, secondary woodland and patches of exotics.

MATERIALS AND METHODS

Observations were made in Kakamega Forest from December 1994 to March 1995 and on additional visits (April & September 1996, June 1997). Identifications were carried out using Pinhey (1951, 1961, 1964, 1967, 1970) and through reference with specimens in the collection of the Natural History Museum, London. Scientific names follow Bridges (1994).

RESULTS

In total 51 species of Odonata were recorded from Kakamega Forest. These are listed in Table 1, with indication of habitat preference and heliophyly. Species new or restricted to Kenyan fauna are also indicated.

Records of presence at water show that *Chlorocnemis pauli, Chlorocypha tenuis, C. curta, Platycypha caligata, P. lacustris* and *Notogomphus butoloensis* are all seasonal. At least around November and December they do not appear at the rivers. *Chlorocypha curta* was only found once in September 1996. As this is a very conspicuous dragonfly it seems to be restricted to a very short breeding season or is probably rare. *Tetrathemis corduliformis, Notiothemis jonesi* and *N. robertsi* may be non-seasonal. I have found reproducing and hatching animals at all times.

Hemistigma albipuncta, Lestes virgatus and *Lokia coryndoni* were only found deep in the forest away from rivers, pools and glades. They may be highly seasonal, or may reproduce in phytotelmata like *Hadrothemis camarense*. The latter was first found in Kakamega Forest while investigating tree holes for mosquito larvae (Copeland *et al.*, 1996). I observed hatching *H. camarense* in tree holes in *Ficus exasperata,* far away from surface water.

Despite spending some time looking for adults, I never succeeded and could only collect exuvae at some other *Ficus*. Little is known about the reproductive behaviour of this species.

Table I. Classified species list of dragonflies observed in Kakamega Forest, Kenya; ***x****: new record for Kenya;* ***K****: in Kenya found only in Kakamega Forest;* ***GL****: glades away from water,* ***RF****: inside the forest away from rivers,* ***RI****: inside the forest along rivers,* ***DI****: disturbed areas along rivers; ☹: shady, 😐: sun-flecked, ☺: sun-exposed*

Family	Species	Distribution			Habitat
Lestidae	*Lestes virgatus*			RF	☹
Protoneuridae	*Chlorocnemis pauli*	x	K	RI	☹😐
Coenagriidae	*Enallagma elongata*			DI	☺😐
	E. glaucum			DI	☺
	E. pseudelongatum			RI	😐
	E. subtile			DI	☺
	Pseudagrion hageni tropicanum			RI, DI	☹😐
	P. guicharci	x	K	RI	😐
	P. kibalense	x	K	RI	😐
	P. melanicterum	x	K	RI	😐
	P. spernatum			RI	☹😐
	P. spernatum gerstaeckeri			RI, DI	😐
Calopterygidae	*Umma sapharina*		K	RI, RF	☹😐
Chlorocyphidae	*Chlorocypha curta*		K	RI	😐
	C. tenuis			RI	😐
	Platycypha caligata			RI, DI	😐
	P. lacustris		K	RI	😐
	P. l. chingolae	x	K	RI	😐
Gomphidae	*Notogomphus butoloensis*			RI	😐
	N. luja	x	K	RI	😐
Aeshnidae	*Aeshna ellioti*			GL	☺
	Anaciaeshna triangulifera			GL	😐☺
	Anax imperator mauritianus			GL	☺
	A. speratus			GL, DI	😐☺
	Gynacantha bullata		K	RI	☹
Corduliidae	*Macromia sylvatica*		K	RI, GL	😐
Libellulidae	*Atoconeura eudoxia*	x	K	GL, RF	😐
	Crocothemis erythraea			GL	☺
	Hadrothemis camarense		K	RF	?
	Hemistigma albipuncta			RF	☹😐
	Lokia coryndoni	x	K	RF	😐
	Micromacromia camerunica		K	RI	☹😐
	Notiothemis jonesi		K	RI	☹😐
	N. robertsi	x	K	RI	☹😐
	Orthethrum brachiale			GL	☺
	O. chrysostigma			GL	☺
	O. guineense			RF	😐☺
	O. julia falsum			GL, DI	☺
	O. machadoi			GL	☺
	O. microstigma			GL	☺
	O. trinacria			GL	☺
	Palpopleura deceptor			GL, DI	😐☺
	P. lucia			GL, DI	☺
	P. lucia f. *portia*			GL, DI	☺
	Pantala flavescens			GL	☺
	Tetrathemis corduliformis	x	K	RI	☹😐
	T. polleni			DI	☺
	Trapezostigma basilaris			GL	☺
	Trithemis stictica			DI	☺
	Urothemis edwardsii			DI	☺
	Zygonyx natalensis			GL, DI	😐

Anaciaeshna triangulifera spends most of the day hanging attached to the vegetation in the shade at about 2 m above the ground. At dusk this species hunts above natural and artificial glades. Sometimes big feeding swarms with *Anaciaeshna triangulifera, Anax imperator mauritianus* and *A. speratus* are formed along forest margins.

Gynacantha bullata was quite common in the deeply shaded regions of the rain forest, always in the vicinity of small rivers or pools. Most of the day the adults spend hanging under leaves like *Anaciaeshna triangulifera.* They move a short distance only when being directly disturbed.

Out of 25 recorded gomphids from Kenya (Clausnitzer, 2000) only two were found in Kakamega Forest, both *Notogomphus* ssp. A similar paucity of forest-stream gomphids is described for Uganda (Miller, 1995), in comparison to West and Central Africa. These consist of vast alluvial plains textured by endless branching rivers. East Africa lacks this river system, which might be one reason for the paucity of forest-stream gomphids.

DISCUSSION

Species that were found in glades (GL) and disturbed areas (DI) depend on direct sun. A lot of these dragonflies are common all over Kenya, inhabiting rivers and pools in savannah and thorn-bush landscapes. They are not confined to rain forest, and benefit from fragmentation of the natural rain forest. *Pantala flavescens* for example reproduces successfully in glades in rain forest as well as in the desert areas in Northern Kenya in puddles after occasional rainfall.

Heliophobic species are restricted to the rain forest areas (RF, RI). Most of these dragonflies are not found any more, if areas larger than about 20 m in diameter are cleared. Reproduction takes place in full shade (*e.g. Chlorocnemis pauli, Micromacromia camerunica*) or in sun-flecked spots (*e.g. Notiothemis, Tetrathemis corduliformis*). Special attention should be paid to these species. Records of rain forest species in Kenya and neighbouring countries are incomplete. Nearly no data has been collected about ecology and habitat needs of these specialised dragonflies, *e.g.* minimum size of forest patches to support a viable population (Miller, 1995).

Most of the rain forest species can be divided in three groups, referring to colouring, behaviour and habitat selection. As not much has been done on the ethology of rain forest species (*e.g.* Lempert, 1988; Clausnitzer & Lempert, 1998), I refer mainly to colouring and habitat selection.

1) *The inconspicuous*: Most of these species develop an inconspicuous body colouring in both sexes: a dark brown or black ground colour with some yellow markings. The distribution of the yellow spots remains similar in all species, including a bright yellow marking on segment seven, yellow stripes on the thorax, a yellow labrum and a labium with specific black spots. Associated with an unobtrusive behaviour, the black and yellow colouring is an excellent camouflage in the light and shade mosaic on the forest floor. These colour patterns have been developed in different families of the Anisoptera. In some genera nearly all species bear similar characteristics, *e.g. Notogomphus* (Gomphidae), *Macromia* (Corduliidae), *Tetrathemis* (except *Tetrathemis polleni*), *Micromacromia, Notiothemis, Tetrathemis, Atoconeura* (Libellulidae). Related species inhabiting savannah and thorn-bush, *e.g. Tetrathemis polleni*, show a bright colouring and distinctive sexual dimorphism. This extends speculations about a possible correlation between habitat choice and the strength of sexual selection (Miller, 1993). The black and yellow body colouring is

combined with an unobtrusive behaviour and next to no sexual dimorphism. Selection due to predation seem to have a more dominant role than sexual selection.

Another adaptation to cryptic life on forest floors is shown by *Gynacantha* spp. These greenish to brownish coloured large aeshnids are active at twilight and spend most of the day motionless under leaves. Occasionally they change their position or patrol briefly above potential breeding places. Even when disturbed, they rarely leave their resting site and are easily overlooked. Like the species mentioned above, they do not show a distinctive sexual dimorphism. Few observations on courtship, mating and egg-laying behaviour exist (Corbet, 1962; Gambles, 1960).

2) *The semi-conspicuous*: Many damselflies show more striking colouring and behaviour. Species which prefer shady parts of the forest floor with single sunny patches have developed small bright markings, mainly yellow or orange, on the last abdominal segments (*e.g.* Megapodagriidae and some Protoneuridae) or iridescent wings (many Calopterygidae). Male Protoneuridae combine the visible colour patch on their abdomen with a special courtship behaviour. Pinhey (1951) describes this for *Chlorocnemis nigripes*: "... The adults have a dancing movement in flight, in and out of shafts of sunlight, the males holding their abdomen almost vertically downwards...". *Chlorocnemis pauli* shows the same behaviour near stagnant or slow running water under dense vegetation. Due to the twilight the visibility of the dragonfly was reduced to a moving bright spot. This colouring and the inclusion of the shade-light mosaic might be a compromise between a visible courtship behaviour and protection from predators. The iridescent wings and the butterfly-like flight of some Calopterygidae, *e.g. Sapho bicolor* or in this study *Umma sapharina* have a similar effect. These damselflies can be very striking while flying over sun-patches, but "disappear" a moment later in the light-shade mosaic on the forest floor.
3) *The conspicuous*: The Chlorocyphidae are among the most striking dragonflies inhabiting rain forest streams (*e.g.* Miller, 1993; Lempert, 1988). They have bright and extensive body markings, prefer the sunny patches along streams, show a distinctive courtship behaviour and have a marked sexual dimorphism. They resemble libellulids inhabiting savannah streams, *e.g. Trithemis* spp. The preference for the sunny parts of rain forest streams is correlated with sexual dimorphism, courtship behaviour and bright colouring. Most of the Chlorocyphidae seem to depend on clean running water and the vicinity of forest.

Of course there are more, often very specific adaptations to the rain forest habitat. For example *Hadrothemis camarense* does not fit into the categories mentioned above. All *Hadrothemis* spp. are defined to rain forest and develop a more or less conspicuous body colouring. It is likely that *H. camarense* spends nearly all its adult life in the tree canopies. Larvae were more often found in higher than in lower tree holes. The highest investigated tree hole at 22.5 m contained *H. camarense* larvae (Copeland *et al.*, 1996). In West Africa *H. camarense* larvae have been found in tree stumps (Legrand & Couturier, 1985) and in bamboo (Corbet, 1983), but phytotelmata high above the ground have not been examined.

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