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NOTES ON THE SPECIES DIVERSITY OF EAST AFRICAN ODONATA, WITH A CHECKLIST OF SPECIES

V. CLAUSNITZER
Geography Department, University of Marburg, 35032 Marburg, Germany,
e-mail: wesche@mailer.uni-marburg.de

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Preliminary considerations concerning the species diversity of East African dragonflies and the problems of identifying and using such diversity figures are given. For a detailed approach the basic problem is lack of sufficient data in that area. A checklist of species recorded so far for East Africa is given. Looking at pure species number in relation to area, Uganda is definitely more important for dragonfly diversity than its eastern neighbouring countries. If taking endemism and taxonomic singularity into account, the coastal forests of Tanzania and Kenya are very important too.

INTRODUCTION

Biodiversity is a common and frequently used term nowadays, not only in scientist's or conservationist's circles. Although much has been achieved in documenting biodiversity on a broad scale pattern, questions about existing patterns and the understanding of the multiple factors that play a role in the distribution of biodiversity are still a challenge (GASTON, 2000).

Biodiversity is a useful catchword for political argumentation and for fund raising. Most often no further definition is given, whether it is used as species richness (α--diversity), as species diversity with an adjustment for sampling effects and species abundance or as functional diversity with different weighted species, as key-stone species, endemics, etc. If it is used to compare diversity of different areas, difficulties start as to how to weight such parameters as species richness, endemism, distinctness or taxonomic singularity (VANE-WRIGHT et al., 1991).

The present knowledge of East African Odonata is too small to use more than species richness on a very large geographical scale. Functional diversity assumes a profound knowledge of the species ecology and biogeography and is therefore

difficult to apply to dragonflies of tropical Africa, specially for rain forest species. Often mere species lists are either missing or only very local and/or from short term inventories (e.g. CLAUSNITZER & CLAUSNITZER, 1999; MILLER, 1993).

Despite these shortcomings dragonflies prove to be a very good taxon for biodiversity studies, specially if aiming at applied aspects in the long run. Because they are easy to collect and comparatively well studied taxonomically, ecologically and ethologically dragonflies belong to the priority taxa for biodiversity research and as indicator species (DICASTRI et al., 1992; KIM, 1993; STORK & SAMWAYS, 1995). Dragonflies are already widely used and well accepted in Europe for different indication problems (e.g. CORBET, 1993).

The studies of PINHEY (e.g. 1958; 1961; 1962a; 1969; 1970a; 1974; 1980) provide a firm basis for surveying East African dragonflies. Based on Pinhey's works dragonflies are amongst the very few insect groups in tropical Africa for which comprehensive knowledge on systematics, ecology and distribution for the whole region can be acquired in a reasonable frame of time. In the long run, these data can help to generate biodiversity maps and monitoring programs to aid conservation planning and other management-related topics.

African wetlands in general are argued to belong to some of the most productive ecosystems of the world (KABII, 1996). The survey and conservation of this areas needs to have priority status, because of excessive exploitation and other threats, e.g. changes in water quality due to industrial effluent, agricultural pesticides, siltation and the introduction of alien species (e.g. the Nile Perch *Lates niloticus* or the Water Hyacinth *Eichhornia crassipes*).

The area looked at in this account is restricted to Kenya, Tanzania and Uganda only.

DIVERSITY HOT-SPOTS IN EAST AFRICA

Concerning endemism of forest species in general, the lowland and montane forests of western Uganda, the coastal forests of Kenya and the forests of eastern Tanzania are listed as important areas for East Africa (STUART et al. 1990). Some of these coastal forests have hardly been studied (e.g. NJUNGUNA, 1995) but from preliminary work they appear to support high numbers of endemic species from different taxa (Davenport, pers. comm.). The Eastern Arc forests of Tanzania have been classified amongst the 14 most threatened tropical forest hot-spots world-wide (MYERS, 1988; 1990) and are listed amongst the 25 hot-spots on Earth (MYERS et al., 2000). Some of the Arc forests have experienced a comparatively high attention amongst scientists and conservationists (e.g. CAMMAERTS, 1978; HOCHKIRCH, 1996; MAKUNDI, 1995; NEWMARK, 1999), but the most southern ones especially are still "white spots".

In Kenya, the Kakamega Forest is the last guineo-congolian rain forest patch (see Fig. 1) (KOKWARO, 1988) and is listed as "priority biodiversity conservation

area" for the country (WASS, 1995). There is heavy pressure on the forest in terms of logging and fragmentation (e.g. BROOKS et al., 1999). On the national level, the Kakamega Forest is of considerable importance and gains lots of attention (e.g. ROGO et al., 1999). But comparing the Kakamega Forest with forests in Uganda, it is more or less an impoverished form of the latter.

Concerning wetlands in East Africa, Lakes Victoria and Kyoga in Uganda and the swamps of western Tanzania (Fig. 2) are listed as centres of endemism in STUART et al. (1990).

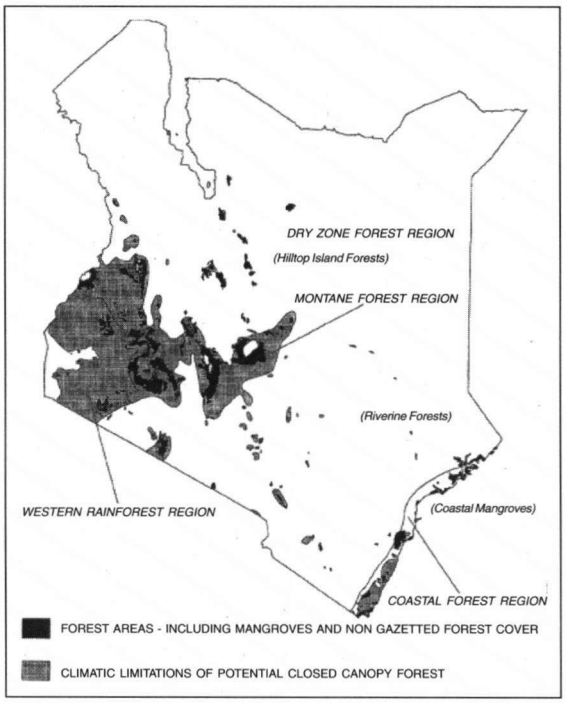


Fig. 1. Distribution of forest and potential forested regions in Kenya (after WASS, 1995).

Kenyan wetlands are more of national importance, since there are only a few of them (CRAFTER et al., 1993). Areas in Kenya, which are important for dragonflies, either in terms of pure species richness or in terms of endemism and taxonomic singularity, coincide with most areas listed as important bird areas (IBA) in BENNUN & NJOROGE (1999).

Unlike Uganda and Kenya the wetlands of Tanzania seem to be hardly studied at all, although almost 10 % of the country's surface area has been estimated to be covered by wetlands (KAMUKALA & CRAFTER, 1993). "Tanzania has extensive but poorly known wetland areas . . . As well as permanent swamps, Tanzania also has seasonally inundated flood plains . . . These (lakes) are all important for their large number of endemic fish and invertebrate species (the details of many of which are poorly known)" (STUART et al., 1990, p. 205).

Uganda is considered as a centre of high biodiversity in Africa (POMEROY, 1993). This is mainly triggered by Uganda's high habitat diversity, ranging from snow-capped mountains to endless swamp and lake areas and its position between the guineo-congolian and the somali-massai savanna region. Most of Uganda's species richness (Tab. 1) is caused by the different forest types and extensive swamp areas (see also HOWARD, 1995b). In Uganda the forest and wetland areas are

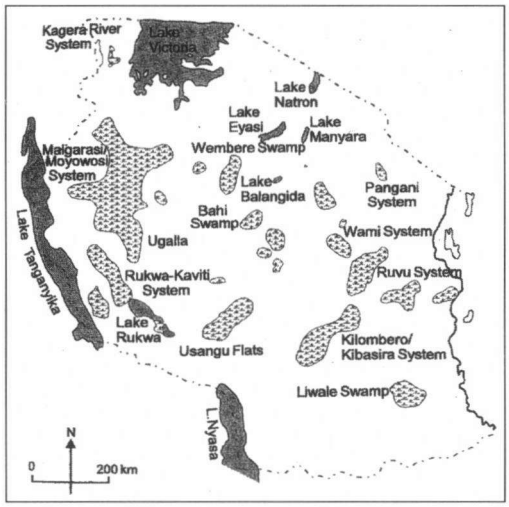


Fig. 2. Map of Tanzania, showing the distribution of swamps and lakes (after KAMUKALA & CRAFTER, 1993).

currently surveyed for different taxa and the data are incorporated in the National Biodiversity Data Bank (e.g. FULLER et al., 1998; POMEROY, 1995; REYNOLDS et al., 1999).

Although mountainous areas in Africa are generally considered to be of high conservation value, they are very poor in dragonfly diversity and endemism. A pond on Mt. Elgon (Saito Dam, 2750 m a.s.l.) was inhabited by five species only (*Aeshna e. ellioti*, *Enallagma pseudelongatum*, *E. subfurcatum*, *E. subtile*, *Orthetrum caffrum*) all of them being very common generally. The highest records are made for *Pseudagrion bicoerulans*, which can be found up to over 3000 m a.s.l. on most mountain ranges. It is the only species which can be found in the heather zone and in the afroalpine zone, but it is most common along rivers in the montane forest. There are only a few endemics, e.g. *Platycypha amboniensis* from Mt. Kenya, or *Amanipodagrion gilliesi* from the Usambara Mts. Similar observations of the impoverishing dragonfly diversity with increasing altitude have been made on other mountainous areas in Africa as well (e.g. SAMWAYS, 1989; VICK, 1999).

PROBLEMS WITH DIVERSITY

As already mentioned in the introduction, it is not easy to decide, which type of diversity measures one chooses, especially when comparing different areas or countries. In conservation circles, diversity generally means species diversity, which might be corrected for area; better would be an inclusion of endemism level. In most cases the question of what to use depends on the data available and background information concerning ecology and biogeography on the species level.

In an study about the diversity of rheophilous Odonata in southern Spain, FERRERAS-ROMERO (1999) used three components of biodiversity: richness, taxonomic singularity and geographic rarity (endemism). The information on biogeography was taken from the whole geographic range.

In the Sango Bay, Uganda a biodiversity assessment was attempted, integrating field data of different taxa and remote sensing (FULLER et al., 1998). Dragonflies were amongst the taxonomic groups surveyed. Diversity was calculated in terms of

species numbers and species uniqueness using the surveyed area as reference. With this method airstrip ponds gained the highest overall total biodiversity values for dragonflies. Without having detailed checklists of the survey, I assume confidently that most of the airstrip species are not the ones with the highest conservation value, but more or less mainly typical widespread and euryotopic species of savanna ponds. The major habitats in the Sango Bay area are swamp forests, with a very high conservation value (ACREMAN & HOLLIS, 1996; HOWARD, 1995a) and some very interesting dragonfly species (see also MILLER, 1995). When finally ranking the surveyed areas in terms of biodiversity values and producing biodiversity maps, FULLER et al. (1998) referred to the airstrip ponds as "special sites" and focused on the swamp forest and other forest habitats.

These examples show clearly the importance of a broad knowledge of the taxa within the biogeographical region, such as that used by FERRERAS-ROMERO (1999). If the approach in the Sango Bay area had been made for dragonflies only, and without any background knowledge, airstrip ponds would have become the most valuable habitat in terms of biodiversity.

SOME FIGURES FOR KENYA, TANZANIA AND UGANDA

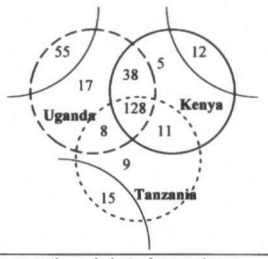
Uganda, even though by far the smallest of the three countries, always comes first in terms of species numbers (Tab. I, Fig. 3). Because of its position between two important biogeographic regions and its extensive wetland and forest areas, it scores for the highest species number. The numbers given in Figure 3 are a bit less than the total number recorded for Uganda (Tab. I), because of species occurring in Uganda and other non-neighbouring countries, e.g. Cameroon. One might argue, that it is a simple bias in study intensity, but this definitely does not apply to Kenya. It is true to some extent for Tanzania, e.g. there are some species with records for Malawi or Zambia and Kenya, but not for Tanzania (see Checklist).

Tanzania, although comparatively poor in species richness (at the present state of knowledge) is the only country with species mentioned in the "Red List of

Table I

Odonates recorded in Kenya, Tanzania and Uganda; neighbouring countries are: Somalia, Ethiopia, Sudan, DRC, Rwanda, Burundi, Zambia, Malawi, Mozambique – [mainly based on literature surveys]

	km^2	Species	Species common to all 3 countries	Species occurring in at least one of the 3 countries	Species occurring in at least 3 countries or in a neighbouring one
Kenya	582,646	194			
Tanzania	942,444	171	128	296	439
Uganda	236,038	249			



Species:	occurring only in 1 of the 3 countries and in neighbouring ones	occurring exclusively in that country	common to only 2 of the 3 countries
Kenya	12	5	11
Tanzania	15	9	8
Uganda	55	17	38

Fig. 3. Odonates recorded only in one or two of the countries Kenya, Tanzania and Uganda, neighbouring countries are: Somalia, Ethiopia, Sudan, DRC, Rwanda, Burundi, Zambia, Malawi, Mozambique [mainly based on literature surveys].

Threatened Animals" (*Amanipodagrion gilliesi*, *Aeshna meruensis*) and in the "Priority Species: Species of Monotypic Genera confined to one country" list (*Amanipodagrion gilliesi*, *Nepogomphoides stuhlmanni*) (MOORE, 1997). One species (*Coryphagrion grandis*) is listed for Kenya and Tanzania under the "Priority species: taxonomically isolated species" (MOORE, 1997), the given distribution "Uganda" is an incorrect locality interpretation (see PINHEY, 1961) and "Mozambique" is later doubted by PINHEY (1981). No dragonfly species occurring in Uganda is mentioned in the "Status Survey and Conservation Action Plan". Of course it is again partially a result of data deficiencies, but taking into account the fact that Tanzania is definitely the worst surveyed country, Uganda is comparatively poor in species with special conservation status.

VICK (1999) lists 180 species for the South-West province of Cameroon and expects a total of at least 200 species. Kenya is about 24 times the area of the province and has a record of at least 194 species (CLAUSNITZER, 1999). Although an increase in Kenya's species number can be confidently expected, it will never reach anywhere near to the area species relation observed in Cameroon. Some areas in Uganda, especially if different habitats along altitudinal gradients are covered, might reach comparative species densities to those observed in Cameroon.

In South Africa 29 dragonfly species (18.7%) are endemic to the area (SAMWAYS, 1999). Looking at the present information available for Kenya, Uganda and Tanzania (Tab. I and Checklist) the degree of endemism is slightly above 5% in each country. But even after an intense survey in all areas, I doubt whether these countries will have a level of endemism comparative to the Cape Region. The percentage of endemics in each country separately from the total dragonfly fauna is even more likely to decrease.

CHECKLIST OF DRAGONFLIES RECORDED IN KENYA, TANZANIA AND UGANDA

Neighbouring countries are only considered, if species have been recorded there and not in Kenya, Uganda and/or Tanzania, but are likely to occur there. Genera

and species are listed alphabetically. The survey is based on BARLOW, 1996, CONSIGLIO 1978a, 1978b, DUMONT 1978, FRASER 1953, 1955, GAMBLES 1979, PINHEY 1961, 1962a, 1962b, 1964, 1966, 1967a, 1967b, 1969, 1970a, 1970b, 1971, 1974, 1978, 1981b, 1982, 1984a, 1984b, 1985 and own records. E. Afr: recorded for Uganda, Kenya and Tanzania (not necessarily exclusive); – DRC: Democratic Republic of Congo (former Zaire); – Moz: Mozambique; – Zam: Zambia; – Mal: Malawi; – Eth: Ethiopia; – Som: Somalia; – Sud: Sudan; – Burundi and Rwanda are not listed separately.

Chlorolestidae	
Chlorolestes elegans Pinhey, 1950	Mal
Lestidae	
Lestes amicus Martin, 1910	s.Tanzania, Moz, s.DRC
L. dissimulans Fraser, 1955	E. Afr.
L. ictericus Gerstäcker, 1869	E. Afr.
L. ochraceus Selys, 1862	Kenya, Mal, Zam,
L. pallidus Ramber, 1842	E. Afr.
L. pallidus f *somalicus* Förster, 1906	Kenya, Uganda, Zam
L. pallidus f. *stigmaticus* Navas, 1924	Kenya, Uganda
L. pallidus f *wahlbergi* (Ris, 1921)	Zam
L. pinheyi Fraser, 1955	Moz, s.DRC
L. plagiatus (Burmeister, 1839)	E. Afr.
L. tridens McLachlan, 1895	E. Afr.
L. uncifer Karsch, 1899	E. Afr.
L. unicolor aldabrensis Pinhey, 1967	Tanzania, Kenya (islands)
L. virgatus (Burmeister, 1839)	E. Afr.
Protoneuridae	
Chlorocnemis abbotti (Calvert, 1892)	Kenya, Tanzania
C. m. marshalli Ris, 1921	Mal
C. marshalli superba Schmidt, 1951	Uganda, DRC
C. montana St. Quentin, 1942	s.Tanzania
C. nigripes semlikiensis Pinhey 1969	Uganda
C. pauli Longfield, 1936	Uganda, Kenya
C. wittei Fraser, 1955	Uganda, s.DRC, Moz, Zam
Elattoneura glauca (Selys, 1860)	E. Afr.
E. pasquinii Consiglio, 1978	Eth
E. tropicalis Pinhey, 1974	E. Afr.
Isomecocnemis cellularis Grünberg, 1902	s.Tanzania
Prodasineura flavifacies Pinhey, 1981	n.Zam
Platycnemididae	
Allocnemis mitwabae Pinhey, 1961	s.DRC
Mesocnemis robusta (Selys, 1886)	Sud
M. singularis Karsch, 1891	E. Afr.
Oreocnemis phoenix Pinhey, 1971	Mal
Platycnemis congolensis Martin, 1908	Uganda, ?Kenya
P. flavipes Navás, 1924	Uganda, ?Kenya
P. nyansana Förster, 1916	Uganda
P. xanthopus Navás, 1924	E. Afr.
Megapodagrionidae	
Amanipodagrion gilliesi Pinhey, 1962	n.Tanzania
Coryphagrion grandis Morton, 1924	Kenya, Tanzania
Coenagrionidae	
Aciagrion africanum Martin, 1908	Zam, Moz, s.DRC, Mal
A. congoense (Sjöstedt, 1917)	Uganda, DRC, Moz
A. gracile attenuatum Fraser, 1928	Mal, Moz, Zam
A. g. gracile (Sjöstedt, 1909)	E. Afr.
A. hamoni Fraser, 1955	Uganda, DRC
A. h. heterostigma Fraser, 1955	Zam, s.DRC
A. heterostigma karamoja Pinhey, 1972	Uganda
A. s. steeleae Kimmins, 1955	Zam, DRC
A. steeleae f. *abercornensis* Pinhey, 1958	Zam, ? s.Tanzania

A. zambiense Pinhey, 1972	Zam
Agriocnemis aligulae Pinhey, 1974	Uganda, DRC
A. exilis Selys, 1872	E. Afr.
A. forcipata Le Roi, 1915	Zam, DRC, Sud
A. gratiosa Gerstäcker, 1891	Uganda, Tanzania, s.Sud
A. inversa Karsch, 1899	Uganda, Kenya, DRC
A. palaeforma Pinhey, 1959	Uganda
A. pinheyi Balinsky, 1963	Moz, Zam
A. pygmea sania Nielsen, 1959	n.Kenya, Eth
A. victoria Fraser, 1928	Uganda, Zam
A. zerafica Le Roi, 1915	Uganda, Kenya, s.Sud, Zam,
Ceriagrion bakeri Fraser, 1941	Uganda, Zam, s.DRC, ? Kenya
C. bidentatum Fraser, 1941	Uganda, DRC, Mal
C. corallinum Campion, 1914	Uganda
C. glabrum (Burmeister, 1839)	E. Afr.
C. katamborae Pinhey, 1961	Zam
C. kordofanicum Ris, 1924	E. Afr.
C. moorei Longfield, 1952	Uganda, Kenya
C. platystigma Fraser, 1941	Uganda, Kenya, Zam
C. sanguinostigma Fraser, 1955	Uganda, Zam, s.DRC
C. suave Ris, 1921	E. Afr.
C. whellani Longfield, 1952	E. Afr.
Enallagma elongatum (Martin, 1907)	E. Afr.
E. glaucum (Burmeister, 1893)	E. Afr.
E. longfieldae Fraser, 1947	Kenya, Uganda
E. nigridorsum Selys, 1876	E. Afr.
E. pseudelongatum Longfield, 1936	E. Afr.
E. sinuatum Ris, 1921	Tanzania, Zam, DRC
E. somalicum Longfield, 1931	Som
E. subfurcatum Selys, 1876	E. Afr.
E. subtile Ris, 1921	E. Afr.
E. vansomereni Pinhey, 1955	n.Uganda
Ishnura senegalensis (Rambur, 1842)	E. Afr.
Mortonagrion stygium (Fraser, 1954)	n.Uganda, DRC
Pseudagrion acaciae Förster, 1906	E. Afr.
P. assegaii Pinhey, 1950	Zam
P. basicornu Schmidt, 1936	DCR
P. bicoerulans Martin, 1907	Kenya, n.Tanzania
P. coelestis Longfield, 1947	Zam, Mal
P. coelestis samfyae Pinhey, 1964	Zam
P. commoniae nigerrimum Pinhey, 1950	E. Afr.
P. deningi Pinhey, 1961	Zam, s.DRC
P. epiphonematicum Karsch, 1891	DRC, ?Uganda
P. flavipes Sjöstedt, 1900	DRC
P. fisheri Pinhey, 1961	Zam
P. gamblesi Pinhey, 1978	E. Afr.
P. glaucescens Selys, 1876	E. Afr.
P. glaucoideum Schmidt, 1936	DRC
P. greeni Pinhey, 1961	Zam, s.DRC
P. guichardi Kimmins, 1958	Kenya, Eth
P. hageni tropicanum Pinhey, 1966	E. Afr.
P. hamoni Fraser, 1955	E. Afr.
P. helenae Balinsky, 1964	Zam, Mal
P. inconspicuum Ris, 1931	Zam, Mal, s.DRC
P. kaffinum Coniglio, 1978	Eth
P. kersteni (Gerstäcker, 1869)	E. Afr.
P. kibalense Longfield, 1959	Uganda, Kenya, Zam, DRC
P. lindicum Grünberg, 1902	Kenya, Tanzania
P. makabusiensis Pinhey, 1950	Zam
P. massaicum Sjöstedt, 1909	E. Afr.
P. melanicterum Selys, 1876	E. Afr.
P. niloticum Dumont, 1978	Eth
P. nubicum Selys, 1876	E. Afr.
P. quadrioculatum Pinhey, 1964	DRC
P. r. risi Schmidt, 1936	DRC
P. risi rufocinctum Pinhey, 1955	Uganda
P. rufostigma Longfield, 1947	Zam
P. salisburyense Ris, 1921	E. Afr.
P. serrulatum Karsch, 1893	DRC
P. sjöstedti beadlei Pinhey, 1961	Zam, Uganda, ?Kenya
P. sjöstedti jacksoni Pinhey, 1961	Uganda, Zam, s.DRC
P. sjöstedti pseudosjöstedti Pinhey, 1964	Tanzania, Moz
P. s. sjöstedti Förster, 1906	E. Afr.
P. sjöstedti wittei Fraser, 1949	DRC
P. spernatum gerstaeckeri	E. Afr.

Karsch, 1899	
P. spernatum natalense Ris, 1921	Zam, Mal
P. s. spernatum Selys, 1881	E. Afr.
P. sublacteum (Karsch, 1893)	E. Afr.
P. sublacteum f *rusingae* Pinhey, 1956	E. Afr. (L. Victoria)
P. s. sudanicum Le Roi, 1915	Sud, n.DRC
P. sudanicum rubroviride Pinhey, 1955	Uganda, Zam, DRC, Mal
P. sudanicum f *vansomereni* Pinhey, 1961	n.Uganda
P. symoensii Pinhey, 1967	Zam
P. thenartum Fraser, 1955	DRC
P. torridum Selys, 1876	Kenya, Uganda, DRC
P. torridum f *orientis* Schmidt, 1951	n.Kenya
P. williamsi Pinhey, 1961	Zam
Calopterygidae	
Phaon iridipennis (Burmeister, 1839)	E. Afr.
Umma cincta (Hagen, 1853)	DRC
U. declivium Förster, 1906	Tanzania
U. distincta Longfield, 1933	Zam, s.DRC
U. electa Longfield, 1933	s.DRC
U. longistigma (Selys, 1869)	DRC
U. saphirina Förster, 1916	Uganda, Kenya
Chlorocyphidae	
Chlorocypha aphrodite Le Roi, 1915	DRC
C. consueta (Karsch, 1899)	s.Tanzania, DRC
C. curta (Hagen, 1853)	w.Kenya, Uganda
C. curta f *curta* (Hagen, 1853)	n.DRC
C. cyanifrons (Selys, 1873)	DRC
C. frigida Pinhey, 1961	nw.Zam
C. hintzii (Grünberg, 1914)	Uganda
C. jacksoni basilewsky Fraser, 1955	Burundi
C. j. jacksoni Pinhey, 1952	w.Uganda
C. molindica Fraser, 1948	Uganda, DRC
C. molindica hasta Pinhey, 1960	Tanzania
C. rubida (Hagen, 1853)	DRC, ?Uganda
C. schmidti Pinhey, 1967	nw.Tanzania, DRC
C. selysi Karsch, 1899	?DRC
C. tenuis Longfield, 1936	w.Kenya, Uganda
C. trifaria (Karsch, 1899)	Uganda, DRC, s.Sud
C. victoriae (Förster, 1914)	Uganda, DRC
C. wittei Fraser, 1955	n.Zam, s.DRC
Platycypha amboniensis (Martin, 1915)	Kenya (central Mts)
P. auripes (Förster, 1906)	Tanzania (coast)
P. c. caligata (Selys, 1853)	E. Afr.
P. l. lacustris (Förster, 1911)	Uganda, w.Kenya, DRC
P. lacustris chingolae Pinhey, 1962	Kenya, Zam, s.DRC
P. pinheyi Fraser, 1950	Tanzania
Gomphidae	
Ceratogomphus pictus Selys, 1854	s.DRC, Zam
Cinitogomphus d. dundoensis (Pinhey, 1961)	n.Zam, s.DRC
Crenigomphus abyssinicus (Selys, 1878)	Eth
C. cornutus Pinhey, 1956	Zam, ?s.DRC
C. denticulatus Selys, 1892	Eth
C. hartmanni (Förster, 1898)	E. Afr.
C. renei Fraser, 1936	E. Afr.
Diastatomma ruwenzorica Pinhey, 1961	Uganda (Ruwenzori)
D. selysi Schouteden, 1934	Zam, DRC
D. soror Schouteden, 1934	N.Zam, DRC
Gomphidia bredoi Schouteden, 1934	Uganda, Tanzania
G. madi Pinhey, 1961	Uganda
G. quarrei confinii Pinhey, 1974	Moz
G. quarrei Schouteden, 1934	Kenya, s.DRC, Mal
Ictinogomphus ferox (Rambur, 1842)	E. Afr.
Lestinogomphus africanus (Fraser, 1926)	Tanzania, Uganda, Kenya
L. angustus Martin, 1911	E. Africa
Microgomphus mozambicensis Pinhey, 1959	Moz
M. nyassicus (Grünberg, 1902)	s.Tanzania, n.Zam, s.DRC
M. schoutedeni (Fraser, 1949)	Uganda
Nepogomphoides stuhlmannii Karsch, 1899	Tanzania
Neurogomphus agilis (Martin, 1908)	DRC
N. featheri Pinhey, 1967	w.Kenya
N. fuscifrons Karsch, 1890	Uganda
N. martininus (Lacroix, 1921)	DRC

N. pinheyi Cammaerts, 1968	Kenya, Uganda
N. uelensis Schouteden, 1934	Tanzania, DRC
N. wittei Schouteden, 1934	w.Kenya, DRC, Zam
Notogomphus butoloensis Fraser, 1952	Uganda, w.Kenya
N. cataractae Consiglio, 1978	Eth
N. cottarellii Consiglio, 1978	Eth
N. dendrohyrax (Förster, 1906)	Tanzania
N. dorsalis (Selys, 1857)	Uganda, w.Kenya
N. flavifrons Fraser, 1952	Kenya, Uganda
N. immisericor Campion, 1923	w.Kenya
N. kilimanjaricus (Sjöstedt, 1909)	Tanzania, Kenya
N. lecythus Campion, 1923	Eth
N. leroyi (Schouteden, 1934)	Uganda
N. lujai (Schouteden, 1934)	Uganda, w.Kenya
N. meruensis (Sjöstedt, 1909)	n.Tanzania, Kenya
N. nigripes (Sjöstedt, 1909)	Tanzania
N. praetorius (Selys, 1878)	Zam, s.DRC
N. rueppeli (Selys, 1858)	Eth, Kenya
N. speciosus (Sjöstedt, 1909)	E. Afr.
N. zernyi (St. Quentin, 1942)	s.Tanzania
Onychogomphus bwambae Pinhey, 1961	Uganda
O. kitchingmani Pinhey, 1961	Zam
O. pilosus (Martin, 1911)	Tanzania
O. quirkii Pinhey, 1964	Zam
O. styx Pinhey, 1961	Uganda, Tanzania
O. supinus Selys, 1854	Moz
O. supinus nigrotibialis Sjöstedt, 1909	E. Afr.
Paragomhpus alluaudi (Martin, 1915)	Kenya, Tanzania
P. cataractae Pinhey, 1963	Zam
P. cognatus (Rambur, 1842)	E. Afr.
P. elpidius (Ris, 1921)	E. Afr.
P. fritillarius f *acuminatus* (Selys, 1892)	DRC
P. fritillarius f *sabicus* Pinhey, 1950	Moz
P. genei (Selys, 1841)	E. Afr.
P. magnus Fraser, 1952	e.Kenya, Moz
P. nyassicus Kimmins, 1955	Mal
P. pumilio (Rambur, 1842)	n.Kenya, Eth, Sud
P. viridior Pinhey, 1961	Kenya, Uganda
P. zambeziensis Pinhey, 1961	Zam
Phyllogomphus brunneus Pinhey, 1976	Zam
P. latifasciae Pinhey, 1961	Mal
P. orientalis Fraser, 1957	Kenya, Uganda
P. symoensis Lieftinck, 1969	s.DRC, ?Zam
Aeshnidae	
Aeshna e. ellioti Kirby, 1896	E. Afr.
A. ellioti usambarica (Förster, 1906)	ne.Tanzania, Kenya Moz
A. meruensis Sjöstedt, 1909	Tanzania, ? Kenya
A. moori Pinhey, 1981	nw.Zam
A. rileyi (Calver, 1892)	E. Afr.
A. subpupillata (McLachlan, 1896)	Moz
A. wittei Fraser, 1955	Zam, s.DRC
Anaciaeshna triangulifera McLachlan, 1896	E. Afr.
Anax bangweulensis Kimmins, 1955	Zam
A. chloromelas Ris, 1911	Uganda, Mal, Zam, Moz, DRC
A. congoliath Fraser, 1953	DRC
A. ephippiger (Burmeister, 1809)	E. Afr.
A. imperator mauricianus Rambur, 1842	E. Afr.
A. parthenope Selys, 1839	Som
A. speratus Hagen, 1867	E. Afr.
A. tristis Hagen, 1867	E. Afr.
Gynacantha africana (P.deBeauvois, 1805)	Uganda
G. bullata Karsch, 1891	Uganda, Kenya, Mal
G. cylindrata Karsch, 1891	Uganda, Som
G. manderica Grünberg, 1902	E. Afr.
G. ochraceipes (Pinhey, 1960)	Tanzania
G. sevastopoloi Pinhey, 1961	Tanzania, Uganda
G. sextans McLachlan, 1896	Zam, DRC
G. usambarica Sjöstedt, 1909	Tanzania, Kenya
G. vesiculata Karsch, 1891	E. Afr.
G. victoriae (Pinhey, 1961)	Uganda
G. villosa Grünberg, 1902	E. Afr.
G. zuluensis (Balinsky, 1961)	Mal, Moz
Heliaeshna cynthiae Fraser, 1939	Zam, Uganda
H. libyana (Fraser, 1928)	Uganda
H. trinervulata Fraser, 1955	Uganda, Tanzania
H. ugandica McLachlan, 1896	Uganda, ? Kenya
H. ukerewensis Pinhey, 1961	Tanzania
Corduliidae	
Hemicordulia asiatica Selys, 1878	Uganda, Mal

Phyllomacromia africana Selys, 1871	Uganda, ?Mal
P. aureozona Pinhey, 1966	DRC
P. bifasciata (Martin, 1912)	E. Afr.
P. bispina Fraser, 1954	Uganda, Zam, DRC
P. congolica Fraser, 1955	DRC
P. flavimitella Pinhey, 1966	Uganda
P. kimminsi junior Pinhey, 1961	E. Afr.
P. melania Selys, 1871	Uganda
P. monoceros Förster, 1906	E. Afr.
P. nyanzana Grünberg, 1911	E. Afr.
P. overlaeti Schouteden, 1934	Zam, DRC
P. pallidinervis (Förster, 1906)	Kenya
P. paula Karsch, 1892	Som, DRC
P. picta Selys, 1871	E. Afr.
P. pseudafricana Pinhey, 1961	Uganda
P. seydeli Fraser, 1954	DRC
P. subtropicalis Fraser, 1954	Zam, DRC
P. sylvatica Fraser, 1954	w.Kenya, Uganda
P. unifasciata Fraser, 1954	Zam, s.DRC
L i b e l l u l i d a e	
Acisoma panorpoides ascalaphoides Rambur, 1842	E. Afr.
A. trifida Kirby, 1889	E. Afr.
Aethiothemis bequaerti Ris, 1919	Mal, Zam, s.DRC
A. carpenteri (Fraser, 1944)	Uganda
A. diamangae Longfield, 1959	Zam, Mal, s.DRC
A. discrepans Lieftinck, 1969	Zam, s.DRC, Mal
A. mediofasciata Ris, 1931	Mal
A. palustris Martin, 1912	?Som
Aethriamanta rezia Kirby, 1889	E. Afr.
Allorhizucha klingi Karsch, 1890	Zam, DRC
A. preussi Karsch, 1891	Uganda, Zam, DRC
Atoconeura b. biordinata Karsch, 1899	Tanzania, DRC
A. biordinata kenya Longfield, 1953	Kenya
A. biordinata pseudeudoxia Longfield, 1953	Uganda
A. eudoxia (Kirby, 1909)	Uganda, w.Kenya
Brachythemis lacustris (Kirby, 1889)	E. Afr.
B. leucosticta (Burmeister, 1839)	E. Afr.
B. wilsoni Pinhey, 1952	n.Uganda, s.Sud,
Bradinopyga cornuta Ris, 1911	E. Afr.
B. strachani (Kirby, 1900)	E. Afr.
Chalcostephia flavifrons Kirby, 1889	E. Afr.
Crocothemis brevistigma Pinhey, 1961	n.Zam
C. divisa Karsch, 1898	E. Afr.
C. erythrea (Brullé, 1832)	E. Afr.
C. sanguinolenta (Burmeister, 1839)	E. Afr.
C. saxicolor Ris, 1919	Mal, Moz, Zam
Cyanothemis simpsoni Ris, 1915	DRC
Diplacodes deminuta Lieftinck, 1969	Kenya, Uganda, Mal, Zam
D. lefebvrii (Rambur, 1842)	E. Afr.
D. okavangoensis Pinhey, 1976	Zam
Eleuthemis buettikoferi Ris, 1910	Uganda, Tanzania
E. quadrigutta Pinhey, 1974	Moz
Hadrothemis camarensis (Kirby, 1889)	Uganda, Kenya
H. coacta (Karsch, 1891)	Uganda
H. defecta pseudodefecta Pinhey, 1961	Uganda
H. defecta (Karsch, 1891)	DRC
H. infesta (Karsch , 1891)	Uganda
H. scabifrons Ris, 1910	Kenya, Tanzania
H. versuta (Karsch, 1891)	Zam, DRC
Hemistigma albipunctata (Rambur, 1842)	E. Afr.
Lokia berenice Fraser, 1953	DRC
L. circe (Ris, 1910)	DRC
L. coryndoni Fraser, 1953	Uganda, Kenya
L. ellioti Lieftinck, 1969	Zam
L. erythromelas Ris, 1910	DRC
L. gamblesi Lieftinck, 1969	Zam
L. incongruens (Karsch, 1893)	?Uganda, DRC
Macrodiplax cora (Kaup, 1867)	Som
Malgassophlebia b. bispina Fraser, 1958	DRC
M. bsipina longistipes (Pinhey, 1964)	nw.Zam
Micromacromia cameruni-ca Karsch, 1890	Kenya, Uganda

M. miraculosa (Förster, 1906)	Tanzania
Monardithemis flava Longfield, 1947	Zam
Neodythemis fitzgeraldi Pinhey, 1961	n.Zam, ?s.Tanzania
Nesciothemis farinosa (Förster, 1898)	E. Afr.
N. fitzgeraldi Pinhey, 1955	n.Zam
Notiothemis j. jonesi Ris, 1919	E. Afr.
N. jonesi auricolor Fraser, 1944	Uganda
N. robertsi Fraser, 1944	Uganda, Kenya, Zam, DRC
Olpogastra fraseri Pinhey, 1955	Uganda
O. fuelleborni Grünberg, 1902	E. Afr.
O. lugubris (Karsch, 1895)	E. Afr.
Orthetrum abbotti Calvert, 1892	E. Afr.
O. africanum (Selys, 1887)	DRC
O. angustiventre (Rambur, 1842)	Uganda, Kenya, Zam
O. austeni (Kirby, 1900)	Uganda, Zam
O. brachiale (P.deBeauvois, 1805)	E. Afr.
O. caffrum (Burmeister, 1839)	E. Afr.
O. caffrum camerunense Gambles, 1959	DRC (Ruwenzori)
O. chrysostigma (Burmeister, 1839)	E. Afr.
O. guineense Ris, 1910	E. Afr.
O. hintzii Schmidt, 1951	E. Afr.
O. icteromelans cinctifrons Pinhey, 1970	E. Afr.
O. j. falsum Longfield, 1955	E. Afr.
O. j. julia Kirby, 1900	Uganda, w.Kenya, Mal
O. kristenseni Ris, 1911	Eth
O. latihami Pinhey, 1966	DRC
O. machadoi Longfield, 1955	E. Afr.
O. macrostigma Longfield, 1947	Tanzania, s.DRC
O. microstigma Ris, 1911	E. Afr.
O. monardi Schmidt, 1951	E. Afr.
O. ransonneti (Brauer, 1865)	Sud
O. robustum Banlinsky, 1965	n.Zam
O. sabina (Drury, 1770)	Sud
O. saegeri Pinhey, 1966	Uganda, Zam, DRC
O. stemmale (Burmeister, 1839)	E. Afr.
O. taeniolatum (Schneider, 1845)	Som, Sud, n.Kenya
O. trinacria (Selys, 1841)	E. Afr.
Oxythemis phoenicosceles Ris, 1910	Uganda
Palpopleura deceptor (Calvert, 1899)	E. Afr.
P. jucunda (Rambur, 1842)	E. Afr.
P. jucunda radiata Pinhey, 1982	Som
P. lucia (Drury, 1773)	E. Afr.
P. lucia portia (Drury, 1773)	E. Afr.
Pantala flavescens (Fabricius, 1798)	E. Afr.
Parazyxomma flavicans (Martin, 1908)	Uganda
Philonomon luminans (Karsch, 1893)	E. Afr.
Porpax asperipes Karsch, 1896	Zam, DRC
P. risi Pinhey, 1958	Moz, Zam
Rhyothemis mariposa Ris, 1913	Zam, s.DRC
R. notata fenestrina (Rambur, 1842)	E. Afr. (Cl)
R. semihyalina separata (Selys, 1849)	E. Afr.
Sympetrum fonscolombei (Selys), 1840	E. Afr.
S. navasi Lacroix, 1921	Uganda, Kenya, Mal
Tetrathemis bifida Fraser, 1941	Uganda
T. camerunensis (Sjöstedt, 1900)	Uganda
T. corduliformis Longfield, 1936	Uganda, Kenya
T. denticauda Fraser, 1954	Uganda
T. polleni (Selys, 1877)	E. Afr.
T. ruwensoriensis Fraser, 1941	Uganda
Thermochoria equivocata Kirby, 1889	Uganda, Zam, Mal
T. jeanneli Martin, 1915	Kenya, Tanzania
Tholymis tillarga (Fabricius, 1798)	E. Afr.
Tramea basilaris (P.deBeauvois, 1805)	E. Afr.
T. continentalis (Selys, 1878)	E. Afr.
Trithemis aconita Lieftinck,	E. Afr.

1969	
T. aenea Pinhey, 1961	DRC
T. africana tropicana Fraser, 1953	DRC
T. annulata (P.deBeauvois, 1805)	E. Afr.
T. anomala Pinhey, 1955	n.Zam, ?s.DRC
T. arteriosa (Burmeister, 1839)	E. Afr.
T. basitincta Ris, 1912	Uganda, Kenya
T. bifida Pinhey, 1970	Kenya, Zam
T. bredoi Fraser, 1953	DRC
T. congolica Pinhey, 1970	DCR
T. dichroa Karsch, 1893	Uganda, Sud, Zam
T. donaldsoni (Calvert, 1899)	E. Afr.
T. dorsalis (Rambur, 1842)	E. Afr.
T. ellenbecki Förster, 1906	Eth
T. furva Karsch, 1899	E. Afr.
T. grouti atra Pinhey, 1961	?Uganda, Zam
T. g. grouti Pinhey, 1961	DRC
T. hecate Ris, 1912	E. Afr.
T. imitata Pinhey, 1961	Uganda, w.Kenya
T. kalula Kirby, 1900	DRC
T. kirby ardens (Gerstäcker, 1891)	E. Afr.
T. monardi insuffusa Pinhey, 1970	Zam, Mal, Moz
T. nuptialis Karsch, 1894	Uganda, Zam
T. pluvialis Förster, 1906	E. Afr.
T. pruinata Karsch, 1899	E. Afr.
T. stictica (Burmeister, 1839)	E. Afr.
T. werneri Ris, 1912	E. Afr.
Urothemis assignata (Selys, 1872)	E. Afr.
U. edwardsi (Selys, 1849)	E. Afr.
U. signata aethiopica Nielsen, 1957	Som
Zygonys atritibiae Pinhey, 1964	Zam
Z. eusebia (Ris, 1912)	nw.Zam, DRC
Z. fallax (Schouteden, 1934)	Uganda
Z. flavicosta (Sjöstedt, 1900)	Uganda, DRC
Z. natalensis (Martin, 1900)	E. Afr.
Z. regisalberti (Schouteden, 1934)	Uganda
Z. torridus (Kirby, 1889)	E. Afr.
Zyxomma atlanticum Selys, 1889	Uganda

CALCULATING ODONATE DIVERSITY?

The approach of WASSCHER & BOS (2000) in calculating normalised species densities for standard areas (250×250 km²: 62,500 km²) is not feasible for East Africa with the current state of knowledge. Although there are figures for some areas, a simple extrapolation using the formula given by WASSCHER & BOS (2000), shown in parentes would generate wrong impressions (S = s log (N)/log (n); S: estimate of the number of species expected in an area of "N", N: 62,500 km², s: number of species known from an area of "n", n: area investigated).

One could calculate the normalised species densities, using the figures given in Table I. Of course I did this and was pleased to see Uganda with 222 species per standard area and Kenya with 161 species per standard area being considerably upgraded. Knowing about the comparatively poor collecting activities in Tanzania, its poor result with 131 species per standard area is not too bad, as it will be definitely increased following to an increase of surveying. But these figures do not say much about the true distribution of dragonflies and their biodiversity status. These figures mainly contribute to science as data for fund-raising and maybe for making political decisions. Kenya for example, with its large desert and semi-desert areas in the north is strongly biased concerning species richness. The coastal areas and the remaining guineo-congolian forest patch in the west (Kakamega

Forest) account for a large part of the total species richness, whereas the dry north is very species poor, but might still contain some very localised and unknown endemics (see also Fig. 1).

The problem with the application of normalised species diversity figures becomes apparent when looking at the simple number of species recorded in the canton Zürich (example given in WASSCHER & BOS, 2000). Seventy species have been observed in an area of 1729 km². Nobody would calculate now the normalised species diversity, (which would be 104), because the total species number for that area is known (80 species). Without this background knowledge, which is the case in many tropical countries, one would be tempted to calculate the normalised species area for comparison with other countries and with this generate wrong impressions for whole countries or areas.

Most often species numbers are corrected for area to obtain a national species density. For countries like Uganda this proves to give "good" results, as the country is small and covered with dragonfly habitats. Kenya would do badly with this method for reasons given above. It is more suitable to compare uncorrected species numbers together with other patterns, e.g. the nationwide distribution of wetlands, the distribution of potential habitats, the number of endangered or rare species, to assess conservation and environmental issues as well.

PURVIS & HECTOR (2000, p. 218) conclude that "biodiversity cannot be reduced to a single number", although "a single number is often what policy-makers want". The authors describe biodiversity as a multitude of facets, of which species richness is only one. Biodiversity considerations on the global scale should be made very carefully (e.g. GASTON, 2000). MYERS et al. (2000) omit invertebrates in general from their documentation, because they are largely undocumented. For East Africa it will still take some time, until the data base allows a comparative approach of species richness on a regional level.

CONCLUDING REMARKS

The most important habitats in terms of diversity for dragonflies in East Africa are mainly rain forest areas, specially the swamp forests in Uganda and the coastal rain forests of Kenya and Tanzania. Although the most common dragonfly habitats, specially in Kenya, are savanna pools and rivers the above-mentioned rain forest areas contain a lot of unique species and, if arguing from the conservational point of view, such habitats are shrinking very fast and experience heavy pressure from outside. For example the Eastern Arc and Coastal Forests of Tanzania and Kenya are cover an area of 2,000 km² today, which is only 6.7% of their original extent (MYERS et al., 2000).

In terms of pure species richness Uganda definitely has a much higher dragonfly diversity than Kenya and Tanzania. But the coastal rain forest areas of Kenya and Tanzania contain some highly localised species, some being endemics and/or of

unique taxonomy (examples given above). The importance of these coastal rain forests is not only seen for dragonflies, for which the database is not that good at the moment, but it is also reflected by other taxa (e.g. WASS, 1995). Over 50% of all threatened forest woody plants in Kenya for example are found in coastal rain forests and 16% are found in the Taita Hills, which are the northernmost Arc Mountains (WASS, 1995). The Kakamega Forest, which belongs to the guineo--congolian rain forest type mainly found in Uganda, is not of major importance when considering on threatened woody plants. Many species found in this forest are rare in Kenya, but not necessarily in the whole geographic region.

Mountainous areas, specially the afroalpine zones are extremely poor in dragonfly species and can be considered as of minor significance in terms of afrotropical dragonfly diversity. This is in contrast to South Africa, where the mountain ranges are considered as sites of special odonatological significance (SAMWAYS, 1999).

The savanna, which cover large areas in Kenya, Tanzania and north Uganda supports a high number of dragonflies, but mainly widespread and euryotopic species. The desert areas in the north of Kenya are poor in species, but also very little known. More surveys could discover new endemics.

As outlined before the major problem is the lack of knowledge on distribution, ecology and biogeography of afrotropical Odonates. For most areas even mere lists of species are not available and this applies not only for dragonflies (e.g. POMEROY, 1995). With the current level knowledge, it is not possible to give applied approaches on East African dragonflies and their diversity, like can be done for South Africa (e.g. SAMWAYS, 1992, 1999), but it should be aimed at. Specially Tanzania is a white spot in terms of odonates (see also PRENDERGAST, 1999). Large areas of Tanzania have never been extensively investigated, if they have been investigated for dragonflies at all. Some species are recorded for Malawi, Zambia, Kenya and/or Uganda, but not for Tanzania (see Checklist), which is probably not the result of a disjunct distribution, but of collecting gaps. In southern Tanzania especially, there appears to be considerable endemism across botanical and zoological taxa in general (Davenport, pers. comm.) and new dragonflies, at least for the country are likely to be found in inventories. But even Kenya seems to be far away from being surveyed to a satisfying level. During a recent trip I found at least 5 species, which have neither been recorded for the country, nor for East Africa before. These are not yet listed in the Checklist.

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