

Malagarasi Aquatic Rapid Biodiversity Assessment

Final Report

October 2009

Millennium Challenge Corporation

MILLENNIUM CHALLENGE CORPORATION
UNITED STATES OF AMERICA

Mott MacDonald

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Millennium Challenge Corporation, 875 Fifteenth Street, N.W., Washington DC 20005

Mott MacDonald, Victory House, Trafalgar Place, Brighton BN1 4FY, United Kingdom
T +44(0) 1273 365000 F +44(0) 1273 365100 W www.mottmac.com

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3. Study Area

3.1 Overview

This RBA sampled 17 sites along the lower Malagarasi River between the delta and start of large upstream wetlands, covering a river distance of approximately 154 km. Sampling was undertaken in the middle of the dry season (when water levels began to subside) from the 4th to 20th of August 2009.

The specific focus of the study on this portion of the Malagarasi River is based on existing knowledge of aquatic endemism within Tanzania. Other parts of the Malagarasi River lack appropriate substrate, and several other rivers within the basin were sampled in 2004 without any indication that target species were present. No species similar to the Igamba Snail have been found in any past aquatic biodiversity survey work in Tanzania, and *Potadomoides* is only known from the Malagarasi (*P. pelsneeri*) and Congo (other *Potadomoides* species). Collections throughout Tanzania and phylogenetic analyses have demonstrated that the Tanzanian *Orthochromis* species, which are territorial and non-migratory, are locally endemic to sub-drainages of single river systems (De Vos and Seegers, 1998). Further, all species within the Malagarasi *Orthochromis* radiation are descended from a common ancestor and apparently have evolved in-situ (Salzburger et al., 2005). The diversity of *Orthochromis* throughout the Malagarasi and nearby drainages has been sufficiently documented that a restricted distribution of the new species to the Igamba region is firmly established.

Sampling efforts focused largely on the target aquatic species within the main river channel. As the aim of the study was to focus on three target species known to be affiliated with high water flows and large rock substrates, these habitats were specifically targeted. Stretches of the river mainly characterised by deep, straight channels with dominantly muddy substrates and slower flow were not sampled given the time constraints and objectives of the RBA.

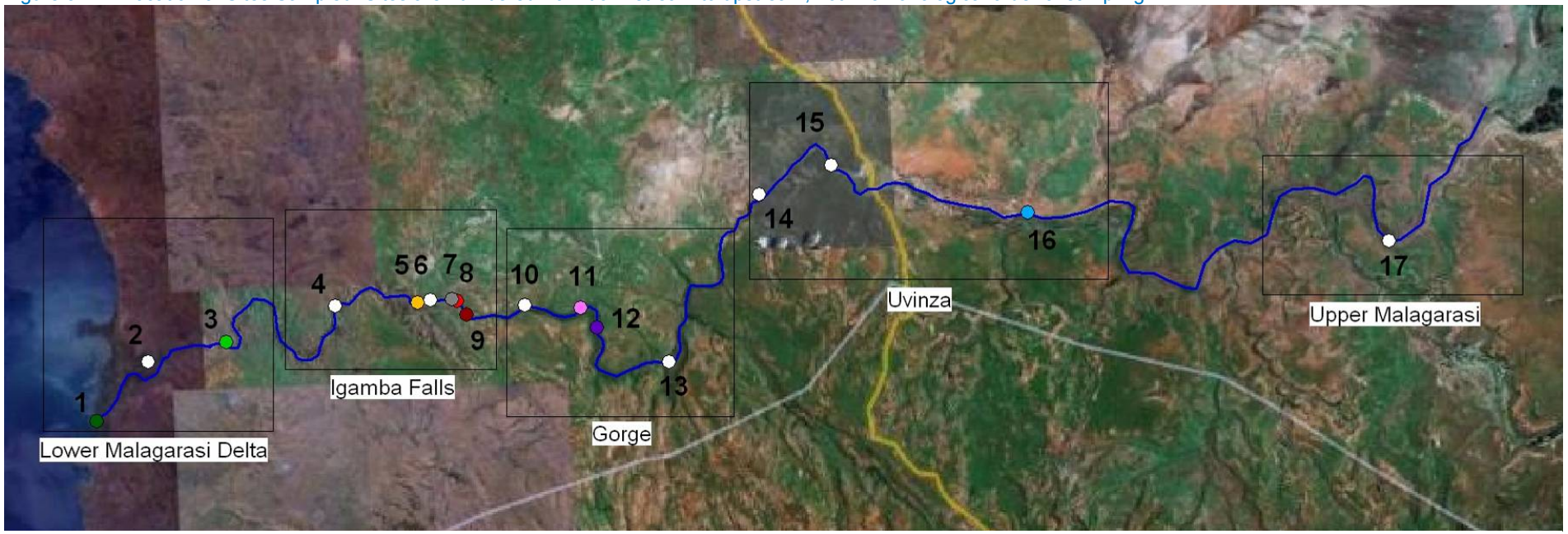
During the first twelve days 13 sites accessible by roads, footpaths and/or boat were sampled. Over the last four days, a helicopter was used to reach sites within the gorge, which is inaccessible by roads or footpaths. The gorge area covers a distance of approximately 30 km and comprises the most proximate upstream area that will be affected by the proposed cascade of hydropower schemes (Stage I,II, and III) (Figure 3.1).

The following sections provide specific descriptions of each site sampled as illustrated in.Figure 3.2.

Figure 3.1: Overview of study area and location of hydropower scheme in relation to the upper and lower Igamba Falls

Source: Google maps (manipulated in GIS)

Figure 3.2: Location of Sites Sampled. Sites are numbered from downstream to upstream, not in chronological order of sampling.



Source: <Insert Source here or delete this table row>

3.2 Ilagala– Lower Malagarasi

Three sites were sampled in the lowest reaches of the Malagarasi River between the most downstream riffles and the delta. Sites 1 and 2 were not specifically target habitats, but provided an opportunity to assess the presence or absence of the target species and confirm whether the Igamba Falls acts as a barrier to up stream dispersal.

SITE 1	Date sampled	Coordinates (decimal degrees)	Elevation
	15-Aug-09	5.25621°S / 29.80183°E	775 m

Access

Delta accessed by boat from Ilagala barge crossing.

Habitat

The furthest downstream site sampled, at the mouth of the river delta. Characterised by deep waters, sand and silt substrate, and thick vegetation along banks. Relatively low gradient with slow flow but good water clarity. It should be noted that Malagarasi water levels were noted to be especially high for dry season sampling during this year's survey.

SITE 2	Date sampled	Coordinates (decimal degrees)	Elevation
	14-Aug-09	5.21171°S / 29.84398°E	893 m

Access

By boat from Ilagala barge crossing.

Habitat

Next to camp site 3, this area was sampled using gill net and was located adjacent to the river barge crossing. Characterised by deep waters, sand and silt substrate, and vegetation along the banks. Evidence of erosion where vegetation has been cleared. Low gradient with slow flow and moderate water clarity.

SITE 3	Date sampled	Coordinates (decimal degrees)	Elevation
	14 Aug 09	5.20134°S / 29.90014°E	823 m
	Access		
	By boat 6.4 km upriver from the Ilagala barge crossing.		
	Habitat		
	Riffle site with shallow waters and high sandy banks located 6.4 km upstream of the Ilagala barge crossing. A small cobble and sand island found midstream of river, with silty substrate along lee side of the island. Evidence of erosion along banks. Moderate gradient with riffle habitat across the entire river for at least 0.5 km distance. Moderate to fast flow and moderate water clarity. Small earthquake during sampling effort demonstrated lack of stability of high sand bank.		

3.3 Igamba

Six sites within the Igamba Falls area were sampled within the area of impact of the proposed hydro scheme. The objectives were to determine the distribution and abundance of target species and to collect data relating to their habitat requirements. In addition, as many other species as possible within this area were sampled to increase the team's confidence in biodiversity lists and tissue samples taken for genetic and isotopic analysis.

The Igamba area habitat is characterised in general by a series of three falls with fast flowing waters. The dominant substrate is bedrock sandstone, mostly expressed as tabular slabs with planar and transverse fractures and including scour pools, and large boulders (up to several metres in diameter). The area also includes pools and straight sections of river flowing between the three falls areas with deposited gravel, sand and silt, fringed by emergent macrophytes.

Figure 3.3 and Figure 3.4 provide an aerial overview of sites sampled within the Igamba area in relation to the proposed Stage II hydro scheme. Individual site descriptions follow these figures.

Figure 3.3: Overview of Upper Igamba Falls and Drill site

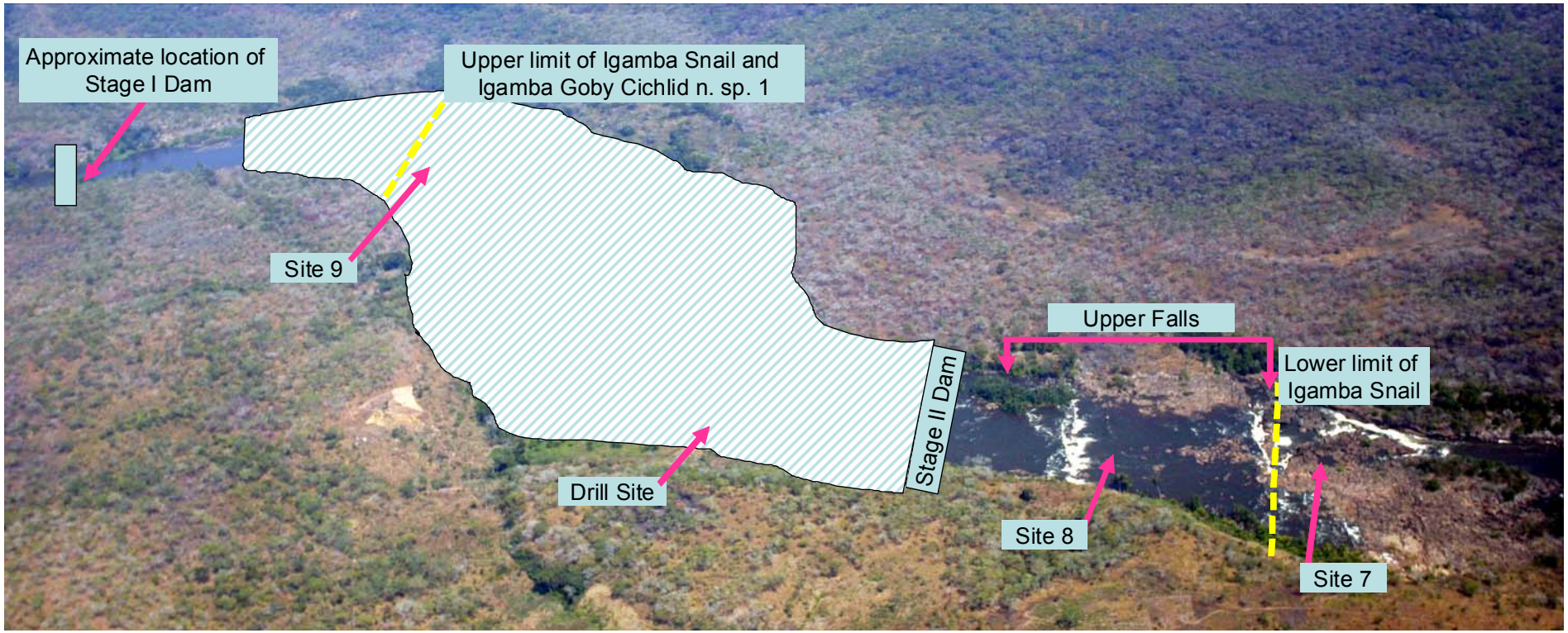


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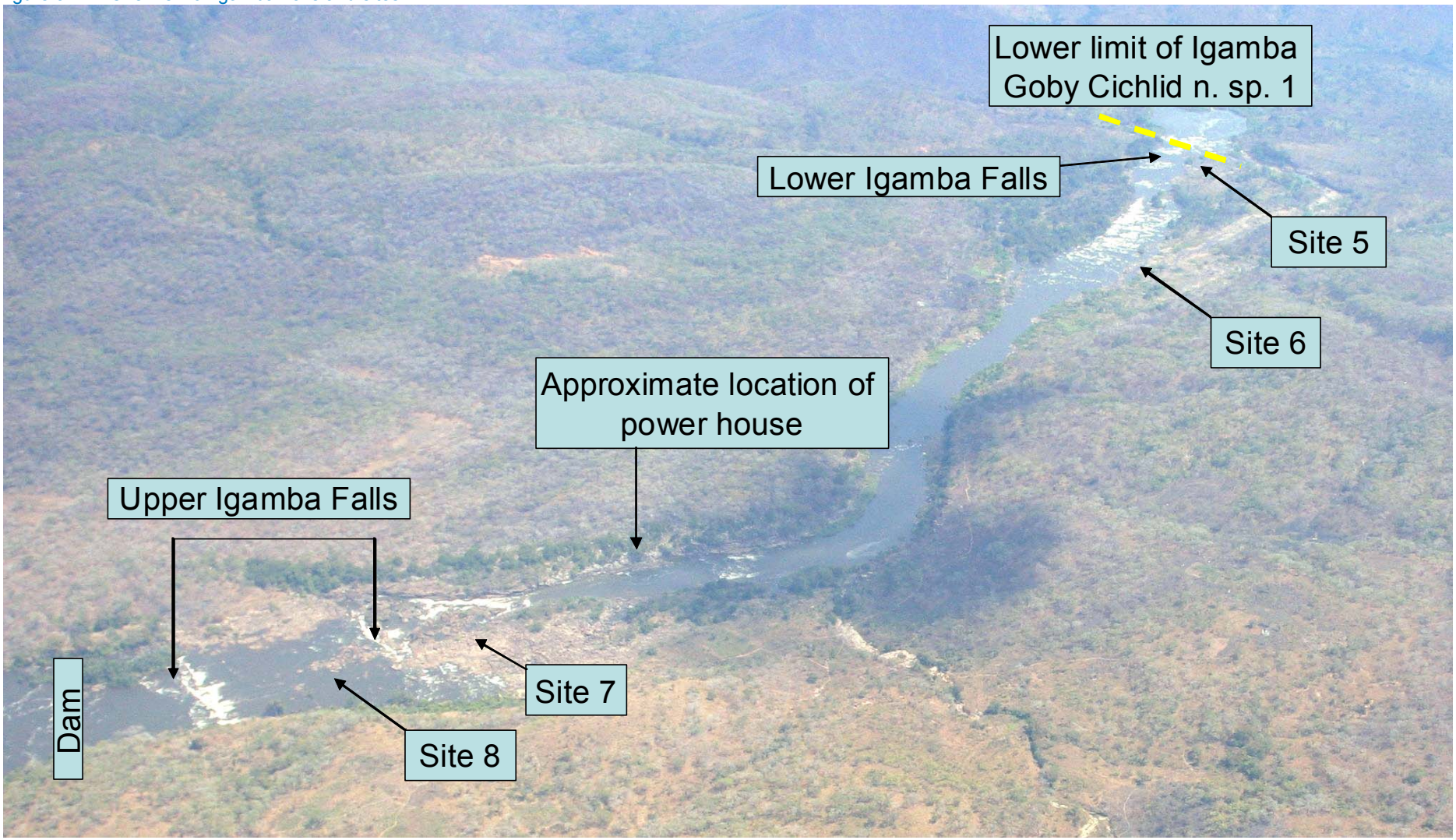
Figure 3.4: Overview of Igamba Falls and sites



SITE 4	Date sampled	Coordinates (decimal degrees)	Elevation
	07-Aug-09	5.17993°S / 29.98035°E	798 m
	Access		
	Accessed by boat, starting from the plunge pool a the base of the lower falls heading 8 km downstream.		
	Habitat		
	Riffles found 8 km downstream of Igamba Falls. Moderate gradient with riffle habitat across the entire river. Moderate to fast flow and high water clarity.		

SITE 5	Date sampled	Coordinates (decimal degrees)	Elevation
	09-Aug-09	5.18001°S / 30.05083°E	802 m
	Access		
	Directly from campsite along footpaths adjacent to the river		
	Habitat		
	Lower Igamba Falls (Kasagwe). Series of two smaller falls crossing the width of the river with a shallow platform between the falls. Site is characterised by interlinking scour pools and high current flowing through scour pools and fissures in sandstone slabs. Directly below the falls is a deep plunge pool with strong eddy currents created by the falls. The falls are characterised by large sandstone slabs intercut with scour pools.		

SITE 6	Date sampled	Coordinates (decimal degrees)	Elevation
	08-Aug-09	5.17826°S / 30.05651°E	--

Access

Accessed by foot along the riverbank, upstream of campsite at the lower falls.

Habitat

Igamba mid-falls area, rushing waters and deep scour pools, downstream of a large pool at the base of the large upper falls, but above the lower Igamba falls. Habitat is characterised by sandstone slabs and scour pools. Very high current flow and high water clarity.

SITE 7	Date sampled	Coordinates	Elevation
	08-Aug-09	5.17843°S / 30.07198°E	--

Access

Accessed by foot along the river bank, upstream of campsite at the lower falls.

Habitat

Platform just below the upper Igamba falls, above a large pool at the base of the upper falls. Habitat characterised by sandstone slabs, large boulders and scour pools. Very high current flows and high water clarity.

SITE 8	Date sampled	Coordinates (decimal degrees)	Elevation
	06-Aug-09	5.17858°S / 30.07306°E	850 m
	Access		
	Accessed by foot along the riverbank, upstream of campsite at the lower falls.		
	Habitat		
	Just above the main upper fall drop. Characterised by sandstone slabs and scour pools. Very high current flows and water clarity. During the field work at Igamba, engineers were undertaking geological surveys and drilling core samples above this site (see Figure 3.3), referred to in the report as “drill site”		

SITE 9	Date sampled	Coordinates (decimal degrees)	Elevation
	19-Aug-09	5.18877°S / 30.07973°E	--
	Access		
	Helicopter drop off on rock slabs.		
	Habitat		
	Malagarasi River approximately 500m above the Igamba drill site (above the hydro scheme dam site). This site is the upper limit of the platform of scour pool rocks above the upper falls. Habitat characterised by sandstone slabs and scour pools. Just upstream from this site the substrate changes and bubble algae is prevalent. Very high current flows and water clarity.		

3.4 Gorge

Four sites were sampled at various points within the gorge, the furthest upstream site approximately 22 km from the proposed Stage II hydropower scheme.

The gorge is characterised by a series of small falls, white water and riffles spread throughout the gorge. The falls were relatively small and the width of the river significantly narrower than at Igamba.

As with other areas sampled along the river, potential sites within the gorge were identified through the aerial surveys. However, the limited number of suitable helicopter landing points constrained the number and location of sites sampled. In addition mobility by foot once in the gorge was largely limited by steep sides with large rock boulders and dense vegetation. There was less evidence of recent burning of vegetation occurring within the Gorge.

SITE 10

Date sampled	Coordinates (decimal degrees)	Elevation
18-Aug-09	5.18548°S / 30.11954°E	877 m

Access

Helicopter

Habitat

Most downstream Gorge site sampled. Habitat characterised by large sandstone boulders and broken slabs. The channel is deep and narrow, with limited extent of rocky shoreline habitat scoured by fast currents.

SITE 11

Date sampled	Coordinates (decimal degrees)	Elevation
18-Aug-09	5.19227°S / 30.15522°E	887 m

Access

Helicopter landing on sandy beach

Habitat

Habitat characterised by large sandstone boulders and broken slabs. The channel is deep and narrow, with limited extent of rocky shoreline habitat scoured by fast currents.

SITE 12	Date sampled	Coordinates (decimal degrees)	Elevation
	18-Aug-09	5.20283°S / 30.16975°E	908 m
	Access		
	Helicopter landing on sandy beach		
	Habitat		
	Habitat characterised by large sandstone boulders and broken slabs. The channel is deep and narrow, with limited extent of rocky shoreline habitat scoured by fast currents.		

SITE 13	Date sampled	Coordinates (decimal degrees)	Elevation
	17-Aug-09	5.22895°S / 30.22403°E	
	Access		
	Helicopter		
	Habitat		
	Furthest upstream site sampled within the gorge at the confluence of a small tributary with dense forest. The site presented a wider, more complex, braided channel, with a greater diversity of shallow habitats over a large area, from muddy backwaters and sandy, deeper runs to riffles and small falls through broken rock slabs. High current flows and water clarity.		

3.5 Uvinza

In total three sites were sampled near Uvinza, upstream of the Igamba Falls. Sites were identified through aerial surveys and determined by accessibility. Sites were characterised by fast flowing waters. Site 14 was of particular interest, with similar bedrock and scour pool features to those found at Igamba Falls.

SITE 14	Date sampled	Coordinates (decimal degrees)	Elevation
	12-Aug-09	5.11563°S / 30.29668°E	1049 m

Access

Access to site from the main road turning off at the no longer operational Red Cross pumping station. Footpath access to rapids.

Habitat

Located at the head of the gorge the site is characterised by scour pools and large rock slabs intercut by fissures. This site had the most similar superficial habitat characteristics to Igamba, based on visual assessment, than any other site sampled. Very high water current and high visibility.

SITE 15A	Date sampled	Coordinates (decimal degrees)	Elevation
	11-Aug-09	5.09793°S / 30.35449°E	962 m

Access

Site accessed by car past the Uvinza salt works and footpath to river

Habitat

Near the village of Nkwasa. Two sites within 500 m of each other were sampled in this area (sites 15A and 15B). Shown and described here, site 15A is characterised by submerged rocks with rapid water overflowing.

SITE 15B

Date sampled	Coordinates (decimal degrees)	Elevation
11-Aug-09	5.09793°S / 30.35449°E	962 m

Access

Site accessed by car past the Uvinza salt works and footpath to river

Habitat

Near the village of Nkwasa. Two sites within 500 m of each other were sampled in this area (sites 15A and 15B). Shown and described here site 15B has similar substrate with shallower wider channel and large rockslabs forming islands within the channel. Both site had high current flows and medium visibility.

SITE 16

Date sampled	Coordinates (decimal degrees)	Elevation
10-Aug-09	5.13986°S / 30.48932°E	992 m

Access

Site accessed by car past the Uvinza salt works and footpath to river

Habitat

Site is approximately 12 km upstream of Uvinza near the village of Kanzibwe. Habitat characterised by extensive quartzite ridges forming small rapids and falls, channels and vegetated islands. High water currents and visibility.

3.6 Upper Malagarasi (Bridge)

The furthest upstream site sampled is at the last set of riffles prior to reaching the start of the upper Malagarasi wetland basin.

SITE 17	Date sampled	Coordinates (decimal degrees)	Elevation
	12-Aug-09	5.17627°S / 30.75262°E	1057 m

Access

Sample site located downstream of bridge near Malagarasi town, accessed by boat launched at bridge.

Habitat

The site is an area of submerged rocks with no rapids approximately 12 km downstream from the Malagarasi Bridge. Characterised by boulders mixed with muddy channel. High current flows and low water visibility.

4.5 Dragonflies and damselflies (Odonata) of the Lower Malagarasi Basin, western Tanzania

Klaas-Douwe B. Dijkstra

National Museum of Natural History Naturalis, P.O. Box 9517, 2300 RA Leiden, The Netherlands <dijkstra@nnm.nl>

Introduction

The insect order Odonata (dragonflies and damselflies, but often called 'dragonflies' as a whole) is receiving increasing attention from scientists, conservationists and the public. These graceful and colourful creatures can function as flagships for freshwater conservation, not only for water-rich habitats such as wetlands and rainforests, but also for habitats where water is scarce and, therefore, especially vital to the survival of life. Their sensitivity to structural habitat quality (e.g. forest cover, water clarity) and amphibious habits make dragonflies well suited for evaluating environmental change in the long term (biogeography, climatology) and in the short term (conservation biology), both above and below the water surface (Corbet, 1999). The larvae are excellent indicators of the structure and quality of aquatic habitats (e.g. water, vegetation, substrate), while adults exhibit high sensitivity with regards to the structure of their terrestrial habitats (e.g. degree of shading). As a consequence, dragonflies show strong responses to habitat changes, such as those related to deforestation and erosion. Ubiquitous species prevail in disturbed or temporary waters, while habitats like pristine streams and swamp forests harbour a wealth of the more vulnerable and localized species. Different ecological requirements are linked to different dispersal capacities. Species with narrow niches disperse poorly, while pioneers of temporary habitats (often created by disturbance) are excellent colonizers. For this reason, dragonflies have a potential use in the evaluation of habitat connectivity (Clausnitzer, 2003; Dijkstra & Lempert 2003). Also a rich dragonfly fauna probably represents high overall aquatic biodiversity.

Because dragonflies possess characteristics distinct from those of relatively well-studied taxonomic groups like fishes, their study supplements environmental assessments. There are also practical advantages to dragonflies as environmental monitors. The conspicuous adults are easy to observe near their aquatic habitats. The number of African species (about 850) is manageable, their taxonomy and distribution patterns are fairly well resolved, and identification is relatively straightforward. Moreover, the interpretation of survey results is facilitated by the inclusion of dragonflies in IUCN's assessment of

African freshwater biodiversity, which summarizes the status, distribution, and threats of all species. Previous rapid assessments in Africa have shown that it is possible to obtain a fairly complete picture of the local diversity within a short period of time (Dijkstra, 2007b; 2007c; 2007d). Particularly in forest and freshwater ecosystems, an emphasis on dragonfly research seems beneficial as a baseline for biodiversity and watershed conservation.

The dragonflies of East Africa have been comparatively well-studied. About 180 species are known from Tanzania, which is the least-known country of the three large nations: Kenya has 170 species, but overall fauna is thought to be poorer, and Uganda 230 species (Dijkstra & Clausnitzer, in prep.). The real Tanzanian figure must approach 200 (Dijkstra & Clausnitzer, 2006) and most of the undiscovered diversity is expected in the west, the least explored part with the closest proximity to the particularly rich Guineo-Congolian fauna. Aside from Pinhey & Pinhey's (1984) treatment of collections by the renowned butterfly researcher Kielland in the mountains bordering Lake Tanganyika (e.g. Mahale) and a few records in Pinhey (1960) no prior data was available, with not a single record obtained previously along or near the Malagarasi, western Tanzania's largest river and the main contributor to Lake Tanganyika.

4.5.1 Methods

Adults and larvae were observed and caught with a hand net during daylight at freshwater habitats. Habitats directly within the course of the Malagarasi were prioritized, especially at Igamba, but stagnant habitats fed by the river, several of its tributaries and the shores of Lake Tanganyika (which it feeds) were also targeted to obtain an overall assessment of diversity in the system. Identifications were made using Clausnitzer & Dijkstra (in prep.) and additional literature (see Dijkstra 2003; 2007a); taxonomy follows Dijkstra & Clausnitzer (in prep.). Specimens were deposited in the collection of the National Museum of Natural History Naturalis (Leiden, The Netherlands).

4.5.2 Results

Eighty eight species were recorded, although two genera (*Lestinogomphus and Neurogomphus*) were found as larvae only and cannot be identified to species (Table B.1). *Agriocnemis victoria*, *Ceriagrion corallinum*, *Pseudagrion sudanicum*, *Ictinogomphus regisalberti*, *Trithemis dichroa* and *T. grouti* were recorded from Tanzania for the first time, while a single *Pseudagrion* species appears to be new to science. None of the recorded species are included in the

IUCN Red List as globally or regionally threatened, nor are any range-restricted or confined to the Malagarasi Basin, although the new species may be unique to Lake Tanganyika (see discussion). Table B.2 summarizes observed habitat preferences, further discussion of the ecology of the species will be provided within the final report.

4.5.3 Discussion

Although different scales and intensities of surveys make them difficult to compare, the discovered diversity was higher than expected. Surveys in rainforest in Liberia (total of 93 species in three well-separated areas), Ghana (72 species, one site) and Congo-Kinshasa (86, one) yielded similar figures, while such habitats overall tend to be more species-rich (Dijkstra 2007b; 2007c; 2007d; Dijkstra & Clausnitzer 2006). Notable is the high number (including most of the novelties) of species typical of rather forested parts of western and central Africa (*Agriocnemis victoria, Ceriagrion corallinum, Ictinogomphus regisalberti, Eleuthemis buettikoferi, Orthetrum austeni, Trithemis dichroa, T. grouti, T. nuptialis,* and *T. pruinata*), which are all unlikely to occur further east in Tanzania.

Especially notable is the presence of *Ictinogomphus regisalberti*, a near-endemic of the Congo Basin, confirming the Malagarasi's affinity with that river. The most forest-dependent west-central species (*Platycypha lacustris, Pseudagrion melanicterum, Gynacantha bullata, G. vesiculata,* and *Notiothemis robertsi*) were found only in a lush side-valley of the gorge. Two species exclusive to forest fragments in eastern Africa (*Chlorocypha consueta, Thermochoria jeanneli*) were also found only there.

Table B.2 shows that just over half the recorded species within the Malagarasi system occur in the river itself (44 plus seven whose use of the river is uncertain). Other habitats contribute the remaining species, especially pools and swamps, which have one of the highest total number of species and most 'primary' ones. This dominance indicates firstly those habitats' distinctness (all other habitats flow; also the lake has much movement) and secondly that most standing-water species disperse well (all appropriate species are usually present if habitat is there). Side-streams also contribute significantly, although there is overlap with smaller river-channels and thus most additional species originate from a single forested tributary in the gorge. On the river itself, it is notable how poor the rocky sections are, including the rapids that are so important for the endemic mollusc and fish. Few dragonfly larvae are adapted to hard substrates and fast currents: only *Zygonyx natalensis*, which occurs throughout Africa, breeds in the waterfalls,

where it is abundant. The obligate rock-pool breeder *Bradinopyga cornuta* was also notably common. Diversity is greatest on the flatter sections with finer sediments and thus more vegetation, as illustrated by the good representation of Gomphidae and *Pseudagrion*, which burrow in soft substrates and require riparian plants respectively. The varied sections, with mosaics of riverine habitat, have fewer species: the scale and frequent presence of gallery vegetation give the parallel channels a stream-like appearance. This is expressed by species as *Elattoneura cellularis*, *Pseudagrion kersteni*, *Anax speratus*, *Orthetrum guineense*, and *Trithemis aconita*. Only *Trithemis dichroa* and *Eleuthemis buettikoferi*, both central African species that are rare in Tanzania, favor these channels above all other habitats.

From a scientific perspective, the most significant discoveries were made on the lakeshore. While aquatic groups like fish and molluscs have 'explosive' endemism in Africa's Great Lakes, only a handful of dragonfly species from Lakes Malawi and Tanganyika may qualify as lake endemics. This can be explained by the terrestrial life stage, the adult: their link to land could make many lake niches inaccessible for larval development, while their capacity for flight inhibits genetic isolation of lakeshore populations from populations on streams, rivers and ponds.

A new species of *Pseudagrion* was discovered on reeds in the wave zone at the mouth of river, and was subsequently found at similar habitat near Kigoma, 50 km north. *Platycypha pinheyi* was known from a few sites around Lake Tanganyika, but whether it inhabited the lake or tributary streams was unknown. It was found to be numerous on rocky lakeshores (Figure 4.11 and Figure 4.12). The new *Pseudagrion* is structurally identical to *P. massaicum*, which was absent locally but is common on a wide range of slow-flowing and stagnant habitats in eastern Africa, but has completely different coloration (Figure 4.13). The *Platycypha*, and another on Lake Malawi, differ only marginally in colour patterns from riverine sister species.

Figure 4.11: Habitat of *Platycypha pinheyi*.

Figure 4.12: Adult male of *Platycypha pinheyi.*

The evolution of lake endemic species in dragonflies may be a recent phenomenon, possibly only occurring when initial separation of a lake population from riverine founders is followed by slight divergence in coloration, which in this visually oriented order can be reinforced by sexual selection. Genetic research on both *Pseudagrion* and *Platycypha* is in development to support this hypothesis.

Figure 4.13: Adult males of the new *Pseudagrion* species (left) and its relative *P. massaicum*.

4.5.4 Conclusion and Conservation Recommendations

While the observed dragonflies indicate that aquatic habitats are diverse and species-rich in the Malagarasi system, especially at Igamba, it is not unique. None of the recorded species are threatened or confined to the basin. The new *Pseudagrion* and *Platycypha pinheyi* are probably unique to Lake Tanganyika, but will not be impacted by the hydro-electric scheme at Igamba. The development, especially Stage II, would flood some valuable aquatic habitats and gallery forest, but ample similar habitat is available upriver of the impacted area.

With its forested and sheltered character, the Malagarasi Gorge contrasts with the drought and fire prone surrounding woodlands, and must function as an important refuge for dragonflies and other animals. This is true for forest-dependent species, as expressed by the high percentage of species observed only there (see Table B.1), as well as those that seek shelter in the dry season: notable adult numbers of some species (*Lestes amicus, Phaon iridipennis, Ceriagrion glabrum, Gynacantha bullata, G. vesiculata, Chalcostephia flavifrons*, and *Thermochoria jeanneli*) were observed in the undergrowth, where they await the advent of the wet season to breed. Improved protection of this relatively pristine environment would be a suitable mitigation measure for any impacts sustained by the Malagarasi ecosystem through the hydro-electric scheme.

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Appendix B. Dragonflies and damselflies species list and habitats

Table Key:

Ta: Lake Tanganyika near Kigoma:

Il: Ilagala;

Ig: Igamba;

Go: Gorge;

Ng: Ngutu;

Nk/Uv: Nkwasa/Uvinza;

Ka: Kanzibwe;

Ma: Malagarasi Bridge.

Note: All records based on adults, except 'L' on larvae or larval exuviae.

Table B.1: Dragonflies and damselflies recorded during the survey

Species	Ta	Il	Ig	Go	Ng	Nk	Ka	Ma
ZYGOPTERA (Damselflies)								
Lestidae								
Lestes amicus				Go				
L. plagiatus					Ng			
Calopterygidae								
Phaon iridipennis			Ig	Go	Ng	Nk	Ka	
Chlorocyphidae								
Chlorocypha consueta				Go				
Platycypha caligata		Il	Ig	Go	Ng	Nk	Ka	Ma
P. lacustris				Go				
P. pinheyi	Ta							
Platycnemididae								
Mesocnemis singularis		Il	Ig	Go	Ng	Nk	Ka	Ma
Protoneuridae								
Elattoneura cellularis			Ig	Go		Nk	Ka	
Coenagrionidae								
Agriocnemis exilis		Il	Ig	Go		Nk	Ka	
A. gratiosa	Ta	Il						
A. victoria					Ng	Nk		
Ceriagrion corallinum			Ig					
C. glabrum	Ta	Il	Ig	Go	Ng	Nk	Ka	
Ischnura senegalensis	Ta	Il	Ig			Nk		
Pseudagrion sp. nov.	Ta	Il						
P. acaciae		Il	Ig			Nk		
P. glaucescens		Il						
P. hageni			Ig	Go	Ng			
P. hamoni		Il	Ig	Go	Ng	Nk	Ka	
P. kersteni			Ig	Go			Ka	
P. lindicum			Ig					
P. melanicterum				Go				
P. nubicum			Ig					Ma
P. sjoestedti	Ta	Il	Ig	Go		Nk	Ka	
P. sublacteum		Il	Ig	Go		Nk	Ka	Ma
P. sudanicum			Ig					
ANISOPTERA (Dragonflies)								
Aeshnidae								
Anax imperator	Ta	Il	Ig		Ng			Ma

Species	Ta	Il	Ig	Go	Ng	Nk	Ka	Ma
A. speratus			Ig		Ng			
Gynacantha bullata				Go				
G. manderica						Uv		
G. vesiculata				Go				
Gomphidae								
Ictinogomphus ferox	Ta		Ig					Ma
I. regisalberti			Ig					
Lestinogomphus sp.		Il						
Neurogomphus sp.		Il						
Paragomphus cognatus				Go				
P. genei		Il	Ig		Ng			
Paragomphus sp.	L							
Phyllogomphus selysi			Ig	Go				
Macromiidae								
Phyllomacromia contumax			Ig					Ma
P. picta			Ig					
Libellulidae								
Acisoma panorpoides	Ta		Ig	Go	Ng			
Aethriamanta rezia			Ig					
Brachythemis lacustris	Ta	Il				Nk		
B. leucosticta		Il	Ig	Go	Ng			Ma
Bradinopyga cornuta			Ig	Go				
Chalcostephia flavifrons				Go				
Crocothemis divisa			Ig	Go	Ng			
C. erythraea	Ta	Il	Ig	Go	Ng	Nk	Ka	Ma
C. sanguinolenta			Ig	Go			Ka	
Diplacodes lefebvrii	Ta		Ig		Ng		Ka	
Eleuthemis buettikoferi			Ig			Nk	Ka	
Hemistigma albipunctum	Ta		Ig		Ng	Nk	Ka	Ma
Nesciothemis farinosa	Ta		Ig	Go		Nk		
Notiothemis robertsi				Go				
Olpogastra lugubris			Ig			Nk		Ma
Orthetrum abbotti				Go	Ng		Ka	
O. austeni			Ig					
O. brachiale			Ig			Nk	Ka	
O. chrysostigma		Il	Ig	Go	Ng	Nk	Ka	
O. guineense			Ig	Go				

Species	Ta	Il	Ig	Go	Ng	Nk	Ka	Ma
O. hintzi			Ig					
O. julia			Ig	Go	Ng		Ka	
O. monardi					Ng			
O. stemmale		Il	Ig	Go			Ka	
O. trinacria	Ta				Ng	Nk		
Palpopleura jucunda					Ng			
P. lucia	Ta	Il	Ig	Go	Ng	Nk	Ka	Ma
P. portia			Ig	Go	Ng	Nk	Ka	
Pantala flavescens			Ig					
Rhyothemis semihyalina			Ig		Ng			Ma
Tetrathemis polleni			Ig		Ng			
Thermochoria jeanneli				Go				
Trithemis aconita			Ig	Go		Nk	Ka	
T. annulata	Ta	Il	Ig			Nk		
T. arteriosa		Il	Ig	Go	Ng	Nk	Ka	Ma
T. dichroa			Ig					
T. donaldsoni			Ig	Go	Ng	Nk	Ka	
T. grouti						Nk		
T. kirbyi		Il	Ig	Go	Ng	Nk	Ka	Ma
T. nuptialis			Ig					
T. pluvialis		Il	Ig	Go		Nk		
T. pruinata			Ig					
T. stictica				Go				
Urothemis assignata	Ta		Ig		Ng			Ma
U. edwardsii	Ta		Ig			Nk		Ma
Zygonyx natalensis		Il	Ig	Go	Ng	Nk	Ka	
Z. torridus			Ig					
Total species	20	27	62	43	32	33	27	17
Unique species	1	3	13	11	3	2	0	0

Table B.2: Habitats of dragonflies recorded during the survey. Main habitats are bold, some have specific features marked italic: these indicated both per site (those sampled for fish and mollusks in numbers, for dragonflies in letters) and species. River section: (1) slower flowing with extensive reedy and grassy banks; (2) varied with great diversity of substrates (rock, vegetation) and cover (open, gallery forest), including stream-like parallel channels; (3) rocky, without vegetation or soft substrates, with either fast (including rapids and waterfalls) or slow to no flow (especially rock pools). Additional features: (1) tributary streams, either open or in forest shade; (2) shore of Lake Tanganyika, with hard (rock) or soft (sand, mud and/or vegetation) substrates; (3) open, swampy pools, typically with muddy bottom and much vegetation. *: species with insufficient data to assess ecology because of low numbers or absence from waterside. ?: found in this habitat but not thought to breed there. Species' primary habitat is underlined. Habitats of dragonflies and damselflies recorded during the survey

site			River section			Additional features		
			Reedy	Varied	Rocky	Tribut.	Lake	Pools
Bottom End		Ta					hard/soft	
	01	Il	reedy				soft	
	02		reedy					
	03	Il	reedy					pools
	04		reedy					
Igamba	05	Ig	reedy					pools
	06	Ig		varied		open/sh		pools
	07	Ig			rocky			
	08	Ig		varied				
	09	Ig			rocky			
Gorge	10	Go			rocky			
	11	Go			rocky			
	12				rocky			
	13	Go		varied		shade		
Top End	14	Ng			rocky	open		
	15	Nk	reedy					pools
	16	Ka		varied				
	17	Ma	reedy					pools

	River section			Additional features		
	Reedy	**Varied**	**Rocky**	**Trib.**	**Lake**	**Pools**
ZYGOPTERA (Damselflies)						
Lestidae						
Lestes amicus*						
L. plagiatus*						?
Calopterygidae						
Phaon iridipennis	reedy	varied		shade		
Chlorocyphidae						
Chlorocypha consueta				shade		
Platycypha caligata	reedy	varied	?	open		
P. lacustris				shade		
P. pinheyi					hard	
Platycnemididae						
Mesocnemis singularis	reedy	varied	fast			
Protoneuridae						
Elattoneura cellularis	?	varied		open		?
Coenagrionidae						
Agriocnemis exilis	reedy					pool
A. gratiosa						pool
A. victoria						pool
Ceriagrion corallinum*						
C. glabrum						pool
Ischnura senegalensis	reedy					pool
Pseudagrion sp. nov.					soft	
P. acaciae	reedy	?				
P. glaucescens						pool
P. hageni				shade		
P. hamoni	reedy					pool
P. kersteni	?	varied		open		
P. lindicum						pool
P. melanicterum				shade		
P. nubicum	reedy					
P. sjoestedti	reedy	varied		?	soft	?
P. sublacteum	reedy	varied				
P. sudanicum*						?
ANISOPTERA (Dragonflies)						
Aeshnidae						
Anax imperator	reedy				soft	pool
A. speratus		varied		open		
Gynacantha bullata*						

			River section			Additional features
G. manderica*						
G. vesiculata*						
Gomphidae						
Ictinogomphus ferox	reedy				soft	pool
I. regisalberti	reedy					
Lestinogomphus sp.	reedy					
Neurogomphus sp.	reedy					
Paragomphus cognatus				shade		
P. genei	reedy	varied	slow	?		
Paragomphus sp.					soft	
Phyllogomphus selysi	reedy	varied				
Macromiidae						
Phyllomacromia contumax	reedy					
P. picta		varied		?		
Libellulidae						
Acisoma panorpoides						pool
Aethriamanta rezia						pool
Brachythemis lacustris	reedy				soft	
B. leucosticta	reedy					?
Bradinopyga cornuta			slow			
Chalcostephia flavifrons*				?		
Crocothemis divisa*			?	?		
C. erythraea	reedy	varied	slow			pool
C. sanguinolenta		varied	?	open		
Diplacodes lefebvrii						pool
Eleuthemis buettikoferi	reedy	varied				
Hemistigma albipunctum						pool
Nesciothemis farinosa						pool
Notiothemis robertsi*				?		?
Olpogastra lugubris	reedy	varied				
Orthetrum abbotti*		?				
O. austeni*		?				?
O. brachiale						pool
O. chrysostigma	reedy	varied	slow	open		
O. guineense		varied		open		
O. hintzi*		?				
O. julia				shade		pool
O. monardi*				?		
O. stemmale						pool
O. trinacria	reedy				soft	pool

			River section			Additional features
Palpopleura jucunda*				?		
P. lucia			slow			pool
P. portia				?		pool
Pantala flavescens			slow			
Rhyothemis semihyalina						pool
Tetrathemis polleni*				?		?
Thermochoria jeanneli*				?		
Trithemis aconita		varied		shade		?
T. annulata	reedy		slow		soft	pool
T. arteriosa	reedy	varied	slow	open		pool
T. dichroa		varied				
T. donaldsoni		varied	fast			
T. grouti	reedy					
T. kirbyi	?		slow	open		
T. nuptialis	?	varied				
T. pluvialis	reedy	varied		open		
T. pruinata				open		
T. stictica*				?		?
Urothemis assignata	?					pool
U. edwardsii	?					pool
Zygonyx natalensis	reedy	varied	fast			
Z. torridus*		?		?		
Total (? included: 83)	**36**	**29**	**15**	**34**	**9**	**37**
Total (? excluded: 59)	**30**	**24**	**12**	**19**	**9**	**27**
Primary habitat (35 species)	**8**	**2**	**2**	**6**	**2**	**15**