National Museums and Monuments of Zimbabwe

RESEARCH REPORT

NAME OF ORGANIZATION

NATURAL HISTORY MUSEUM OF ZIMBABWE

TITLE OF PROJECT

FRESHWATER ODONATA DIVERISTY IN THE EASTERN HIGHLANDS OF ZIMBABWE

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Contents

1. SUMMARY

A survey was conducted at 30 sites (13 lentic habitats and 17 lotic habitats) located within the Afromontane region of Zimbabwe so as to determine the diversity and distribution of Odonata species within the region. A total of 81 spp. (27 Zygoptera and 54 Anisoptera) were recorded from 10 families. Multivariate statistical procedures were used to analyze the relationship between the spp. and the characteristics of their habitat, in order to determine different spp. Biotopes preferences. Anthropogenic factors (landscape modification for ecotourism, commercial plantations, communal settlements, presence of exotic trees in reforested area and mining activities) were also assessed to determine their effects on Odonata diversity and abundance. Most Anisoptera species were found to be wide spread and did not have specific biotope requirements or preference whilst the majority of the Zygoptera species were found to be mostly associated with the artificial dams and ponds. The anthropogenic factors that were identified to be significantly affecting Odonata diversity at lotic habitats (rivers, and streams) compared to those within the protected and undisturbed areas include: Commercial exotic tree plantations, presence of mining activities, vegetation clearing and land scape modification for ecotourism as well as communal settlements and related activities. The assessments also revealed that the mid altitude forests (between 1000m and1400m above sea level) had a significantly lower diversity compared to the low altitude forests (less than 1000m above sea level) and the high altitude forests (above 1800 m above sea level). The results indicate that a number of human activities potentially threaten the existence of freshwater species in this region as well as the freshwater habitats as the human population and human encroachment continues to spread into freshwater habitats.

2. PROJECT RATIONALE

The Eastern highlands are a hub of endemism in Zimbabwe, known for their high number of endemic species of plants and animals. This fact has not spared the area from activities such as illegal gold mining which have negative environmental consequences to the aquatic ecosystem such as land and water pollution, habitat modification and pose a potential threat to the status of a number of endemic species (Gandiwa and Gandiwa, 2012). Freshwater Odonata species have been identified as one of the priority taxa indicators for environmental health and conservation management. Odonata are predators used a biological control for other pests such as disease spreading mosquitoes. They are also used as excellent indicators of ecosystem health, especially aquatic ecosystems due to the complex habitat requirements of individual species. However, they are not widely used in Zimbabwe because many endemics are still not described and many areas still remain poorly explored. The dragonfly record of the eastern highlands of Zimbabwe is fair (Darwall et al. 2009). Two species endemic species, Africallagma cuneistigma and Pseudagrion vumbaense are of high conservation importance because knowledge of these two species remains rudimentary (Darwin, et al. 2009). Africallagma cuneistigma was first recorded in 1958 in Bundi river, Chimanimani Mountain and was again recorded in 2013 at the same locality. Pseudagrion vumbaense was first recorded in 1958 in Vumba and again in 1966 in Mount Selinda. It was most recently recorded in 2013 at 4 other localities. The IUCN Red List provides general

review of the two endemic species and points out the need for more information urgently required to confirm their current range and conservation status.

3. PROJECT APPROACH

The main goal of the project was to identify the important sites for Conservation of Freshwater biodiversity, with a focus on Odonata species in the Eastern Highlands of Zimbabwe. The project focused on the following objectives: 1. to determine the diversity and distribution of Odonata species found in the Eastern Highlands of Zimbabwe 2. To determine habitat preferences the Odonata species in the Eastern Highlands of Zimbabwe 3. To Identify and assess the natural and anthropogenic threats facing these and other Odonata species. 4. To create awareness for the ecological research and conservation needs of Odonata species and their habitats in the Eastern Highlands of Zimbabwe

4. COMPONENTS AND KEY ACTIVITIES

4.1 Study Sites.

The study sites comprised of 30 sites (13 lentic habitats and 17 lotic habitats) located within the Afromontane region of Zimbabwe (Annex. 1). Surveys were conducted once in each of the three seasons recognized in Zimbabwe; i.e. in June (Cold and Dry season), October (Hot and Dry season) and January (hot and wet season) and each site was sampled once each season depending on the accessibility.

4.2 Adult male sampling

Standardized, timed 30 minute survey methodology was used to survey the adult male Odonata. The surveys were conducted by two observers and one recorder, walking through all the riparian habitats and recording any individual males flying over water and emergent vegetation, or within 2 meters of the waters' edge. A 5 by 500 meters transect was be used at each site and the Odonata species encountered were identified and counted. Identification of species was predominantly done for each species using close-focusing binoculars and field guides by the two observers to avoid misidentifications. Where necessary one individual of each species was caught and examined using a hand-lens to confirm identification and subsequently released. In addition species were photographed to provide a permanent record of identification and occurrence. Where further identification was required voucher specimens were captured and transported in labeled paper envelops for further identification by the experts.

4.3 Odonata diversity, distribution and Habitat associations

The Shannon diversity index (H) was used to provide a measure of relative diversity and then the effective number of species (ENS) was then calculated from the Shannon-Wiener index values for each site according to Jost (2006). The true diversity values for the Odonata adult males were not normally distributed, and subsequent comparison of these values was conducted using analysis non-parametric methods. The differences in Odonata abundance and diversity between the lotic and lentic habitat types

were compared using a Mann Whitney test. The study sites were grouped into vegetation types and altitude zones recognized in the Afromontane region by altitude (Timberlake, 1994), i. e high altitude (above 1 800 meters), high to medium altitude (1 400 to 1 800 meters), medium altitude (1 000 to 1 400 meters) and low altitude (below 1 000 meters) and the Krustal Wallis test was used to compares the Odonata diversity across these altitude zones. The sites where also grouped into, biotopes according to Samways (2008) i.e. Swamp forests, Small mountain streams with quiet pools, Fluctuating pools and marshes, Permanent pools, lakes, vleis or marshes, Sluggish rivers with quiet pools, Artificial Ponds and Dams, Swift Rivers and, Streams with invasive alien trees. The principal component analysis (PCA) was also used to determine the association between the Odonata species and these biotopes.

4.4 Identifying and assessing the anthropogenic threats

Lotic habitats located in sites that had been reforested using exotic trees within the protected areas were identified and surveyed during the study period. Lotic habitats located within communal areas, in large scale exotic tree plantations, near illegal mining areas and those located within protected areas where vegetation is regularly cleared and modified for ecotourism were also identified and surveyed. These sites were compared with lotic habitats within protected and undisturbed sites using the Mann-Whitney tests at an alpha level of 0.05, so as to determine the effects of anthropogenic factors on Odonata diversity.

5. RESULTS

5.1 General Diversity and Distribution of Odonata species

A total of 81 spp. (27 Zygoptera and 54 Anisoptera) and 10 families were identified from a total of 2679 individual male adults (Annex 2) recorded within the 30 sites. Libellulidae family recorded the most number of species (44) followed by the Coenagrionidae family (18 species). The abundant species was Trithermis arteriosa (374 individuals) followed by Pseudagrion Kersterni (319 individuals). Of the four endemic species ever recorded in the region according to Dijkstra and Clausnitzer (2014), only two were found during this survey, i.e. Platycypha inyangae at 5 lotic habitats and Pseudagrion vumbaense at 6 sites which included both lotic and lentic habitats. Africallagma cuneistigma and Elattoneura lapidaria may be present in the region but they were not found within the sampling period.

Although the lentic habitats recorded a higher diversity of Odonata species as compared to the lotic habitats, The Mann Whitney test conducted at a significant level of 0.05 indicated that the diversity of the Odonata recorded between the two habitat types where not significantly different ($p=0.319$). The Mann Whitney tests also indicated that the number of species recorded between the lentic habitats and the lotic habitats were not significantly different ($p=0.255$).

A Krustal-Wallis test showed that at there was a significant difference ($H = 8.272$, $p < 0.05$ $DF= 3$, $N=75$) in Odonata diversity and species richness ($H=8.888$, $df=3$, $N=75$) across the altitude zones. The post hoc tests at the significant level of 0.05 adjusted by the bonferroni correction for multiple tests revealed that the mid altitude zones had a significantly lower diversity and species richness compared to the low altitude ($p<0.05$) and the high altitude zone ($p<0.05$). The number of species and Odonata diversity

between the low altitude and mid to high altitude zones (p>0.05), between the low and high altitude zones (P>0.05), and between the mid to high and high altitudes zones (p>0.05) were not significantly different.

5.2 Habitat associations

The first two axis of the components explained 47.3 % of total variation of the dragonfly (Anisoptera) communities combined. Most Anisoptera species where found to be wide spread and did not have specific biotope requirements including *A. imperator, O chysostigma, C. erythreae, C. divisa, T. kirbyi, T. stistica T. furva and T. arterioa* (Fig.1). However, four other main species assemblages could be detected. *P. contumax, P. jucunda, B leucostica, N. farinose, I. ferox, P. pictus O. stemmale and R. semihylina* were found to be associated with the artificial ponds and dams, while *T. werneii*, *O. hintzi, A. vanegatum*, *N. praetrius* and *D. pumula* preferred the swift rivers*. P. genei, B. lacustris, T. aconite, Z. fuelleroni, Z. torridus T. polleni, O. trinacria* and *T. pluvialis* where found to be associated with the artificial ponds and dams as well as the sluggish river with quiet pools. *A. speratus, P. risi, A. biodinata, A. panorides* and *O. icteromela* mostly preferred the small mountain streams with quiet pools as well as the streams with invasive aliens trees. Only *T. annulata* was found to be mostly associated with the permanent pools, vleis lakes or marshes.

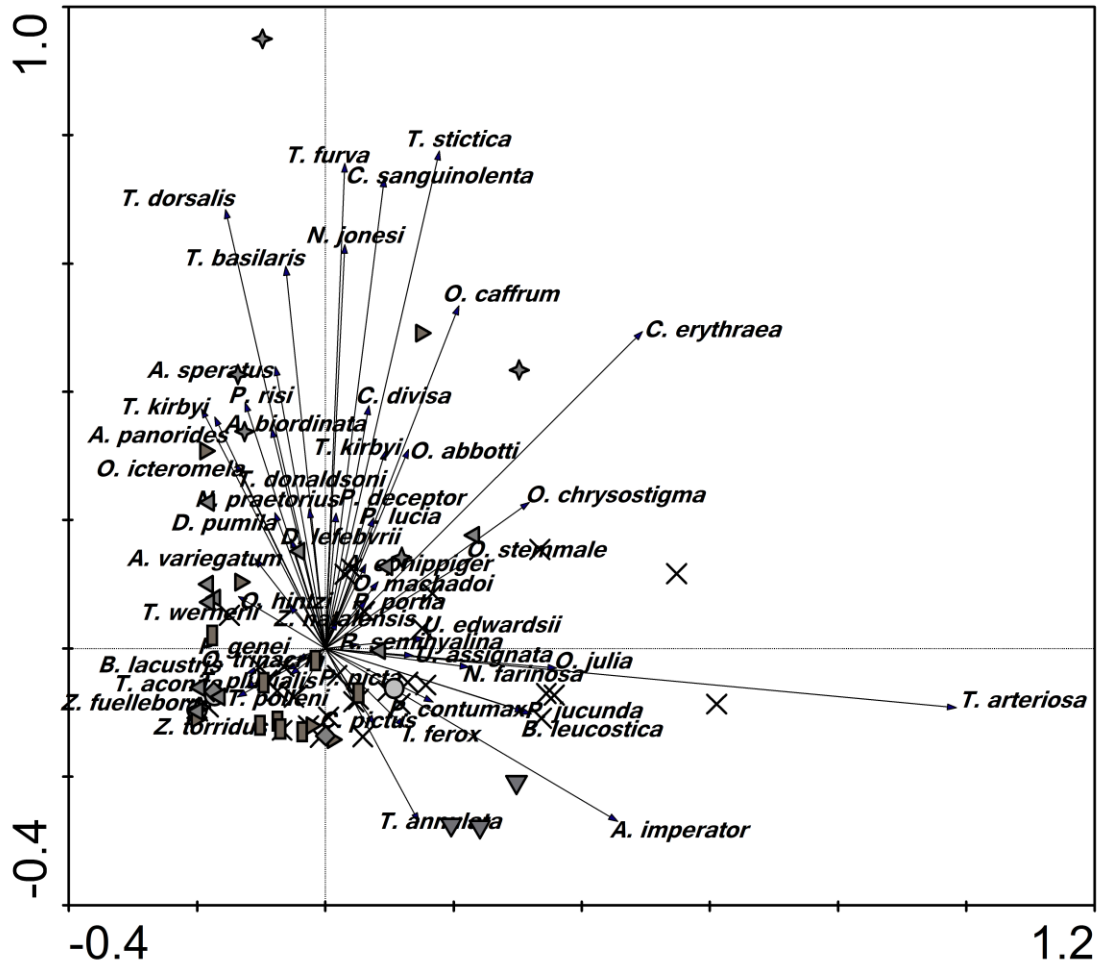

Figure.1 Biplot based on a PCA (first two axes explaining 47.3 % of total variation) illustrating the associations between the aquatic Anisoptera species recorded from the Afromontane region of Zimbabwe between August 2016 and June 2017 (X=Artificial Ponds and Dams; ●= Fluctuating pools and marshes; ◀= Swift Rivers; ▶= Streams with invasive alien trees; ▮=Sluggish rivers with quiet pools; ▼=Permanent pools, lakes, vleis or marshes; ✦=Small mountain streams with quiet pools; t=Swamp forests).

The first two axis of the components explained 66.8 % of total variation of the damselfly (Zygoptera) communities. The majority of the Zygoptera species were mostly associated with the artificial dams and ponds including; *I. senegalensis, A. nigridorsum, C. glabrum, A. fractrum, P. iridipennis*, *A. exilis* and *P. glablum. P.inyange, P. consueta* and *P. salisburyense* that were found to be mostly associated with the small mountain streams with quiet pools as well as the streams with the invasive alien trees while, *P. hamoni, P. hageni, P. caligata, A. marshalli, L. vigratus, L. plagitus* were mostly associated with the sluggish rives with quiet pools as well as the swift rivers. *E. glauca* was found to be mostly associated with the streams with the alien invasive trees, whereas *P. vumbaense, P. kersteni, P. spernatum* and *A. glaucum* were found not have any specific biotope requirements (Fig.2)

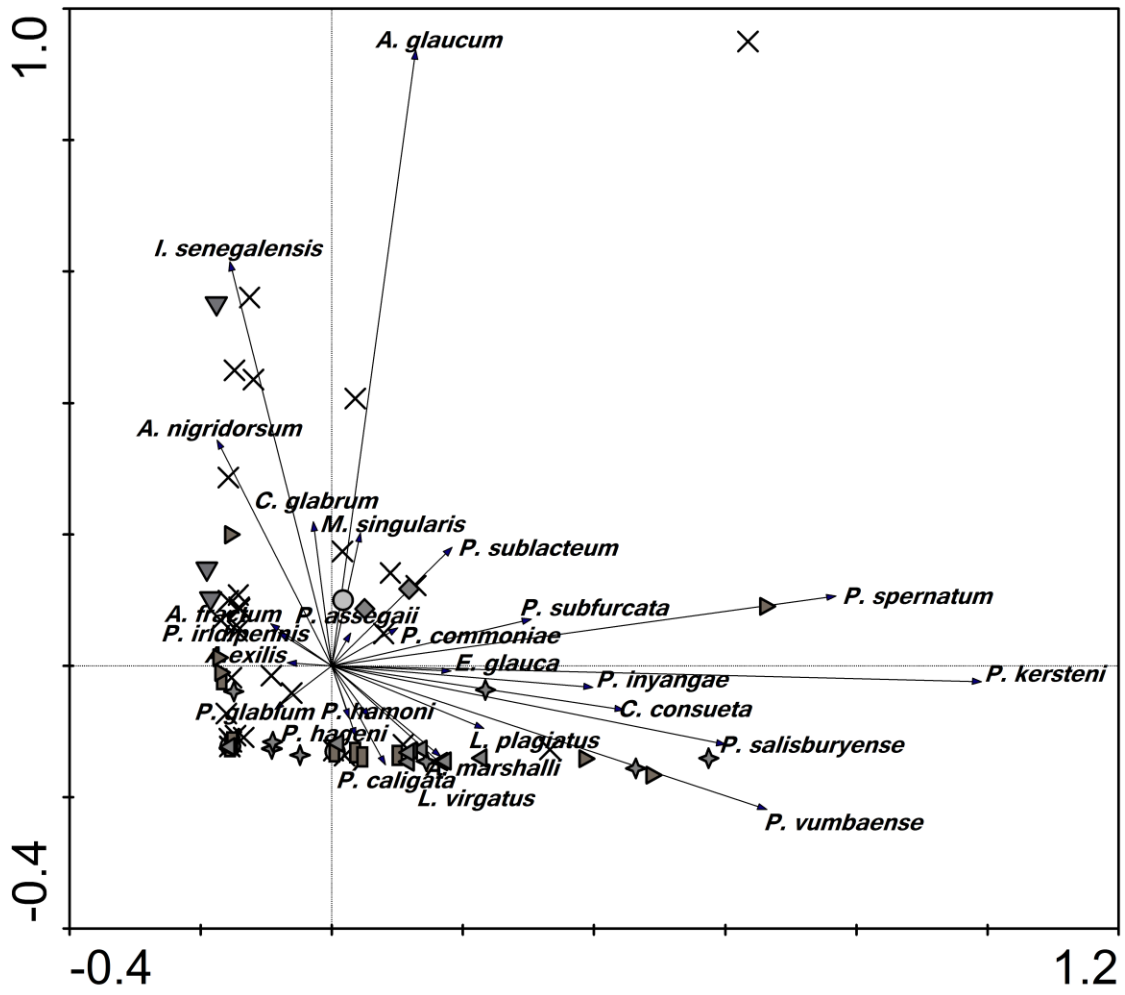

Figure 2. Biplot based on a PCA (first two axes explaining 66.8 % of total variation) illustrating the associations between the aquatic biotopes and Zygoptera species recorded from the Afromontane region of Zimbabwe between August 2016 and June 2017 (X=Artificial Ponds and Dams; ●= Fluctuating pools and marshes; ◀= Swift Rivers; ▶= Streams with invasive alien trees; ▌=Sluggish rivers with quiet pools; ▼=Permanent pools, lakes, vleis or marshes; ✦=Small mountain streams with quiet pools; t=Swamp forests).

5.4 Anthropogenic threats

The results indicated that, lotic habitats located within the protected and undisturbed sites had a significantly high diversity compared to the sites located within the protected areas, where vegetation is regularly cleared and modified for ecotourism (Mann–Whitney U = 1.00, n1=9, n2 = 3, p=0.02 two-tailed). The protected and undisturbed sites also recorded a significantly higher diversity compared to the sites located in the communal areas (Mann–Whitney U = 24.00, n1=12, n2 = 9, p=0.03 two-tailed), in plantation areas (Mann–Whitney U = 1.00, n1=9, n2 = 3, P= 0.02 two-tailed) and those located where

the presence of mining activities (Mann–Whitney U = 1.00, n1=5, n2 = 9, p=0.04 two-tailed) had been identified. However the Odonata diversity recorded at sites within protected areas, that had been reforested using exotic trees was not significantly different (Mann–Whitney U = 17.00, n1=9, n2=6, p=0.24 two-tailed) to the Odonata diversity recorded at sites within the protected and undisturbed areas. The endemic species, *P. inyangae* was recorded at a site that fell outside the protected area along the Haroni River. Communal settlements and related activities including fishing and stream bank cultivation were identified at this site. Pseudagrion vumbaense was also recorded outside the protected area in swampy area near Chikware dams. However this area had been reforested with exotic pine trees (K. Mafuwe, personal Observation, March 2017).

6. DISCUSSION AND CONCLUSION

Lotic and lentic habitats both support an equal diversity of Odonata species within the Chimanimani-Inyanga corridor. Most Anisoptera species were identified to be widespread across the region and occurred within most biotopes. This could be explained by the fact that the most abundant family Libellulidae contains numerous species that are considered generalist, widespread and can easily migrate and adapt to any habitat (Van Huyssteen and Samways 2009). The results from the study by (Van Huyssteen and Samways (2009) suggested that several libellulids are remarkably resilient to changing environmental conditions, with their winter survival as adults associated with their ability also to be abundant and widespread. However, most Zygoptera species were found to be mostly associated with artificial dams and ponds. Artificial pond and dams tend to contain more rainwater especially during the dry period and generally have larger surface area compared to the other biotopes. Therefore they tend to provide more microhabitats and perch sites that can support morespecies. A study by Oertli *et al.* (2002) found that pond size was important for Odonata because they provided more habitats and perch sites. Artificial pond and dams also are the most abundant freshwater habitat sources that were identified and surveyed during this study (Annex 1). Forests that occur within the mid altitude zones were found to support a significantly lower diversity of Odonata compared to the other altitude zones. The extreme temperatures and weather conditions experienced in the low and high altitude zones may not be favorable for human settlement, these vegetation types are therefore restricted to areas that are not suitable for farming, and have a low human population density and less human disturbances. In contrast, the mid altitude forests' vegetation have been cleared for tea and coffee plantations and for dairy farming (Timberlake 2004). Timberlake (1994) also mentions that the threats to the Chirinda Forest Reserve, a mid-altitude forest (Timberlake 2002), include poaching (particularly for blue duiker and guinea fowl), the collection of firewood and the gathering of traditional herbal medicines. Human disturbances can potentially have a negative impact on biodiversity. A number of other human activities namely: Commercial exotic tree plantations, presence of mining activities, vegetation clearing and land scape modification for ecotourism as well as communal settlements were identified and can potentially threaten the existence of freshwater species in this region as well as the freshwater habitats as the human population and human encroachment into the freshwater habitats continue to increase (Bengtsson et al. 2000, Sala et al. 2000, Vörösmarty et al. 2010)

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ACKNOWLEDGEMENTS

This research was made possible by the The Critical Ecosystem Partnership Fund (CEPF). CEPF is a joint initiative of l'Agence Française de Développement, Conservation International, the European Union,

the Global Environment Facility, the Government of Japan, the MacArthur Foundation and the World Bank. A fundamental goal is to ensure civil society is engaged in biodiversity conservation."

ANNEXES

Annex 1. Types of water bodies and their distribution investigated in this study

Site Name	Biotope	Habitat type	Latitude	Longitude
Bridal Veil	Small mountain streams with quiet pools:	Lotic	-19.8	32.8666667
Brown Dam	Artificial Ponds and Dams	Lentic	-19.1928	32.83024
Bundi Valley	Small mountain streams with quiet pools:	Lotic	-19.78258	33.02429
Chako Dam	Artificial Ponds and Dams	Lentic	-20.44045	32.67456
Chikware Dam	Artificial Ponds and Dams	Lentic	-19.08036	32.74143
Chikware Swamp	Swamp forests:	Lotic	-19.02892	1421.5
Chinyika River	Sluggish rivers with quiet pools:	Lotic	-20.43374	32.67718
Esperance Dam	Artificial Ponds and Dams	Lentic	-20.3843	32.71692
Haroni River	Swift Rivers	Lotic	-19.77835	32.97009
Leopard Rock	Artificial Ponds and Dams	Lentic	-19.13475	3278199
Mare Dam	Artificial Ponds and Dams	Lentic	-18.29505	32.77009
Mare River	Streamswith invasive alien trees:	Lotic	-18.28941	3274289
Mutare River	Sluggish rivers with quiet pools:	Lotic	-18.88146	32.66468
Nyamataka river	Sluggish rivers with quiet pools:	Lotic	-19.18035	32.83319
Nyamukwarara	Swift Rivers	Lotic	-18.70442	32.91549
Nyangombe falls	Swift Rivers	Lotic	-18.28505	32.67892
Nyangombe pool and river	Swift Rivers	Lotic	-18.28505	32.67892
Rhodes Dam	Artificial Ponds and Dams	Lentic	-18.28872	32.72503

Small bridge lake	Permanent pools, lakes, vleis or marshes:	Lentic	-18.76335	32.74776
Small bridge stream	Streams with invasive alien trees:	Lotic	-18.74808	32.79109
Smalldel Dam	Artificial Ponds and Dams	Lentic	-20.47201	32.66214
Temporary stream close to Udu dam	Fluctuating pools and marshes:	Lotic	-18.28252	32.69409
Temporary stream close Chako dam	Fluctuating pools and marshes:	Lotic	-20.44202°	32.67486°E
Temporary stream close to Esperance dam	Fluctuating pools and marshes:	Lotic	-20.3843	32.71692
Tessa's pool and Outward bound Vlei	Small mountain streams with quiet pools:	Lotic	-19.76701	32.98336
Udu Dam	Artificial Ponds and Dams	Lentic	-18.28119	32.69708
Umswilizwe River	Sluggish rivers with quiet pools:	Lotic	-20.38421	32.72651
Vumba Botanical Gardens	Artificial Ponds and Dams	Lentic	-19.1156	32.78125
Zona Dam	Artificial Ponds and Dams	Lentic	-20.44326	32.73848
Zonwe Dam	Artificial Ponds and Dams	Lentic	-19.07016	32.84882

Annex2: List of species recorded and abundance

Sub Order	Family	Species	Abundance
Anisoptera	Aeshnidae	Anax ephippiger	3
		Anax imperator	38
		Anax speratus	14
		Zosteraeschna usambarica	2
	Gomphidae	Ceratogomphus pictus	13
		Ictinogomphus ferox	24
		Notogomphus praetorius	1
		Paragomphus genei	12
	Libellulidae	Acisoma panorides	7
		Acisoma variegatum	7
		Atoconeura biordinata	13
		Brachythemis lacustris	1
		Brachythemis leucostica	68
		Crocothemis divisa	9
		Crocothemis erythraea	141
		Crocothemis sanguinolenta	55
		Diplacodes lefebvrii	10
		Diplacodes pumila	2
		Nesciothemis farinosa	37
		Notiothemis jonesi	7
		Orthertrum icteromela	4
		Orthetrum abbotti	20

		Orthetrum caffrum	45
		Orthetrum chrysostigma	67
		Orthetrum hintzi	13
		Orthetrum julia	98
		Orthetrum machadoi	7
		Orthetrum stemmale	8
		Orthetrum trinacria	5
		Palpopleura deceptor	11
		Palpopleura jucunda	62
		Palpopleura lucia	26
		Palpopleura portia	42
		Porpax risi	4
		Rhyothemis semihyalina	3
		Tetrathemis polleni	1
		Tramea basilaris	2
		Trithemis aconita	10
		Trithemis annulata	39
		Trithemis arteriosa	374
		Trithemis donaldsoni	8
		Trithemis dorsalis	32
		Trithemis furva	112
		Trithemis kirbyi	19
		Trithemis pluvialis	17
		Trithemis stictica	107

		Trithemis wernerii	4
		Urothemis assignata	4
		Urothemis edwardsii	13
		Zygonoides fuelleborni	1
		Zygonyx natalensis	4
		Zygonyx torridus	4
	Macromidae	Phyllomacromia contumax	4
		Phyllomacromia picta	2
Anisoptera Total			1636
Zygoptera	Calopterygiade	Phaon iridipennis	15
	Chlorocyphidae	Chlorocypha consueta	6
		Platycypha caligata	13
		Platycypha inyangae	11
	Coenagrionidae	Africallagma fractum	5
		Africallagma glaucum	158
		Agriocnemis exilis	10
		Azuragrion nigridorsum	37
		Ceriagrion glabrum	68
		Ischnura senegalensis	108
		Mesocnemis singularis	8
		Proischnura subfurcata	6
		Pseudagrion assegaii	3
		Pseudagrion commoniae	11
		Pseudagrion glablum	1

		Pseudagrion hageni	5
		Pseudagrion hamoni	2
		Pseudagrion kersteni	319
		Pseudagrion salisburyense	39
		Pseudagrion spernatum	78
		Pseudagrion sublacteum	45
		Pseudagrion vumbaense	41
	Lestidae	Lestes plagiatus	17
		Lestes virgatus	16
	Platycnemidiade	Allocnemis marshalli	4
		Elattoneura glauca	14
	Synlestidae	Chlorestes elegans	3
Zygoptera Total			1043