INVENTORY OF THREATENED ODONATES IN TWO SELECTED AFROTROPICAL FORESTS IN THE ALBERTINE RIFT IN WESTERN UGANDA

By

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Team members

Name	Role	University
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Julius Tumusiime	Logistical arrangements, education campaigns and fieldwork	Mbarara University of Science and Technology
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I also greatly appreciate Dr. Perpetra Akite, and Esther Toloa for their taxonomy support in adult Odonata species confirmation.

In a special way, I would like to thank the Institute of Tropical Forest Conservation –Mbarara University of Science and Technology for availing us with a dedicated and committed citizen scientist.

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1.0 Introduction

1.1 Background

Afrotropical forests form a unique habitat site for specialist and rare odonates in Africa (Dijkstra & Clausnitzer, 2006). These forests include Afromontane forests which are key ecoregions with a high abundance of threatened odonate species (Clausnitzer et al., 2011). Bwindi Impenetrable Forest and Bugoma forest reserves are Afrotropical forests in the Albertine rift with threatened endemic odonate species (Ministry of Wildlife, Tourism and Antiquities (MTWA), 2018). These forests are under pressure from Uganda's population currently growing at a rate of 2.8% (Uganda Bureau of Standards (UBOS), 2024). This study documents the conservation status of odonate assemblage in these forests with a unique focus on rediscovering the threatened endemic species reported by the 2018 National IUCN Redlist of threatened species in Uganda and recommends conservation priority sites to save these organisms from the verge of extinction.

2.0 Project activities

2.1 Odonate survey:

We conducted a 21 days fieldwork, 7 days in Bwindi Impenetrable National Park and other 7 days in Bugoma Central Forest reserve in the wet season in December 2022 and 14 days in the dry season in July 2024. Adult odonates were collected using an entomologist sweep net and nymphs using a scoop net from all the sampled sites. Adult odonates were preserved using acetone to maintain the colouration while the nymphs were preserved in 80% ethanol. Human threats with the potential to deteriorate the odonate habitat quality were recorded for each forest.

Figure 1. Capturing adult odonates using a sweep net at a waterfall on R. Munyaga in Bwindi Impenetrable National Park, photo by J. Ndimulodi

Figure 2. Collecting odonate nymphs using a scoop net in Bwindi Impenetrable National Park. Photo by Aventino

2.2 Sampled morphotypes and their identification

In our fieldwork, we collected 13 and 25 species of odonates from Bwindi Impenetrable National Park and Bugoma Central Forest Reserve, respectively. The specimens were identified to species level using morphological features with the aid of a standard Odonates field guide identification key by Dijkstra and Clausnitzer (2014), and the African Dragonfly and Damselfly Database (http://addo.adu.org.za/). The specimens were confirmed by Dr. Perpetra Akite, a senior entomologist, an IUCN Odonata specialist for Ugandan odonates, and a Senior Lecturer at Makerere University-Uganda in the Department of Zoology. In addition, all the species were assigned a status using the global IUCN Red List status website (https://www.iucnredlist.org/species/60064/86136750), and the IUCN National Red List status (WCS, 2016; MTWA, 2018). We also collected numerous odonate nymphs with the motive of identifying the important breeding areas for the species of interest.

Figure 3: Identifying odonate nymphs in Justus Liebig Giessen University laboratory, Institute of Animal Ecology and Systematics. Photo by M. Rwibutso

Figure 4. I and Marie-Claire Dusabe a PhD student at Justus Liebig University Giessen, and a team member identifying odonate nymphs. Photo by M. Rwibutso

Figure 5. Enjoying some interesting and unique odonate nymphs. Photo by M. Rwibutso

2.3 Water physicochemical parameters:

Physicochemical parameters such as pH, water temperature, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Turbidity, salinity, substrate type, and Dissolved Oxygen (DO), were measured *in situ* using a calibrated HANNA handheld multiprobe meter (HI9829). Water colour was measured in the laboratory using a benchtop HANNA multiparameter photometer (HI83300) following the manufacturer's guidelines. All the above activities were done simultaneously with the odonate survey on all the sampling sites in Bwindi Impenetrable National Park and Bugoma Central Forest Reserve.

Figure 6. Collecting in situ physicochemical parameters using a HANNA multiparameter probe meter. Photo by J. Ndimulodi.

2.4 Setting up a Citizen Scientist Network

We recruited two citizen scientists on the project, one in Ruhija in Bwindi Impenetrable National Park and another one in Bugoma Central Forest Reserve. Each citizen scientist was provided an Android phone with a Kobotool box and a survey questionnaire set and connected to a server. In the first fieldwork, the citizen scientists were selected following recommendation by the local leaders. They were then trained to use the Kobo Collect app to record and upload

field data to a central server, from which it was accessed to the research team. Our citizen scientists sampled 16 sites, 10 in Bwindi Impenetrable National Park and 6 in Bugoma Central Forest Reserve. This increased our sampling effort in these forests.

Figure 7. Teaching our citizen scientist in Bugoma Central Forest Reserve how to use the Kobo Collect mobile application to collect the field data. Photo by J. Ndimulodi

Figure 8. After fieldwork photo. I in the middle, on the right side is our citizen scientist in Bwindi Impenetrable National Park and on the left side is our research assistant, a bachelor's student. Photo by J. Tumusiime

2.5 Sampled sites

In our first fieldwork in the wet season, we surveyed 21 sites in Bwindi Impenetrable National Park, a high-altitude forest and 19 sites in Bugoma Central Forest Reserve a low-altitude forest making a total of 40 sampled. In our second fieldwork in the dry season, we sampled 13 sites in Bwindi Impenetrable National Park. Currently, our citizen scientist network has managed to sample 16 sites, 10 sites in Bwindi Impenetrable National Park and 6 sites in Bugoma Central Forest Reserve making a total of **69** sampled sites.

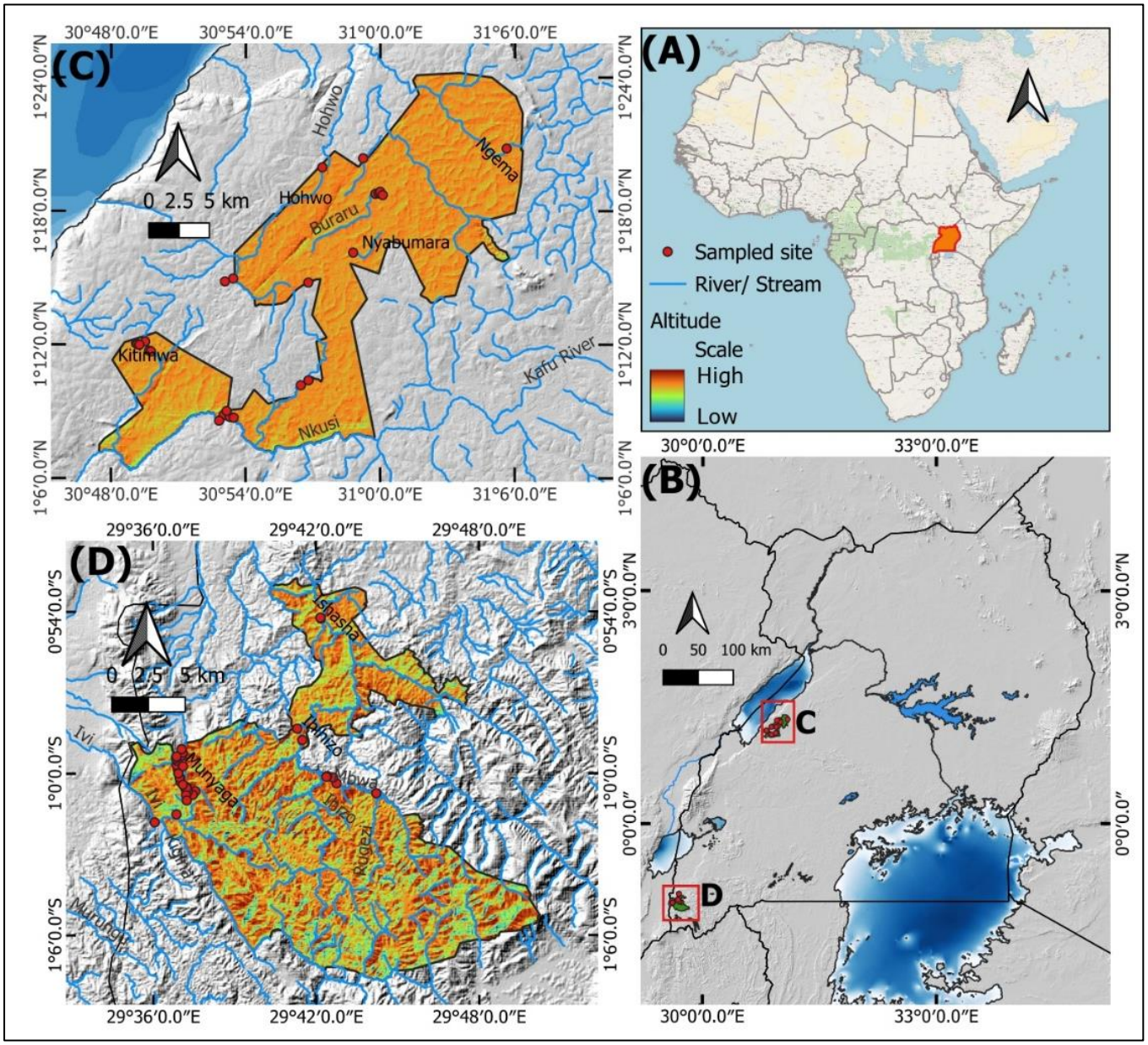

Figure 9. A. Map of Africa showing the location of Uganda, (B) Map of Uganda showing the location of Bugoma and Bwindi Forests, (C) Map of Bugoma Showing the location of the sampled sites, (D) Map of Bwindi showing the sampled sites. Map by F. Ssenkuba

3.0 Results

3.1 Identified odonates

In general, the Bwindi impenetrable forest has more restricted, specialist and odonate species of conservation concern though with a low species richness. On the other hand, Bugoma Central Forest reserve has a very high species richness with more generalists. In the current study, we identified 36 species. We report two globally threatened species namely *Neodythemis munyaga* (**EN**), and *Neodythemis nyungwe* (**VU**). We report the first record of *Neodythemis nyungwe* in Bwindi impenetrable forest and in Uganda. The species was previously thought to range only in Rwanda and endemic to Nyungwe forest. These results are to inform future red list status assessments of *Neodythemis nyungwe*. We also report two nearly threatened species at a global level i.e *Stenocypha molindica*, and *Stenocypha jacksoni*. The two species are respectively endangered and vulnerable at the national level, and Albertine endemic (Figure 11; Table 1).

We also report the nationally vulnerable species *Platycypha lacustris* and *Pseudagrion kibalense* from the Bugoma forest, which are categorized under least concern on a global level.

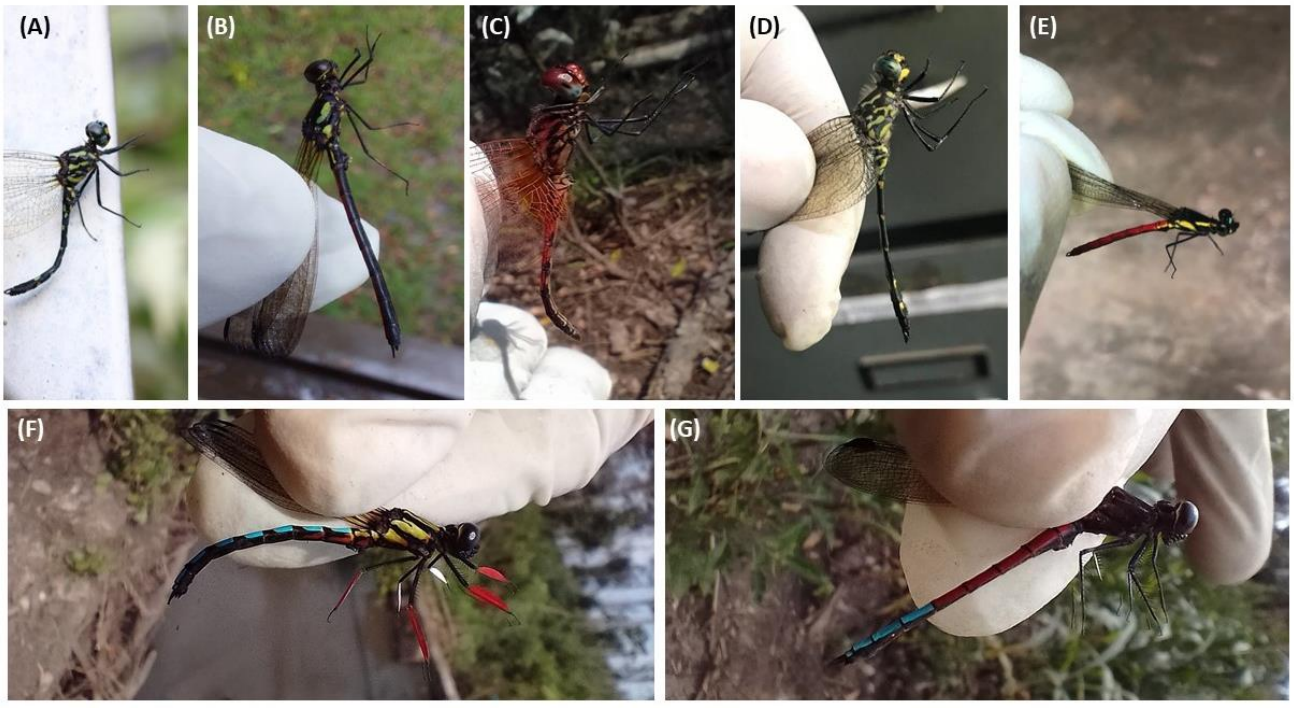

Figure 10: (A) *Neodythemis munyaga* ***(EN)***, (B) *Stenocypha molindica* ***(NT)*** (C) *Trithemis arteriosa* (D) *Neodythemis nyungwe* ***(VU)*** (E) *Stenocypha jacksoni* ***(NT)*** (F) *Platycypha lacustris* (G) *Chlorocypha curta*

Table 1: Species of Odonates collected from Bwindi and Bugoma Forests

Species name	Red list status		Endemism	Forest
	Global	**National**		
Orthetrum caffrum	LC		Not	Bwindi
Africallagma vaginale	LC		Not	Bwindi
Allocnemis nigripes	LC	**VU**	Not	Bwindi
Allocnemis pauli	LC		Not	Bwindi
Neodythemis munyaga	**EN**	**CR**	**Endemic**	Bwindi
Neodythemis nyungwe	**VU**		**Endemic to Nyungwe forest, Rwanda.**	Bwindi
Orthetrum camerunense	LC		Not	Bwindi
Orthetrum guineense	LC		Not	Bwindi
Orthetrum julia	LC		Not	Bwindi
Proischnura subfurcata	LC		Not	Bwindi
Stenocypha jacksoni	**NT**	**VU**	**Albertine Rift endemic**	Bwindi
Stenocypha molindica	**NT**	**EN**	**Albertine Rift endemic**	Bwindi
Umma saphirina	LC		Not	Bwindi
Pseudagrion kersteni	LC		Not	Bugoma
Africallagma vaginale	LC		Not	Bugoma
Agriocnemis gratiosa	LC		Not	Bugoma
Agriocnemis maclachlani	LC		Not	Bugoma
Ceriagrion glabrum	LC		Not	Bugoma
Chlorocypha curta cold	LC		Not	Bugoma
Chlorocypha trifaria	LC		Not	Bugoma
Copera nyansana	LC		Not	Bugoma
Gynacantha bullata	LC		Not	Bugoma
Orthetrum Julia	LC		Not	Bugoma
Orthetrum microstigma	LC		Not	Bugoma
Oxythemis phoenicosceles	LC		Not	Bugoma
Palpopleura lucia	LC		Not	Bugoma
Palpopleura portia	LC		Not	Bugoma
Phaon iridipennis	LC		Not	Bugoma
Platycypha lacustris	LC	**VU**	Not	Bugoma
Pseudagrion hageni	LC		Not	Bugoma
Pseudagrion kibalense	LC	**VU**	Not	Bugoma
Pseudagrion melanicterum	LC		Not	Bugoma
Pseudagrion sjoestedti	LC		Not	Bugoma
Pseudagrion spernatum	LC		Not	Bugoma
Pseudagrion sublacteum	LC		Not	Bugoma

Trithemis arteriosa	LC	Not	Bugoma
Trithemis nuptialis	LC	Not	Bugoma
Umma saphirina	LC	Not	Bugoma

The nymphs were collected from the sampled forest streams, marshes and wetlands and identified to family level. The family diversity for each forest was computed using the Shannon_H index which shows a difference in the nymph diversity between the two forests. Bugoma forest has a higher nymph diversity compared to the Bwindi Impenetrable forest (Figure 11).

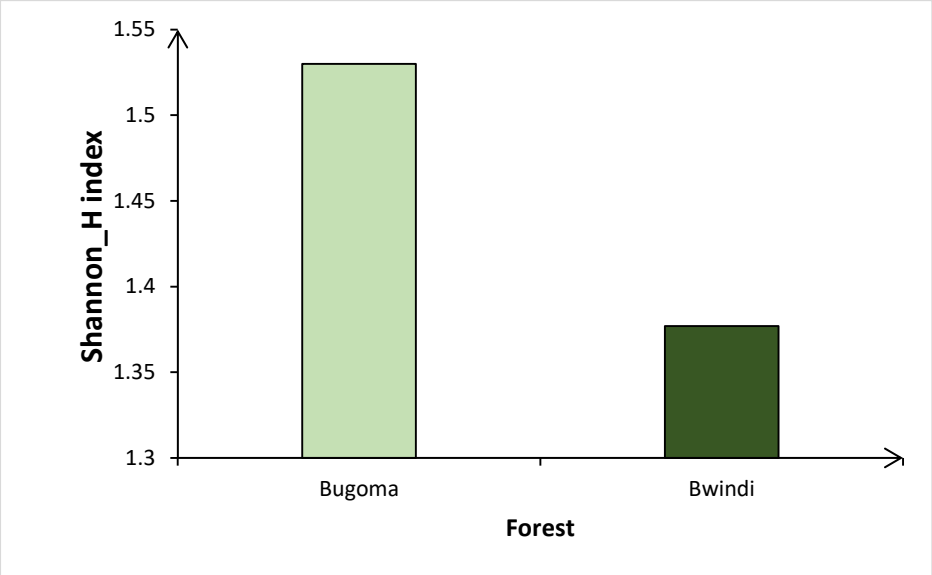

Figure 11: Odonata nymph diversity from the Bugoma and Bwindi forests

3.2 Odonate Conservation priority areas

We used the IUCN threat-based scores adopted from Samways and Simaika (2015) and Uyizeye et al. (2021) to map odonate conservation priority areas considering the presence of globally threatened species. The following scores: 0, 1, 2 and 3 are associated with the following IUCN Red List categories, respectively: Least Concern, Near Threatened, Data Deficient/Vulnerable, and Endangered/Critically endangered were used. In our study, we identified five conservation important areas, three in Munyaga Valley and two in the Ruhija sector (Figure 12).

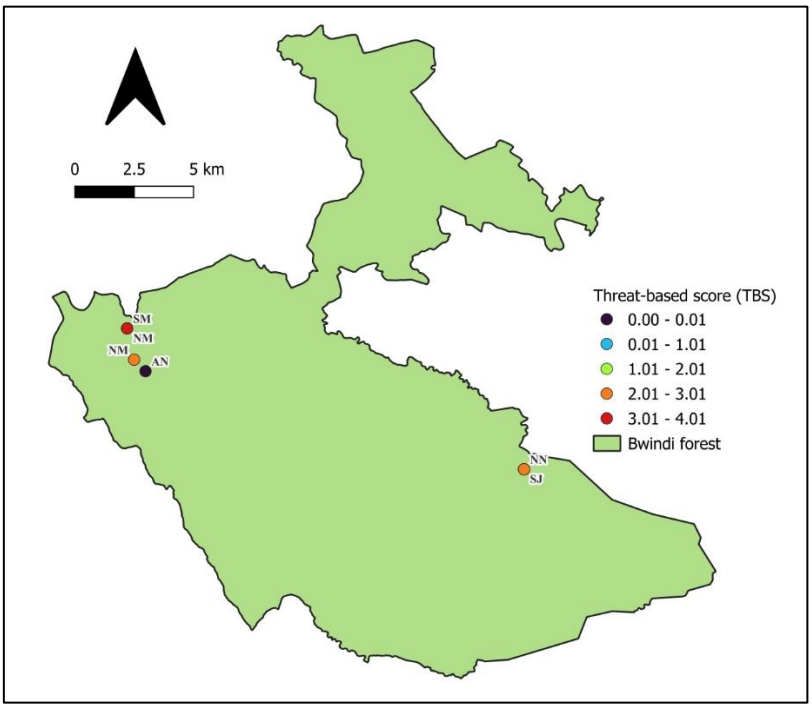

Figure 12: Odonate Conservation priority areas in Bwindi impenetrable national Park; Where NM-*Neodythemis munyaga*, NN-*Neodythemis nyungwe*, SM-*Stenocypha molindica*, SJ-*Stenocypha jacksoni*, AN-*Allocnemis nigripes*

In Bugoma Central forest reserve, we identified one odonate conservation priority area harbouring *Platycypha lacustris* and *Pseudagrion kibalense* both of which least concern globally but vulnerable at the National level (Figure 13).

Figure 13: Odonate Conservation priority areas in Bugoma Central forest reserve. Where PL-*Platycypha lacustris*, PK-*Pseudagrion kibalense*

3.3 Water physicochemical parameters

The Principal Component Analysis (PCA) reliably explained the variations (78.4 %) in the sampled sites from Bwindi Forest and Bugoma forest. The PCA grouped the sampled sites into 2 distinct clusters without overlap based on the water chemistry with PC 1 explaining 64.9% variation and PC2 explaining 13.5% variation. The sites from Bwindi forest are characterised with high altitude and dissolved oxygen levels with lower temperature, EC, TDS and Salinity. On the other hand, the sites from Bugoma are characterised with high Temperature, EC, TDS and salinity with lower DO and altitude.

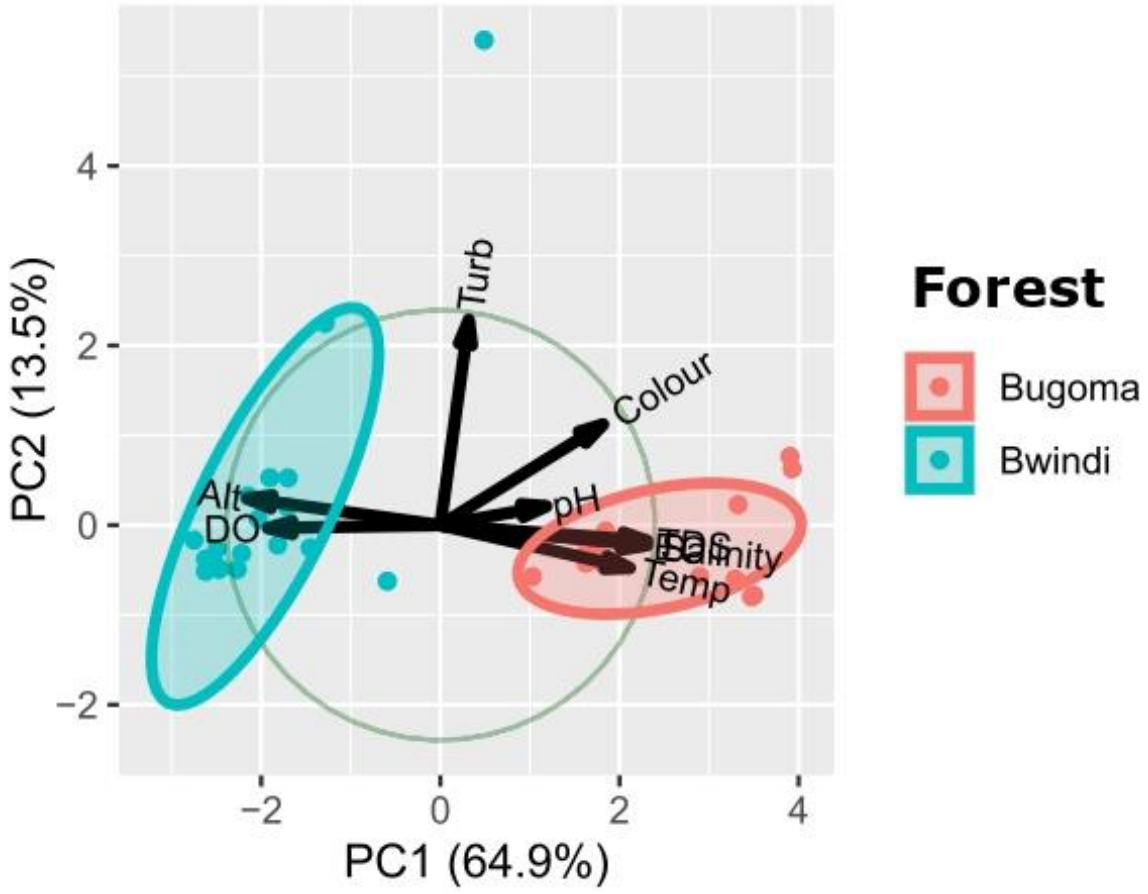

Figure 14: PCA ordination clustering the sampled sites based on water quality parameters

3.4 Odonate conservation awareness campaign

The odonate conservation campaign was held on 30th July, 2024 for three hours at Kisaaru Primary School which is about 100 m away from Bugoma central forest reserve. Written informed consent was sought from the school to allow our team to conduct the campaign at the school. In this campaign, the upper primary classes i.e. primary 6 and primary 5 were considered with a total number of 100 pupils. Fifty pupils out of 100 were selected randomly,

subjected to a pre-campaign questionnaire and then a post-campaign questionnaire to evaluate the impact of the education campaign on their knowledge and attitudes towards conservation. The questionnaire entailed a series of questions assessing the pupils' prior background knowledge about the ecology of odonates, Bugoma forest conservation, and their attitudes and perceptions towards odonates and the forest at large. Struggling pupils were provided with a mild assistance i.e. translation and interpretation through the exercise. A participatory approach was employed in conducting the campaign were the pupils were engaged in interesting conservation quizzes supplemented with prizes i.e. books, mathematical sets, pens, pencils, t-shirts and reusable water bottles for the winners.

Figure 15: Fun time with the pupil after the campaign

3.4.1 Participants' Biodata

Of the 50 participants, 29 (58%) were females and 21 (42%) males. Forty-six respondents (92%) were between the age of 12 to 18 years and only 4 (08%) below the age of 12 years. Nineteen pupils (38%) reported living within a Bugoma forest perimeter less than 1 mile, 21 (42%) pupils in 1 mile and 10 pupils living within a distance greater than 1 miles.

3.4.2 Background knowledge

In this exercise, all the respondents reported to have ever seen and knew dragonflies and damselflies.

There was a significant change in pupils' knowledge (X^2 = 21.56, df = 5; p=0.001) about the ecological functions of odonates. The number of pupils reporting all the listed ecological functions of odonates in the questionnaire increased from 1 pupil in the pre-campaign assessment to 15 pupils in the post-campaign assessment (table 1). Furthermore the number of pupils reporting wrong alternatives (others) decreased from 20 pupils in the pre-campaign assessment to eight pupils in the post-campaign assessment (Table 2).

Table 2: Cross tabulation of the reported ecological functions of odonates before and after the campaign

Issue time	Ecological functions of odonates						
	Pest control only	Vector control only	Biological indicator only	Food for birds only	Pest control, vector control, Biological control, & food for birds	Others	Total
Pre-	4	1	13	11	1	20	50
Post-	5	5	8	9	15	8	50
Total	9	6	21	20	16	28	100

The pupils' knowledge about the ecological habitats of odonates changed significantly (X^2=13.56; df = 4; p=0.009). The number of pupils reporting forest streams increased significantly from 13 pupils in the pre-campaign assessment to 24 pupils in the post-campaign assessment. Furthermore, the number of pupils reporting polluted streams and degraded forest decreased from 31 to 16 pupils and from 3 to 1 pupil respectively (Table 3).

Table 3: Cross tabulation of the reported preferred habitats by the odonates before and after the campaign

Issue time	Preferred habitats by odonates					
	Desert sand	Polluted streams	Grassland	Forest streams	Degraded forest	Total
Pre-	3	31	0	13	3	50
Post-	5	16	4	24	1	50
Total	8	47	4	37	4	100

3.4.3 Conservation knowledge

We report a significant increase in pupils' knowledge about the importance of odonates from 21 pupils to 41pupils and a reduction in the number of pupils reporting that odonates are not important from 29 pupils to 9 pupils (X^2=16.98, df =1, p=0.000; Figure 16).

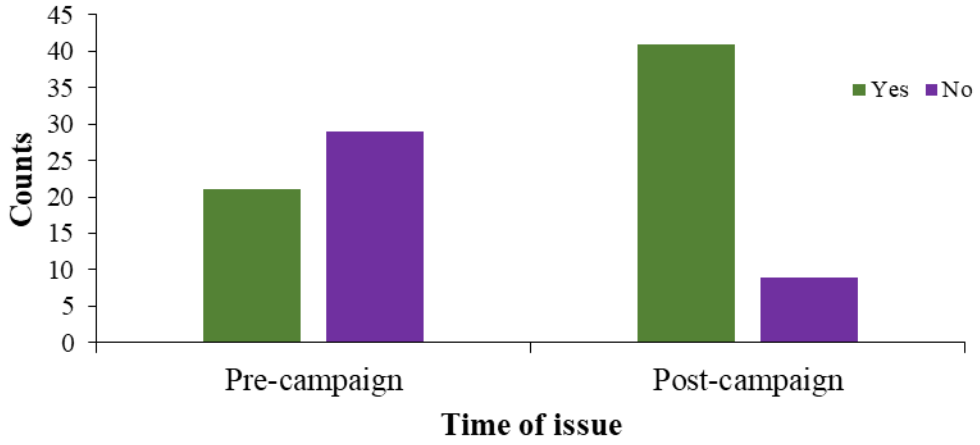

Figure 16: The number of pupils reporting whether odonates are important or not before and after the campaign

In our campaign we reported a significant change in pupils' knowledge about the considerations to be made to ensure odonate conservation (X^2=19.54; df=3; p=0.000). The number of pupils selecting wrong alternatives (others) decreased from 22 pupils in the pre-campaign assessment to three pupils in the post-campaign assessment (Table 4).

Table 4: Cross tabulation of the reported ways of ensuring odonate conservation before and after the campaign

Issue time	Ways of ensuring odonate conservation				
	Stop washing clothes in the forest streams and Stop lumbering in Bugoma forest	Stop lumbering in Bugoma forest only	Stop washing clothes in the forest streams only	Others	Total
Pre-	25	1	2	22	50
Post-	43	2	2	3	50
Total	68	3	4	25	100

Pupil's knowledge about the threats pertaining to odonates and the forest conservation significantly changed as shown in table 4 below (X^2=14.27; df=4; p=0.006; Table 5).

Table 5: Cross tabulation of the reported threats to odonate and forest conservation before and after the campaign

Issue time	Threats to odonate conservation and the forest at large					
	Tree cutting	Pesticide use	Polluting streams	Bush burning	Agriculture	Total
Pre-	19	16	4	9	2	50
Post-	13	8	17	12	0	50
Total	32	24	21	21	2	100

3.4.4 Conservation attitudes and perceptions

We further report a significant change in pupils' attitudes towards odonate conservation were the number of pupils reporting that its relevant to conserve odonates significantly increased from 15pupils in the pre-campaign assessment to 37 pupils in the post-campaign assessment

and the number of pupils selecting that its irrelevant to conserve odonates decreased from 35pupils in the pre-campaign assessment to 13 pupils in the post-campaign assessment (X^2=19.39; df=1; p=0.000; Figure 17).

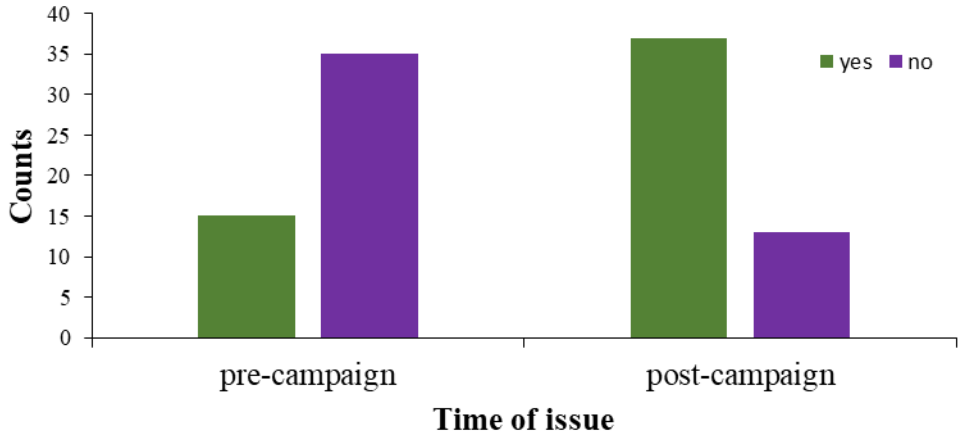

Figure 17: The number of pupils reporting whether odonate conservation is relevant or not

Pupils' attitude and perception towards odonates significantly changed (X^2 = 29.74; df=1; p=0.000). The number of students reporting that they like odonates significantly increased from 15 pupils in the pre-campaign assessment to 42 pupils in the post-campaign assessment and those reporting that they dislike odonates reduced from 35 pupils in the pre-campaign assessment to 8 pupils in the post-campaign assessment (Figure 18).

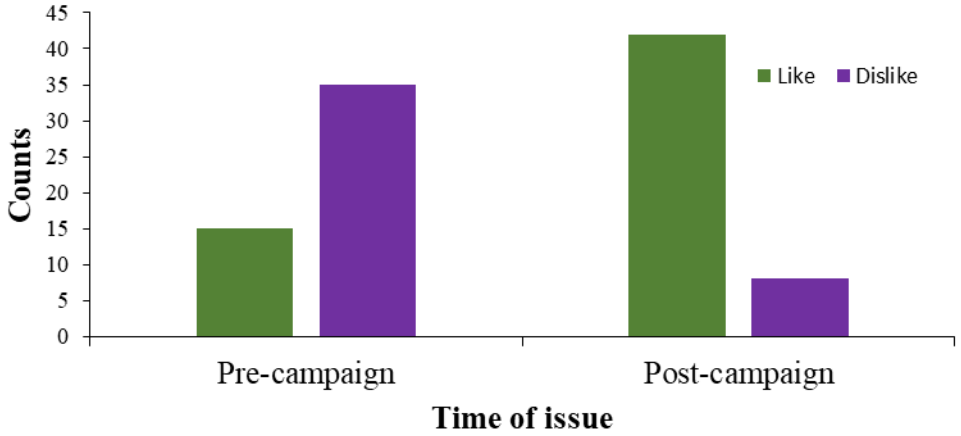

Figure 18: The number of pupils reporting their attitude towards odonates

3.4.5 ADDRESSED MIS-CONCEPTS

In our interaction with the future generation, we learnt that there are myriad misconceptions pertaining to the odonates. One among the many is a myth that dragonflies and damselflies carcass when dried and mixed in vaseline can increase a man's chance to persuade a woman. Another one is about the odonate water darting behaviour using their abdomen, which is a characteristic of ovipositing adult female odonates when laying their eggs in the water. This has always been misinterpreted as odonates mating with water surfaces.

All these misconceptions were scrutinized and comprehensively addressed by our team to the pupils and the school teachers who attended the campaign.

3.4.6 CONCLUSION

According to our evaluation, there is no doubt that our conservation campaign has contributed significantly to pupils' knowledge, attitudes, and perceptions change towards the odonates and Bugoma forest conservation. The learners were encouraged to share this profound knowledge to their friends and relatives in the community. The pupils assured us to act as odonate and the forest conservation ambassadors and not to allow this important message go to waste.

3.5 Identified Conservation Threats

We have identified several threats to the conservation of the sampled odonates and their habitat at large. The threats are mainly anthropogenic with charcoal burning, firewood collection, illegal lumbering and agriculture leading due to the fact that the local communities living close to these forests are poor with no alternative energy sources and hence entirely depend on the forest resources for energy. We also identified one natural threat: the parasitic red mites (figure 25). In general, we found out that the situation in Bugoma Central Forest Reserve is alarming with most of the forest patches degraded. It is on this note, we conducted our Odonate conservation campaign in Kisaaru Primary School close to the Bugoma Central Forest Reserve to inculcate a conservation attitude in the young generation close to this disappearing resource. Bwindi Impenetrable National Park is relatively pristine with few conservation threats due to the strict managerial strategies of the Uganda Wildlife Authority. One future threat in Bwindi Impenetrable forest is the prospect of contracting a road that connects Buhoma town to Kisoro District through Munyaga Valley in the National park which is a vital habitat for *Neodythemis munyaga*, an endemic species to this valley and globally endangered. *Neodythemis munyaga* was also inflicted by the parasitic red mites.

Figure 19. Maize plantation in the fore ground and a sugarcane plantation in the background in the Bugoma Central Forest Reserve. Photo by F. Ssenkuba

Figure 20. A cleared site for agriculture in Bugoma Central Forest Reserve. Photo by F. Ssenkuba

Figure 21. Charcoal kiln in Bugoma Central Forest Reserve. Photo by F. Ssenkuba

Figure 22. Illegal tree cutting. Photo by F. Ssenkuba

Figure 23. (A) A debarked tree in Bugoma Central Forest Reserve for medicinal purposes. (B) Tree burning in Bugoma Central Forest Reserve. Photo by F. Ssenkuba

Figure 24. An active charcoal burning site in Bugoma Central Forest Reserve. Photo by F. Ssenkuba

Figure 25. A cleared forest into grazing land in Bugoma Forest Reserve. Photo by F. Ssenkuba

Figure 26. Animal grazing in Bugoma Central Forest Reserve. Photo by F. Ssenkuba

Figure 27. Parasitic red mites (in the yellow shape) on Orthetrum sp. *dragonfly. Photo by F. Ssenkuba*

4.0 Summary of Recorded Success

We collected a species listed on the IUCN red list among the endangered dragonflies at a global level and as critically endangered at a national level *Neodythemis munyaga* (figure 10) endemic to Bwindi Impenetrable National Park with a restricted range. We also collected two threatened Albertine endemics; *Stenocypha molindica* (figure 10) nearly threatened at a global level and endangered at the national level, and *Stenocypha jacksoni* (figure 10) a nearly threatened species at the global level and vulnerable at the National level. We have also collected a globally endangered dragonfly *Neodythemis nyungwe* from one locality in Bwindi Impenetrable forest, a first record in Uganda. In this study we report the current natural and anthropogenic threats towards the conservation of these unique odonates in the two forests.

We also trained two citizen scientists one from each forest building their capacity in odonata and the forest conservation.

In this project, we recruited one bachelor's student, inspiring him in odonata conservation research and building his capacity in this field. He acquired the necessary research skills including: Odonata sampling and identification of adults and nymphs, testing of water physicochemical parameters, data analysis and presentation, etc. He acquired enough data for his research report that enabled him accomplish his bachelors' research project.

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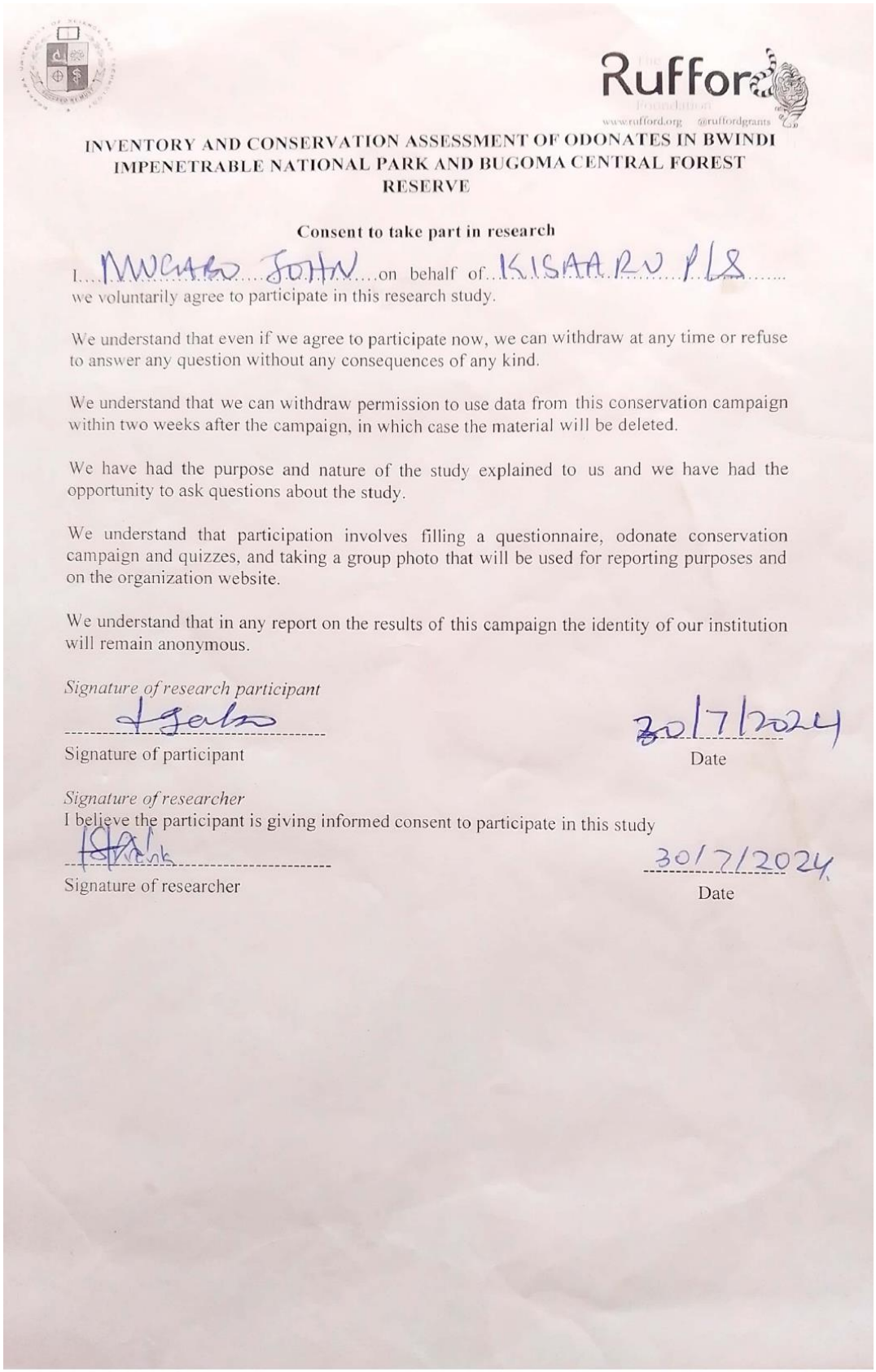
Appendices:

Appendix 1. The Odonata awareness campaign consent form



INVENTORY AND CONSERVATION ASSESSMENT OF ODONATES IN BWINDI IMPENETRABLE NATIONAL PARK AND BUGOMA CENTRAL FOREST RESERVE

Consent to take part in research

I, MWCHEO JOHN on behalf of KISAARU P/S
we voluntarily agree to participate in this research study.

We understand that even if we agree to participate now, we can withdraw at any time or refuse to answer any question without any consequences of any kind.

We understand that we can withdraw permission to use data from this conservation campaign within two weeks after the campaign, in which case the material will be deleted.

We have had the purpose and nature of the study explained to us and we have had the opportunity to ask questions about the study.

We understand that participation involves filling a questionnaire, odonate conservation campaign and quizzes, and taking a group photo that will be used for reporting purposes and on the organization website.

We understand that in any report on the results of this campaign the identity of our institution will remain anonymous.

Signature of research participant

Signature of participant — Date: 30/7/2024

Signature of researcher

I believe the participant is giving informed consent to participate in this study

Signature of researcher — Date: 30/7/2024

Appendix 2: Pictorial presentation of some sampled morphotypes