Sustainability and Biodiversity Conservation

Understanding habitat requirements for captive breeding and conservation of the Goliath frog in Cameroon

Nchang Chrysanthus[*1], Simon Awafor Tamungang[1], Patricia Bi Asanga Fai[2]

[1]*Department of Forestry and Wildlife Technology, College of Technology, University of Bamenda, Cameroon*
[2]*Department of Agricultural and Environmental Engineering, College of Technology, University of Bamenda, Cameroon*
**Email: chrysanthusn@yahoo.com*

Received: 19 February 2024 / Revised: 30 March 2024 / Accepted: 29 April 2024/ Published online: 06 May 2024.
How to cite: Chrysanthus, N., Tamungang, S. A., Fai, P. B. A. (2024). Understanding habitat requirements for captive breeding and conservation of the Goliath frog in Cameroon. Sustainability and Biodiversity Conservation, 3(1):63-77.
DOI: https://doi.org/10.5281/zenodo.11123465

Abstract

The Goliath frog came into prominence in the early 19th century, and to date, recent studies show that the ecology is still understudied. This study aims to determine major ecological and ethological patterns and their contributions to the abundance and breeding activity of the Goliath Frog. A descriptive ecological study was used in which data was collected on the ecological variables and the outcome (presence of frogs), used to describe associations (habitat characteristics) important in conservation and breeding. A non-probability purposive sampling technique was used, where villages included in the study were chosen. Information on ecological variables such as wind speed, precipitation, and humidity was obtained daily using the weather App (*weather.com/weather*) installed on phones. Reproductive activities were estimated based on the signs of the presence of the frogs within the reproductive months such as nesting patterns. Data was analyzed using SPSS version 21. Findings indicate that at temperatures of 25^{0}C to 28^{0}C, the greatest numbers of frogs were seen **(**$P < 0.001$). An increase in humidity levels resulted in the least number of frogs seen ($P \leq 0.219$); that wind speed is not a variable of interest for the presence of the Goliath frog ($P = 0.747$); that the number of frogs increased with an increase in the amount of rainfall recorded over successive days ($P < 0.001$). It was also seen that Goliath frogs mostly used water-filled depressions encircled by rocks for nesting. The probability of finding frogs increased significantly in the thick bushes (CF = 2.6232; $p < 0.001$), and the possibility of finding the frogs increased significantly within the dry season (CF = 2.8769; $p < 0.1$). This indicates that Goliath frogs are nocturnal and frog species that prefer undisturbed forests. These results are expected to improve knowledge of husbandry needs important in conservation programs.

Keywords: Biodiversity, Ecology, Enhanced breeding, Habitat characteristics

Introduction

Cameroon is known as the hotspot of African Amphibian biodiversity with more than 200 amphibian species believed to be living in various areas (Fretey et al., 2012). Amphibian populations are vanishing worldwide and though declines and extinctions of many populations have been attributed to chytridiomycosis, a disease induced by the pathogenic fungus

Batrachochytrium dendrobatidis (Bd); in Africa, however, changes in amphibian assemblages have typically been attributed to habitat change. This is seemingly the case of the Goliath frog restricted to Southwestern Cameroon and Northern Equatorial Guinea, where it occurs in lowland to mid-altitude rainforests below 1,000 masl (Stuart et al., 2004; Channing & Rödel, 2019). Its natural habitat is usually near fast-flowing rivers, which is rather typical and characteristic for this type of frog. These rivers are usually clear and particularly oxygenated which is what attracts the frogs the most (Gonwou & Rödel, 2008). They can also be found in places with sandy bottoms in the middle parts of Cameroon and Equatorial Guinea. Threats to the survival of this species include habitat loss and fragmentation, climate change, overharvesting both for local consumption and export, pet trade, diseases, and the increasing presence of chemicals in the environment as well as the destruction of the eggs laid by females; construction of dams and opening of plantations is also a major threat to their breeding ground and this species is particularly vulnerable to habitat alteration due to its highly restricted range among others (Collins & Crump, 2009). Professionalized hunting methods (traps, machetes, hooks, spears, throwing nets, etc.) have been developed specifically to collect Goliath Frogs (Amiet, 2004; Gonwouo & Rödel, 2008; Schäfer et al; 2019). The hunt for subsidiary consumption, as well as for local bush meat markets, might be one of the main factors driving the population decline of Goliath Frogs. As a result of these pressures, this species is currently listed as Endangered by the IUCN and Class "A" under Cameroon forestry law (MINFOF, 2006; IUCN Amphibian Specialist Group 2019a), though this law is still to be enforced on the field as thousands of frogs are hunted and sold on the Douala-Nkongsamba highway and open markets with impunity.

Previous studies on the Goliath Frog have focused mostly on its distribution and local ecological knowledge of the riverine population (Tagagoum, 2016), taxonomy, and phylogeny (Nguiffo et al., 2015; Blackburn et al., 2020). Some studies have also investigated various aspects of life history, including larval development, parasites, and reproduction (Nguiffo et al., 2015). Parental care has recently been documented in the species (Schäfer et al., 2019), as well as the impact of

land use and proximity to human settlements on the relative abundance, demographics, and body size of Goliath Frogs (Gonwouo et al., 2022). However, very little is known concerning critical ecological characteristics of the Goliath frog habitat such as temperature of the microhabitats, rainfall, humidity, and site selection for oviposition to minimize risks of predation ensuring survival among others. This information is key to simulating alternative habitats for preserving the existing population in case numbers reduce significantly in the wild and there is a risk of extinction. The key to successful captive breeding in frogs is in part owing to an appreciation of the habitat characteristics in which they live and adequate knowledge of breeding in their natural habitat. That is why additionally, this study focuses also on other physical characteristics such as river color, nature of the base and, nature of the vegetation cover in the Moungo Division known to be the hotspot for the frogs in Cameroon; all important for sound conservation strategies; for making informed decisions about conservation of this endangered amphibian species. In the absence of research on the habitat requirements of the Goliath Frog, the development and implementation of appropriate conservation measures are difficult.

Material and methods

Study area

This study was carried out in the Moungo Division, Littoral Region of Cameroon, precisely in Loum (N: 4°41 'and E: 009°43'), Njombe Penja (LN: 4°45 'and LE: 009° 45'), Manjo (LN: 4°42' and LE: 009°41') and Nlonako (LN: 4°40' and LE: 009°43') with an average altitude of 700m. The research site can be seen on the map of the Moungo Division below.

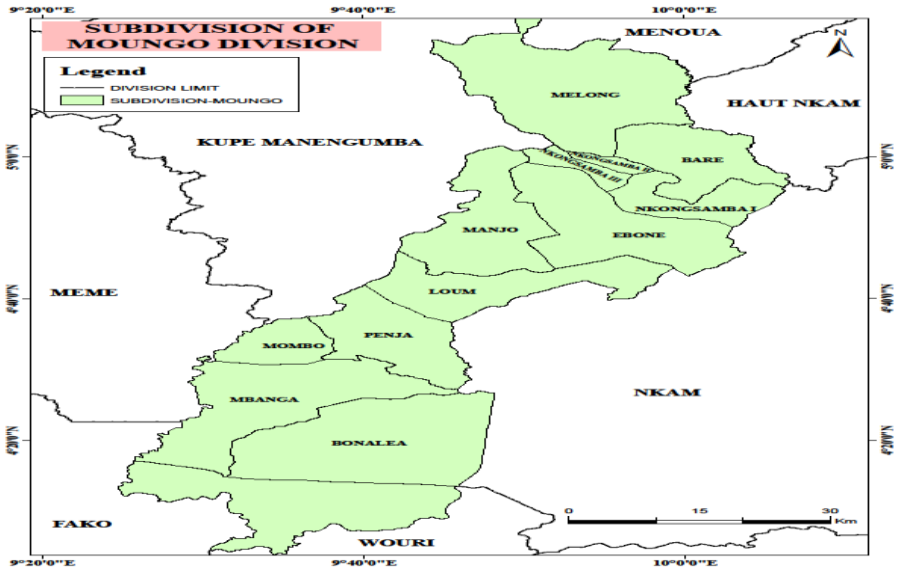

Figure 1. The Moungo division indicates areas where to study was conducted (ACEFA, 2019)

Climate and hydrography

The climate is of equatorial type like much of the rest of Cameroon, strongly influenced by the Guinean monsoon. It is characterized by a short dry season (November to February) and a long rainy season (March to October). The average annual precipitation is 2800 mm, with temperatures varying between 22 ^{C} to 32^{o}C and relative humidity of 74%. The hydrographic network is dense and includes many rivers namely the Dibombe and Mbo (Manjo), Nkam and Ham (Bare Bakem), Tingue and Sole (Nlonako), Mbete and Mpoula (Njombe Penja), Ngounjap (Loum). These rivers overflow their banks in the rainy season, but reduce in size in the dry season, though they are all permanent rivers. The vegetation along the rivers is very dense, dominated by dense forests. Several industrial plantations are also seen in these areas dealing in cocoa, rubber, and plantain. The fauna is mainly terrestrial with many wild herbivores such as antelopes and hares, predatory snakes, aquatic (crocodiles, sea turtles, fishes, aquatic invertebrates, and sympatric species of frogs such as *Conraua robusta, Conraua crassipes,* and *Rana esculenta*.

Relief

The Moungo is characterized by a series of plateaux and hills, mainly in the south of the Moungo, up to Loum with altitudes of over 900m. The highest mountains of the region are found in the Moungo and include Manengouba (2 250m), Kupe (2 070m), and Nlonako (1 850m).

Flora and Fauna

The division is made up of vast plantations of coffee and cocoa owned by individuals, as well as cocoa, coffee, bananas, and rubber cultivated on an industrial scale. Some fruit plantations of pineapples, pawpaw, and vegetables are also present. Some natural plants such as the mangrove in Dibombari and Bonalea can be seen, as well as some reserves and secondary forests where wild animals such as antelopes, monkeys, grass cutters, pangolins, snakes, and hippopotami can be seen, (MINADER,2009).

Research Design

This study adopted a descriptive ecological approach in which data was collected on the exposure (ecological) variables and the outcome (presence of frogs) at the same time to describe associations (habitat characteristics) important in the conservation and breeding of the Goliath frog.

Sampling Technique

A non-probability purposive sampling technique was used, where villages to be included in the study were chosen after we had verified that rivers in which the Goliath frogs could be found were in their locality.

Nocturnal search for Goliath frogs

The Goliath frog is nocturnal, and the time of the night/period of the month was very crucial in determining the possibility of finding the frogs inhabiting the concerned rivers, thus, the potential sites were marked during the day alongside the hunters/ guides. Nocturnal visits were then conducted from 7 pm when the frogs came out to feed with special emphasis on the nest sites. The visual count method (Crump & Scott, 1994) was adopted where the investigators moved along river courses covering at least 1km (line transect) searching on both sides of the river courses to find either the live frogs that could be spotted at 5 to 10m before they jumped into rapids and/or the signs of their presence (nests or egg clutches sticking on rocks or vegetation). The same rivers were revisited to maximize chances of detecting the frogs whose adults are becoming increasingly rare in the natural habitat.

Characteristic features of the rivers

Here, the following characteristics were verified: the color of the river, depth, altitude, width, and nature of the river base. Altitude measurements were done using a GPS Garmin *etrex 22*, and the color, nature of the base, and vegetation cover were recorded. During this search, the following data was collected:

- The name of the river and village where it traverses
- The color of the water was considered clear if we could see the floor and dark if the river floor could not be seen.
- The nature of the floor of the river was either sandy if after extracting the content of the floor with the spade plunged into water it was mainly composed of sand or muddy if mud dominated the content of the river floor.
- The type of vegetation surrounding the rivers (bushy, plantations, primary or secondary forests)

Data Collection Procedure

Here we examined the relationship between ecological (environmental variables – specifically, air temperature, wind speed, rainfall, and humidity on the breeding activity of the Goliath frog. Air temperatures were measured using field thermometers, during the breeding and non-breeding seasons, and recorded in degree Celsius using field thermometers.

Information on wind speed, precipitation, and humidity was obtained daily by the researcher and field guides using the weather App (weather.com/weather) installed on phones; measurements were taken at 8 am. Reproductive activities were estimated based on the signs of the presence of the frogs within the reproductive months (Van Sluys, 2008); such as nests and tadpoles. Specific reproductive behavior such as nesting patterns was observed during the breeding period.

Data analysis

The above environmental (climatic) features and characteristics of the rivers studied were tabulated per river/subdivision, and correlational analysis using the Statistical Package for Social Sciences (SPSS VERSION 21) was done to compare environmental variables measured with the presence/absence of frogs. Also, relationships were established between each environmental variable per river and subdivision, and levels of significance were found. Descriptive data on types of nests seen was represented on tables, and to evaluate the influence of season and color of the rivers, types of vegetation, and nature of river based on the presence/abundance of the Goliath frog, logistic regression analysis was employed and levels of significance were found.

Results

Relationship between environmental variables and the presence of Goliath frogs in the Moungo division

Here we examined the relationship between environmental variables – specifically, air temperature, wind speed, precipitation, and humidity on the presence and breeding activity of the Goliath frog as seen below.

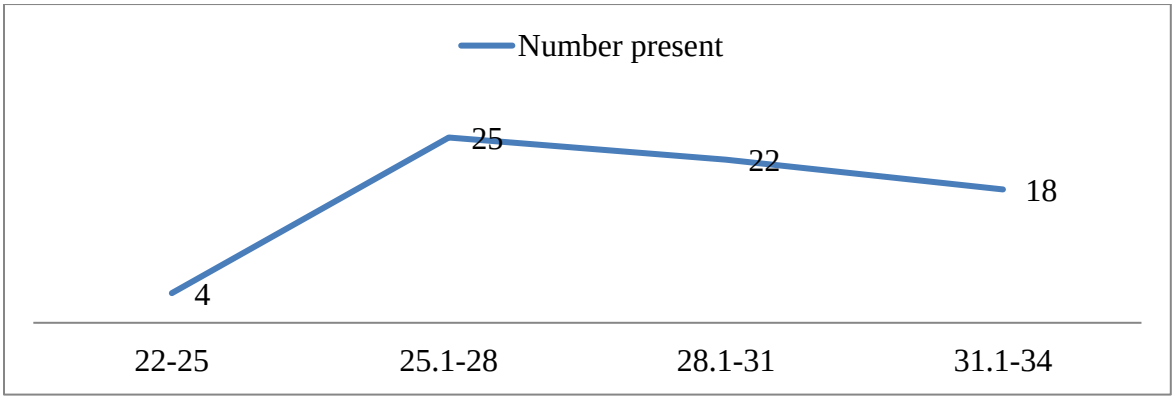

Figure 2. Variations in environmental temperature versus the presence of the frogs

The (fig. 2) above presents the variations in environmental temperatures compared with the number of frogs seen on the field. Results indicate that at temperatures of 25.1 0C to 280C, the

greatest number of frogs was seen, while at 22^0C to 25^0C, the least number of frogs were seen (P < 0.001). This means that temperature is a variable of interest for the presence/survival of the Goliath frog. This is further justified by the fact that the greatest numbers of frogs (25) were seen at temperatures of 250C to 280C. Humidity was the next variable considered as seen below.

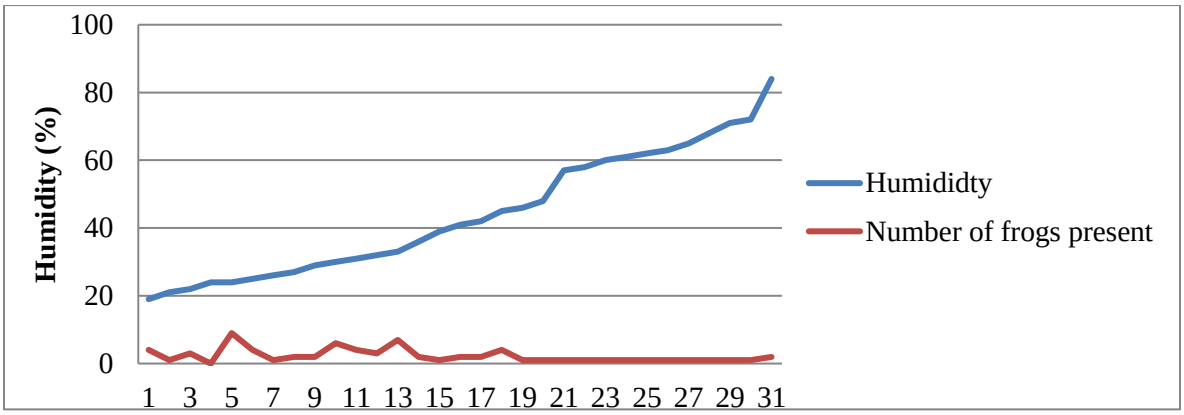

Figure 3. Relationship between Humidity and the number of frogs present

The (fig. 3) above depicts variations in humidity patterns during the period of study. Humidity levels varied from 20% during the dry season to 85% during the peak of the rainy season, but humidity levels decreased with an increase in the number of frogs spotted. From the figure above, it can be seen that an increase in humidity levels resulted in the least number of frogs seen ((P ≤ 0.219). This means that the frog requires low levels of humidity for its survival in its natural habitat. Wind speed was also measured as seen below.

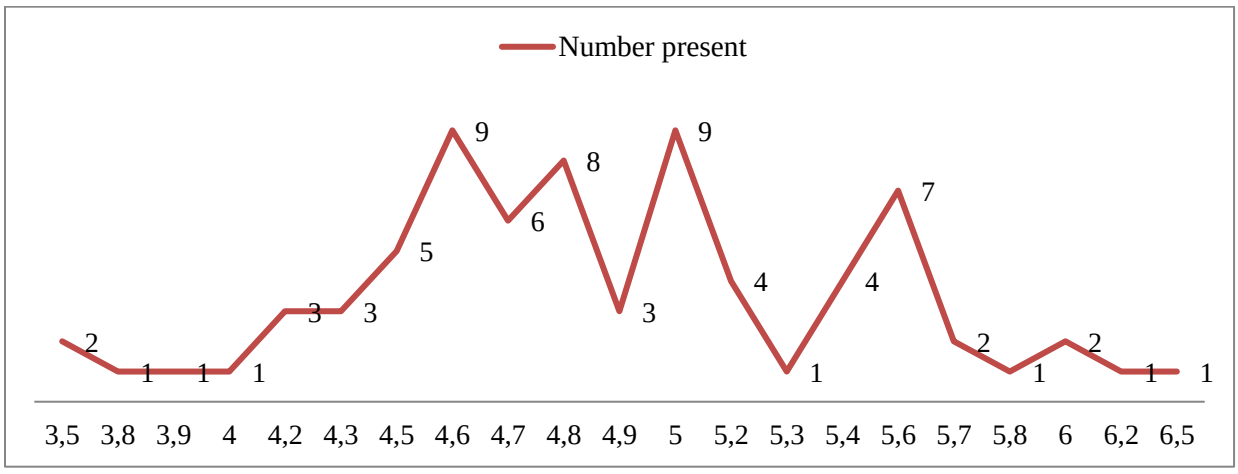

Figure 4: Relationship between wind speed and number of frogs seen

The (fig. 4) above indicates the variation in wind speed versus the number of frogs spotted during the study period. It can be seen that wind speed varied from 3.5m/s to up to about 6.5m/s at the peak of the dry season; but at wind speed of 4.5m/s to 5m/s, the greatest number of frogs were spotted. The above figure shows that wind speed is not a variable of interest for the presence/survival of the Goliath frog (P = 0.747) because wind speed fluctuations had no direct influence on the presence or absence of the frog. Rainfall patterns are presented below.

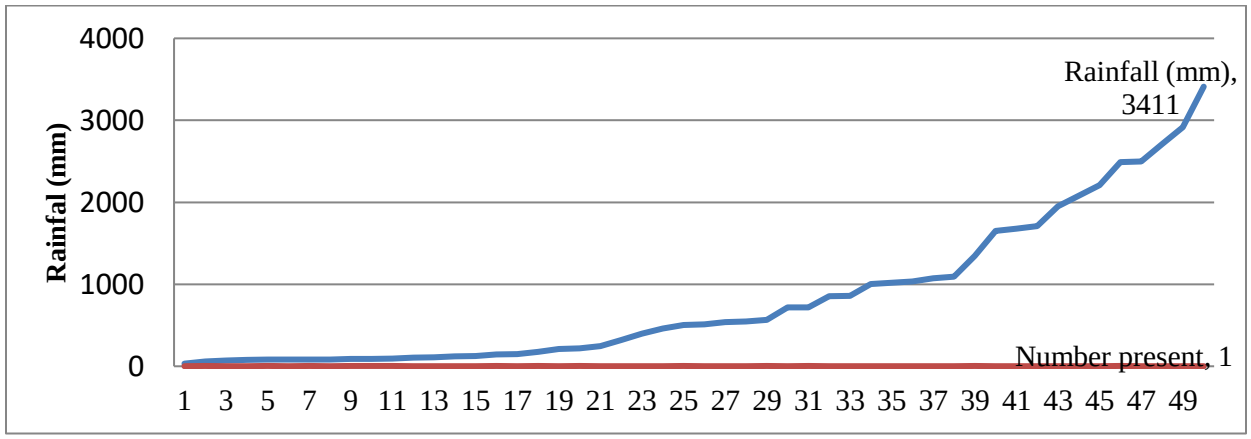

Figure 5. Relationship between rainfall and the presence of frogs

The (fig. 5) above presents the relationship between rainfall patterns observed during the period of study compared with the number of frogs spotted. It can be seen that rainfall patterns varied from less than 500mm during the dry season to about 3400 mm at the peak of the rainy season. The figure indicates that the number of frogs increased with an increase in the amount of rainfall recorded over successive days (P < 0.001). This indicates that rainfall is an important variable for the presence and survival of the Goliath frog. Specific reproductive behaviors such as nesting patterns were observed during the breeding period through nocturnal visits, and presented in (Table 1) below.

Table 1. Types of nests seen in the Moungo Division

Date	Temp.(0C)	Rainfall(mm)	Humidity (%)	Wind speed(km/s)	Type of nest	Nest with eggs only	Nest with tadpoles
6-Nov-2021	27.8	720	32	4.5	c	No	Yes
08-Nov-21	27.2	670	32	4.5	b	Yes	No
14-Nov-21	27.9	165	32	4.6	a	Yes	No
26-Nov-2021	26.9	540	56	5.5	b	No	Yes
27-Nov-21	27.7	178	31	5	c	Yes	No
29-Nov-2021	26.3	395	33	4.5	f	No	No
3-Dec-2021	28.5	220	24	4.9	b	No	No
10-Dec-21	29.5	108	25	4.9	d	No	Yes
12-Dec-2021	28.8	245	31	4.6	e	No	Yes
6-Oct-2022	31	245	32	4.6	b	Yes	No
10-Oct-2022	32.2	138	29	4.8	b	Yes	No
16-Oct-2022	29.5	760	41	4.5	c	Yes	No
16-Nov-22	29.6	210	29	4.4	c	No	Yes
20-Dec-22	32.5	165	21	5.4	g	No	No

The table above indicates the different types of nests constructed and used by Goliath frogs for egg deposition during the breeding season. It can be seen that the nests were seen between October to December and that temperatures varied from 26^0C to 32.5^0C, rainfall was generally less than 700mm, wind speed varied from 4.5m/s to 5.5m/humidity varied from 21% to 41%, and that most nests had only eggs. Findings herein indicate that most nests with eggs were found between October and November and that most nests with tadpoles were found between November and December. The table indicates that Goliath frogs used four nest types; rock pools within river beds (a), water-filled depression encircled by larger rocks oriented away from the direction of water current (b), shallow pools near river banks, shallow pools at the center of rivers containing either fine grain sand or gravel (c), shallow pools besides massive rocks (d), shallow pools at the raised central portion of the river (e), water-filled depressions on the river banks (e), water-filled depression at river banks (f) and washout pool at raised central portion of the river (g).

Characteristic features of the rivers

The following characteristics were verified: the color of the river, the nature of the river base, and the vegetation. Generally, the rivers had a sloppy nature. They all had similar appearance, constituted of rocks and rapids, with rapid flow. They were either clear or slightly dark in color during the dry season, while in the rainy season, heavy rainfall resulted in color changes from time to time. Vegetation cover was partial and/or complete for the river banks included in this study,

indicating that Goliath frogs are typically nocturnal and frog species that prefer intact or undisturbed forests. Vegetation types and their influence on the frog's presence are seen below.

Table 2. Influence of type of vegetation on the presence of the Goliath frog (Significant influence at a probability level of 0.001)

		Estimation	Standard Error	P-value
Type of vegetation	Thick bushes	2.6232	2.5238	21.251
	Secondary forest	-2.3265	0.4569	-4.909
	Agroforestry Plantations	-0.7222	0.1534	-5.316

The (Table 2) above presents the influence of the type of vegetation on the presence of Goliath frogs. Findings indicate that the river banks were characterized by thick bushes, secondary forests, and agroforestry plantations. Results obtained showed that the type of vegetation influenced the presence or signs of finding the Goliath frog. The influence of season, river color, and nature of the base on the presence of the Goliath frogs can be seen below.

Table 3. Influence of the season, color, and nature of the river floor on the abundance of the Goliath frog (Significant influence at a probability level of 0.001 and 0.1)

Season, color, and nature of river base	Estimation	Standard Error	P- value
Intercept	2,8769	1,5222	1,648
Rainy season	-2,6870	0,9254	-2,451
Sandy	-2,7038	1,5145	-2.342
Dark	0,7286	0,9411	0,861
muddy	-17,233	4,1323	-0,005

(Table 3) above indicates the influence of season, color, and nature of the river floor on the abundance of the Goliath frog. From the table above, it can be seen that the possibility of finding the frogs increased significantly with the season of the year, (coefficient of regression = 2.8769; $p < 0.1$), and reduced significantly in the rainy season (coefficient of regression = -2.6976; $p < 0.001$).

Discussion

Major ecological and ethological patterns and their contribution to the presence and breeding activity of the Goliath frog

We set out to determine major ecological and ethological patterns and their contributions to the presence/abundance and breeding activity of the Goliath Frog in the Moungo division. Findings indicate that at temperatures of 25.1 ^{0}C to 28^{0}C, the greatest numbers of frogs were seen. This means that temperature is a variable of interest for the presence/survival of the Goliath frog. Environmental temperatures have been seen to be critical for keeping frogs alive and for providing thermoregulation opportunities, affecting development (Gong & Mu, 2008), while seasonal variations were seen to be important for survival and lifetime reproductive fitness in frogs. Therefore optimal environmental temperatures for survival and possibly breeding seen in this study are between 25^{0}C to 28^{0}C for the Goliath frog and could be simulated in an ex-situ study. It was also seen that an increase in humidity levels resulted in the least number of frogs seen (($P \leq 0.219$). This means that the Goliath frogs require low levels of humidity for survival in their natural habitat. This is further justified by the fact that during the reproductive months, humidity is as low as 32%, indicating that low humidity levels are essential for the development, breeding, and survival of the Goliath frog. Humidity is strongly associated with rainfall events; the greater the number of rainfall events and consistency over a certain period, the higher the humidity levels. Rainfall was seen to be heaviest from July to September with rainfall measuring up to 3900mm per day, and this coincides with humidity levels of up to 85%. These findings are quite similar to Tagagoum (2015), who found that a rise in precipitation of close to 4000 mm led to an increase in humidity levels of up to 88% within the Moungo division. This however represents nonreproductive periods of the Goliath frog (Sabater, 1985), indicating that high temperatures and humidity levels may be important for survival but not necessarily for breeding success in the Goliath frogs.

The results of this study show that wind speed is not a variable of interest for the presence/survival of the Goliath frog ($P = 0.747$) because wind speed fluctuations had no direct influence on the presence or absence of the frog. Oseen and Wassersug (2002), found that increases in wind speed resulted in a decrease in the calling activity of frogs, and consequently desiccation of laid eggs; this could be the case of the Goliath frog that has no vocal cords, and thus males attract females with a typical whistling noise that will be perturbed with an increase in wind speed. An increase

in wind speed may also dislodge eggs sticking on rocks and vegetation during the dry months of the year when water levels drop drastically exposing submerged rocks and aquatic vegetation. Consequently; this will negatively affect the breeding success of this frog. Findings also indicate that the number of frogs increased with an increase in the amount of rainfall recorded over successive days ($P < 0.001$). This indicates that rainfall is an important variable for the presence and survival of the Goliath frog. Studies by Ulloa et al. (2019), indicated that rainfall has been recognized as the most important environmental variable in triggering explosive breeding in frogs; and that breeding responds to two specific events; consistency within the past 48 to 72 hours and amount during the previous 24 hours. But the Goliath frog is not an explosive breeder, and breeding takes place when rainfall events have greatly reduced, and there is a great possibility of building nests. However, the results of this study showed that the highest number of frogs was seen with an increase in the amount of rainfall. Besides, rainfall patterns are closely related to humidity; and this study rather shows that at high humidity levels, fewer frogs were spotted. Thus, it can be deduced here that heavy rainfall might provide inundated areas for the survival of the frogs and not breeding, and in a typical simulated habitat provision could be made as such, where simulated fountains and rapids can be provided on a sloppy terrain resembling rainfall events, but with small

Nesting patterns of the Goliath frogs seen in the Moungo division

Findings on reproductive behavior indicate that Goliath frogs mostly used water-filled depressions encircled by rocks, and washouts or shallow pools near river banks. These nests were always oriented away from the direction of water currents and being near the banks represented areas where water currents had the least effect as well as made it difficult for predators to move across the rocks to consume the eggs. The least used were the shallow pools at the central portion of the river, water-filled depressions at river banks, and washout pools at the central portion of the river are likely the ones that are easily accessible to predators such as shrimps and fishes, as well as those that are prone to flooding events resulting in eventual spillage of eggs since water currents will easily dislodge them sticking on rocks or vegetation on the river bed. The findings herein depict a more detailed picture than that of Schafer et al. (2019), who studied the reproductive biology of the Goliath frog in the Mpoula River and identified three types of nests. This is probably because the study was conducted only within the Mpoula River, contrary to this present study that considered four subdivisions, and many rivers over a long period. Generally, two or more generations of tadpoles were seen in some nests probably indicating a possibility of use and re-use

of the nests by the frogs, but also indicating the possible absence of intraspecific competition amongst conspecifics. If this assertion is plausible, it could mean that Goliath frogs though territorial, may tolerate members of the same species. Below are some nests seen in the Moungo division islands, where the frogs can always bask during the day.

Figure 6. Nests types (Mpoula) and nest type (Dibombe)

Characteristic features of the river habitats

Findings of the study indicate that the probability of finding the frogs increased significantly in the thick bushes (coefficient of regression = 2.6232; $p < 0.001$), this probability decreased significantly in secondary forests (coefficient of regression = -2.3265; $p < 0.001$), as well as in agroforestry plantations around the rivers (coefficient of regression = -0.7222; $p < 0.001$). The probability of finding Goliath frogs in farms abandoned over the years increased because they are not subject to human activities like farming; the frog is a solitary hunter in its natural habitat compared with secondary forests subject to perturbations through hunting and logging as well as plantations that are busy with human activities daily. Studies by Gonwouo et al. (2022), noted higher frog abundances, including larger-sized adults, with increasing distance from human settlements. Therefore, the further the abandoned farm daily land was in this study, the more chances of finding larger frogs. Meanwhile, the possibility of finding the frogs increased significantly with the season of the year (coefficient of regression = 2.8769; $p <0.1$) and reduced significantly in the rainy season (coefficient of regression = -2.6976; $p < 0.001$). The highest numbers of frogs were spotted during the dry season and this can be explained by the fact that the dry months correspond to the breeding season, where the males build nests, and attract the females with a whistling noise to lay their eggs (Schafer et al., 2019). During the rainy season, water levels rise significantly such that according to Perret (1966), the frogs became almost inactive and

invisible as they had to hide within flooded aquatic vegetation, waiting for water levels that had submerged rocks to drop so that they could resume their normal attitude of basking on rocks for sometimes before returning to the water.

The possibility of finding the Goliath frogs increased significantly when the rivers were clear (coefficient of regression = 2.8769; $p < 0.1$), but was not significantly different when the river floor was dark (coefficient of regression = 0.7286; p= 0.861). Clear rivers are known to be oxygenated, have neutral pH, less heavy metals, and carry fewer sediments that allow the penetration of sunlight leading to higher temperatures important for larval development (Hernandez, 1989), and are generally healthy for aquatic life. Studies by Mills and Barnhart (1999), indicated that levels of oxygen in the water below 9.08 mg L−1 could suppress the hatching of eggs in frogs while hampering larval development. Meanwhile, the possibility of finding the Goliath frogs or signs of their presence increased enormously when the river base was sandy (coefficient of regression = 2.8769; $p < 0.1$), but decreased significantly when the river base was muddy (coefficient of regression = -17.233; $p < 1$). The nature of the river base can be quite important in the Moungo division since muddy water could disturb the mobility of frogs underwater, and the ability to find aquatic prey.

References

ACEFA. (2002). Restitution du diagnostic agraire dans le Moungo **:** Étude des systèmes de production dans le cadre de l'établissement de la situation de référence des exploitations familiales agropastorales au Cameroun, Région du Littoral, département Moungo, 93p.

Amiet, J.L. **(**2004). Conraua goliath. The IUCN red list of threatened species: [online].Available on: https: //www.iucnredlist.org/details/5263/0. (Accessed: 07/04/2016).

Blackburn, D.C., Nielsen, S.V., Barej, M.F., Doumbia, J., Hirschfeld, M., Kouamé, N.G., Lawson, D., Loader, S., Ofori-Boateng, C., Stanley, E.L., et al**. (**2020). Evolution of the African Slippery Frogs (Anura: Conraua), including the world's largest living frog. Zoologica Scripta 49, 684–696. https://doi.org/10.1111/zsc.12447

Channing, A & Rödel, M.O. (2019). Field Guide to the Frogs & Other Amphibians of Africa. Cape Town, South Africa: Struik Nature.

Crump, M.L. & Scott, N.J. (1994).Visual encounter survey. In: Heyer, W.R.Donnelly, MA; MacDiarmid, R.W, Donnelly, Hayek, L.C, & Foster, M.S.(Eds) Measuring and monitoring Biological diversity, Standard Methods for Amphibians Smithsonian Institution Press, Washington D.C, 84-91.

Collins, J.P. & Crump, M.L. (2009). Extinction in our times. Oxford University Press, New York.

Fretey, T., Dewynter, M & Blanc, P. (2012). Illustrated identification key of the amphibians from Gabon and Mbini, herpetological review. 43(4), 666-667.

Gong, D & Mu, M. (2008). Behavioral observations and descriptions of the endangered knobby newt *Tylototriton wenxianensis* and their application in conservation. Asiatic Herpetological Research, 1, 31–38.

Gonwou, L.N & Ro¨del, M.O. (2008). The importance of frogs to the livelihood of the Bakossi people around Mount Manengouba, Cameroon, with special consideration of the hairy frog *Trichobatrachus robustus*. Salamandra, 44 (1), 23–34.

Gonwouo, N.L., Schäfer, M., Tsekané, S.J., Hirschfeld, M., Tchassem, F.A.M., Rödel, M.O. (2022). Goliath Frog (Conraua goliath) abundance in relation to frog age, habitat, and human activity. Amphibian & Reptile Conservation 16(2), 104–119 (e319).

Hernandez, Briz. (1989). La Rana Cria Y Explotacion. ISBN 10: 8471142368 / ISBN 13: 9788471142368.

Institut Nationale de la statistique. (2015). Agence Régionale du Littoral.

IUCN criteria to perform rapid assessments of at-risk taxa. (2019a). Biodiversity and Conservation, 28, 863–883.

Ulloa, J.S., Aubin, T., Llusia, D. et al. (2019). Explosive breeding in tropical anurans: environmental triggers, community composition, and acoustic structure, Biodiversity Management Committees Ecology, 19, 28 https://doi.org/10.1186/s12898-019-0243-y.

Mills, N.E & Barnhart, M.C. (1999). Effects of hypoxia on embryonic development in two Ambystoma and two Rana species. Physiological and Biochemical Zoology, 72, 179-188.

MINADER. (2009). Rapport annuelle des activités dans le département du Moungo, 48 p.

MINFOF. **(**2006**).** Arrêté n°0649/MINFOF du 18 décembre portant répartition des espèces de la faune en groupe de protection et fixant les latitudes d'abattage par type de permis sportif de chasse.

Nguete, N.D., Wondji, C.S., Pone Wabo, J., Mpoame, M. (2019)**.** Microfilariae infestation of goliath frogs (*Conraua goliath*) from Cameroon. PLOS ONE, 14(5), e0217539. https://doi.org/10.1371/journal.pone.0217539.

Nguiffo, N.D., Wabo, P.J., Mpoame, M. (2015). Gastro-intestinal helminths of goliath frogs (Conraua goliath) from the localities of Loum, Yabassi, and Nkondjock in the Littoral Region of Cameroon, Global Ecology and Conservation, 4,146–149.

Oseen, K.L & Wassersug, R.J. (2002)**.** Environmental factors influencing calling in sympatric anurans. Oecologia 133 (4), 616–625.

Perret, J.L. (1966). Les amphibiens du Cameroun. Zoologische Jahrbücher (Systematik). 8, 289–464.

Sabater-Pi J. (1985). Contribution to the biology of the Giant Frog (Conraua goliath Boulenger, 1906). Amphibia-Reptilia, 6 (2), 143-153.

Schäfer, M., Tsekané, S.J., Tchassem, A.M., Drakulić, S., Kameni, M., Gonwouo, N.L and Rödel, M.O. (2019). Goliath frogs build nests for spawning – the reason for their gigantism? Journal of Natural History, 53, 1263-1276, https://doi.org/10.1080/00222933.2019.1642528.

Stuart, S.N., Chanson, J.S., Cox, N.A., Young, B.E., Rodrigues, A.S.L., Fischman, D.L., et al. (2004). Status and trends of amphibian declines and extinctions worldwide. Science, 306(5702), 1783–1786. https://doi.org/10.1126/science.1103538

Tagagoum, K.U. (2016). Connaissances écologiques locales et contribution à l'écologie de la grenouille goliath (*Conraua goliath* Boulenger, 1906) dans le département du Moungo, Région du littoral, Cameroun, Unpublished MSc thesis, Department of Animal Biology,Faculty of Science, University of Dschang,124p

Van Sluys, M., Kriger, K.M., Phillott, A., Campbell, R., Skerratt, L., Hero, J.M. (2008). Storage of samples at high temperatures reduces the amount of amphibian chytrid fungus Batrachochytrium dendrobatidis DNA detectable by PCR assay. Dis Aquat Organ, 81, 93–7. Pmid: 18924373.