Progress Report

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Extinction Risk Assessment and Conservation Measures for *Sudanonautes nkam*: a Threatened Freshwater Crab From Yabassi in the Ebo Forest, Cameroon

by

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The aims of this project was to collect data on population structure (sex ratio, size, and abundance), and reproductive biology (breeding needs, recruitment, and fecundity) for *Sudanonautes nkam*, useful to assess its IUCN Red List status.

Habitat for *Sudanonautes nkam* Mvogo Ndongo et al. 2024.

The monthly biotic surveys were taken place at the hydrographic networks of the Ebo Forest, drainage of the rivers of Sanaga, Lake Ossa, Nyong and Lokoundje of Cameroon. As a result of these biotic surveys, the following crab and snail species were collected.

As per crab species, the following were recorded :

- Three populations of *Sudanonautes nkam* from Yabassi at the Eboforest zone and from Lake Ossa,
- *Sudanonautes* sp.1., a new threatened species from Lake Ossa and from a threatened habitat of Yaounde campus,
- *Sudanonautes* sp.2. a new threatened species only know from Lake Ossa,
- *Louisea yabassi* known from Eboforest zone.

Figure 1 : Threatened Crab species collected during the biotic surveys. A= *Sudanonautes* sp.1, B= *Sudanonautes* sp.2., C= *Louisea Yabassi, D= Sudanonautes nkam*

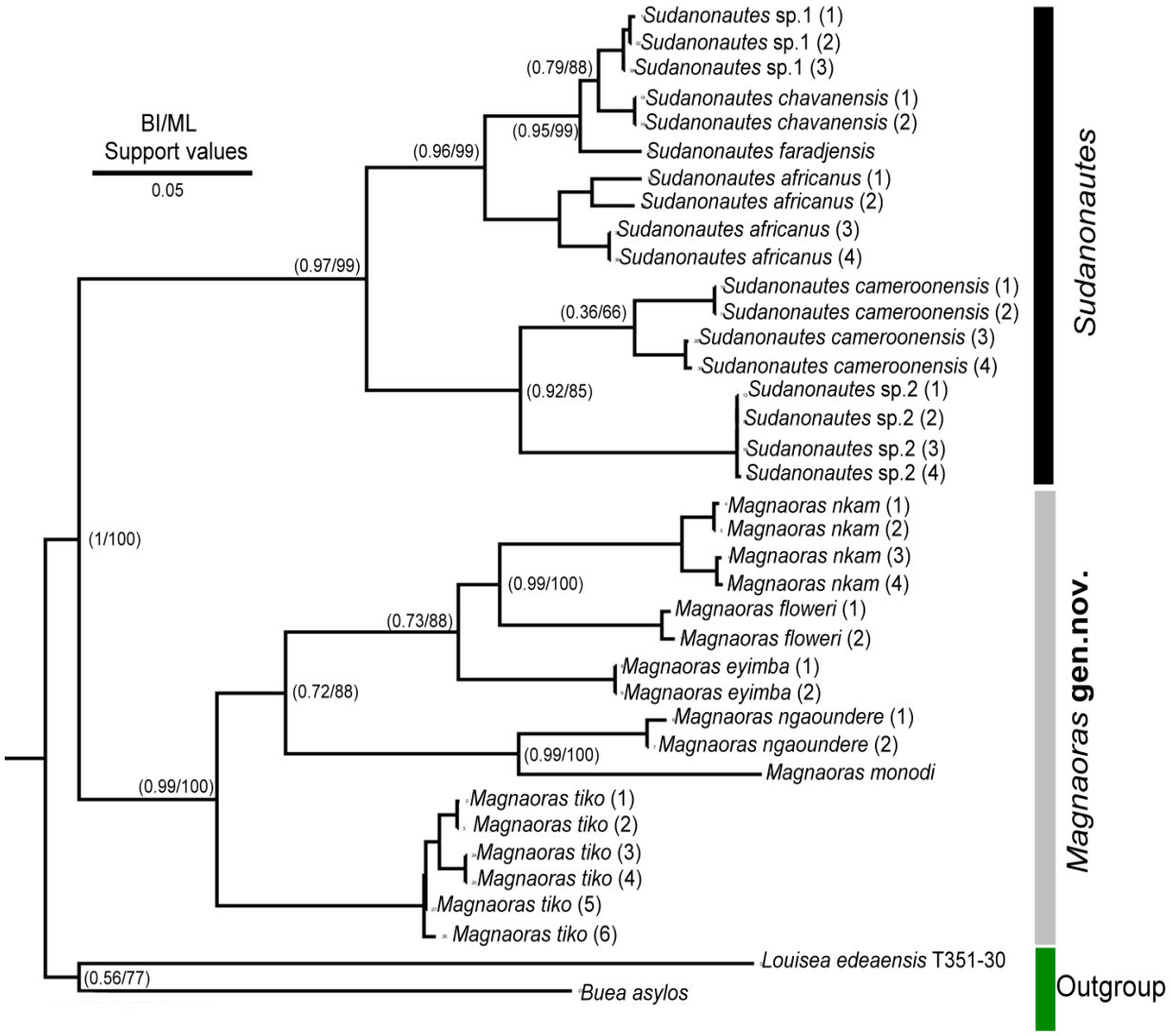

Figure 2. Phylogenetic relationships among 12 *Sudanonautes* s.l. species from West and Central Africa and two other species representing genera of Liberoautinae derived from mtDNA sequences corresponding to four loci (partial mt16S rRNA and mtCOI). Relationships were analysed by the Bayesian Inference (BI) and Maximum Likelihood (ML) methods, with *Buea asylos* Cumberlidge (1993) and *Louisea edeaensis* (Bott, 1969) as the outgroup taxa. Statistical values (%) on the nodes indicate posterior probabilities and bootstrap support values above 0.5 (BPP) and 50% (bootstrap), respectively.

As per snail, the *Potadoma* species that are interested to our research structure were collected. These species are :

- *Potadoma freethii,* a population collected from the Eboforest zone,
- *Potadoma zenkeri,* an endangered species collected from small stream flowing to Lokoundje river,

- *Potadoma nyongensis*, an endangered species collected from Nyong river,
- *Potadoma trichiformis*, an endangered species collected from Sanaga river,
- *Potadoma angulata*, *a critical endangered species* collected from Sanaga river,

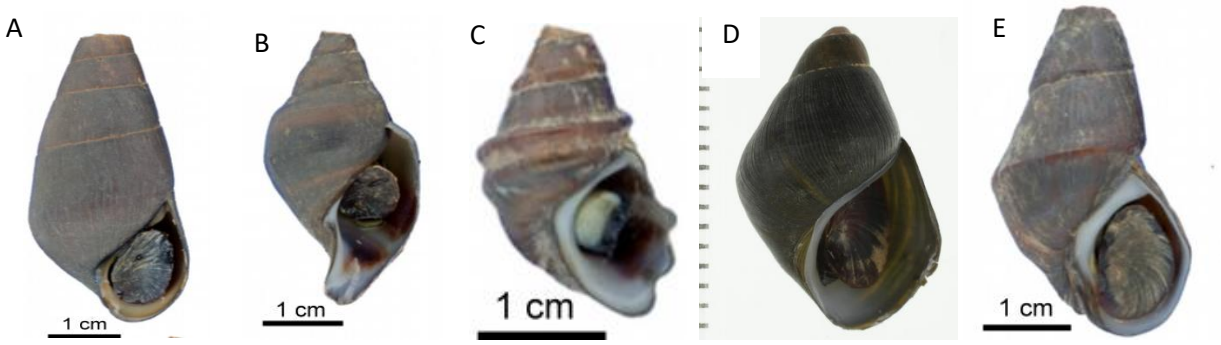

Figure 3 : Threatened Snail species collected during the biotic surveys. A= *Potadoma freethi*, B= *Potadoma zenkeri*, C= *Potadoma nyongensis*, *D= Potadoma trichiformis*, *E= Potadoma angulata*

For our project, we investigated population structure and reproductive biology for *Sudanonautes nkam*. Therefore, we combined data with those obtained by Mvogo Ndongo and Gamnsi Kevin, 2024 on *Louisea yabassi*, since both crab species are living in the same habitats.

Population structure of *L. yabassi* and *S. nkam*, including gathering data on sex ratios, breeding season, fecundity, distribution and monitoring changes in population levels and habitat.

A total of 59 crabs belonging to two species (*Louisea yabassi* and *Sudanonautes nkam*), were collected at Yabassi and Ndokbanguegue as seen in table 1. The majority of the crabs collected were males constituting 59.3% of the sample size and most abundant growth stage in the population was the sub-adult population making up 55.5%, followed by adult with 32.2% (table 1). The estimated population density of *L. yabassi* ranged from 1 to 4 individuals/transect during our early surveys, while the population density of *S. nkam* ranged from 1 to 12 individuals/transect and the population consisted mostly of adult and sub-adult individuals.

No ovigerous females or females carrying hatchlings were encountered during that study so there is still no basic reproductive information available on the number of eggs laid, and the number of hatchlings produced, and when the breeding season occurs. The water body in Yabassi from which the sample was obtain had an average temperatures 26^0C, pH of 6.9, salinity (0) g/kg and conductivity 34.3 S/m respectively. The species of crabs in Yabassi were subsidiary *Sudanonautes nkam* whose habitat constituted boarders of river and under stones without water. The water body from which Crabs where collected in Ndokbanguegue had an average temperature 26ºC, pH of 8.9, salinity of 16 g/kg and conductivity of 30 S/m. The species of crabs in Ndokbanguegue were predominantly *louisea yabassi* that lived in burrows of swamps or marshy area.

Table I : Size of crabs collected in the study (number and percentage)

Variable	Category	Number	Percentage (%)
Species	*Louisea yabassi*	28	47.5
	Sudanonautes nkam	31	52.5
	Total	59	100.0
Sex	Female	24	40.7
	Male	35	59.3
	Total	59	100.0
Age	Juvenile	7	11.9
	Sub Adult	33	55.9
	Adult	19	32.2
	Total	59	100.0

Population structure of both species

Specie	Categories	Variable	Nº Collected	Percentage	Chi-squared	P value
Louisea yabassi	Sex	Female	5	17.9	20.643	<0.001
		Male	23	82.1		
		Total	28	100.0		
	Age	Juvenile	5	17.9	6.535	0.038
		Sub Adult	14	50.0		

		Adult	9	32.1		
		Total	28	100.0		
Sudanonautes nkam	Sex	Female	19	61.3	2.32	0.127
		Male	12	38.7		
		Total	31	100.0		
	Age	Juvenile	2	6.5	21	<0.001
		Sub Adult	19	61.3		
		Adult	10	32.3		
		Total	31	100.0		

N^{O}=Number, P=probability value

The population structure of the freshwater crabs *Louisea yabassi*, entails by sex and age that they were less population of females (17.9%) than males (52.1%) emphasizing environmental factors had an influence on the number of species existing in the ecosystem. Whereas, all the age classes that include juvenile, sub adult and adult crabs indicates more of adults with juvenile were pretentious by a set of environmental conditions. Moreover, variation in the population structure by sex were significant as the probability value was derived 0.001, which is significant at the level 0.05 for females and males. Main while, for juvenile, sub adult and adult at age level was 0.038 is significant at the level of 0.05 with respect to the standard probability value reference (Table1).

On the other hand, the population structure exceptionally for *Sudanonautes nkam* on the contrary by sex indicate there were more of female crabs (61.3%) than males (38.7%) with a probability value insignificant at 0.127 signifying no variation in population structure as more of males are high-flown than females. Furthermore, all the classes by age that include juvenile sub adult and adult indicates a significant variation of population as probability value of 0.001 is less than the standard 0.05 value (Table1).

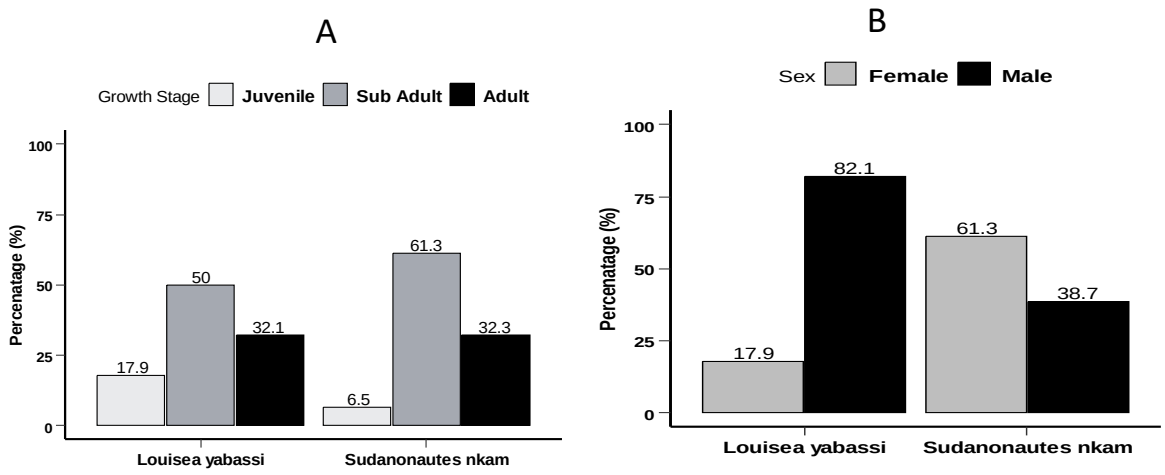

Figure 4: A= Population distribution by Growth stage, B= Population distribution by sex

Growth and size classes in *Louisea yabassi* and *Sudanonautes nkam*

This was assessed from ontogenetic development through morphological variation given in table 2. Amongst the categories *L. yabassi* and *S. nkam* there was no relationship between the variables female and male given their average CW of 15.60 mm and CW of 29.95 mm respectively as p=0.353. On the contrary, the variables juvenile, sub adults and adult by size classes shows there was a significant difference given average CW of 15.60 mm and 29.95 mm respectively as P=0.001 less than the standard P=0.05 for both *(L. yabassi* and *S. nkam*).

Table II: Morphological Characteristics in the different species of crabs in terms of growth

Categories	Variable	Mean CW	P value	Mean CL	P value	Mean CH	P value	Mean FW	P value	Mean WG	P value
L. yabassi	Female	17.03	0.353	12.04	0.302	7.51	0.5975	5.43	0.3671	1.64	0.3258
	Male	15.29		10.76		6.95		4.94		1.25	
	Total	15.60		10.99		7.05		5.03		1.33	
	Juvenile	10.79	<0.001	8.19	<0.001	4.53	<0.001	3.91	<0.001	0.63	<0.001
	Sub Adult	14.74		10.36		6.12		4.78		1.08	
	Adult	19.61		13.52		9.88		6.03		2.02	
	Total	15.60		10.99		7.05		5.03		1.33	

	Female	29.91	0.816	22.13	0.739	12.28	0.846	8.70	0.585	4.49	0.298
S. nkam	Male	30.01		21.57		12.54		8.35		3.82	
	Total	29.95		21.91		12.38		8.56		4.23	
	Juvenile	14.25	<0.001	12.32	<0.001	6.57	<0.001	4.94	<0.001	1.20	<0.001
	Sub Adult	28.30		20.35		11.77		8.01		3.84	
	Adult	36.91		26.81		14.71		10.33		5.58	
	Total	29.95		21.91		12.38		8.56		4.23	

CW=carapace width, Cl=carapace length, CH=carapace height, FW=front width, W=weight

The advancement through morphological variation given in table 3, explains more of the ventral characters of the variables females and males which signifies by chi-square test female's size classes dominated males for (*L. yabassi* and *S. nkam*) respectively. The evolution at the growth stage indicates that adults were greater in size classes than sub adults and juveniles as the P=0.001 signifies.

Table III: Morphological characters of the different species of crabs from the ventral view

Categories	Variable	Mean PFW	P value	Mean PL	P value	Mean PW	P value	Mean PLA	P value	Mean ALA	P value
	Female	7.06	0.083	11.28	0.382	4.56	0.218	6.76	0.106	6.02	0.271
Louisea yabassi	Male	5.55		10.17		5.39		5.10		3.44	
	Total	5.82		10.37		5.25		5.40		3.90	
	Juvenile	3.70	<0.001	5.43	<0.001	4.67	<0.001	3.86	<0.001	3.40	<0.001
	Sub Adult	5.37		9.99		4.93		4.86		2.76	
	Adult	7.71		13.70		6.05		7.10		5.96	
	Total	5.82		10.37		5.25		5.40		3.90	
	Female	11.61	0.715	18.86	0.869	7.66	0.617	10.93	0.326	10.77	0.594

Sudanonautes nkam	Male	11.27		19.16		8.08		10.11		9.80
	Total	11.48		18.98		7.82		10.61		10.39
	Juvenile	6.55	<0.001	9.20	<0.001	3.69	0.001	5.52	<0.001	2.69	<0.001
	Sub Adult	10.70		17.80		7.40		10.08		8.71	
	Adult	13.93		23.17		9.46		12.63		15.13	
	Total	11.48		18.98		7.82		10.61		10.39	

PFW=post frontal width, PL=propodus length, PW=propodus width, PLA=posterior length of abdomen, ALA=anterior length of abdomen

The morphological progression of the species by size classes (*L yabassi* and *S. nkam*) as given in table 4, the assessment of the variables females and males by sex indicated in tables 4, shows that the average mean by size classes of females is greater than that of males for the species *(L. yabassi* and *S. nkam*) respectively. On the other hand, the variables by growth aspects implies adults dominated sub adults and juveniles as such a significant difference according to the test of variance give that P=0.001 less than the P<0.05 by reference.

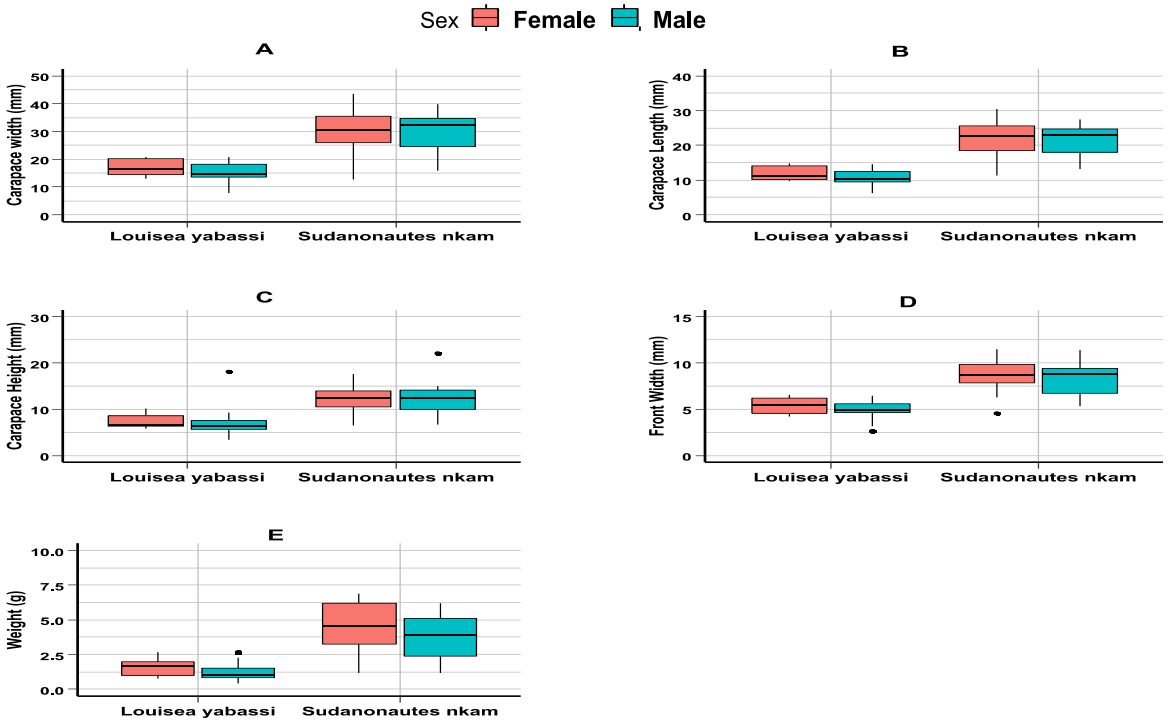

Figure 6: A-E morphological characteristics distribution by Sex

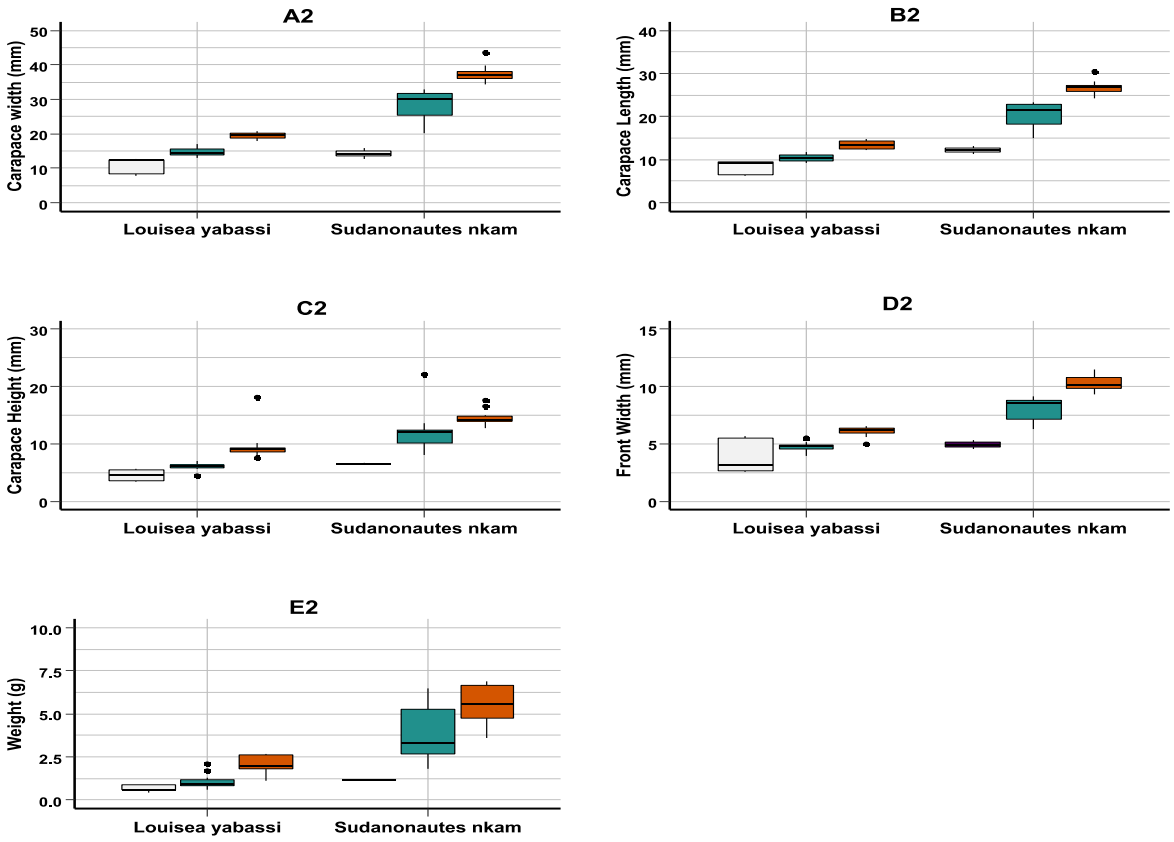

Figure 7: A-E morphological characteristic definition by growth stage

Identified threats for *Sudanonautes nkam* and *Louisea yabassi*

In order to tackle the conservation strategy, we assessed (by observation) some threats to the locality of both *S. nkam* and *L. yabassi*. These threats comprise anthropogenic disturbances that include habitat destruction, chemicals from washing clothes in the water that can potentially affect different size classes of crabs (table 4).

Table IV; Threats reported for *S. nkam* and *L. yabassi*

Original Location	Species	New locations	Estimate of plastic non-biodegradable	Frequentation by local people	Destruction of natural vegetation	Population density	Number of dead crabs	Chemicals from washing clothes in the water
Ndokbanguegue	*L. yabassi*	00	few	few	Large	1 to 4 individuals/transect	11	Not
Yabassi	*S. nkam*	00	Large	Large	Large	1 to 12 individuals/transect	03	Large

Both *L. yabassi* and *S. nkam* are known only from a single locality, Ndokbanguegue and Yabassi respectively. Their extinction risk status was not assessed using IUCN red list protocol. But this extinction should be based on the available knowledge on extent of occurrence (EOO) and area of occupancy (AOO) of both species. Unfortunately, this study adds no other location and the available locations are still not enough to allow the accurate calculation of a revised geographic range (EOO) and AOO using GeoCAT (http://geocat.kew.org; Bachman et al., 2011). In order to mitigate these threats, we develop educational messaging aimed to bring local community to adopt practices that are less damaging to the species and the sensitive forest habitat upon which it depends. This activity was ongoing basis during the fieldwork.

Comments

Population structure of *Louisea yabassi* and *Sudanonautes nkam*

The goal of the study was to better understand the population structure, sex ratios, breeding season, fecundity, and distribution of the species *L. yabassi* and *S. nkam* in which it was found males were greater than females and females larger than males observed in the average carapace width of the different sexes. The male and female were collected within 1 to 4 individual/transect and 1 to 12 individual/transect in the month of February to Match attributed that this was the month where sexually mature females and males were caught as breeding month.

Increase in the number of males during the breeding season was attributed to (a) the migration of males towards the sexually mature females for breeding purpose and (b) burrowing of ovigerous females after mating. The Pattern of fluctuation in sex ration of presently studied crabs also finds relation with categoric absence of ovigerous females in the study area that possibly undergo burrowing a commonly observed phenomenon among ovigerous females in breeding season as also held. However, it was found that juvenile percentage occurrence decreased with a decline in ovigerous female percentage occurrence, whereas sub adult percentage occurrence increased due to seasonal changes. Such outcomes demonstrate that the species were influence by environmental risk throughout the year because of slow reproduction and a long incubation period. Fecundity vary with regard to the latitudinal range, habitat, and food availability. Fecundity is determined by not only the female body size but also by the average EN and the brood frequency. A variety of abiotic and biotic

variables, including water temperature (Head & Backwell, 2019), salinity (Huang et al., 2022), the nutritional quality of the females (Matias et al., 2016), and the threat of predation (Mestre & Warkentin, 2006), affect the reproductive maxima among populations. It was found that the average body weight of both species *L. yabassi* and *S. nkam* was 1.33g and 4.23g respectively indicating a significant different of the genders.

Growth and size classes in *Louisea yabassi* and *Sudanonautes nkam*

Ontogenetic development in our population sample of *L. yabassi* and *S. nkam* from Yabassi and Ndokbanguegue is discussed here in terms of three size categories (juveniles, sub adults, and adults) following the criteria proposed by Cumberlidge, (1999). The natural population of the species includes male and female specimens in a range of body sizes that are grouped here into: (1) juveniles (small-bodied non-reproductive specimens), (2) sub-adults (medium-sized but non- reproductive specimens), and (3) adults (large sexually mature adults). Juveniles of both sexes are characterized by their small size CW up to 15.60 mm and CW up to 29.95 mm respectively by the morphological similarity between male and female specimens; both sexes have a similar-shaped abdomen for males and females. The equal-sized chelipeds for the sub adult size class and the gonopods (males) and pleopods (females) are short and undeveloped for juvenile and sub adult. The abdomen of juveniles of both sexes is a slim elongated triangle that tapers to a rounded telson and covers only the sub abdominal cavity.

The G1 and G2 of juvenile males are both short, straight, and similar in size, whereas juvenile females possess four pairs of small, narrow pleopods. Sub adult crabs (CW up to 14.74 mm) and (CW up to 28.30) for *L. yabassi* and *S. nkam* respectively and characterized by their partial development towards the adult form as a result of allometric (accelerated) growth of the abdomen and pleopods (females) or of the major cheliped and gonopods (males). The abdomen of sub adult female crabs is broad and wide but only partially covers the thoracic sternum and is distinctly broader than the slim triangular abdomen of juvenile females and all size classes of male crabs. Although the gonopods of sub adult males are long enough to reach sternal segment s6 they are still undeveloped (mostly straight with only a slight outward curve). The abdomen of the only sexually mature adult male (CW 19.61 mm) and (CW 36.91 mm) respectively from yabassi and Ndokbanguegue is slim and triangular covering the narrow sub abdominal cavity, whereas the abdomen of adult females (CW 17.03 mm) and (CW 29.91

mm) respectively is conspicuously wide and covers most of the thoracic sternum and overlaps the coxae of the walking legs (p2–p4) (see Mvogo-Ndongo et al., 2017).

The sub abdominal cavity of adult males is deep and narrow and contains the G1 and G2, whereas that of adult females is broad, shallow, and includes four sets of well-developed plumose pleopods for attachment of egg masses. The major cheliped of adult males is distinctly larger than the minor cheliped, and the dactylus is arched so that a distinct space remains between the closed fingers. The chelipeds of females grow isometrically and are not dramatically different from each other in any of the three size classes and one cheliped is not conspicuously enlarged with respect to the other (as is the case for adult males). The morphological differences shown by the three size classes in *L. yabassi* and *S. nkam* can be understood in terms of the isometric (proportional) growth and allometric (accelerated) growth shown by some of the important taxonomic characters. All characters in juveniles show only isometric growth, whereas sub adult and adult males show different degrees of allometric growth (accelerated development) in the major cheliped and gonopods but not in their abdomen, while subadult females show allometric growth in their pleopods and abdomens (but not in their chelipeds). The boundary between juveniles (with all characters proportional) and sub adults is detected when specimens show accelerated growth of their abdomen and pleopods (females) or of their chelipeds and gonopods (males) (Mvogo Ndongo et al., 2017).

The boundary between sub adults and adults is the pubertal moult from non-reproductive to reproductive animals. This moult is most clearly recognized in females who are considered to be adults when their allometrically growing abdomen has increased to the point where its edges cover the coxae of the walking legs (and their allometrically growing pleopods are long, broad, and feathery, and capable of supporting eggs and or hatchlings). Male and female freshwater crabs go through the pubertal moult at the same size, so the carapace width that signals that a female specimen is an adult can be used to establish whether a male specimen is an adult (but in the absence of an adult female, a male with a prominent enlarged major cheliped and well-developed gonopods can be judged to be adult with confidence). The differences between sub adult (non-reproductive) and adult (reproductive) freshwater crabs is that sub adult males have enlarged gonopods and a major cheliped in comparison with juveniles.

Conservation strategies for *Sudanonautes nkam* and *Louisea yabassi.*

When we conserve and protect the whole ecosystem, its biodiversity at all levels is protected. This implies we save the entire forest to save the species entitle to it. This approach is called in situ (on site) conservation. However, when there are situations where an animal or plant is endangered or threatened (organisms facing a very high risk of extinction in the wild in the near future) and needs urgent measures to save it from extinction, ex situ (off site) conservation is the desirable approach.

Deforestation, alteration of drainages patterns, and pollution are major threats to these crabs. Thus, freshwater crabs species are sensitive to polluted water and cannot survive if exposed to pollution (Brook et al., 2003). Consequently, there is the risk of extinction of many essential freshwater species. There are major threats that alters the population of freshwater crabs which include deforestation, alteration of drainage patterns, pollution are major threats of these species. Freshwater crabs species are sensitive to polluted water and cannot survive due to a lack of knowledge and conservation plans. So there is the need to conserve these freshwater due to their ecological, medicinal and economic importance (Padghane et al., 2016).

Development of strategy between governmental, non-governmental organizations and the community through educational sensitization in schools, meetings and njangui houses could save the threatened freshwater crabs before they decline to the levels from which they cannot be recovered. This can be done by protecting the forest through creation of national parks and consistent monitoring of the species and maintaining good water quality. The most strategies used here were to educate all people encountered during field survey.

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