Vegetation and height preference of juvenile frogs (*Hyperolius*) in the Amani pond, Amani Nature Reserve, Tanzania

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Abstract
Like other amphibians, anurans (frogs and toads) are usually restricted to moist or humid areas. *Hyperoliidae*, a common frog family of East Africa needs emergent vegetation as well. In this study the frog abundance on vegetation in Amani pond, situated in Amani Nature Reserve was investigated. Therefore transect were analysed and two cage set-ups were build in the Amani pond. It was found that a high diversity of plants, increased frog abundance. Another finding was that *Myriophyllum aquaticum*, an invasive water weed can become a problem, since it reduces habitat for the juvenile frogs.

INTRODUCTION

Like other amphibians, anurans (frogs and toads) are usually restricted to moist or humid areas. One of the reasons is that their permeable skin is, which easily desiccates. Another reason for many amphibians to live in humid environment is for reproductive purposes. This constraint influences their behaviour in all life stages.

For juvenile frogs it is particularly important to feed and grow fast into mature stage, since this might reduce the time till first reproduction. Therefore they should maintain a balance between maximum growth and reducing desiccation and predation risks.

The family *Hyperoliidae* (reed frogs) is common in Africa with four genera being represented in Amani Nature Reserve (ANR) in the East Usambara Mountains (EUM): *Kassina, Leptopelis, Hyperolius and Afrixalus* (Harper & Vonesh, 2003). *Hyperolius* is a common and widespread genus with a characteristic horizontal pupil. Members of this family are slender, small to moderate sized with long hind limbs. It is common for this genus to bask in full sunlight on vegetation above the water surface (Passmore & Carruthers, 1995). Relatively many studies have been conducted on *Hyperoliidae* but little is known about the ecology of juveniles.

The most abundant species in the pond in ANR are *Hyperolius puncticulatus* and *Hyperolius mitchelli* (Beeuwkes & Scott-Manga, personal observation). Juveniles are abundant and enable studies with a high number of replicates.

Amani pond used to be a habitat with open water, Cyperaceans, ferns and other aquatic plants. At present, this pond is almost completely overgrown with an invasive weed *Myriophyllum aquaticum* (parrotfeather), which has feather-like leaves arranged in whorls around the stem. The stems can extend over several meters on the water surface, forming a thick floating mass. This plant seems to have significant effects on plant diversity and thus availability of different habitats for frogs of different species and live-stages (Odhiambo & Dixon, 2000).

Myriopyllum aquaticum may form a habitat for predators like spiders and snakes. Vonesh (2005) observed that spiders in aquatic vegetation were predating on juvenile frogs. In addition, Odhiambo & Dixon (2000) also showed that there was greater abundance of frogs in harvested *M. aquaticum* areas than un-harvested, which suggest that a pond which is overgrown with this plant may reduce frog numbers in the pond.

Van de Wiel & Ujoh (2003) showed that there was a positive correlation between frog abundance and erected Cyperacean vegetation in Amani pond. This might be interpreted as a strategy of frogs to climb in emergent vegetation in order to reduce their predation risks from these predators.

This study investigates vegetation and height preference in juvenile *Hyperolius* frogs, in order to assess the effect of the current *M. aquaticum* infestation on the availability of suitable supportive plant structures in Amani pond.

We show that juvenile *Hyperolius* frogs prefer to sit on vegetation that provide enough support. In addition it is shown that high plant diversity increases frog abundance. Our study may have implications for the management of the Amani pond.

MATERIALS & METHODS

Study Site

The study was carried out in Amani Nature Reserve, Tanzania, located 5°6’S and 38°38’E. in the northern side of an artificial pond dug out during the German colonial period. It is located close to the IUCN hostel and renowned for its frog abundance and diversity (Harper &Vonesh, 2003).

Study species

A particular species of *Hyperolius* was not selected because the identification of juveniles is impossible in the field. The size of the juvenile frogs was between 8 and 13 mm.

Transect analysis

A pilot survey showed that the northern side of the pond had three main different habitat types. Thus, the transects in the pond were selected by stratified sampling 2.5 m by 8 m long and demarcated with red flags and yellow tapes and were. Transect 1 was set out on the pond edge, transect 2 was set out in *M. aquaticum* and transect 3 was set out in a deeper area of the pond with a majority of the tall reed *Cyperus exaltatus*. For each transect the coverage % of three plant types (reed species, *M. aquaticum* and other plants) was estimated visually at a 5% accuracy level.

Cage experiments

A cage was constructed using bamboo sticks (diameter 1 cm), mosquito net, 70 x 70 x 75 cm and sisal ropes. The mosquito net was spread over the frame and secured at the bottom by bamboo sticks with a diameter of 5 cm, to prevent the juvenile frogs from escaping.

On the mornings of the cage experiments forty frogs were collected at different locations in the pond far from the transects between 7 and 8 am. The frogs were kept in four plastic bags and released between 8 and 9 am at the four sides of the study cage.

Cage experiment 1

The first set up had four plant types; *M. aquaticum* and a pair each of *Cyperus rotondus*, *Asplenium* sp. and *C. exaltatus* 35 cm (short) and 70 cm high (tall), planted in a natural bed of *M. aquaticum* on the bottom of the cage (figure 1). The cage experiment was repeated once.

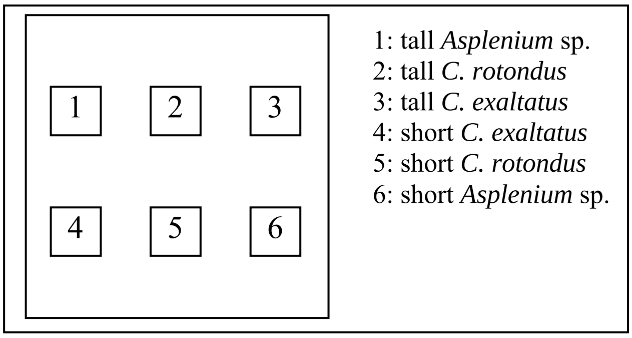

Figure 1. Topview of cage set up 1

Cage experiment 2

The second cage experiment was done in the same cage. Bamboo sticks (diameter 1 cm.) of height 70 cm replaced the plants from experiment 1. These bamboo sticks having cross bars of 35 cm long nailed at 35 cm and 70 cm height (figure 2). This cage experiment was repeated once as well.

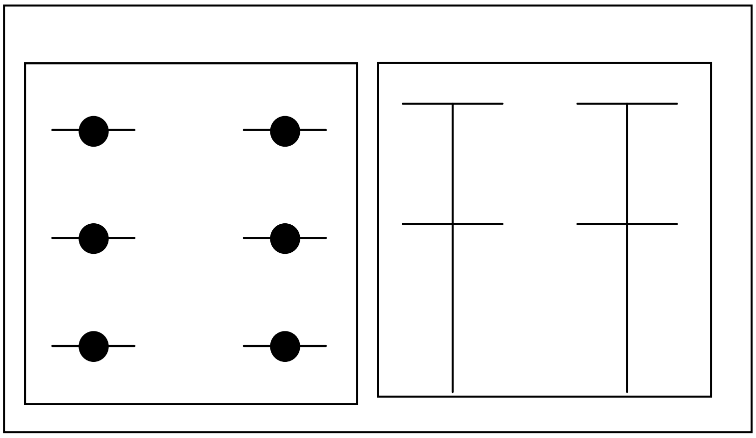

Figure 2. Top and side view (respectively) of cage set up 2

Data was collected according to the time schedule displayed in table 1.

Table 1. Time schedule of conducted experiments

	date	time
transect analysis	17-18-19 September	10.15; 15.30; 20.45
cage experiment 1a	18 September 19 September	10.00; 15.15; 20.30 09.00
cage experiment 1b	19 September 20 September	10.00; 15.15; 20.30 09.00
cage experiment 2a	21 September 22 September	10.00; 15.15; 20.30 09.00
cage experiment 2b	22 September 23 September	10.00; 15.15; 20.30 09.00

Each of the transects was searched for 15 minutes by the authors, considering about 60 cm on both sides. It was noted whether frogs were found on; *M. aquaticum*, reed or other plants. During evenings head torches were used.

For cage experiment 1 and 2, the frogs were observed for 15 minutes. For both the experiments the height and structure on which the frogs were found was noted. At 20.30 hrs, head torches were used to locate juvenile frogs. All the information was recorded in pre-prepared data sheets.

The maximum number of frogs seen at the end of each day was assumed to be the total number of frogs in the cage. 'Missing frogs' in other observations with lower maximum numbers were assumed to be in *M. aquaticum*.

Data Analysis

The data was analysed using Excel 2003. G-tests for goodness-of-fit were used to test for differences in height and vegetation preference. Expected values for the G-test significances (table 2, figures 4, 5) were based on equal distribution over the different categories; figures 6 and 7 were based on surface area estimates; and figure 3 was based on relative cover of vegetation type.

Significance in graphs and tables is expressed as * (significant at α=0.05), ** (significant at α=0.01) and *** (significant at α=0.001).

In the analysis of cage experiment 1 frogs on the net and bamboo frame were not taken into account, we recorded them in experiment 2, since the cage was built of bamboo structures.

RESULTS

Vegetation-preference

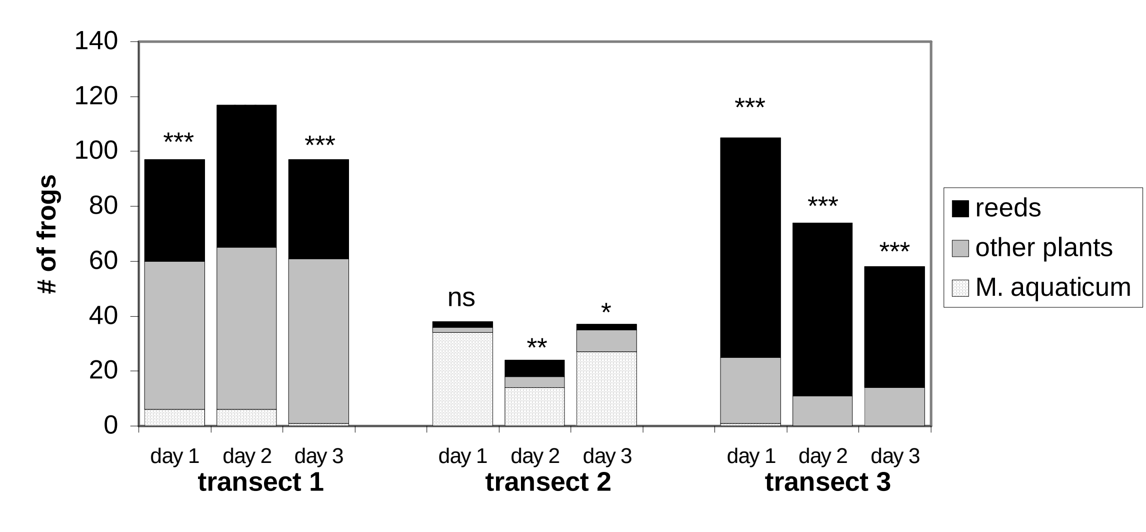

Figure 3. Vegetation preference on transects in 3 days.

In transects 1 and 3, a majority of 80, 63 and 44 frogs respectively, were found on reed species, and 54, 59 and 60 frogs respectively, in other plants. Figure 3 shows significant difference only for day 2 and 3, where a majority of 34, 14 and 27 frogs, respectively, were found in the *M. aquaticum*.

Table 2. Frog numbers per transect.

	1	**2**	**3**	**significance**
day 1	97	38	105	***
day 2	122	25	75	***
day 3	92	36	57	***
TOTAL	311	99	237	

Most frogs on transect 1 were observed with significant differences between the transects for each of the 3 days.

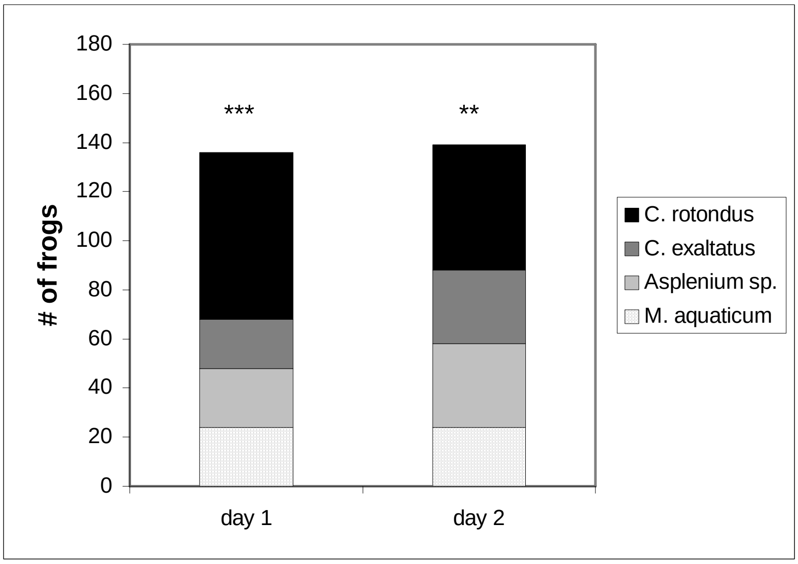

Figure 4. Plant preference for cage experiment 1.

In cage experiment 1, plant preference in both days 1 and 2 was highly significantly different (Fig. 4)

Table 3. Vegetation structure preference for transects (average for 3 days)

	transect #		
	1	**2**	**3**
leaves other plants	93%	23%	98%
M. aquaticum	4%	76%	1%
stems other plants	3%	1%	1%
TOTAL	100%	100%	100%

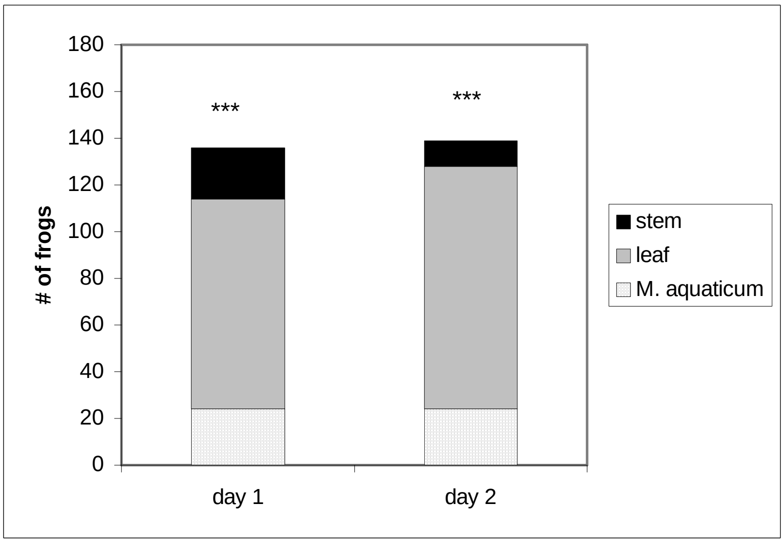

Figure 5. Vegetation structure preference for cage experiment 1.

In all three transects the lowest percentage of frogs was found on stems of other plants (Table 3). This is supported by results of the cage experiment 1, which shows high significant differences in vegetation structure preference (Figure 5).

Height preference

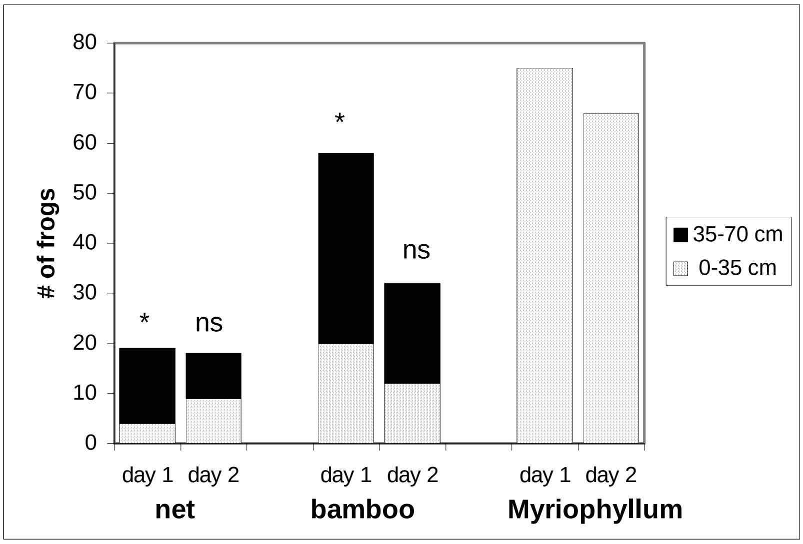

Figure 6. Height and structure preference for cage experiment 2.

Table 4. Distribution of total number of frogs over height zones in cage experiment 2

	height zone		
	0-35 cm	**35-70 cm**	**TOTAL**
day 1	65%	35%	100%
day 2	74%	26%	100%

Frog numbers were higher on the bamboo structures than on the net, which covered the cage, with a significant difference between bamboo and net on day 1 (Figure 6.). On both days the highest percentage of frogs was in the 0-35 cm zone (Figure 4).

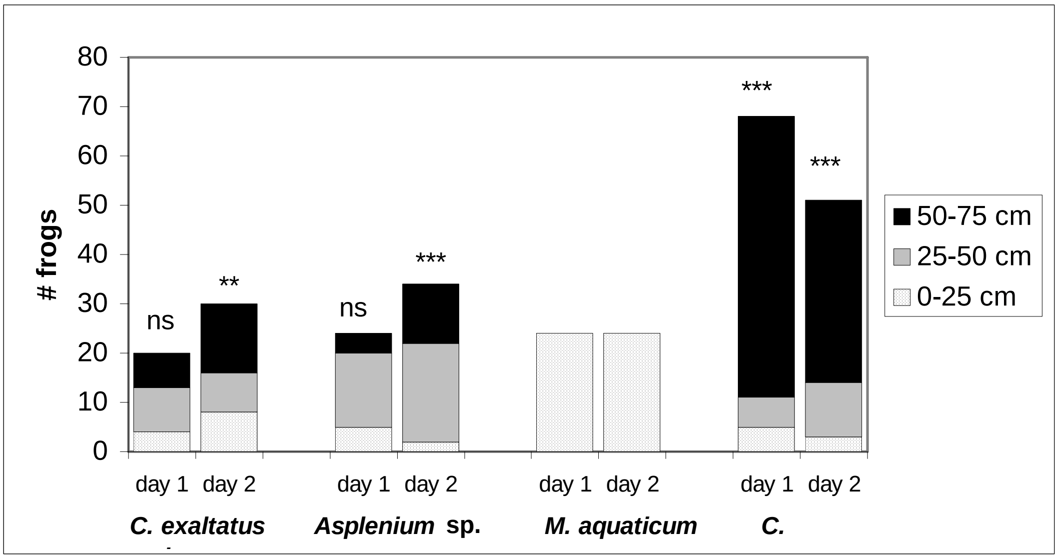

Figure 7. Plant- and height preference for cage experiment 1.

A significant majority of respectively 57 and 37 frogs prefer the height zone 50-75 cm on *C. rotondus* on both days (Figure 7). The height zone 25-50 of the same plant offers the same structure, but only 6 and 11 frogs respectively were found in this zone. Only day 2 shows highly significant differences for height preference on *Asplenium* sp. and *C. exaltatus*.

DISCUSSION

Frog numbers were highest in transect 1, which is situated at the pond edge. This can be explained by the wide variety of vegetation types, estimated to be 25% *M. aquaticum*, 25% reed, and 50% other plants. The habitat covered by transect 1 may be more preferable, because frogs have the choice to change their position according to the situation; hiding from predators; preventing desiccation or find a site to bask in the sun.

Although *M. aquaticum* and reed have equal estimated cover in the transect, reed is significantly more preferred, because reeds offers support for basking in the sun, which is common behaviour of *Hyperolius* in contrast with most other frog species (Passmore & Carruthers, 1995).

Transect 2 had lowest number of frogs. This can be explained by the predominant occurrence of *M. aquaticum* (90%) We suggest that *M. aquaticum* provides little structure for frogs to rest on given that the stem and leaves are flexible and do not have a flat surface. The plant also did not grow higher than 30 cm and a habitat which has a high predator presence (Vonesh, 2005).

Transect 3 was situated in a bed of *Cyperacean*, at a cover of 90% followed by 5% *M. aquaticum* and other plants. More frogs were found on other plants although they had the same cover than *M. aquaticum*. Reeds are the plants on which most frogs were found, probably because it was the only emergent plant within this habitat.

Cyperus rotondus was significantly preferred in cage experiment 1, probably due to the presence of horizontal leaves. However, horizontal bamboo structures in cage experiment 2 did not seem to be equally preferred and the horizontal orientation of an object does not seem the influential factor of influence.

Differences in plant preference occur between the two days, which could be explained as behavioural changes in response to weather changes. However, the number of frogs in *M. aquaticum* does not increase with their numbers in *Asplenium* sp. and *C. exaltatus*. We suggest that this is due to the more static microclimate of *M. aquaticum* since it is a dense structure.

Investigating vegetation structure preference, stems were found to be less preferred to leaves in both the transects and the cage. *Myriophyllum* stems and leaves were not differentiated, because the distance between the stem and the whorled leaves is short.

Stems of plants on the edge of the pond were observed to be narrow and may be uneasy for frogs to rest on, while leaves may allow better resting position and provide a higher surface area exposed to sunlight.

In the transects and in cage experiment 1 it was found that frogs were climbing up on emergent vegetation whenever present. Cage experiment 2 however showed that the majority of frogs stayed in *M. aquaticum*, although emergent bamboo structures were offered. Since plants do not lack supply of water, it may be assumed that their stomata are open during the day. Therefore we suggest that artificial structures are less attractive because they do not provide possible compensation for water loss of the frogs. Another reason that explains the high frog numbers in the *M. aquaticum* may be that green plants are attractive for insects which can serve as food.

For cage study 1 we have no explanation for the fact that a higher number of frogs was found in zone 50-75 cm on *C. rotondus*, although the same plant species was offered at 25-50 cm.

There are slight differences between the days of the observations. We observed, but did not measure, weather/microclimate changes between and throughout days. And differences in frog numbers between days could be attributed to climatic differences.
Our results show that plant variety increases frog abundance. We argue that a diverse habitat with many plant types, provide more possibilities for juvenile frogs to choose a site according to their needs. Cage experiment 1 and 2 showed that leaves are more preferred than stems and artificial structures. This supports the suggestion that a diverse habitat increases frog abundance, since a variety of leaf structures will provide choices for sitting position.
We suggest that management of the *M. aquaticum* infestation in the Amani pond should be considered, in order to increase plant diversity.

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