STUDIES ON THE ANURAN FAUNA OF THE PEAT SWAMP FOREST AT KOTA SAMARAHAN (UNIMAS TEMPORARY CAMPUS), SARAWAK

Khairul Anuar Bin Omar

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DIETARY STUDIES ON THE ANURAN FAUNA OF THE PEAT SWAMP FOREST AT KOTA SAMARAHAN (UNIMAS TEMPORARY CAMPUS), SARAWAK

KHAIRUL ANUAR BIN OMAR

This project is submitted in fulfilment of the requirements for the degree of Bachelor of Science with honors (Animal Resource Science and Management)

FACULTY OF RESOURCE SCIENCE AND TECHNOLOGY
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Dietary Studies on the Anuran Fauna of the Peat Swamp Forest at Kota Samarahan (UNIMAS Temporary Campus), Sarawak

Khairul Anuar Bin Omar

Animal Resource Science and Management Program
Faculty of Resource Sciences and Technology
Universiti Malaysia Sarawak

ABSTRACT

A dietary study of the anuran fauna at UNIMAS peat swamp forest, behind the sports complex, was conducted for 17 days sampling between September 2005 to April 2006. Similarities in use of food and microhabitat resources were assessed. The line transect method was applied during sampling and a total of 11 species, represented by 78 individuals, were collected. Overall, anurans in peat swamp forest consume a large proportion of Coleoptera (23.2%) followed by Hymenoptera (21.7%) and Arachnida (21.7%). From these analyses, there seems to be a considerable overlap of prey and microhabitat utilization.

Key words: Anura, diet, microhabitat use, peat swamp forest, Sarawak, Malaysia.

ABSTRAK

Satu kajian tentang anurans telah dikendalikan di hutan paya gambut UNIMAS secara khususnya di hadapan kompleks sukan antara September 2005 hingga April 2006 selama 17 hari persampelan. Persampelan ini telah menggunakan kaedah ‘line transect’ dan berjaya menangkap 11 species dengan 78 individu. Secara keseluruhannya, anurans di hutan paya gambut UNIMAS memakan sejumlah bilangan yang besar Coleoptera (23.2%) ditukui oleh Hymenoptera (21.7%) dan Arachnida (21.7%). Daripada kajian, terdapat pertindihan dalam pemakanan anurans dan juga dalam mikrohabitat.

Kekunci: Anurans, pemakanan, hutan paya gambut, pertindihan.
1.0 Introduction

Living amphibians are classified into three orders, namely, Anura, Gymnophiona and Caudata. According to Zug et al. (2001), there are about 4,200 species of anurans worldwide. Most live in aquatic and terrestrial habitats from lowlands to mountain tops, their diversity higher in moist tropical areas. Previous studies by Ramlah (2006) show that there are approximately 12 species in peat swamp forests of Borneo, based on field work conducted till 2003. This increased to 19 species with the increment of seven species in 2005 (Inger et al., 2005). According to Inger and Stuebing (1989), the major role in the distribution of species is microhabitat tolerances. Life histories, patterns of movement of individuals and habitat tolerances are aspects of the diversity of Bornean frogs.

Amphibians are dietary opportunists with diets reflecting the availability of food of appropriate sizes (Duellman and Trueb, 1986; Larsen, 1992; Stebbins and Cohen, 1995). They seem to be generalist feeders, ingesting prey items of appropriate size that enter their line of vision. Some frogs are specific feeder. In Panama, Toft (1980a,b) categorised leaf-litter frogs could be categorized as either ant-specialists or non-ant (fewer, larger prey) specialists although there are a few generalists.

Almost all adult frogs are carnivorous. Their diet consists of invertebrates especially insects, crustaceans, worms and mollusc, although larger frogs may sometimes take vertebrates (Feder and Burggren, 1992; Zug, 1993; Beebee, 1997). Rarely, vegetable
matter is found in frog guts. Frogs eat a variety of food, so there is a tendency to partition food type more consistently than that seen in salamanders and lizards (Toft, 1985).

Compared to the Neotropical region, frog densities in tropical Asian forests are lower (Heyer and Berven, 1973; Scott, 1976; Inger, 1980). Peat swamp forests are believed to have low abundance of frogs as peat swamps are acidic. However, some frogs manage to adapt but with lower density (Ramlah, 2006).

Few studies have been done on the resource utilization of anuran communities (see Inger and Marx, 1961; Duellman, 1978; Toft, 1980a,b, 1982; Das, 1992; Pinero and Durant, 1993). The studies were conducted at the Neotropics and in lowland dipterocarp forests of tropical Asia but there is little knowledge available on the diet of peat swamp frogs. The ecological relationships between frogs and their surrounding and the interaction with food abundance in such habitats remain unknown. This study was to investigate the food ingested and microhabitat used by different species of frogs at a peat swamp.

2.0 Literature Review

2.1 Species of the peat swamp

In Kota Samarahan peat swamp forest, 12 species of frogs have been recorded, including Leptobrachium nigrops, L. hendricksonii, Limnonectes malesianus, L. paramacron, L. ingeri, Bufo quadriporcatus, Rana baramica, R. glandulosa, Occidozyga laevis.
Polypedates colletti, *P. otilophus* and *Rhacophorus appendiculatus* (Inger and Tan, 1996a,b). Recent studies by Ramlah (2006) found that at the Kota Samarahan peat swamp forest, the family Ranidae contributes 66% of individuals sampled, followed by Bufonidae (28%) and Rhacophoridae (6%). Seven additional species however were discovered by 2005 (Inger et al., 2005).

2.3 Feeding strategy

There are two modes of feeding strategies in animals, which are also relevant to frogs: sit-and-wait foraging and active foraging (Das, 1996; Zug et al., 2001). Species that are sit-and-wait foragers do not move but wait for potential prey to come within their field of vision or other senses. Based on that, they may possess special characteristics such as enhanced vision, cryptic coloration and/or morphology, so that neither the prey nor their predators can detect them. This kind of strategy can save energy compared to active foraging (Das, 1996).

Active foragers search for prey throughout a particular habitat and can use a combination of visual and chemical cues for prey detection. They can locate immobile, clustered and hidden prey that might not be detected by sit-and-wait foragers (Zug et al., 2001).

Amphibians use one or more cues to detect prey. The two cues are visual to detect moving prey and chemical to detect non-moving prey (Zug et al., 2001).
2.4 Prey selection, types and sizes

Prey selection depends on the prey availability, habitat, seasonality (Toft, 1980b) and ontogenetic changes (Donnelly, 1971; Labanick, 1976; Flowers and Graves, 1995; Christian, 1982; Lima and Moreira, 1993; Lima, 1998). Prey availability implies what type of prey is present in the locality. The more abundant the prey species, the more preferred it is by the amphibian predator, all things remaining the same. Indeed, the study of Labanick (1976) in tropical forests shows that the abundance of food items in the stomach was correlated with the relative prey abundance in its habitat.

Larger predators find different and relatively larger preys. Ontogenetic changes include changes in the number of teeth, mobility and gape increase. According to Toft (1980a), gape is the factor in the size of prey eaten by various species of anurans. Small species cannot eat the same size of prey as one that is large. In Caldwell and Vitt’s (1999) study, the mean size of prey eaten was correlated to the body size of frogs (and lizards) which implies that body size has a significant influence on prey selection.

Habitat also has a large influence on food. It is related to the abundance of prey availability where the prey availability varies between localities. In forested habitats, the main diets of frogs are insects while in brackish water habitats (a challenging habitat for arthropods, for physiological reasons), the main diet comprises crustaceans (Elliot and Karanukaran, 1974). Vitt and Caldwell's study (cited in Zug et al., 2001) shows that in
leaf litter habitats of the Brazilian Amazon, the frog _Leptodactylus mystaceus_ relies heavily on beetles, termites and grasshoppers.

Seasonality affects the food of amphibians and reptiles, whereby some species are abundant during the rain season, some during the drier months (Toft, 1980b).

### 2.5 The diet

Generally, there are two types of organism in terms of diet: the generalist and the specialist. Generalists randomly ingest prey as available in a particular habitat, while specialists select portions from the prey spectrum availability (Das, 1996).

Frogs and toads primarily feed on insects. According to Sluys _et al._ (2001), who studied leaf litter frogs in the Neotropics, the main food in the stomachs are arthropods. Some large-growing species of frogs can eat other frogs, snakes, birds and small mammals (Inger and Stuebing, 1961; Beebee, 1997). However, frogs eat anything that move as long as it fits their gape (Donnelly, 1991).
3.0 Materials and Methods

3.1 Study site

The study area (shown in Figure 1) is located at the peat swamp forest adjacent to the temporary campus of Universiti Malaysia Sarawak (UNIMAS), in Kota Samarahan (GPS: 01° 27' 34.2" N; 110° 27' 25.9" E; datum: wgs84). The elevation from the sea level is 9 m while the relative humidity is 90.6% RH. The temperature is about 27.7°C at night. The site is about 32 km from Sarawak's capital city, Kuching. The study site is in the proximity to the coast and to rivers. This site has been logged 50 years ago, but at present, secondary peat swamp forest survives. Some part of the peat swamp area has been destroyed for development purposes, including the construction of the university campus and the road system. Fragmentation is believed to have decreased the animal diversity in the peat swamp forest. The site was selected for this study for reasons of ease of access.

During the sampling period from September 2005 to April 2006, the rainfall was constant for every month, except in February, when heavy rainfall occurred. The study site was flooded and the water level reached 1 meter.
3.2 Sampling period

Sampling was conducted from late of September 2005 to early of April 2006, except in November 2005 due to lack of man power. In total, 17 night days sampling was done.
3.3 Sampling technique

Sampling was done by walking slowly for distances of 200 to 300 m following a pre-established forest transect set, marked with trail-markers. Frogs were observed at night by sight and sound, for 5 m on either side of the trail. All frogs were caught by hand. The frogs captured were taken to the laboratory for flushing of stomach content. Some frogs were released the next day at their natural habitat and some were preserved to serve as vouchers. Data on weight, W (gm), snout vent length, SVL (mm), head width, HW (mm), date and time, microhabitat (see Appendix 2, Table 4) and food content were recorded.

3.4 Food Sample Identification

The frog stomachs were flushed by inserted water using a syringe affixed with a plastic tube into the frog's mouth. The concept of this technique is same as vomit ideology. For each food sample, volume (ml) was measured by volumetric displacement, through displacement of fluid in a graduated cylinder (Das, 1996; Sluys et al., 2001). This method was applied to value the mass weight of the food sample. Some identifiable and small items were examined under a microscope. The content in the stomach was identified to ordinal level by using Bland and Jaques (1978) and Hill and Abang (2005).
3.5 Fixation

Some of the frogs that are new record were preserved. They were fixed in 4% formalin solution and preserved in 70% ethanol. Data such as locality, date and time were recorded.

3.6 Materials

The equipments taken to the field were glass jar, dip-net, plastic zip-lock bags, plastic bags, torchlight, head lamp, trail marker, frog data sheet and field notebook.

The laboratory equipment were syringe (6 ml), vernier caliper, ethanol, formalin, chlorobutanol, plastic tube for stomach flushing, Petri dishes, data sheet, a field guide (Inger and Stuebing, 1997) and insect identification book (Bland and Jaques, 1978; Hill and Abang, 2005).
4.0 Data Analysis

Data was analyzed using Jaccard’s Index model $C_j = j / (a+b-j)$. The model was used to analyze data on dietary and microhabitat overlap (Jacobs, 1974).

where:

\[ j = \text{number of resource states in common between two species} \]
\[ a = \text{number of resources state in species } A \]
\[ b = \text{number of resources state in common species } B \]

The indexes were then analyzing using SPSS version 11.5 to test species association based on diet and microhabitat features.
5.0 Results

Table 1 shows the number of individuals with food items according to species. There are 11 species of frogs with 78 individuals were caught but only 43 individuals in eight species had food items in stomachs which are B. quadriporcatus, F. cancrivora, F. limnocharis, L. paramacrodon, R. baramica, R. erythraea, P. lecomystax and N. pictus. F. cancrivora, F. limnocharis, R. baramica, R. erythraea, P. lecomystax fulfil the desired sample sizes with eight total samples in each species while P. signata, R. pardalis, B. quadriporcatus, L. paramacrodon, R. chalconota and N. pictus are represented by less than eight individuals. No food was found in P. signata, R. pardalis and R. chalconota and one individual in each three species of B. quadriporcatus, L. paramacrodon and N. pictus was found.

Table 1: Number of individuals with food items according to species.

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of individuals</th>
<th>Individuals with food items</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fejervarya cancrivora</td>
<td>14</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Fejervarya limnocharis</td>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Rana baramica</td>
<td>12</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Rana erythraea</td>
<td>12</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Polypedates lecomystax</td>
<td>22</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Pelophryne signata</td>
<td>3</td>
<td>0</td>
<td>Sample size n = 8</td>
</tr>
<tr>
<td>Rhacophorus pardalis</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Bufo quadriporcatus</td>
<td>1</td>
<td>1</td>
<td>Sample size n &lt; 8</td>
</tr>
<tr>
<td>Limnonectes paramacrodon</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Rana chalconota</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Nyctixalus pictus</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

* New record for the Kota Samarahan peat swamp
Taxonomy Diversity of Diets

The diet of frogs in the study consists of 10 items.

Table 2: Diet of frogs in Order level found in frog stomachs.

<table>
<thead>
<tr>
<th>Order</th>
<th>Food items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthoptera</td>
<td>Crickets, grasshoppers</td>
</tr>
<tr>
<td>Dictyoptera</td>
<td>Roaches</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>Beetles</td>
</tr>
<tr>
<td>Diptera</td>
<td>Mosquitoes</td>
</tr>
<tr>
<td>Lepidoptera</td>
<td>Moths</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>Ants, flying ants</td>
</tr>
<tr>
<td>Insect larvae</td>
<td>Caterpillar</td>
</tr>
<tr>
<td>Arachnida</td>
<td>Spiders</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Snails</td>
</tr>
<tr>
<td>Unidentifiable item</td>
<td>Jelly-like items</td>
</tr>
</tbody>
</table>

Diet preferences

Figure 1 shows the frequency of prey occurrence in frog stomach samples. Coleoptera (23.2%), Hymenoptera (21.7%) and Arachnida (21.7%) were the most preferable food. Prey groups such as Orthoptera, Dictyoptera, Diptera, Lepidoptera, insect larvae, Mollusca, and prawn larvae seem to be less preferred by frogs.

Figure 2 shows the volume of prey ingested by frogs. As coleopterans (beetles) were the most preferable food, they were consumed in large quantities (32.6% by volume). \textit{F. limnocharis} ate large proportion (22.6%) of Hymenoptera (ants) as the prey type are relatively small and tend to be social, and hence, show clumped distribution. On the other hand, \textit{R. baramica} consumed a high proportion of Arachnida (spiders) in terms of volume (17.2%). This type of feeding has been reported by Parmelee (1999) in his study, where he showed that two New World species, \textit{Colostethus marchesianus} and \textit{Epipedobates
*pictus* eat about the same average size of prey but the latter eats almost twice the number of prey items because the prey size was relatively small.

**Figure 1:** The number of prey consumed by peat swamp frogs.

**Figure 2:** Volume (in ml) of prey consumed by peat swamp frogs.
Fejervarya cancrivora

F. cancrivora ingested a higher proportion of Coleoptera (beetles). Orthoptera (crickets) and Diptera (mosquitoes) shared the same proportion in the diet, secondary to Coleoptera. Coleoptera was the main diet for R. cancrivora because beetles are the heaviest and biggest prey that can potentially provide more energy compared to mosquitoes that may also be more difficult to harvest. Beetles, in this habitat, are as such a substitution to crabs, as reported from other habitats (Elliot and Karunakaran, 1974; Premo and Atomowidjojo, 1987).

Figure 3a: Numeric percentage of prey item in the diet of Fejervarya cancrivora.

Figure 3b: Volumetric percentages of prey item in the diet of Fejervarya cancrivora.
*Fejervarya limnocharis*

The diet of *F. limnocharis* consisted of Hymenoptera (ants), Coleoptera (beetle) and Lepidoptera (moth). The number of Hymenoptera consumed is correlated with the volume. Coleoptera takes the second place as they play an important role in the food web, followed by Lepidoptera. *F. limnocharis* seem as an ant-specialist because the primary content in their stomach is always ants.

![Figure 4a: Numeric percentages of prey item in the diet of Fejervarya limnocharis.](image)

![Figure 4b: Volumetric percentages of prey item in the diet of Fejervarya limnocharis.](image)
*Rana baramica*

*R. baramica* is an arboreal species that tend to be found on tree trunks, typically about a meter above ground. Some can be found under trees. The diet reflects its microhabitat which they tend to consume a higher proportion of Arachnida (spider), Dictyoptera (cockroaches) and Orthoptera (cricket), that are typically associated with trees.

![Figure 5a](image1.png)  
**Figure 5a:** Numeric percentages of prey item in the diet of *Rana baramica*.

![Figure 5b](image2.png)  
**Figure 5b:** Volumetric percentages of prey item in the diet of *Rana baramica*.
**Rana erythraea**

*R. erythraea* is a generalist feeder. They consume a variety of food types including Coleoptera (beetle), Lepidoptera (moth), Hymenoptera (ants), Mollusca (snail), Orthoptera (cricket and grasshopper), insect larvae (caterpillar) and Arachnida (spiders). *R. erythraea* has apparently adapted to more open environments, due to their capability to consume many prey resource types, which may explain why it is also found in disturbed habitats. Some miscellaneous items such as grass and hay were also found in the stomach. Evans and Lampo (1996) and Zug *et al.* (1975) suggested that the vegetation was ingested on purpose. Vegetation is believed to function as roughage to assist grinding invertebrate exoskeleton, aid in elimination of intestinal parasites or to provide moisture. The other possibility is the plant has insect on them and both items were ingested incidentally, or the movement of such prey-sized plant pieces appeared to the frog as animal prey.

![Figure 6a: Numeric percentages of prey item in the diet of *Rana erythraea.*](image)

Figure 6a: Numeric percentages of prey item in the diet of *Rana erythraea.*
Polypedates leucomystax

P. leucomystax is also a generalist feeder. Its diet comprised of Lepidoptera (moth), Dictyoptera (cockroaches), Diptera (mosquitoes), Hymenoptera (ants), insect larvae (caterpillar) and some unidentified items. The unidentified item found was a jelly-like and green-yellowish solid that was unidentifiable.
Cluster analysis on dietary similarities between selected species

Based on Figure 8 and 9, *R. erythraea* shares similar dietary resources with *P. leucomystax* (Hymenoptera, Dictyoptera, Diptera, Lepidoptera, insect larvae, unidentified item) except for Mollusca which is absent in *P. leucomystax*. This is due to the size and head or mouth width of *R. erythraea* (snout-vent length, ± 40.5–83.0 mm; head width, ± 12.5–23.5 mm) is larger than in *P. leucomystax* (snout-vent length, ± 37.1–47.5 mm; head width, ± 12.5–22.0 mm). Another possibility is that these two species did not share the same microhabitat: while *R. erythraea* can be found at the river-edge, *P. leucomystax* more likely to be in arboreal situations. This was demonstrated by Werner *et al.* (1995) who showed that habitat differences between bullfrogs and green frogs were reflected in the diet composition.