7. The Food of the Amphibians and Reptiles

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INTRODUCTION

The amphibians and reptiles collected on the expedition offered an opportunity to examine the diet of a restricted fauna in relation to its ecology. Knowledge of the food of the Malayan amphibians is restricted to a single study of the food of *Bufo melanostictus* Schneider (Berry and Bullock, 1962) while in the reptiles only the snakes have received attention (Lim, 1956). As has been noted by Hendrickson (this *Bulletin*, p. 72) the amphibians were represented on Tioman by numerous individuals, but relatively few species, and these circumstances provide good conditions for determining the extent of feeding segregation of the different species. The reptiles had a greater species representation but again were generally more abundant than on the mainland and for many species sufficient data were obtained to indicate the type of diet.

MATERIALS AND METHODS

The entire collection of amphibians and reptiles resulting from the expedition was used for this study although a number of specimens contained no food, e.g., all the snakes, and these, except in special cases, are not included in the account. The amphibia were all collected by hand and were killed by immersion in 70 per cent alcohol, usually within an hour of capture and always within three hours. The specimens were sorted and labelled on the same day as they were killed and the wall of the abdomen cut with fine scissors to ensure penetration of the viscera and preservation of the gut and its contents.

The reptiles were treated in much the same way as the amphibia except that these were almost entirely collected by shooting with "dust" shot so that death may be considered to have been instantaneous. Preservation of specimens was often rather delayed because they were collected while out on a day's collecting when preservative could not be carried.

For examination, the abdomen was opened by a longitudinal cut in the abdominal wall and a lateral cut along the lower edge of the pectoral girdle. The stomach was then removed by cuts across the oesophagus and the small intestine and placed in a tube of 70 per cent alcohol together with a copy of the collection number of the specimen. Analysis of the contents was made by opening the stomach with fine scissors either in a petri dish or, in the case of small stomachs, e.g. *Pelophryne signata*, in a glass block under a dissecting microscope. The contents were then classified as far as possible, no identification being taken beyond family since this was the furthest that most specimens could be taken with any degree of accuracy.

TABLE 1

The food of five species of amphibia, expressed as a percentage of stomachs containing each item.

Species	*blythii*	*erythraea*	*chalconota*	*cancrivora*	*P. signata*
No. of stomachs containing food	46	31	21	7	6
Annelida	9	—	—	—	—
Mollusca					
Slugs	4	—	5	—	—
Snail	17	—	14	—	—
Crustacea					
Amphipoda	—	12	—	43	—
Isopoda	—	—	10	14	—
Decapoda	15	— (3?)	—	29	—
Arachnida					
Thelyphonida	2	—	—	—	—
Scorpionida	2	—	—	—	—
Phalangida	6	—	—	—	—
Aranea	33	36	34	57	17
Acari	—	—	—	—	67
Myriapoda					
Chilopoda	9	—	—	—	—
Diplopoda	17	—	5	—	—
Insecta					
Machilidae	2	—	—	—	—
Collembola					
Arthropleona	—	6	—	—	—
Symphyleona	—	6?	—	—	33
Ephemeroptera	2	—	—	—	—
Odonata	2	—	5	—	—
Blattaria	13	6	—	14	17
Orthoptera					
Gryllidae	11	—	10	—	—
Tettigoniidae	—	3	19	—	—
Tridactylidae	—	3	—	—	—
Acrididae	—	3	—	—	—
non-determined	24*	—	14	14	—
Isoptera	4	—	5	—	—
Thysanoptera	—	—	5	—	17
Homoptera					
Cicadidae nymph	4	—	—	—	—
Jassoidea	—	3	—	—	—
Fulgoroidea	—	—	5	—	—
non-determined	—	—	5	—	—
Heteroptera					
Hydrometridae	—	6	—	—	—
Gerridae	—	52	—	14	—
Veliidae	—	3	—	—	—
non-determined	6	3	—	—	—
Trichoptera	2	—	—	—	—
Lepidoptera	4	—	5	—	—
larvae	17	3	10	—	—
Coleoptera					
Scarabaeidae	4	—	5	—	—
Carabidae	4	—	—	—	—
Melolonthidae	11	—	—	—	—
Curculionidae	4	—	—	—	—
Elateridae	6	—	—	—	50
Cerambycidae	6	—	5	—	—
Lycidae	2	—	—	—	—
non-determined	36	—	14	—	17
Hymenoptera					
Formicidae	33	18	29	—	100
non-determined	—	12	—	—	—
Diptera					
Muscoidea	4	—	—	14	—
Tipuloidea	2	—	—	14	—
non-determined	—	18	—	—	17
pupae	—	—	—	14	—

*Apparently mainly Stenopelmatidae with a few Gryllidae.

TABLE 2

The food of the same five species as in Table 1, expressed as the number of items per 10 stomachs, with an estimate of their importance. (V= Very important in diet (also indicated by bold-face setting); I=Important in diet; S=Slight importance in diet; U=Unimportant.)

Species	*blythii*	*erythraea*	*chalconota*	*cancrivora*	*P. signata*
No. of stomachs	46	31	21	7	6
Annelida	0.9 S	—	—	—	—
Mollusca					
Slug	0.9 S	—	0.5 S	—	—
Snail	2.0 I	—	2.0 I	—	—
Crustacea					
Amphipoda	—	2.3 I	—	**22.9** V	—
Isopoda	—	—	0.7 S	5.7 I	—
Decapoda	1.8 I	0.3? S	—	**4.3** V	—
Arachnida					
Thelyphonida	0.2 S	—	—	—	—
Scorpionida	0.2 S	—	—	—	—
Phalangida	0.7 S	—	—	—	—
Aranea	3.9 S	4.7 I	4.0 S	10.0 I	1.7 S
Acari	—	—	—	—	67.0 V
Myriapoda ..					
Chilopoda	0.9 S	—	—	—	—
Diplopoda	2.4 I	—	0.3 U	—	—
Insecta					
Machilidae	0.2 U	—	—	—	—
Collembola					
Arthropleona ..	—	0.7 U	—	—	—
Symphypleona ..	—	2.7 U	—	—	6.7 S
Ephemeroptera ..	0.2 U	—	—	—	—
Odonata	0.2 U	—	0.3 U	—	—
Blattaria	2.0 I	1.7 I	—	1.4 S	5.0 I
Orthoptera					
Gryllidae	**1.6** V	—	**1.0** V	—	—
Tettigoniidae ..	—	0.3 I–S	**2.3** V	—	—
Others	**2.6** V	0.6	**1.0** V	1.4 S	—
Isoptera	7.8 S	—	4.5 S	—	—
Thysanoptera	—	—	0.3 U	—	1.7 U
Homoptera					
Cicadidae n.	0.4 S	—	—	—	—
Jassoidea	—	0.3 U	—	—	—
Cercopoidea	—	—	0.7 U	—	—
non-determined ..	—	—	0.3 U	—	—
Heteroptera					
Hydrometridae ..	—	0.7 U	—	—	—
Gerridae	—	**23.3** V	—	1.4 U	—
Veliidae	—	0.3 U	—	—	—
non-determined ..	0.7 U	1.7 S	—	—	—
Trichoptera	0.4 U	—	0.3 U	—	—
Lepidoptera	0.4 U	—	0.3 U	—	—
Larvae	2.0 I–S	0.3 S	0.7 S	—	—
Coleoptera	**9.1** V	—	2.5 I	—	10.0 I
Hymenoptera					
Formicidae	11.3 S	2.0 S	7.5 I–S	—	**80.0** V
non-determined ..	—	1.3 U	—	—	—
Diptera					
Muscoidea	0.4 U	—	—	1.4 U	—
Tipuloidea	0.2 U	—	—	2.8 S–U	—
non-determined ..	—	5.3 S	—	—	6.7 U
pupae	—	—	—	* U	—
Mean no. of items per individual	5.34	4.85	2.89	5.13	17.88

*A confused mass of pupae in one stomach only.

Records were kept of the number of specimens of each group found in the individual stomachs and, where specimens were more or less complete, the length was also noted. Since the main purpose of this study was to answer two questions: "What food do the various species take?" and "What differences exist between the diets of different species?" it was not considered necessary to measure the volume of the items as has been advocated by Inger and Marx (1961). The answer to the first question is obtained from the straight identification of the stomach contents and that of the second by determining the frequency of occurrence in stomachs (Table 1) and the number of items per stomach (Table 2). That this gives no indication of the actual food value to the animal is true, but it must be doubted whether the use of volume gives any but the very broadest indication of this, since two assumptions are made which are certainly doubtful:

(i) that the food value of prey of the same size is approximately equal.

(ii) that different types of prey undergo digestion at the same rate. (Inger and Marx (loc. cit.) only accepted items which were more or less entire, i.e., undigested).

It is considered that adequate identification coupled with a simple record of length gives satisfactory data. Thus, a scarabaeid beetle is always roughly the same shape, an ant is always ant-like, etc. On this basis, various items have been assessed as very important (V), important (I), of slight importance (S), and unimportant (U), having due regard to the number of items and their relative size (Table 2).

THE FOOD OF THE AMPHIBIA

Of the eleven species of amphibia collected, only three yielded sufficient data for conclusions to be drawn as to their feeding habits, while two others yielded sufficient information to give a reasonable indication of diet. These are summarised in Tables 1 and 2, which show respectively the percentage of stomachs in which each item was recorded (Table 1), and the mean number of items per 10 stomachs and the rank accorded to the items on a basis of relative size (Table 2).

Rana blythii

The dominant group taken by this frog was Coleoptera which were found in some 67 per cent of all the stomachs examined. Breakdown of the Coleoptera to family level reveals a wide range with no definable feeding preference. The next most frequent order was the Orthoptera in which gryllids and stenopelmatids were the main families. The next in terms of the number of stomachs from which they were recorded were the ants and the spiders. The ants were small and of slight dietary value as may be seen by reference to their ranking and this is reinforced by the fact that 28 of the 52 ants recorded were found in one stomach. The spiders were very variable; some large mygalomorphs obviously made a definite contribution to the diet, but others (and these were in the majority) were small specimens of little significance. Of the remainder, blattids, snails, diplopods, lepidopteran larvae and crabs formed a major item in the diet of some specimens whilst other items were too small and/or too infrequent to be of significance.

The diet is thus dominated by predominantly litter-dwelling forms[22] with the exception of some of the Coleoptera. Of these latter, however, many of the forms found spend at least part of their life on and below the soil surface, e.g., melolonthids often oviposit on the soil and the immature stages are subterranean. The few forms which are normally found in flight may be accounted for by the accidents

22. For a discussion of insects occurring in different habitats see Bullock, this *Bulletin* p. 104.

which flying insects encounter, to descents to objects within "frog-range" of the litter layer or to actual occurrence on the layer either at emergence or at oviposition. The considerable diversity of items shows little selectivity and it is apparent that the majority of litter-dwelling forms are readily taken (with the possible exception of ants).

Rana erythraea

The outstanding item in the diet by number of stomachs, numbers taken, and size was the gerrids, whilst spiders of a size comparable to that of the gerrids figured frequently. No other items were found sufficiently often to warrant consideration as major items in the diet although the character of several are worthy of notice since they are forms which are closely associated with water, i.e. hydrometrids, veliids, amphipods and adult chironomids, together with one of the Orthoptera, a tridactylid, which was only found near water. The spiders were mainly tetragnathines which were particularly abundant over the pool where all the specimens of this frog were collected.

The frogs were mainly immatures and adult males (which are appreciably smaller than the adult females) and were collected from a floating algal mat and from the edges of a pond. The character of the diet reflects this habitat; the principal prey comprised animals occurring on the surface of the water while blattids, etc., were possibly captured during short excursions on to the shore. It should be noted, however, that the capture of terrestrial forms might be due either to their incursion on to the algal mat, or to their falling into the pond. The evidence indicates that *R. erythraea* does not feed on the truly aquatic animals, of which there was an abundance in the pond, nor does it stray far from water.

Rana chalconota

In this species the most important item of diet, both by number of stomachs and bulk, was the Orthoptera and of this order the tettigonids were the most frequent. Ants and spiders also contributed to a slight extent but this cannot be regarded as very significant in terms of bulk, whilst the Coleoptera were less important than in *R. blythii*. Other categories were poorly represented and, in fact, few of the animals appeared to have fed well, the mean number of items per stomach being about two-thirds that of the other ranids with little or no indication of a proportional increase in the size of the prey (cf. Table 2, last line).

The diet suggests that *R. chalconota*, which was collected from the same habitat as *R. blythii*, differs from the latter in that different emphasis is placed on the food available. Thus among the Orthoptera, tettigonids replace gryllids and stenopelmatids; blattids do not occur; the myriapods are represented by a single specimen; and the significance of the Coleoptera, especially the heavier forms, has decreased. This, therefore, suggests the partial elimination of the litter-dwelling forms and their replacement by leaf-dwelling types, in accordance with the frog's habit of perching on branches above the ground.

Rana cancrivora

The diet of this species, insofar as 7 stomachs can give an indication, was dominated by non-insectan elements with amphipods and crabs of greatest importance. Both these forms are littoral and this impression of the diet is enhanced by the presence of isopods, a gerrid and both adult and pupal limoniids. The diet therefore reflects a habitat confined to the proximity of water, but not necessarily carrying an insect fauna, the majority of forms being characteristic of the more or less brackish meanders (cf. Bullock, p. 113), near which all specimens of the frog were collected.

Pelophryne signata

The diet of this small bufonid consisted of small ants and mites together with a number of other forms, including a small elaterid beetle. Over 90 per cent of the items recorded were less than 2.5 mm. in length, and only one specimen, an ant, exceeded 4 mm. The small size of the prey is in part related to the small size of the toad, but even so the size of prey is disproportionately small when compared with the Ranidae; this is reflected in the greater number of items recovered from each stomach (Table 2, last line). The feeding pattern therefore indicates a small animal feeding on numerous very small arthropods and not relying, as do the ranids, on fewer comparatively large animals. *P. signata* lives in primary forest as do *R. blythii* and *R. chalconota* but it is far less confined to the proximity of water. Even if this were not the case, the very small forms constituting its diet would effectively prevent competition with the ranids. (*P. signata* is incidentally so small that it could well form an item of food for *blythii*.) Although the toad was occasionally taken on foliage, the items recorded are more typical of the litter layer.

Other species examined

Bufo parvus.—The single specimen had taken a mixed diet of ants (8), isopods (9), a gryllid and a phalangid.

Ansonia tiomanica.—The two specimens had taken between them ants (17), arthropleonan collembola (7), a beetle, a heteropteran bug, a dipterous larva, a parasitic wasp, a chilopod, a spider and a mite, and the vast majority of these items were taken from a single specimen found outside a cave; the second specimen, which came from within the cave, only accounted for one ant and the wasp.

Rana (*Discodeles*/*Platymantis*) sp.—The only identifiable remains were of a lone ant.

Megophrys monticola nasuta.—All four specimens had fed poorly and only two ants, an isopod, two spiders (one large), and a large, well-digested orthopteroid could be discerned.

Racophorus leucomystax.—The stomach of the single specimen contained only a lygaeid bug.

SUMMARY OF THE FEEDING HABITS OF THE AMPHIBIA

The diet of *R. blythii* is dominated by the litter-dwelling or litter-visiting forms and that of *chalconota* by the types living on herbage above the litter. *Pelophryne signata* is not competing with these two species since its small size confines it to prey of lesser size, and it is less restricted in habitat than the two ranids which are confined to the riparian fringe. Moreover it appears to accentuate this division by concentrating on prey which is proportionately smaller than that of the other two. *R. erythraea*, which on Tioman was only recorded in one place, is apparently confined in its feeding to those animals which find their way onto the floating algal mat on which it was normally found, although it may occasionally wander into the littoral zone. In this wandering, it may overlap with *R. cancrivora* which was also confined to the coastal area but the nature of the latter's diet suggests a preference for crustacea. It is apparent that feeding is confined by:

(*a*) the preferred feeding site of the amphibian; and

(*b*) the size range of prey which is acceptable.

Apart from these two factors, there is little evidence of selectivity except that ants, which were a very prominent constituent of the litter fauna, might have been expected to occur in greater numbers in the diet of *blythii*. This, however, may not

have been the result of a preference in diet but in feeding site, e.g., avoidance of ant runs. Tyler (1958) has noted an avoidance of ants in *Rana esculenta* but the percentage of *blythii* which had taken ants, albeit only in small numbers, renders such an explanation doubtful in this case.

THE FOOD OF THE REPTILIA

The collection of reptiles was more limited in terms of length of series than was the amphibian collection and consequently it is more difficult to delimit the diets. A single table of stomach contents (Table 3) has therefore been drawn up to indicate the presence or absence of items in the diet. An indication of the apparent significance in the diet is also given as well, based on the number of stomachs in which the item was recorded.

Goniocephalus grandis

Eight stomachs of this large lizard contained food and the identifiable items suggest a catholic diet. Six specimens contained caterpillars measuring between 10 and 25 mm., three had been feeding on large beetles including both cerambycids and chrysomeloids, and large orthopteroids were recorded in three specimens. Other large items included two thelyphonids about 30 mm. long which were found in one stomach, and large ants (presumably *Camponotus gigas*) which were found in two. Various smaller arthropods, including small ants, beetles, flies and spiders, were also recorded together with a single ascalaphid larva.

The general picture of the diet suggests a mainly arboreal form although the presence of thelyphonids and a large cockroach may indicate that the lizard, at least occasionally, descends to the ground to feed.

Goniocephalus chamaeleontinus

Of the six specimens examined, only three contained any identifiable food remains, although one of the "empty" stomachs is of interest in that it was full of soil. All recognisable items of foods were large, the largest being a scolopendrid centipede measuring over 40 mm. Other items were two large caterpillars, a large orthopteroid, a polydesmoid millipede and an earthworm. Although this is insufficient evidence from which to draw general conclusions, it can be asserted that *G. chamaeleontinus* hunts on the ground for part of its food, as is indicated by the presence of soil and of an earthworm, whilst the large myriapods are more likely to have been found there than in an arboreal habitat.

Goniocephalus armatus

Only three specimens were examined, including one collected by Hendrickson on his visit to Tioman in 1958. One of these had taken two earthworms and a scarabaeid beetle (elytra 9 mm.) and in a second the only identifiable remains were of a small ant. The third specimen had an empty stomach but examination of the rectum revealed a mass of soil. This evidence again clearly suggests a terrestrial foraging habit.

Draco melanopogon

The outstanding item in the stomach of all eight specimens was ants of which approximately 300 were recognisable and included several species of which the majority were 4-5 mm. long. Other forms were relatively few although both larval and adult beetles, two millipedes, two isopods and six termites were found. It is obvious that these were of little importance in the diet and that *D. melanopogon* has a highly specialised diet to which its habit of hunting on the trunks of trees is admirably adapted.

TABLE 3

Occurrence of items in the stomachs of lizards. (+ = Present in one stomach only; ++ = Present in more than one but not more than 50% of stomachs*; +++ = Present in more than 50% but less than 90% of stomachs†; ++++ = Present in more than 90% of stomachs.)

	Gonicephalus grandis	*G. chamaeleontinus*	*G. armatus*	*Draco melanopogon*	*D. volans*	*Calotes*	*Lygosoma*	*Cnemaspis kendalli*	*Cnemaspis sp.*	*Aphaniotis*	*Dasia*	*Mabuya*
No. of stomachs ..	8	3	2	8	6	3	3	3	4	8	4	4
Annelida ..		+	+					+				
Mollusca												
Snails ..	+											
Crustacea												
Isopoda ..												++
Arachnida												
Thelyphonida ..	+											
Phalangida ..							+					
Aranea ..	+											++
Myriapoda												
Chilopoda ..		+										
Diplopoda ..		+		++			+	+		++		
Insecta												
Collembola ..							+					
Orthoptera												
Gryllidae ..												+
Tetrigidae ..												+
non-determined	++			+					++			
Blattaria ..	+											
Isoptera ..				+	++					+		
Thysanoptera ..				+								
Heteroptera ..	+											
Neuroptera larva	+											
Lepidoptera larvae	++++			+		+	+		+	+++	+	
Lepidoptera pupa										+		
Coleoptera												
Chrysomeloidea	+											
Cerambycidae	+											
others ..	++					+	++	+	+	++	+++	+
larvae ..	+		+	++								
Hymenoptera												
Formicidae ..	++		+	++++	++++	+	++	+	+	++	+	+
Apidae ..	+					++					++	
non-determined							++					
Diptera												
Muscoidea ..	++					+					+	
Reptilia												
Scincid scutes ..											+++	
Soil remains‡ ..		++	+					++				

*Not applied to *G. armatus*; where only three stomachs were examined the item was recorded from more than one.

†Not applied where less than four stomachs were examined.

‡Includes stomachs otherwise empty.

Draco volans

As in the previous species, the diet of this lizard is dominated by ants. The only other constituent in the six specimens examined was a few alate termites, and the diet clearly indicates a similar feeding preference to that of *D. melanopogon*.

Calotes cristatellus

The data obtained from the three specimens examined and found to contain food is too slight for any conclusions to be drawn. Two specimens had taken large aculeate hymenopterans, together with an ant in one and the remains of a large fly in the other. The third specimen contained a large beetle (probably Scarabaeidae) and a caterpillar about 14 mm. long.

Aphaniotis fusca

The diet of this species is clearly dominated by caterpillars which were recorded from five of the eight stomachs examined and which, when sufficiently intact for measurement, ranged between 9 mm. and 15 mm. in length. Other forms recorded included a number of beetles, three polydesmoid millipedes, two cockroaches and seven termites. Ants were few, a total of five being recorded, which contrasts strongly with *Draco* which lives in the same habitat and feeds almost exclusively on these forms. The evidence indicates an arboreal feeding habit with the species clearly not competing for food with *Draco*, a species of similar size as well as habitat.

Mabuya multifasciata

Four of the stomachs contained food, but no item occurred in more than two. Three specimens of a large cockroach *circa* 24 mm. long were recorded in one stomach while isopods and spiders occurred in two. Other forms were represented by single specimens only and these included a tetrigid, a large ant, a grylloid and a small bug. The inference is that *M. multifasciata* feeds on litter- and rock-dwelling forms, which accords with its known habitat preference.

Lygosoma scotophilum

Three stomachs contained food and in one of these the only item was a small rock-dwelling beetle, probably a lichen feeder, of which at least ten specimens had been taken. The other two had taken a varied diet including caterpillars (*circa* 10 mm. long), ants, a phalangid, a polydesmoid millipede and two collembolans. All these forms are likely to be found on boulders, or in crevices amongst them, and the diet suggests a fairly catholic acceptance of arthropods within the scincid's chosen habitat.

Dasia olivacea

Of the four specimens examined, three contained scincid scutes. Although in one specimen only a tail could be discerned, in a second specimen remains of the body were clearly visible including a foot and parts of the trunk. Unfortunately, accurate identification is not possible but it seems very probable that these records indicate cannibalism especially since this species did not overlap with either of the other two scincids recorded on the island (Hendrickson, this *Bulletin*, p. 66).

The rest of the diet offers little evidence on the feeding habits. Small bees (probably *Trigona* sp.) were recorded in two stomachs, and beetles in three but these were too far digested to permit identification even to family. The only other items were a caterpillar, an ant and a large muscoid fly. The presence of so many bees cannot be taken as conclusive proof of arboreal feeding since some bees frequently nest on or near the ground and the lizard may have been feeding at the entrance to such a nest.

Cnemaspis kendalli

Six stomachs of this gekkonid were examined and although only three contained food, two of the others are of interest since they contained large quantities of soil. A further specimen had taken two ants and again the stomach was full of soil. Of the other two, one only contained pieces of an earthworm and the other a small scarabaeid and pieces of a small polydesmoid millipede. This diet therefore indicates a terrestrial-foraging form which concentrates more on the soil layer than on the litter-dwelling forms.

Cnemaspis sp.

The diet of this form, as indicated by the four stomachs which contained food, is distinctly different from that of *C. kendalli*. In no case was soil recorded, nor was there evidence of soil-dwelling forms. One specimen had taken two caterpillars, one of which was a geometrid measuring *circa* 20 mm. in length, while well-digested orthopteroid remains were recovered from two stomachs. The only other items found were a beetle and an alate ant. The evidence, whilst indicating reasonable catholicity, is too slight for conclusions about the feeding site to be drawn although the geometrid suggests at least partly arboreal feeding.

Hemidactylus frenatus

The single specimen examined only contained a small muscoid fly.

Gehyra mutilata

Again only a single specimen contained food and the only identifiable item was an isopod although two much-digested small insects were also present together with a large leg, probably that of a cockroach.

Varanus nebulosus

The only specimen containing food was a juvenile which had taken one small cricket. However the form was frequent about Kg. Tekek and specimens were observed foraging amongst refuse on several occasions.

Ophidia

None of the specimens collected contained identifiable food remains. Hendrickson (p. 67) recorded a python (*Python reticulatus*) in a sea cave on the east side of the island which had recently eaten a mouse-deer.

SUMMARY OF THE FEEDING HABITS OF THE REPTILIA

The general impression of the diets of the forms examined is of reasonable catholicity of taste with the exception of the two species of *Draco* which concentrated on ants to the near exclusion of other forms. In all other cases the diet appears to be correlated with the preferred habitat and feeding site of the species. Thus

Goniocephalus grandis and *Aphaniotis fusca* have mainly arboreal diets although in at least the former there is evidence to suggest occasional descents to the ground. The other two species of *Goniocephalus, chamaeleontinus* and *armatus*, are clearly terrestrial foragers for at least part of their food and both appear to forage in the soil as well as in the litter layer. *Cnemaspis kendalli* parallels these two forms whilst *Cnemaspis* sp. is probably partly arboreal. Both *Mabuya multifasciata* and *Lygosoma scotophilum* are terrestrial feeders but whilst *multifasciata* feeds generally in this zone, *scotophilum* is probably more or less confined to the vicinity of boulders. Of the other forms, no indication of feeding niche can be obtained although in both *Calotes cristatellus* and *Dasia olivacea* there are indications of a catholic diet. None of these res ılts contradict Hendrickson's observations on the habits of the animals.

TABLE 4

Summary of the habitats, feeding sites and type of food taken by the commoner species of Amphibians and Reptiles* collected on P. Tioman

Species	*Habitat*	*Feeding site*	*Type of food*
Rana blythii ...	... Primary forest	Terrestrial	Catholic
Rana chalconota	... Primary forest	Shrub	Catholic
Rana erythraea	... Coastal plain	Freshwater	Mainly water-surface forms
Rana cancrivora	... Coastal plain	Edges of freshwater and brackish pools	Littoral, mainly Crustacea
Pelophryne signata	... Primary forest	Litter and herb layers	Very small forms
Draco volans ...	... Plantations	Tree trunks	Mainly ants
Draco melanopogon	... Primary forest	Tree trunks	Mainly ants
Goniocephalus grandis	... Primary forest	Arboreal (mainly)	Catholic
G. chamaeleontinus	... Primary forest	Terrestrial (at least partly)	Soil and litter forms
G. armatus ...	... Primary forest	Terrestrial	Soil and litter forms
Aphaniotis fusca	... Primary forest	Arboreal	Catholic
Mabuya multifasciata	... Primary forest	Terrestrial	Litter forms
Lygosoma scotophilum	... Primary forest	Boulders	Mainly rock-surface forms
Cnemaspis kendalli	... Primary forest	Terrestrial (boulders)	Soil and litter forms
Cnemaspis sp.	... Primary forest	Arboreal (at least partly)	Catholic
Dasia olivacea	... Coastal	Partly arboreal	?Catholic
Calotes cristatellus	... Mainly coastal	Belukar and riparian fringe	?Catholic
Varanus nebulosus	... Coastal and forest	Mainly terrestrial (but capable of tree climbing)	?Catholic (Scavenging)

*I have utilised data in Hendrickson's account of the reptiles in preparing part of this table.

INTERSPECIFIC COMPETITION

Amongst the amphibians from which a definite indication of feeding habits was obtained, the data show more or less complete feeding segregation depending on habitat, feeding site, and size of the items taken. In the lizards, feeding segregation is less clear cut although habitat, feeding site and, in the case of *Draco*, food preferences play their part. In the two species of *Draco*, the food taken is the same, but these two forms are separated by their habitat preference, *D. melanopogon* occurring in primary forest and *D. volans* being confined to the coastal plantation area. *Goniocephalus grandis* and *Aphaniotis fusca* occupy the same habitat, are both mainly arboreal and both take the same type of food with caterpillars the most frequent item. In this case it may well be that there is sufficient food for both and that other requirements keep the two species from competing. There is some indication that the adult *grandis* subsists to a great extent on items too large for the considerably smaller *fusca* to take but this could hardly apply to the juveniles. Between *G. chamaeleontinus* and *G. armatus* there is again no evidence of segregation and these two and *Cnemaspis kendalli* appear to be living in competition in so far as our knowledge of their requirements goes. Where conclusions can be drawn as to diet in the other forms, it is apparent that habitat and feeding site supply an adequate segregation.

SUMMARY

The food of the amphibians and reptiles on Pulau Tioman, as indicated by an examination of the stomach contents of the specimens collected in 1962, is discussed and the evidence is used in an attempt to show ecological segregation. Where differences can be discerned, these are attributable to broad habitat requirements and to preferred feeding sites. Only in *Pelophryne signata* and the two species of *Draco* could definite food preferences be distinguished.

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