Diet of the giant toad, *Bufo marinus* (Amphibia: salientia), in a coastal habitat of the Philippines

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In Batangas province, Philippines, *Bufo marinus* consumes a broad variety of land arthropods and ingests substantial amounts of plant matter and inorganic debris. Termites, ants and beetles make up the largest number of prey. It appears on the whole to be agriculturally beneficial. A minority of toads collected while active were found to have fasted on at least one preceding night.

Keywords: Biological control, *Bufo marinus*, diet, giant toad, marine toad

Bufo marinus (Linn.) is a very large, sexually monomorphic member of the cosmopolitan frog family Bufonidae, known as "toads". *B. marinus* is variously known as the giant toad, marine toad or cane toad. Zug et al. (1975) and Niven (1988) have reviewed the scattered literature on this species. Native to the New World tropics and subtropics (Wright and Wright 1949; Zug and Zug 1979), it has been widely introduced into the Old World tropics. It has been the subject of ecological study in both areas, including the Philippines (Alcala 1957; Alcala and Brown 1970; Espiritu 1985; Rabor 1952; Soriano 1964).

B. marinus was introduced into the Philippines about 60 years ago as an intended pest-control agent (Merino 1936) and now occupies a variety of lowland habitats throughout the islands. It is nocturnally active, seeking cover during the day (Zug and Zug 1979; pers. obs.). A given individual may not emerge every night to forage. Reports on its diet consistently show it to be a generalist predator on small land animals, primarily insects, and a sloppy feeder which takes in much indigestible and inorganic matter with its prey.

Here we analyze the food taken by *B. marinus* at Matuod, Lian, Batangas (14°03N, 120°38E), a coastal village of central Luzon. The intention is to give a more exact taxonomic accounting of the prey than has previously been done for this species in Southeast Asia, to compare diet between sexes and seasons, and to contribute to an assessment of *B. marinus* as an unmanaged pest-control agent. Our quantitative results are of numbers of individual prey, complementing Espiritu's (1985) volumetric approach to the diet of *B. marinus* in northern Luzon.

We collected active, exposed toads by hand, mostly between 19:00 and 22:00, on six dates: 17 August 1985, 7 September 1985, 28 September 1985, 5 October 1985, 15 March 1986 and 27 March 1986. The rainfall pattern in the area shows a well-defined dry season which includes August-October and a well-defined wet season which includes March (unpublished data from PAGASA, the national weather service).

Toads were sexed by internal examination. Identification of prey in stomachs was mostly by head-capsules. We also made a subjective assessment of whether each stomach contained substantial amounts of plant matter or rocks.

The taxonomic distribution of prey is shown in Table 1. Termites (Blattaria: Isoptera) and ants (Hymenoptera: Formicidae)

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made up the numerical bulk. These were mostly workers and (in termites) soldiers, rather than winged sexuals. The only other well represented order was the beetles (Coleoptera), which accounted for 10.0% of individuals and roughly 15-25% of total prey volume. Some larger prey, such as earth worms (Annelida: Oligochaeta), grasshoppers and crickets (Orthoptera), cockroaches (Blattaria other than termites), caterpillars (Lepidoptera) and the few vertebrates undoubtedly contribute more to the toads' diet than their small numbers would suggest, although still almost certainly a minority of total volume. All identifiable prey were from groups which the toad would encounter on dry land. Predominant among the ants were the introduced fire ant *Solenopsis geminata* and weaver ant *Oecophylla smaragdina*.

Table 1: Taxonomic distribution of prey from stomachs of 129 *Bufo marinus*. Division into prey classes is based on convenience and relative representation, more abundant taxa being more finely divided. Only fractions of at least 2% are included in the last column

Prey class	Number of prey: Wet season (58 toads)	Dry season (71 toads)	Total	Fraction of total
Annelida: Oligochaeta	10	2	12	
Arthropoda: Chilopoda	4	3	7	
Arthropoda: Diplopoda	15	0	15	
Arthropoda: Crustacea				
Decapoda	5	0	5	
Arthropoda: Arachnida				
Araneae	3	4	7	
Opiliones	0	2	2	
Arthropoda: Insecta				
Orthoptera	7	8	15	
Blattaria: non-Isoptera	10	21	31	
Blattaria: Isoptera	19	2093	2112	52.8%
Dermaptera	5	2	7	
Hemiptera: Scutellaridae	8	9	17	
Hemiptera: miscellaneous	13	30	43	
Coleoptera: Tenebrionidae	0	223	223	5.6%
Coleoptera: Staphylinidae	6	0	6	
Coleoptera: Scarabaeinae	56	87	143	3.6%
Coleoptera: Melolonthinae	8	0	8	
Coleoptera: Curculionidae	7	10	17	
Coleoptera: miscellaneous	52	10	62	
Diptera	2	0	2	
Lepidoptera (larvae)	14	5	19	
Hymenoptera: Formicidae	953	259	1252	31.3%
Hymenoptera: miscellaneous	1	0	1	
Chordata: Vertebrata	2	4	6	
Total	1180	2812	3992	

Table 2: Seasonal comparison of stomach contents from field-caught *Bufo marinus*

	Mean prey individuals (range)	Mean prey classes (range)	---- Stomachs with ---- plant matter	stones
Wet season (n = 29♀♀+29♂♂)	22.5 (0-314)	3.5 (0-8)	22 (34%)	12 (21%)
Dry season (n = 39♀♀+39♂♂)	42.4 (1-329)	3.7 (0-10)	27 (38%)	28 (39%)
Total (n = 68♀♀+68♂♂)	33.5 (0-329)	3.6 (0-10)	49 (36%)	40 (31%)

As seen in Table 2, at least 31% of the stomachs in each season and sex contained significant plant matter, while at least 21% had significant rocks.

Females in our samples were on average heavier than males (mean weight 105g vs 85g: two-way analysis of variance, $p<0.01$). Nonetheless, the sexes did not differ significantly in the average numbers of prey per stomach ($p>0.05$) or the numbers of prey-classes represented ($p>0.05$).

Toads in our samples were on average heavier in the wet than the dry season (Table 2; two-way analysis of variance, $p<0.01$). On the other hand, the number of prey per stomach was greater in the dry season ($p<0.05$). The numbers of prey-classes represented show no significant seasonal difference ($p > 0.05$).

The data reported here are consistent with the view of *B. marinus* as a generalist predator on small animals of the ground layer, eating almost everything that it could be expected to encounter and capture (Zug and Zug 1979). Stomach contents include great numbers of insects that would appear noxious or virtually inedible but which are present in the habitat in large numbers. On the other hand, fast-flying insects are hardly at all represented.

The few vertebrates found in stomachs included at least one lizard and at least one mammal. Similar prey have been recorded in other localities, including elsewhere in the Philippines (Alcala and Brown, 1970; Rabor, 1952; P.P. Milan, pers. comm.). Nonetheless, we found no evidence of vertebrates as a sizable part of the diet or of *B. marinus* as a significant predator of any vertebrate.

Our results corroborate the interpretation of Espiritu (1985), Zug and Zug (1979) and others of *B. marinus* as a sloppy feeder that takes in much incidental debris. It makes sense that an animal that can ingest small stinging insects and hard-bodied beetles without apparent ill effects need not be careful in its choice of prey. It is presumably most economical to simply strike at any moving object of the right size, and the toad's broad, sticky tongue should often take in neighboring inert matter as well.

The tendency for both sexes to eat more in the dry than the wet season is probably not due to a greater abundance of potential prey at that time. It is accepted as a general rule that insects are less abundant during tropical dry seasons, and we saw no reason to think that our study site is an exception to this rule. More likely, toads tend to hunt more actively toward the end of the dry season as a way to maximize their productivity of gametes in advance of the first rains, which is presumably the start of the breeding season.

In order to characterize stomach contents

after known periods of fasting, we maintained initially fed captive toads with ample water and shade but without food, withdrawing and dissecting a sample of at least five individuals after each of one, two, three and four days.

Examination of toads fasted for varying periods showed a consistent pattern of change in the stomach contents. As illustrated in Figure. 1 unfasted toads typically had fresh prey and debris in the stomach cavity and attached to the lining. After one day there remained significant amount of prey and debris, but the prey tended to be fragmented into body parts, while the stomach was lined with a clean mucus layer. After two days there remained only scattered prey fragments and an entirely clean lining, and after three and four days of fasting the stomach was empty.

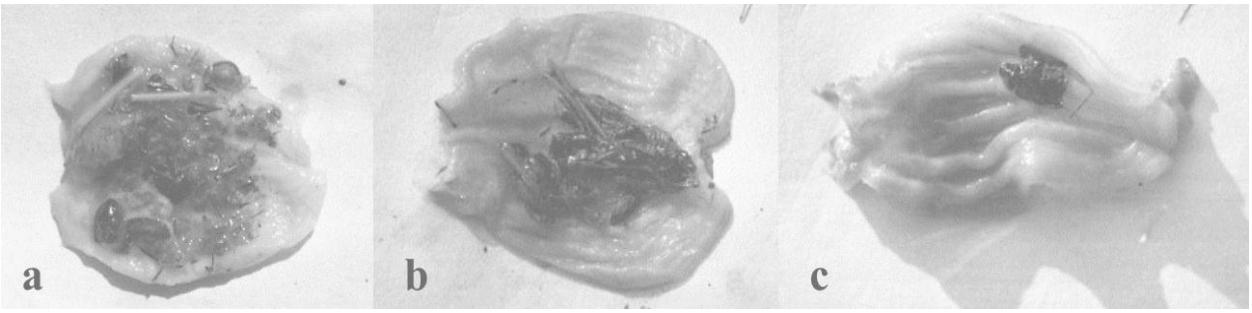

Figure 1: Typical stomach lining and contents of initially fed adult *Bufo marinus* after varying periods of fasting. a. No fasting. b. One day. c. Two days.

With a knowledge of the stomach characteristics of fasted toads, there is little difficulty in recognizing those which have not yet eaten on the night of capture, and it can often be confidently said whether a given toad has fasted for one, two or at least three nights. To a lesser extent it can be inferred whether a toad that has just begun to feed on the night of capture had fasted on the one or more previous nights. Among the active (i.e. moving freely about in the open) toads that we examined, a significant minority gave evidence of not feeding every night. Although we made no attempt to study this question rigorously, the fraction of such toads appeared to be at least 12%.

On balance, *B. marinus* seems beneficial to agriculture for two reasons. Much of what it eats consists of known or supposed pest insects. More importantly, as a generalist predator *B. marinus* can be expected to respond to any sharp rise in the numbers of any potential prey by consuming it in quantity. Consistent with this expectation is Zug and Zug's (1979) observation that one prey species usually forms the majority of individuals in any given stomach. If a pest lives exposed in the ground layer, *B. marinus* may serve as a significant agent of biological control.

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