PREY — SIZE AND PARASITE RELATIONSHIPS IN THE COMMON TOAD *BUFO BUFO*

C. P. WHEATER

Department of Zoology, University of Manchester, Manchester, U.K.

(Accepted 1.5.85)

ABSTRACT

The gut contents of 188 Common Toads from a range of sizes were examined and 1898 prey items from 22 prey groups recorded. The use of combined gut contents (stomach and hind gut) is discussed in relation to the greater numbers of prey found in the stomach and the differences in the proportions of prey in the different parts of the gut; hind gut contents having a larger proportion of hard bodied prey. Acari, adult Coleoptera, Formicidae and Collembola were found to be the most abundant prey groups, although differences were recorded with toad size. A positive linear relationship between prey and toad size was found. A nematode gut parasite (*Cosmocerca ornata*) was recorded and the degree of infection and the percentage incidence were found to increase with toad size.

INTRODUCTION

Common Toads (*Bufo bufo*) are mainly nocturnal, opportunistic feeders, although they will feed during the day. A wide variety of prey have been noted (Smith, 1954; Frazer, 1983) and although a number of workers (including Cott, 1940; Lescure, 1964; Mazure, 1966; Mathias, 1971) have investigated the food of the Common Toad, all have concentrated on adults. The present study examines the differences between the prey of toads of different sizes, especially juveniles and sub-adults.

METHODS

The animals were captured during an investigation into the surface active Coleoptera of two areas in Cheshire (Wheater, 1984). The sites used were an area of *Phragmites* adjacent to Tabley Mere at Tabley Hall estate (grid reference SJ 727769) and a marshy site at Abbots Moss Hall (grid reference SJ 593681). More detailed descriptions of the sites have already been presented (Wheater, 1985).

At each site the animals were caught in 15 large (13.5cm deep and 9cm diameter) plastic pitfall traps laid in grids 5m by 3m. These contained 5 per cent formalin solution and remained in situ for a year, being examined at fortnightly intervals. Toads were, therefore, trapped accidentally and this paper is an attempt to examine prey differences in animals fortuitously caught. In this study 188 toads of a range of sizes were used. They were sorted into four size groups, based on snout to vent length (size I, less than 20mm; size II, between 20 and 30mm; size III, between 30 and 40mm; size IV, greater than 40mm). Few large individuals were captured, the largest being three gravid females in excess of 60mm in length. This was probably due to the size of the traps, larger animals being able either to avoid or escape from the traps. All the specimens are lodged in the Manchester Museum (catalogue numbers C975-C1001, C1014 and C1016).

The toads were dissected and the entire gut removed. This was then slit longitudinally and the contents removed. The gut contents were examined and the prey identified as far as possible. The features used in identification varied between the groups and are indicated in Table 1. These were based on the system used by Tatner (1983). Prey items were quantified, mainly on the numbers of heads or jaws present.

Prey	Structures
Isopoda	scutes, heads
Acari	usually the whole animal
Opiliones	heads, legs
Araneae	heads, palps
Myriapoda	rings, heads
Collembola	usually the whole animal
Orthoptera	heads
Hemiptera	heads
Coleoptera (adults)	heads, jaws, elytra
Coleoptera (larvae)	heads, integument, legs
Lepidoptera (larvae)	jaws, integument, prolegs
Diptera (adults)	heads, wings
Diptera (larvae)	integument
Formicidae	heads, jaws
Mollusca	shells

TABLE 1: Structures used in the identification of prey

The stomach contents were examined separately from those of the intestine and rectum.

The prey species were divided into groups based on size. This was achieved by ranking each prey type during gut content sorting. Whilst it is accepted that most taxa could overlap the size groupings, in practice this was not the case. The following scheme was used.

Group 1 — very small
Acari, Collembola, Pseudoscorpiones.

Group 2 — small
Formicidae, Aphididae, Diptera (adults), Ichneumonidae, Diptera (larvae).

Group 3 — medium
Other Hemiptera, Orthoptera, Araneae, Opiliones, Dermaptera, Coleoptera (larvae), Coleoptera (adults), Staphylinidae.

Group 4 — large
Carabidae, Neuroptera, Mollusca, Lepidoptera (larvae), Isopoda, Myriapoda.

RESULTS

It can be seen from Table 2 that the most numerous prey are the Acari, Collembola, adult Coleoptera and Formicidae. Many more prey items were found in the stomach than in the hind gut and there was a significant difference between the proportions of species from the two areas of the gut; this shows a greater proportion of hard bodied animals in the hind gut than in the stomach, with a corresponding decrease in soft bodied animals. A number of workers have used the combined gut contents as a measure of the prey type; however, in view of these results, it appears that this would bias the prey spectrum towards those animals having hard exoskeletons and therefore recognisable fragments in the hind gut. In further analysis in this study stomach contents alone were used.

The array of prey species was found to differ between toad size groups (Table 3) and the differences were statistically significant ($X^2_{63} = 557.4$, $p<0.0001$). Spearman's rank correlation coefficients, between prey numbers and toad size, were calculated. Of the 22 prey groups recognised, six were more numerous in large toads (Isopoda, Opiliones, Araneae, Myriapoda, Carabidae and Mollusca) and two were more numerous in smaller toads (Acari and Collembola). It seems that it is larger prey types that are more numerous in larger toads, whereas the smaller prey are favoured by small toads.

This impression is confirmed when the prey are aggregated into size categories (Table 4). The different sizes of toads clearly take prey of significantly different sizes ($X^2_9 = 347.95$, $p<0.0001$).

The pitfall traps were primarily intended to catch invertebrates, and the numbers so caught were compared, using Chi-squared tests, with those found in the toads' guts. In all size groups of toads, there was a highly significant difference ($p<0.0001$) between the contents of pitfall traps and the guts of different sized toads (Fig. 1). This is also the case with total prey capture and may be due to aspects of toad foraging behaviour. It is possible that the Araneae are under represented in the toads' guts because of their diurnal, ground-running habit, toads tending to be nocturnal hunters. Collembola are also under-represented in the prey and may be too small or too fast for toads to catch. The mechanism of pitfall trapping may also have an effect. Adult Diptera are possibly attracted to formalin (Wheater, 1984) and if so will be found in greater numbers in the pitfall traps. Other prey (Acari, adult Coleoptera, Formicidae and Diptera larvae were found to be more numerous in toad gut contents than in pitfall traps. It may be that these groups are selected by the toads.

In Group 1 the most abundant prey were Acari (45.8 per cent), Collembola (16.09 per cent) and Formicidae (10.68 per cent).

Prey items	Stomach contents		Hind gut contents	
	No. of items	per cent of items	No. of items	per cent of items
Acari	590	31.1	218	51.9
Other Chelicerata	173	9.1	2	0.5
Collembola	236	12.4	5	1.2
Coleoptera (adults)	281	14.8	99	23.6
Coleoptera (larvae)	33	1.7	1	0.2
Diptera (adults)	66	3.5	5	1.2
Diptera (larvae)	79	4.2	4	1.0
Formicidae	271	14.3	78	18.6
Other Insecta	61	3.2	4	1.0
Mollusca	21	1.1	1	0.2
Other	87	4.6	3	0.7
Total	1898		420	
Difference between stomach and hind gut	$\chi^2_{10} = 182.22$		$p<0.00001$	

TABLE 2: Comparison of stomach and hind gut contents

In Group 2 a similar situation was found: Acari (24.67 per cent), Formicidae (19.08 per cent) and Collembola (11.3 per cent). Total adult Coleoptera were also found in high numbers (17.13 per cent).

In Group 3, Staphylinidae (14.97 per cent), Acari (14.4 per cent), Formicidae (14.43 per cent) and Araneae (11.23 per cent) were found in greatest numbers. There was also an increase in total adult Coleoptera (24.06 per cent).

In Group IV there were more Myriapoda (19.82 per cent), Araneae (13.51 per cent), Carabidae (11.71 per cent) and Opiliones (11.71 per cent). Total adult Coleoptera comprised 22.52 per cent of the prey.

Prey	Toad size I	II	III	IV	Correlation rs	p
Isopoda	0	0.34	0.40	0.47	0.341	0.001
Acari	4.24	3.03	1.35	0.24	-0.369	0.001
Opiliones	0.01	0.39	0.25	0.76	0.245	0.001
Pseudoscorpiones	0.01	0	0	0	-0.075	0.304
Araneae	0.44	0.81	1.05	0.88	0.159	0.030
Myriapoda	0.06	0.19	0.40	1.29	0.324	0.001
Collembola	1.49	1.39	0.80	0.12	-0.245	0.001
Orthoptera	0.02	0.07	0.05	0.06	0.082	0.264
Dermaptera	0	0	0	0.06	0.124	0.091
Aphidoidea	0.07	0.13	0.10	0	0.010	0.894
Other Hemiptera	0.01	0.24	0	0	0.040	0.584
Carabidae	0.12	0.43	0.40	0.76	0.224	0.002
Staphylinidae	0.44	1.06	1.40	0.41	0.105	0.152
Other Coleoptera	0.27	0.61	0.41	0.29	0.052	0.478
Larval Coleoptera	0.12	0.27	0.25	0	-0.003	0.965
Larval Lepidoptera	0.01	0.01	0.10	0.18	0.139	0.059
Diptera	0.27	0.42	0.50	0.29	0.069	0.347
Larval Diptera	0.58	0.31	0.25	0.24	0.021	0.771
Neuroptera	0	0	0.05	0	0.097	0.185
Formicidae	0.99	2.34	1.35	0.24	-0.017	0.815
Ichneumonidae	0.06	0	0.10	0.12	0.049	0.508
Mollusca	0.02	0.22	0.10	0.12	0.164	0.025
Mean items/toad	9.25	12.28	9.35	6.53		
Number of toads	84	67	20	17		
Differences between toad sizes	$\chi^2_{63} = 557.4$		$p<0.00001$			

TABLE 3: Prey in toads of different sizes. The spectrum of prey groups found in the different toad size groups was compared using a Chi-squared test. The figures in the body of the table show the mean numbers of each prey group per toad. Spearman's ranked correlation coefficients were used to identify linear relationships between toad size and prey numbers.

Prey size groups	Toad size groups I No.	%	II No.	%	III No.	%	IV No.	%
1	482	62	296	36	43	23	6	6
2	116	21	215	26	46	25	15	14
3	101	13	213	26	64	34	42	38
4	28	4	99	12	34	18	48	43
Total	777		823		187		111	
Differences between toad size groups			$\chi^2_9 = 347.95$, $p<0.00001$					

TABLE 4: Comparison of prey sizes found in different sizes toads

	Toad size groups				
	I	II	III	IV	Total
Total toads	39	38	12	11	100
Number of infected toads	2	1	3	4	10
Percentage occurrence	5	3	25	36	10
Number of nematodes per host	2	1	5	36	44
Mean nematodes per infected host	1	1	1.67	9	4.4
Standard deviation	0	0	0.94	7.65	6.15

TABLE 5: Nematode infection; incidence and mean numbers per host for different toad sizes.

PARASITES

A non-food item was also recorded: specimens of the nematode *Cosmocerca ornata* were found in the small intestines of some of the toads. A mean of 4.4 per host and an incidence of 10 per cent was observed from the Abbots Moss site. Cox (1971) provides results from Slapton Ley in South Devon showing an incidence of 40 per cent and 3.8 parasites per host. He also records a similar incidence from Skomer. It seems, therefore, that the results from this study are relatively low. However, it can be seen (Table 5) that the incidence and numbers of parasites increase with size group, and therefore age, of the host. Although he doesn't mention the fact, it seems likely that Cox's results are based on adult animals rather than a range of ages. As has previously been mentioned, the animals caught during the current study range from juveniles to adults but include few larger individuals. The results for the largest size range (Table 5) show an incidence of 36.36 per cent and are, therefore, more in line with Cox's results. The mean number of parasites per host (9) is higher here than in the 1971 study (3.8). This may be the result of the low numbers of animals caught (11) and the high level of infestation in two of these (the standard deviation is 7.65).

Specimens collected from Tabley Hall contained no nematodes and this population may be completely free of the parasite.

DISCUSSION

Cott (1940), investigating toads from Land's End, found the most frequent prey group to be Formicidae (40 per cent of all prey items), followed by Coleoptera (15 per cent) and Isopoda (14 per cent). Lescure (1964) examined the guts of 50 common toads from various areas in France and Mazure (1966) worked on toad feeding in two areas in Poland. Both workers recorded Formicidae (Lescure, 62.9 per cent; Mazure, 36.0 per cent and 76.6 per cent) and Coleoptera (Lescure, 14.3 per cent; Mazure, 55.2 per cent and 17.9 per cent) to be the most important prey species. Mathias (1971) had similar results from Ainsdale (Formicidae, 69 per cent and Coleoptera, 12.36 per cent).

During the present study, Acari were found to be the most numerous prey (31.1 per cent) with adult Coleoptera (14.8 per cent), Formicidae (14.3 per cent) and Collembola (12.4 per cent) next. Presumably the increased representation of Collembola and Acari is due to the smaller sizes of toads examined during this study, compared to those investigated by other workers.

Differences in the abundances of prey groups can be seen between toads of different sizes, and it appears that while toads consume animals from a number of groups, they do select their prey to a certain extent. Although large prey items may have more nutritional value than smaller ones, toads of different sizes have different preferred prey sizes. The range of prey types does not seem to vary much with toad size, however the relative proportions of each group in the diet is size dependent.

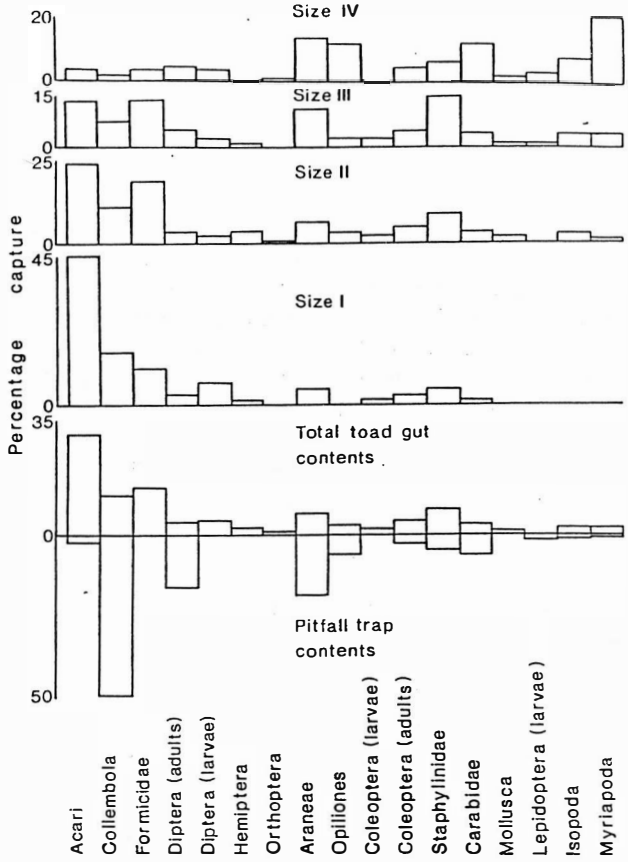

Fig. 1 Comparisons of invertebrate numbers found in the gut contents of different sized toads with those caught in pitfall traps. All are expressed as percentages of the total captures.

ACKNOWLEDGEMENTS

I would like to thank Professor D. M. Guthrie for providing facilities in the Department of Zoology at Manchester, Manchester University Estates Department and Mr. and Mrs. Hamilton for permission to collect on their land, Dr. J. H. Kennaugh for identifying the parasites and Dr. D. W. Yalden for his advice during this study and for reading and commenting on the manuscript.

REFERENCES

Cott, H. B. (1940). *Adaptive Colouration of Animals*. Methuen, London.

Cox, F. E. G. (1971). Parasites of British Amphibians. *Journal of Biological Education* **5**, 35-51.

Frazer, J. F. D. (1983). *Reptiles and Amphibians in Britain*. Collins, London.

Lescure, J. (1964). L'alimentation du Crapaud Commun, *Bufo bufo*. *Vie et Milieu* **15**, 757-764.

Mathias, J. H. (1971). *The Comparative Ecologies of two species of Amphibia* (B. bufo and B. calamita) *on the Ainsdale Sand Dunes National Nature Reserve*. Ph.D. Thesis, Manchester.

Mazure, T. (1966). Preliminary studies on the composition of Amphibians food. *Ekologia Polska* **14**, 309-319.

Smith, M. (1954). *The British Amphibians and Reptiles*. Collins, London.

Tatner, P. (1983). The diet of urban Magpies *Pica pica*. *Ibis* **125**, 90-107.

Wheater, C. P. (1984). *The Ecology of some surface active Coleoptera*. M.Sc. Thesis, Manchester.

Wheater, C. P. (1985). Size increase in the Common Toad (*Bufo bufo*) from Cheshire. *Herpetological Journal* **1**, 20-22.

HERPETOLOGICAL JOURNAL, Vol. 1, pp. 66-70 (1986)

MORPHOMETRY IN THE CHELID TURTLE, *PLATEMYS PLATYCEPHALA*

CARL H. ERNST* AND JEFFREY E. LOVICH†

** Department of Biology, George Mason University, Fairfax, Virginia 22030, U.S.A.*

†Institute of Ecology, University of Georgia, Athens, Georgia 30602 U.S.A.

(Accepted 7.5.85)

ABSTRACT

A study of growth of the shell and its scutes was conducted on 121 *Platemys platycephala* (Testudines: Chelidae). Straight-line carapace length, width and height increase at approximately the same rate as the straight-line plastron length, and are highly correlated to plastron length. Similar trends were noted for increases in bridge length and the width of both the anterior and posterior plastral lobes in relation to plastron length. Unequal growth rates occur in the vertebral scutes which may be correlated with development of carapacial curvature. The femoral scute grows faster than the other six plastral scutes. Development of the middorsal groove, plastral concavity in males, and loss of the juvenile scute rugosities are also discussed.

INTRODUCTION

The relative growth of a part in relation to the entire organism, has been studied in various turtles. These studies have compared either changes in the mass or weight of the turtle with growth of the shell, or the growth of the shell scutes or other body parts in relation to increases in shell length. Cryptodiran turtles in the families Chelydridae (Lagler and Applegate, 1943; Mosimann and Bider, 1960), Kinosternidae (Moismann, 1956, 1958; Hulse, 1976), Emydidae (Mosimann, 1958; Jolicoeur and Mosimann, 1960; Graham, 1971; Brown, 1971; Rouault and Blanc, 1978; Meek, 1982), and Testudinidae (Grubb, 1971; Bourn and Coe, 1978; Jackson, 1978, 1980; Hirth and Abdel Latif, 1981; Meek, 1982) have been previously studied. Pritchard and Trebbau (1984) summarized what little growth data have been published on South American pleurodirans, but until now no serious study has been reported. We here report the results of such a study on the neotropical chelid turtle, *Platemys platycephala*.