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Seasonal fluctuations in the diet composition of *Rhinopoma hardwickei* in the Rajasthan desert

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Abstract. The small mouse-tailed bat, *Rhinopoma hardwickei*, collected from various districts of Rajasthan, is primarily an insectivorous species. Orthoptera, Dictyoptera, Lepidoptera, Hymenoptera, Coleoptera and Diptera are preferred in all main four seasons in varying amounts, while Isoptera are consumed in all but the winter season. Occurrence of ground dwelling insects, caterpillars, spiders and water beetles in the stomachs of bats have been discussed in the light of behavioural adaptations of this species. Presence of fur of same bat species in stomachs coincides with its breeding season. Presence of various polyphagous insect pest species of crops in feeding menu of bats shows that this species plays an important role in biological management of harmful insects.

Keywords. *Rhinopoma* ; diet composition ; biological management; insect pest.

1. Introduction

The small mouse-tailed bat, *Rhinopoma hardwickei* Gray, 1831 (Chiroptera : Rhinopomatidae) is a fairly well distributed species in Rajasthan which is part of the Great Indian *Thar* desert (24·5–30·5° N ; 60–70° E). Associated with arid and semi arid regions, of which it is adapted ecophysiologically, this species is confined to subtropical latitudes. In the Indian subcontinent this bat is absent from forested regions of Ghats. In its diurnal roost, it coexists with other bat species of *Rhinopoma microphyllum kinneari* and *Taphozous* spp. inhabiting natural caves, man made cellars, and underground irrigation tunnels.

In spite of the occurrence of *R. hardwickei* in abundance, constituting of 9·63% of the total bat fauna of desert biome of Rajasthan (Advani 1981a), except some reports (Advani and Vazirani 1981 ; Prakash 1963 ; Sinha and Advani 1976), little is known about the ecology, biology and behaviour of this species. The present studies were undertaken to investigate the food composition and seasonal variation in the feeding pattern of this species.

2. Study area

The Indian desert has four distinct seasons in one year, receiving different magnitudes of rainfall, temperature fluctuations, relative humidity and sun shine hours. These factors individually and/or combinely have an impact on reproduction, abundance and activity of animal life in the desert including insects and bats. In winter, the mean maximum and minimum temperatures are 25·4 and 9·5° C respectively, with a mean rainfall of 2·8 mm and a mean relative humidity of 22% (Prakash *et al* 1971). In summer, the temperature is very high (mean max t = 39·8° C, mean min t = 27·9° C), with 18·2 mm mean rainfall and 20·1 mean relative humidity. In the monsoon months, the mean rainfall is 110·5 mm, relative humidity being 47·5% and the temperature (mean max t = 34·5° C, mean min. t = 25·1° C) lesser than that of summer. In post-monsoon season (October and November) the temperature fluctuations are 28·5° C (max.) to 10·8° C (min). The relative humidity is 20·5%.

3. Materials and methods

The bats were collected during various seasonal and periodical faunistic surveys conducted by Desert Regional Station, Zoological Survey of India of twelve districts—Jodhpur, Barmer, Nagaur, Pali, Dungarpur, Banswara, Jhalawar, Tonk, Boondi, Ajmer, Sawai Madhopur and Kota, well distributed in arid and semi arid parts of Rajasthan State. 171 individuals were collected and examined. For each season, the break up of the sample size (N) is shown in table 1. After anaesthesia the bats were dissected and their alimentary canals cut open. The stomach contents were taken out with a brush and forceps and then dried on filter paper at room temperature. After sorting, stomach items were identified to the lowest taxonomic level feasible (Order-Family) through the aid of microscope later these items were weighed on the balance to calculate their percent frequency of occurrence in the stomach contents following Murton *et al* (1964).

The seasonal fluctuations in the feeding pattern were determined by pooling data among four main seasons occurring in the Indian desert.

4. Results

The examination and analysis of the stomach contents revealed that *R. hardwickei* is primarily an insectivorous species, though some traces of vegetable matter were also observed in summer and monsoon (rainy) seasons (table 1). Fur of the same bat species occurred during summer and monsoon, whereas, it was completely absent during post-monsoon and winter. There were no remains of other animals except insects and spiders.

In winter December to February, Orthoptera (gryllids, house crickets) and Coleoptera (beetles) constitute more than 45% of the total diet. However, Hymenoptera (ants) Lepidoptera (moths), Dictyoptera (Cockroaches) and diptera (flies, mosquitoes) are also preferred in appreciable amounts in decreasing order. Araneida (spiders) were noted in the stomach in moderate proportions during this season.

Table 1. Seasonal fluctuations in stomach contents of *Rhinopoma h. hardwickei*, expressed in percent of total dry mass.

Stomach items	Seasons			
	Winter (Dec.–Feb.) $N = 36$	Summer (Mar.–June) $N = 43$	Monsoon (July–Sept.) $N = 45$	Post-monsoon (Oct.–Nov.) $N = 47$
Orthoptera				
Gryllidae	22·3	15·1	12·1	10·4
Acrididae	4·0	8·5	5·5	2·9
Isoptera				
Termitidae	...	10·0	28·2	6·8
Dictyoptera	10·9	11·8	1·3	4·7
Lepidoptera				
Noctuidae	4·5	8·1	3·8	4·4
Arctidae	6·1	8·2	10·1	8·2
Unidentified	1·2	...	1·0	0·5
Caterpillars	...	1·2	3·2	1·1
Hymenoptera				
Vespidae	1·2	5·0	5·8	8·8
Formicidae	14·2	4·3	4·5	7·4
Neuroptera				
Mantispidae	2·4	...	1·4	1·3
Diptera				
Chironomidae	3·7	...	...	2·2
Culicidae	4·5	1·2	1·3	...
Unidentified	1·0	...	1·1	0·5
Coleoptera				
Scarabaeidae	8·5	4·9	8·3	14·1
Curculionidae	3·4	7·3	3·2	11·5
Carabidae	4·1	2·0	2·0	12·2
Bruchidae	2·0	1·0	...	...
Dytiscidae	1·2	4·0	...	...
Unidentified	...	1·3	2·2	3·0
Araneida (Spiders)	4·9	1·2	...	...
Bat's own fur	...	4·9	3·8	...
Plant parts	...	0·5	1·2	...

Table 2. '*P*' values indicating seasonal difference in diet composition of *R. hardwickei.*

Major stomach items	*W-S N=79	'*P*' values S-M N=88	between successive seasons M-PM N=92	PM-W N=83
Orthoptera	0·05	0·05	NS	0·05
Isoptera	0·001	0·001	0·001	0·001
Dictyoptera	NS	0·001	0·05	0·001
Lepidoptera	0·01	NS	NS	NS
Hymenoptera	0·05	NS	0·05	NS
Neuroptera	0·001	0·01	NS	NS
Diptera	0·001	NS	0·05	0·001
Coleoptera	0·05	0·05	0·001	0·001
Araneida	0·05	0·01	0·05	0·001
Bat fur	0·001	NS	0·001	NS
Plant parts	0·05	0·05	0·05	NS

*W—Winter, S—Summer, M—Monsoon, PM—Post-Monsoon, NS—Non Significant, N—Total number of bats observed after dissection.

In summer there is an increase in the relative occurrence of Lepidoptera ($P < 0·01$) while Isoptera, (termites, *Odontotermes obessus, Anacanthotermes* sp.) which are absent in winter, form about 11% of the total diet (table 2). However, Hymenoptera, Diptera and spiders reduce considerably ($P \pm 0·05$, 0·001 and 0·05 respectively). Preference for Coleoptera ($P < 0·05$), Orthoptera ($P < 0·05$) and Dictyoptera remains more or less same as in winter season.

During monsoon months, when there is abundant insect life in nature, there is a significant rise in the consumption of winged soft-bodied termites (*Microtermes obesii, O. obessus, Anacanthotermes* sp.), slightly less than three times (28·2%) of the summer season ($P < 0·001$). Relative percent frequency of Coleoptera ($P < 0·01$) and Orthoptera ($P < 0·01$) declines further, while that of Hymenoptera, Diptera and Lepidoptera increases slightly. However, drastic reduction is observed with regard to relative occurrences of Dictyoptera and Spiders in the diet ($P < 0·001$ and 0·01).

In the two months of post-monsoon season, October and November, beetles mainly belonging to families Scarabaeidae (while grubs, *Holotrichia* spp.), Curculionidae and Carabidae constitute major proportion of the diet of bats. Occurrence of ants also increases considerably in the stomachs. Isoptera reduces abruptly, whereas, moderate decline is found regarding consumption of Orthoptera and Lepidoptera. Spiders, bat's own fur and plant parts do not figure at all in this season.

4. Discussion

The small mouse-tailed bat, *R. hardwickei* is primarily an inhabitant of the cave and rocky habitat while about 16% population roosts near or in the midst of human settlement (Advani 1981a). Its roosting habitats have certainly an impact on its feeding behaviour particularly in deciding the composition and seasonal relative occurrence of various insect orders like Diptera, Dictyoptera, Hymenoptera and Orthoptera which are available in and around human environment and Coleoptera (bruchids, scarabaeids, carabidds), Isoptera and Lepidoptera which occur in abundance in agro-ecosystems and forested rocky habitat. However, it appears that the feeding habits of this species are also probably a combination of opportunism and selective predation, varying with local ecobiotic conditions such as relative abundance of different kinds of vegetation patterns on which the insect fauna exists. Occurrence of traces of plant parts in the stomachs of bats during summer and monsoon is perhaps due to the remains of undigested gut contents of insects eaten by bats. The presence of orthopterans, caterpillers of Lepidoptera, spiders and some ground beetles suggests that this species also feeds by picking these animals from the ground or other surfaces. Likewise, as observed the drinking behaviour of *R. hardwickei* of skimming over the water surfaces is also very similar to those of allied species *R. microphyllum* (Advani 1981b). However, the requirement of water is also compensated in the desert by the almost exclusive diet of the insects which contain 80–90% water (Robinson 1928). The presence of water beetles (dytiscids : *Lacconectus* sp., *Agabus* sp. *Rhantus* sp.) in the stomachs indicate the ability of bats to swoop over the water surfaces and pick up the most active insects. Regarding composition of food items, *R. hardwickei* markedly differs from the Indian false vampire, *Megaderma lyra lyra* which depends upon an equal proportion of insect and the vertebrate (lizards, fishes, birds etc.) animal diet (Advani 1981c) on an annual basis.

Seasonwise, during winter when temperature falls to about 4·5° C in the Rajasthan desert, the bats are relatively inactive and they thrive upon insects available in their vicinity or home ranges. These include mosquitoes, flies, gryllids, house crickets, cockroaches, ants and beetles, forming major portion of their diet. In this season bats under extreme climatic conditions can also subsist upon their own fat reserves which they accumulate after the monsoon season. During summer and monsoon months preference for termites is quite obvious, as this period coincides with emergence of winged, soft bodies, slow flying termites after the first few showers (From mid June onwards) in Rajasthan. Likewise, in post-monsoon season, occurrence of winged ants and wasps and abundant beetles determine the diet composition of this species. However, the climatological differences among four main seasons, mainly temperature and rainfall variations, govern reproduction, metamorphosis and abundance patterns of various insect orders which act as food for insectivorous bats. These parameters also cause changes in activity and behaviour of bats, as in winter being relatively less active their foraging range is confined to places nearby roosting habitat.

The survival of bats upon some of the most prominent and polyphagous insect species of summer as well as winter crops in Rajasthan desert like *O. obessus*,

M. obesii (termites) ; White grubs (*Holotrichia* spp.) and Cuculionids (Coleoptera) and several grasshopper species, evidently show that this species plays an important role in the ecological balance of the population of these harmful insects in natural crop ecosystem. On the other hand, occurrence of predatory insects like Neuroptera in stomachs, though in low relative percentages, points out towards non-beneficial aspect of feeding ecology of this species.

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