ON THE PREY OF THE INDIAN EAGLE OWL *BUBO BENGALENSIS* (Franklin, 1831) IN AND AROUND PONDICHERRY, SOUTHERN INDIA

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ABSTRACT

A total of 2,467 prey items of the Indian Eagle Owl Bubo bengalensis *were identified accounting for an estimated biomass (dry weight) of 1,35,575.37g in 35 months at four study sites. Mammals accounted for an estimated biomass of 86.93% of which rodents occupied pride of place with 64.91%.* Tatera indica *(24.96%),* Rattus rattus *(20.43%),* Bandicota bengalensis *(12.28%),* Mus *spp. (4.67%),* Bandicota indica *(2.34%) and* Funambulus palmarum *(0.15%) featured prominently among rodent food, but* Millardia meltada *(0.06%) was conspicuous by its near absence. Increased predation was noticeable only when young were present, but other than this no distinct statistical variations were discernable. Trapping exercises showed only marginal seasonal fluctuations in rodent populations (the greatest monthly variation being 4.63% for* Rattus rattus*), and this was linked to the year round availability of plant food in the region. Another basic food was* Lepus nigricollis *(20.06%), though, at one study site free from poaching pressure, it accounted for 30.16%, leading to the postulation that historically, before poaching became rampant, it could have been the primary prey resource.* Suncus murinus *(1.36%) and Chiroptera (0.58%) were the other mammal prey. Birds (8.28%) were the most important non-mammal food, followed by batrachians (2.75%), both of which showed distinct seasonal fluctuations.* Varanus bengalensis *(1.64%) and a single* Amphiesma stolata *were the reptiles consumed. Arthropods accounted for 0.34%, of which Coleoptera dominated with 0.24%. The venomous* Heterometrus swammerdami *and* Scolopendra morsitans *also formed part of the prey spectrum, albeit in negligible quantities (a combined biomass of 0.022%).*

KEYWORDS

Arthropods, biomass, birds, Bubo bengalensis*, Indian Eagle Owl,* Lepus nigricolis*, prey, rodents, small mammals*

The Genus *Bubo* contains some of the world's largest species of owls, most, if not all of which, are tertiary consumers and excellent indicators of ecosystems they inhabit. Authorities differ in opinion about the number of species in the Genus which varies from 16 (http://owlpages.com/species/Default.htm; del Hoyo *et al*., 1999) to 18 (http://www.omne-vivum.com/b/3399.htm). Of all these, the prey spectrum and dynamics of only two (both Northern Hemisphere species) have been studied in detail - *viz*., the Eurasian Eagle Owl *Bubo bubo* (Bayle *et al*., 1987; Blondel & Badan, 1976; Choussy, 1971; Donazar, 1987; Herrera & Hiraldo, 1976; Martinez *et al*., 1992; Martinez, 2003, Mysterud & Dunker, 1982; Orsini, 1985; Penteriani *et al*., 2002; Simeonov *et al*., 1998; Uttendorfer, 1939, 1952) and the American Great Horned Owl *Bubo virginianus* (Adamcik *et al*., 1978; Austing & Holt, 1966; Houston & Francis, 1995; McInvaille & Keith, 1974; Rohner, 1995, 1996, 1997; Rohner & Hunter, 1996; Rohner & Smith, 1996). Like most others of its genus, the Indian Eagle Owl *Bubo bengalensis* (also known as the Indian Great Horned Owl, Bengal Eagle Owl, Rock Horned Owl and Rock Eagle Owl, and till recently considered a subspecies of *Bubo bubo*) has received scant attention. A preliminary report on the prey of the species exists (Ramanujam, 2001), but this left a lot to be desired as, in addition to other shortcomings, it relied fundamentally on pellet analysis of just two unconnected subjects and no effort was made to specifically identify the rodent prey base. All other literature concerning the diet of the species are short notes of casual observations (Ali, 1969, 1996; Ali & Ripley, 1987; Barnes, 1981; Dharmakumarasinhji, 1954; Grewal, 1995; Jerdon, 1862; Whistler, 1986).

This report aims to identify the prey spectrum of *Bubo bengalensis*, categorise components of prey consumed (and in the process identify the main food resources), review fluctuations in prey occurence and corelate the primary prey base to climatic factors and plant phenology of the region.

METHODOLOGY

Area and Subjects

The region extending from Ousteri Lake ($11^0$95'N & $79^0$73'E) north-eastwards to Success-Ravena on the Auroville plateau ($11^0$98'N & $79^0$81'E), all in a radius of ca.12-15km from Pondicherry City, is corrugated by a number of ravines and gullies. This broken-up country is the habitat of *Bubo bengalensis*. Field studies concentrated on four breeding pairs and their young in the ravines and forested areas adjoining the Sri Aurobindo Ashram Trust's wasteland development programme at Merveille, and the Auroville International Township communities of Aranya, Hermitage and Success - all involved in afforestation programmes and giving priority to the re-creation of the Tropical Dry Evergreen Forest, the indigenous forest type of this region. All are surrounded by human habitations and encroachments are very common. Except Aranya (which is well guarded), all others are extensively hunted by tribal Nari-Kuravas, villagers and sportsmen from Pondicherry whose prime target is the Black-naped Hare *Lepus nigricollis nigricollis*. Feral dogs too take their toll on this species.

The entire study period lasted from 3 February 2001 to 30 December 2003 - a period of 35 months (a month short of 3 years). However, during this period, the study of a single

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breeding pair could not be carried out from start to finish due to anthropogenic factors which influenced the termination of data collecting exercises at individual sites. The following is a brief review of individual study sites and reasons for abandonment of studies at them:

Merveille: Data collection lasted from 3 February 2001 to 21 April 2002 (15 months). The pair of Eagle Owls inhabiting this site bred twice during the study period. A pair of eggs was laid in February 2001 and a single chick was successfully raised which stayed with the parents till August. Three eggs were laid in December in the same year, two of which hatched and the chicks remained alive for two months (January & February 2002), but were found in badly emaciated condition on 7 March 2002. These had disappeared when the nest site was again visited on 12 March. Further to this, the adults abandoned the ravines for an existence in adjacent coconut and mango groves which precluded data gathering exercises. The reason for a sudden drop in food availability could be traced to the proliferation of invasive *Acacia colei*, *Acacia tumida*, *Acacia ampliceps* and *Acacia torlusa* saplings which had completely overrun the open hunting spaces necessary for the survival of these raptors. The fact remains that, for a carnivorous creature with an enclave or contractor type territory (like *Bubo bengalensis*), the removal or destruction of a key foraging patch will make the territory unsustainable for the creature inhabiting it and it will collapse (Kruuk & Macdonald, 1985).

Aranya: Effective data collection lasted from 5 May 2001 to 26 February 2003 (22 months). The pair of owls inhabiting this site successfully raised three young, which remained with the parents from April to October 2002. Unfortunately, pebble mining activities and the resultant human intrusions into key habitat areas had adverse effects on these shy owls which abandoned their usual haunts.

Hermitage: Data collection lasted from 1 August 2001 to 26 March 2003 (20 months). The pair of owls here bred twice, both unsuccessfully. A single chick was discovered on 12 January 2002 which fledged, but was found dead on 3 May - the cause was due to gunshot wounds. On 1 January 2003 four eggs were discovered, but had disappeared by our next visit on 7 January. A replacement clutch of four was again found on 15 January and all hatched by 19 February. The last chick disappeared immediately (presumably due to natural causes), and the remaining three nestlings were last seen on 26 February. Hermitage was the most disturbed study site - it still remains,to date, the shortcut from Kasipalayam village to Pondicherry, poaching is a perennial problem, vandalism by village children (who use it as a sort of playground) is all too common and illegal pebble mining is rampant. Hense it was thought rather unwise to expend efforts at this site until some degree of protection was afforded to the study subjects.

Success: Our attention was drawn to this site at the start of January 2003 when two fully fledged chicks were discovered here. These remained with the parents till August. Data collection lasted from 7 January to 30 December 2003 (12 months) - the end of the set study period.

Materials and Methods

Till quite recently, the pellet analysis method (Errington, 1930, 1932) was the standard practice for the identification of the prey of owls. Analysis relying fundamentally on pellets was found to yield inaccurate estimates of the overall diet of owls, and hence carcass remains too were found to be of importance (Simmons *et al.*, 1991). A simple key for the identification of rodents in pellets (based on structure of lower mandibles), as well as the methodology (and reasons) for an unbiased estimate of prey consumed by *Bubo bengalensis* is in existence (Ramanujam, 2004). This was reasoned to be the number of pairs of lower mandibles in a pellet, in addition to the number of carcasses with heads to give an accurate figure of rodents predated on by a pair / family of owls within their territory. With some commonsense modifications, the same system was used for the quantification of other vertebrates. Identification of prey remains in pellets relied on the reference collection and a guide to closely related species (Anon., 1995). Identification of carcasses followed basic morphological characteristics in literature, *viz*., for bats (Bates & Harrison,1997), rodents (Ellerman, 1947a,b), birds (Ali, 1996; Ali & Ripley, 1987; Kazmierczak, 2000), reptiles (Daniel, 1992) and amphibians (Daniels, 2005). It was not possible to specifically identify bat, bird and amphibian remains from pellets. Arthropods were identified by an entomologist up to the Family level using established literature on the subject (Borror, 1992; Mani, 1990).

Biomass (quantitative percentage) of food consumed was calculated by dry weight estimates. Dry weight was chosen as the principal measure because differences in moisture content of rodents and insects bias volumetric and wet weight data (Sugden, 1973), and also because it has more direct nutritional interpretation (Reinecke, 1979). Dry weight of each food item was measured after drying in a bake-oven for 48 hours. The categories of particular components of food consumed was assessed according to a pre-established system in place for calculating trophic connections of owls in India (Kumar, 1985; Ramanujam & Verzhutskii, 2004; Verzhutskii & Ramanujam, 2002). This recognises four classes: Basic food - prey occurring with a frequency above 20%; Constant food - prey occuring with a frequency between 5-20%; Supplementary food - prey occurring with a frequency between 1-5%; and Chance food - prey occurring with a frequency below 1% (Kumar, 1985).

An earlier report (Ramanujam, 2003) documented the use of the tape playback method (Bergerhausen & Willelms, 1988; Falls, 1982; Martin, 1986) to determine the territorial boundaries of each pair of owls in the study area, which was imperative to this study. Intensive pellet and carcass gathering exercises were simultaneously undertaken with bird watching sessions. This allowed us to visit each site and/or territory at least once a week. Pellets were soaked in water, placed on a newspaper to drain for about ten minutes, then gently teased apart with tweezers. All bones were preserved in individual packets and exist in the study collection. Carcass remains, most of which had reached advanced levels of putrefaction, were buried after

identification. The intact ones were used for dry weight analysis (Yalden & Morins, 1990).

Murid rodent populations were estimated in the study area by the standard trapping method (Barnett & Dutton, 1995). Three trapping stations, each 100m^2 in extent and forming a grid of 6 x 6 trap lines (each trap 2m apart), were maintained during the years 2002 and 2003 in the three types of habitats in the region - *viz*, ravine, grassland on plateau and tropical dry evergreen forest (TDEF) plantation. Two trapping nights every month, fifteen days apart, was the practice adopted and monthly trap success was the sum of traps entered on these two nights. The percentage trap success and / or rodent abundance was calculated as follows:

% trap success = (traps entered / no. of traps set) x 100

To the best of our knowledge, the populations of rodents and plant phenology affecting them showed no significant variations between years. Hence, the data of both years was pooled and expressed as mean monthly estimates for a single year.

Basic gut analysis of rodents was undertaken to determine their food regime. The stomach and contents were preserved in 75% ethyl alcohol in the field and taken to a botanist's laboratory for identification. Unfortunately it was not possible to identify grass seeds in guts of *Tatera indica* and *Mus* spp., which occurred in quantifiable amounts after the end of the north-east monsoons. Fruiting phenology relied on data of another biologist (DeHollander, pers. comm.).

The entire area, like all regions along the southeastern seaboard of peninsular India, has a dissymmetric climatic regime (Blasco & Legris, 1972; Meher-Homji, 1977). In contrast to the rest of peninsular India (where rainfall is from June to the first half of October), the bulk of precipitation in these parts is in October and November resulting from depressions formed in the Bay of Bengal during the north-east monsoon. January is the statically coolest month with a maximum temperature of 30^{0}C and a minimum of 17^{0}C. May and June are the hottest months when day-time temperatures can soar to 41^{0}C (minimum 25^{0}C) and this coincides with the peak fruiting season.

Results

A total of 2,467 prey items were identified from pellets and carcass remains, accounting for a biomass (dry weight) of 1,35,575.37g. Three general classes of prey were distinguishable - mammals, non-mammal vertebrates and arthropods.

Mammals: The importance of mammals, and more so rodents, in the diet of *Bubo bengalensis* was a striking feature. The percentage of estimated weight was the most for mammals (86.93%), of which rodents dominated with 64.91%. Specific basic food (>20%) included the Indian Gerbil *Tatera indica* (24.96%), House Rat *Rattus rattus* (20.43%), and Black-naped Hare *Lepus nigricollis nigricollis* (20.06%). But an anomaly does exist - *Lepus nigricollis* accounted for 30.16% in Aranya, more than any other food resource at this site. Among mammals, a source of constant food (5-20%) was the Lesser Bandicoot or Mole Rat *Bandicota bengalensis*, which accounted for 12.28%. After *Tatera indica* and *Rattus rattus*, Mice *Mus* spp. topped numerically with 464 individuals, but constituted only 6,333.6g or 4.67% of estimated biomass consumed. Another supplementary food (1-5%) was the Common Bandicoot *Bandicota indica*, which though low on individuals (15), accounted for a biomass of 3,178g or 2.34%. The diurnal Three-striped Palm Squirrel *Funambulus palmarum* featured as chance food (0.15%) and occurred in greater numbers than the Soft-furred Field Rat or Metad *Millardia meltada* (0.06%). This was surprising because *Millardia meltada* was a primary component in the diet of the Barn Owl *Tyto alba* in agroecosystems and rural areas in Tamil Nadu (Neelanarayan, 1997; Neelanarayan *et al.*, 1994, 1999; Santhanakrishnan, 1987, 1995). The Musk Shrew *Suncus murinus* accounted for 1.36% (supplementary food) and bats 0.58% (chance food). It may sound surprising that a predator like *Bubo bengalensis*, adapted to catching prey crawling along the ground, can capture bats, but in fact, bats are known to occur in greater numbers than expected in the diet of owls (Bauer, 1956; Perry & Rogers, 1964; Ruprecht, 1979).

Monthly estimates of food consumed showed a substantial increase only when young were present, and this is understandable. Other than this, no striking variations were discernable regarding basic food. Rodent trapping sessions too did not show any major variations. Trapping sessions were successful only regarding *Tatera indica*, *Rattus rattus* and *Mus* spp. (*Bandicota* spp. and *Millardia meltada* did not feature in trap success). Trap success did show that two species preferred particular habitats over others - *Tatera indica* occurred in all three habitats, but *Rattus rattus* occurred in good numbers only in TDEF plantations, rarely in ravines and never in grasslands, and *Mus* spp. predominated in grasslands and ravines and rarely in TDEF plantations. A marginal peak in *Tatera indica* and *Mus* spp. numbers was observed during the months of May-July. *Rattus rattus* also showed a marginal increase in numbers during the same time and a decline during November and January. The greatest range of fluctuation recorded was very small: 2.31% for *Tatera indica*, 4.63% for *Rattus rattus* and 3.24% for *Mus* spp. (for details refer Fig. 2). This is directly linked to food availability in this region. Gut analysis of rodents disclosed the fact that they feed on the fruit of 65 plant species. The greatest number fruited during the months of May and June (75.38%), and the lowest fruiting time was in December and January (40.0% and 41.53% respectively). Twenty-one species were recorded to fruit throughout the year, assuring a constant source of food for primary consumers. For details of fruiting phenology refer Table 6.

Non-mammal vertebrates: Birds (8.28%) formed a source of constant food and were the most important of non-mammal vertebrate food as far as biomass was concerned. Two periods of predatorship were distinct, *viz*., March-June and August-December. The species too varied between these times. Between March and June the species identified from carcasses were Red-wattled Lapwing *Vanellus indicus*, Grey Partridge

Francolinus pondicerianus and Oriental Skylark *Alauda gulgula*. Between August and December species identified were Pariah Kite *Milvus migrans govinda*, Indian Pitta *Pitta brachyura*, Orange-headed Thrush *Zoothera citrina*, Paddyfield Pipit *Anthus rufulus* and Grey Wagtail *Motacilla cinerea*. Among reptiles small to medium-sized Monitor Lizards *Varanus bengalensis* (1.64%) and a single Striped Keelback *Amphiesma stolata* were preyed upon. Frogs were supplementary food (2.75%) and occured from the onset of the monsoon rains till the time the reservoirs (man-made to conserve runoff rainwater) dried up. Only two species of frogs were found in these seasonal reservoirs - Skipper Frog *Euphlyctis cyanophlyctis* and Marbled Balloon Frog *Uperodon systoma.*

Arthropods: Though 236 arthropods were consumed, they accounted for only a small proportion of biomass injested. The total estimated biomass was 468.39g or 0.34%, of which Coleoptera dominated with 0.24%. Among the 196 beetles consumed, the vast majority, 170, belonged to the Family Scarabaeidae. All the Orthoptera belonged to the Family Acrididae. The Freshwater Crab *Paratelphusa* sp. and Rock Scorpion *Heterometrus swammerdami* were preyed upon during the monsoon season (August-December). It was striking to note the occurrence of the venomous *Heterometrus swammerdami* and Tiger Centipede *Scolopendra morsitans* in the diet of *Bubo bengalensis.* For further details refer Tables 1-5.

DISCUSSION

Rodents may have formed the principal prey of *Bubo bengalensis* in this region, but historically, the scenario may have been different. A clue lies in *Lepus n. nigricollis* forming the principal food in Aranya, and this is because, devoid of hunting pressure, it is found in sufficient numbers to form a viable prey base at this site. In other words, it is possible that *Lepus n. nigricollis* was the prime basic food of *Bubo bengalensis* in this region before human pressures had an impact on prey density. Closely related species *Bubo bubo* and *Bubo virginianus* are specialised hare and rabbit hunters, and their lifestyles are in sync with the highs and lows of their prey cycles (Adamcik *et al.*, 1978; Bayle *et al.*, 1987; Blondel & Badan, 1976; Delibes & Hiraldo, 1979; Herrera & Hiraldo, 1976; Houston & Francis, 1995; Martinez, 2003; Penteriani *et al.*, 2002; Rohner, 1995, 1996; Rohner & Hunter, 1996; Rohner & Smith, 1996).

That *Bubo bengalensis* could switch to alternate primary prey resources (rodents) shows the adaptibility of the species. Opportunistic feeding tendencies, depending upon availability of food, has also been recorded in other species of owls; for eg., *Tyto alba* (Czarnecky *et al.*, 1955; Herrera & Jaksic, 1980; Ruprecht, 1971, 1979), *Athene brama* (Kumar, 1985) and *Otus bakkamoena* (Verzhutskii & Ramanujam, 2002).

Rodents being plentiful, naturally formed the basic source of food of *Bubo bengalensis*. The nocturnal terrestrial *Tatera indica*, and arboreal and terrestrial *Rattus rattus* formed the main prey base. *Bandicota indica* and *Bandicota bengalensis* occured in less quantity probably due to their more fissorial

Table 1. The prey of* Bubo bengalensis*: Cumulative data for all four study sites

	Prey	Merveille				Aranya				Hermitage				Success				Summary			
		Total nos	Estimated Biomass	% of Biomass	Cate-gory	Total nos	Estimated Biomass	% of Biomass	Cate-gory	Total nos	Estimated Biomass	% of Biomass	Cate-gory	Total nos	Estimated Biomass	% of Biomass	Cate-gory	Total nos	Estimated Biomass	% of Biomass	Cate-gory
1	*Suncus murinus*	2	74.26	0.34	OF	18	668.34	1.16	SF	12	445.56	1.38	SF	18	668.34	2.75	SF	50	1856.50	1.36	SF
2	Chiroptera	2	93.48	0.42	OF	8	373.92	0.65	OF	1	46.74	0.14	OF	6	280.44	1.15	SF	17 [1]	794.58	0.58	OF
3	*Funambulus palmarum*	1	51.56	0.23	OF	1	51.56	0.08	OF	2	103.12	0.32	OF	-	-	-	-	4	206.24	0.15	OF
4	*Tatera indica*	145	7876.40	36.21	BF	137	7441.84	12.96	CF	176	9560.32	29.70	BF	165	8962.80	36.96	BF	623	33841.36	24.96	BF
5	*Rattus rattus*	75	3764.25	17.30	CF	209	10489.71	18.29	CF	151	7578.69	23.54	BF	117	5872.23	24.21	BF	552	27704.88	20.43	BF
6	*Millardia meltada*	2	86.60	0.39	OF	-	-	-	-	-	-	-	-	-	-	-	-	2	86.60	0.06	OF
7	*Bandicota indica*	6	1271.22	5.84	CF	6	1271.22	2.21	SF	-	-	-	-	3	635.61	2.62	SF	15	3178.05	2.34	SF
8	*Bandicota bengalensis*	60	4996.80	22.97	BF	89	7411.92	12.91	CF	36	2998.08	9.31	CF	15	1249.20	5.15	CF	200	16656.0	12.28	CF
9	*Mus* spp.	59	805.35	3.70	SF	282	3849.30	6.70	CF	103	1405.95	4.36	SF	20	273.0	1.12	SF	464	6333.60	4.67	SF
10	*Lepus nigricollis*	2	824.34	3.79	SF	42	17311.14	30.16	BF	15	6182.55	19.21	CF	7	2885.19	11.89	CF	66	27203.22	20.06	BF
11	Aves	8	987.76	4.54	SF	49	6050.03	10.54	CF	19	2345.93	7.28	CF	15	1852.05	7.63	CF	91 [2]	11235.77	8.28	CF
12	*Varanus bengalensis*	4	470.56	2.16	SF	9	1058.76	1.84	SF	4	470.56	1.46	SF	2	235.28	0.97	OF	19	2235.16	1.64	SF
13	*Amphiesma stolata*	-	-	-	-	1	39.95	0.06	OF	-	-	-	-	-	-	-	-	1	39.95	0.29	OF
14	Anura	14	411.74	1.89	SF	40	1176.40	2.04	SF	31	911.71	2.83	SF	42	1235.22	5.09	CF	127	3735.07	2.75	SF
15	*Paratelphusa* sp.	-	-	-	-	6	54.66	0.09	OF	1	9.11	0.02	OF	1	9.11	0.03	OF	8	72.88	0.05	OF
16	*Heterometrus swammerdami*	-	-	-	-	2	15.30	0.02	OF	-	-	-	-	2	15.30	0.06	OF	4	30.60	0.02	OF
17	*Scolopendra morsitans*	-	-	-	-	1	3.02	0.005	OF	-	-	-	-	-	-	-	-	1	3.02	0.002	OF
18	Orthoptera	-	-	-	-	9	8.91	0.01	OF	14	13.86	0.04	OF	4	3.96	0.01	OF	27 [3]	26.73	0.01	OF
19	Coleoptera	19	32.49	0.14	OF	70	119.70	0.20	OF	65	111.15	0.34	OF	42	71.82	0.29	OF	196 [4]	335.16	0.24	OF

BF (Basic food) - prey occurring with a frequency > 20%; CF (Constant food) - prey occurring with a frequency between 5 – 20%; SF (Supplementary food) - prey occurring with a frequency between 1 – 5 %; OF (Chance food) - prey occurring with a frequency below 1%

[1] 16 Megachiroptera, 1 Microchiroptera; [2] 2 *Milvus migrans*, 4 *Francolinus pondicerianus*, 10 *Vanellus indicus*, 7 *Pitta brachyura*, 3 *Alauda gulgula*, 3 *Anthus rufulus*, 3 *Zoothera citrina*, 3 *Motacilla cinerea* (all identified from carcasses); [3] all Acrididae; [4] 9 Cerambycidae, 10 Elateridae, 4 Curculionidae, 3 Carabidae, 170 Scarabaeidae.

Table 2. Month by month breakdown of prey of* Bubo bengalensis *at Merveille: February 2001 – April 2003

	Prey	2001											2002			
		F	M*	A*	M*	J*	J*	A*	S	O	N	D	J*	F*	M*	A
1	*Suncus murinus*							1			1					
2	Chiroptera										1		1			
3	*Funambulus palmarum*												1			
4	*Tatera indica*	1	18	12	14	7	20	9	6	6	2	4	30	15	1	
5	*Rattus rattus*	2	8	8	8	8	18	9	3	1	1	2	3	4		
6	*Millardia meltada*						2									
7	*Bandicota indica*						3	2				1				
8	*Bandicota bengalensis*	3	2	2	5	3	18	11					5	9		2
9	*Mus* spp		2	2		4	17	2	4	4	3	3	7	6		5
10	*Lepus nigricollis*												1	1		
11	Aves		2	1				1			1	3				
12	*Varanus bengalensis*	2	1											1		
13	Anura	1								4	5	1	1	1	1	
14	Coleoptera						2		1	2	1		11	1	1	

* Young with parents

Table 3. Month by month breakdown of prey of* Bubo bengalensis *at Aranya: May 2001 – February 2003

	Prey	2001								2002											2003	
		M	J	J	A	S	O	N	D	J	F	M	A*	M*	J*	J*	A*	S*	O*	N	D	J	F
1	*Suncus murinus*		1	2										4	4	1	5					1	
2	Chiroptera								1									1	2		2		2
3	*Funambulus palmarum*															1							
4	*Tatera indica*	7	1	4	5	2	3	4	13	10	4	3	15	15	4	11	10	5	2	1	6	6	6
5	*Rattus rattus*	6	7	9	5	1	1	1	1	1	3	2	21	22	16	20	25	22	18	7	8	6	7
6	*Bandicota indica*	2		1											1	1					1		
7	*Bandicota bengalensis*	9	9	14	7		1		1			1	16	12	5	3	2		2		2	4	1
8	*Mus* spp.	7	3	30	2	6	1		10	1	1		40	54	49	23	18	20	9		2	6	1
9	*Lepus nigricollis*												6	9	3	7	3	5		1	2	5	1
10	Aves	3	3					3	6			4	3	7	6		3	3	2	2	4		
11	*Varanus bengalensis*									1					2		3	1	1		1		
12	*Amphiesma stolata*																	1					
13	Anura							2	1	2							17	8	2	2	2	4	
14	*Paratelphusa* sp.					1												1	4				
15	*Heterometrus swammerdami*																	1	1				
16	*Scolopendra morsitans*																					1	
17	Orthoptera							1		2				1			2			1	1	1	
18	Coleoptera					1	1	4	4	1			3	3	4	7	16	5	3	2	7	7	2

* Young with parents

Table 4. Month by month breakdown of prey of Bubo bengalensis at Hermitage: August 2001 – March 2003

	Prey	2001					2002											2003		
		A	S	O	N	D	J*	F*	M*	A*	M*	J	J	A	S	O	N	D	J	F*	M
1	*Suncus murinus*									6	1	1			1					1	2
2	Chiroptera																1				
3	*Funambulus palmarum*		1			1															
4	*Tatera indica*	14	7	6	6	9	20	25	12	6	8	2	1		17	7	6	1	1	22	6
5	*Rattus rattus*	11	8	7	4	2	9	13	5	8	11	4	11	7	19	6	5	5	3	10	3
6	*Bandicota bengalensis*							8	7	6	2	1			7	3	1	1			
7	*Mus* spp.		4	1	7	10	6	3	2	27	9	4	3	6	10	6	1	1	1	2	
8	*Lepus nigricollis*	1						1	1					1	6		1		2	2	
9	Aves		1		2	3			2	1	2	1			2	2	1	2			
10	*Varanus bengalensis*	2								1					1						
11	Anura	1	2	1	3	5								1	5	4	2	2	2	3	
12	*Paratelphusa* sp.													1							
13	Orthoptera					3		1		2	3	1	3							1	
14	Coleoptera				2	9	2	9	3	3	4	6	9	2	1	4	8	1		2	

* Young with parents

Table 5. Month by month breakdown of prey of* Bubo bengalensis *at Success: January – December 2003

	Prey	2003											
		J*	F*	M*	A*	M*	J*	J*	A*	S	O	N	D
1	*Suncus murinus*		1	8	3	3	1			2			
2	Chiroptera					2	3				1		
3	*Tatera indica*	12	16	13	19	15	29	17	12	9	7	6	10
4	*Rattus rattus*	4	12	19	10	12	25	10	7	6	6	4	2
5	*Bandicota indica*					3							
6	*Bandicota bengalensis*		2	7			1	2			1	2	
7	*Mus* spp.	2	1	1	1	2	1	5	1	1		1	4
8	*Lepus nigricollis*					2	2			1		1	1
9	Aves				4	3	2			1	2	3	
10	*Varanus bengalensis*				1								1
11	Anura	2	1						4	8	12	9	6
12	*Paratelphusa* sp.										1		
13	*Heterometrus swammerdami*								2				
14	Orthoptera					1	1	2					
15	Coleoptera				2	2	17	11	7	1		1	1

* Young with parents

existence and *Funambulus palmarum* due to its diurnal habits. The near lack of *Millardia meltada* in the diet of *Bubo bengalensis* and complete lack in trap success may be due to the species' affinity for rocky areas (Srinivasulu *et al.*, 2004), grasslands with heavy soils (Rana & Prakash, 1984) and agricultural fields (Barnett & Prakash, 1975; Fall, 1977; Rana & Prakash, 1980, 1984). These types of habitats were not in existence in the study area.

Major fluctuations with resultant impacts on predators occur in rodent populations in temperate zones (Elton, 1942; Lockie, 1955; McWilliam, 1941; Pitelka *et al.*, 1955). In tropical climates, with food available throughout the year, only minor stastical differences in seasonal variations occur in the wild, as evidenced in this study. Yet major fluctuations,coinciding with farming practices, have been recorded in rodent populations in agricultural fields in India (Rana & Prakash, 1984; Kumar, 1985), though when living in granaries, with year long stocks of food, no major variations were discernible (Advani & Rana, 1984). Thus, it could be safely concluded that, as primary producers influence populations of primary consumers, perennial sources of food result in a stable prey base.

Seasonal fluctuations in diet concerning birds were quite distinct. It was not possible to positively identify bird remains from pellets, but if carcass remains were any measure to go by, then a strong pattern emerges. The first season (March-June) co-incides with the breeding season of species identified - *Vanellus indicus, Francolinus pondicerianus* and *Alauda gulgula*. The second season (August-December) coincides with the arrival of migrants after the south-west monsoons and lasts till the coolest month of December. Of the five species identified, three were migrants and November onwards is the breeding season for *Anthus rufulus*. The reason for predation on *Milvus migrans govinda is* not clear, but it could be that these owls are intolerant towards other raptors, and once having killed them are attracted to their flesh. Reptiles being at the lower end of the frequency occurrence, no pattern of predation was visible. Frogs, needing water in which to breed and exist, naturally occur only after the rainy season when water stagnates in the many reservoirs.

Terrestrial arthropods formed part of the prey spectrum of *Bubo bengalensis,* albeit in low quantities, but it is significant that insects have more protein-rich material compared to vertebrates (Reinecke, 1977) and, hence, are of great nutritional value.

This report is just the beginning of an exercise in unravelling the prey spectrum of *Bubo bengalensis*, and we still have a long way to go in understanding the dynamics of predator-prey relationships and their ramifactions on the environment. Studies on *Bubo bubo* have reached the stage where food items influence predictive models of habitat preferences (Martinez, 2003) and landscape structure and breeding preformance (Penteriani *et al.*, 2002). Such studies are still in their infancy, but a start has been made and it may be possible to use data presented here in Population and Habitat Viability Assessments (PHVA); for example, the quantity of *Lepus nigricollis* predated on to give the intrinsic value of a breeding site. This is important because long-lived species like *Bubo bengalensis* are ideal bioindicators of environmental change, and given their position towards the top of food chains and their fundamental role in ecological processes, they should be considered key species in landscape management.

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Table 6. Fruiting phenology of plant whose fruits were diagonised as food of murid rodents from gut analysis.

	Species	Fruiting Months											
		J	F	M	A	M	J	J	A	S	O	N	D
1	*Alangium salviifolium*				X	X	X	X	X				
2	*Azadirachta indica*					X	X	X	X				
3	*Buchanania axillaries*			X	X	X	X						
4	*Capparis brevispina*						X	X	X				
5	*Capparis divaricata*				X	X	X	X	X				
6	*Capparis rotundifolia*					X	X	X	X	X	X		
7	*Capparis sepiaria*	X	X	X	X	X	X	X	X	X	X	X	X
8	*Capparis zeylanica*			X	X	X	X	X	X	X	X		
9	*Carissa spinarum*	X	X	X	X	X	X	X	X	X	X	X	X
10	*Cissus quadrangularis*	X	X	X	X	X	X	X	X	X	X	X	X
11	*Cissus vitiginea*	X	X	X	X	X	X	X	X	X	X	X	X
12	*Clausena dentate*							X	X	X			
13	*Coccinia grandis*	X	X	X	X	X	X	X	X	X	X	X	X
14	*Cocculus hirsutus*	X	X	X	X	X	X	X	X	X	X	X	X
15	*Cordia monoica*	X	X						X	X	X	X	X
16	*Dendrophtoe falcate*	X	X	X	X	X	X	X	X	X	X	X	X
17	*Diospyros melanoxylon*			X	X	X							
18	*Drypetes sepiaria*			X	X	X	X	X	X	X			
19	*Ehretia pubescens*		X	X	X	X	X	X	X	X	X	X	
20	*Eugenia bracteata*	X	X	X	X	X	X	X	X	X	X	X	X
21	*Ficus amplissima*			X	X	X							
22	*Ficus bengalensis*				X	X	X	X	X				
23	*Ficus hispida*	X	X	X	X	X	X	X	X	X	X	X	X
24	*Ficus racemosa*			X	X	X	X	X					
25	*Garcinia spicata*				X	X	X	X	X				
26	*Glycosmis mauritiana*	X	X	X	X	X	X	X	X	X	X	X	X
27	*Gmelina asiatica*				X	X	X	X	X	X			
28	*Grewia bracteata*	X	X	X	X	X	X	X	X	X	X	X	X
29	*Grewia rhamnifolia*	X	X	X	X	X	X				X	X	X
30	*Jasminum angustifolium*							X	X	X	X		
31	*Lannea coromandelica*			X	X	X	X						
32	*Lantana camara*	X	X	X	X	X	X	X	X	X	X	X	X
33	*Madhuca indica*				X	X	X	X	X	X	X		
34	*Madhuca longifolia*				X	X	X	X	X	X	X		
35	*Manilkara hexandra*		X	X	X	X	X						
36	*Mangifera indica*					X	X	X	X				
37	*Memecylon umbellatum*							X	X	X	X	X	
38	*Mimusops elengi*	X	X	X		X	X	X	X	X	X	X	X
39	*Morinda pubescens*	X	X	X	X	X	X	X	X	X	X	X	X
40	*Mukia maderaspatana*	X	X	X									
41	*Murraya paniculata*	X	X	X	X	X	X	X	X	X	X	X	X
42	*Ochna obtusata*				X	X	X	X	X				
43	*Olax scandens*			X	X	X	X	X	X	X	X	X	
44	*Pachygone ovata*			X	X								
45	*Passiflora foetida*	X	X	X	X	X	X	X	X	X	X	X	X
46	*Pavetta indica*						X	X	X	X			
47	*Phoenix pusilla*				X	X							
48	*Polyalthia longifolia*					X	X	X					
49	*Premna corymbosa*		X	X	X								
50	*Premna serratifolia*	X	X	X	X	X	X	X	X	X	X	X	X
51	*Premna tomentosa*		X										
52	*Salacia chinensis*				X	X	X	X	X	X	X		
53	*Solanum trilobatum*		X	X	X								
54	*Spondias pinnata*				X	X	X						
55	*Strynchos minor*							X	X	X	X		
56	*Syzygium cumini*									X	X		
57	*Tarenna asiatica*	X	X	X	X	X	X	X	X	X	X	X	X
58	*Tinospora cordifolia*	X	X	X	X	X	X	X	X	X	X	X	X
59	*Toddalia asiatica*	X	X										
60	*Tricalysia sphaerocarpa*						X	X	X	X	X	X	
61	*Tylophora indica*	X	X	X	X	X	X	X	X	X	X	X	X
62	*Ventilago maderaspatana*	X	X	X	X	X	X	X	X	X	X	X	X
63	*Viscum orientale*	X	X	X	X	X	X	X	X	X	X	X	X
64	*Walsura trifoliatata*					X	X	X	X	X			
65	*Ziziphus oenoplia*	X									X	X	X
Number of species fruiting		27	31	37	43	49	49	48	47	40	37	29	26
Fruiting percentage		41.53	47.69	56.92	66.15	75.38	75.38	73.84	72.30	61.53	59.92	44.61	40.00

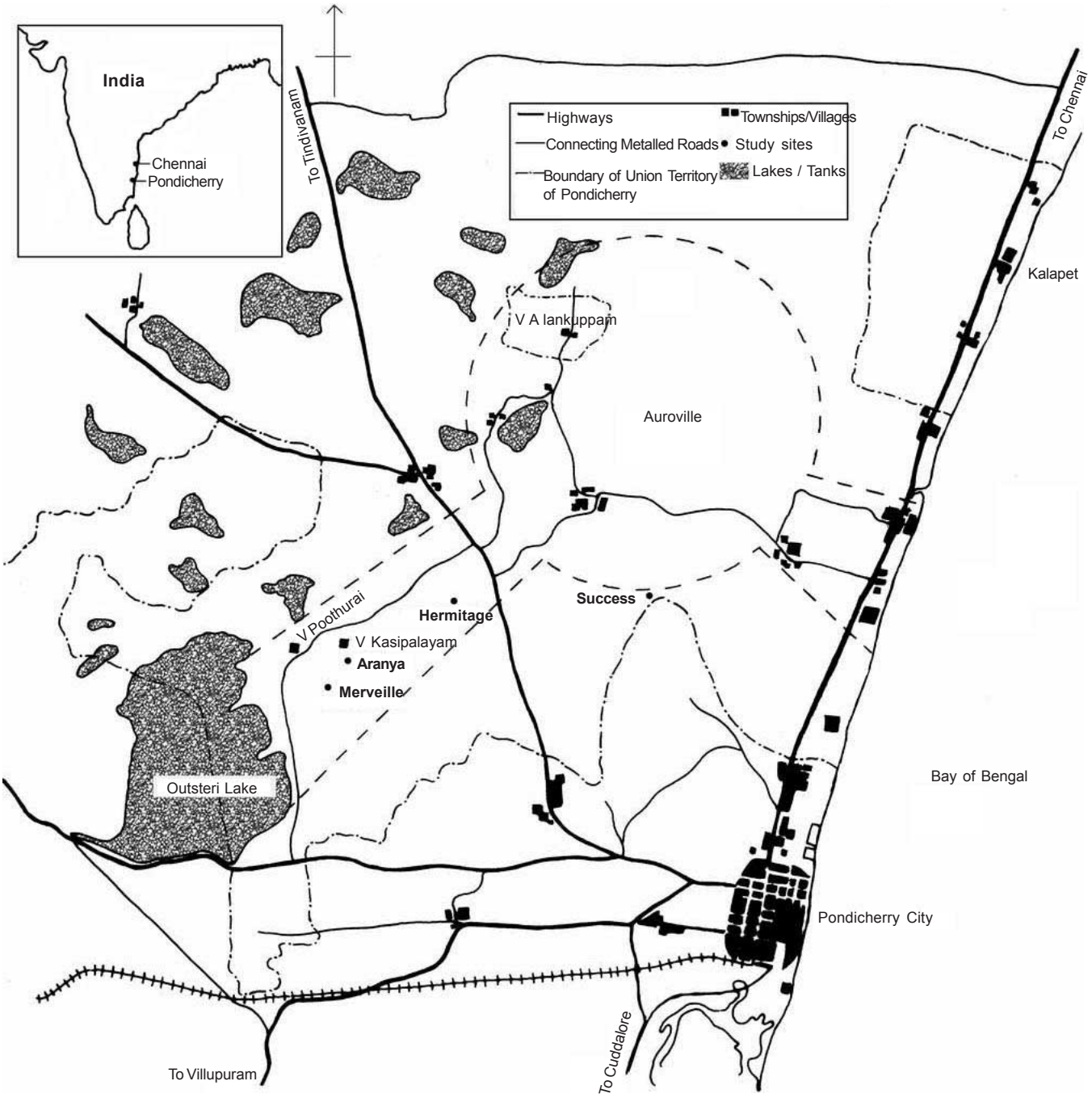

Figure 1. Map of study area and sites

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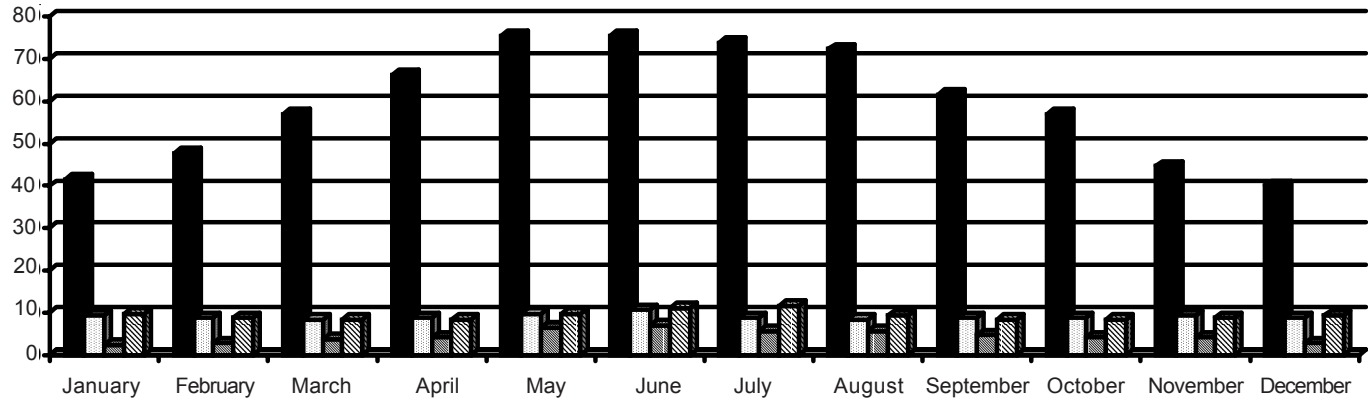

Month	Fruiting percentage	Mean percentage trap success		
		Tatera indica	*Rattus rattus*	*Mus* spp.
J	41.53	9.25	2.31	9.72
F	47.69	8.79	2.77	8.79
M	56.92	8.33	3.70	8.33
A	66.15	8.79	4.16	8.33
M	75.38	9.72	6.48	9.72
J	75.38	10.64	6.94	11.11
J	73.84	8.79	5.55	11.57
A	72.3	8.33	5.55	9.25
S	61.53	8.79	4.62	8.33
O	56.92	8.79	4.16	8.33
N	44.61	9.25	4.16	8.79
D	40.0	8.79	2.77	9.25

Figure 2. Mean rainfall, fruiting percentage and percentage trap success for three species of rodents in the years 2002 and 2003.

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