



METHODS

Amphibian and Reptilian Inventories Augmented by Sampling at Heronries

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Abstract.—An alternate method for supporting amphibian and reptilian inventory was tested. This experimental method involved the collection of regurgitated food from water bird nestlings from a total of 10 heronries: four mixed-species and six single-species heronries in Gujarat State, India, during 1997 to 1999. We verified the presence of twelve species of amphibians, and twelve species of reptiles were recovered intact.

Various methods are used to evaluate the diversity of amphibians and reptiles, many of which are resource-dependent in terms of both time and money (e.g., Heyer et al. 1994). The verification process in such diversity surveys generally requires the collection of voucher specimens for establishing the credibility of the work (Dubois and Nemesio 2007; Funk et al. 2005). Vouchers also facilitate further taxonomic studies and the identification of cryptic species, especially when species complexes occupy the area being surveyed. The collection of specimens requires permission from the appropriate government authority. Because relevant authorities in India often are hardcore believers of the philosophy of “*Jiv Daya*” (a Jainist concept involving compassion for all beings) and unaware of the need for voucher specimens, acquisition of permits to collect in protected areas (sanctuaries and national parks), even for studies of biodiversity and environmental assessments is extremely difficult. Even when permission for voucher collection is granted, strict time constraints are imposed. These render surveys of large areas almost impossible, particularly because vouchers ideally involve a series of specimens of various species (Goodman and Lanyon 1994) and collection methods often are very time consuming. Consequently, methods that are less time-consuming and less expensive are needed. Herein, we test one such alternative.

Materials and Methods

We collected amphibians and reptiles from heronries of egrets, herons, and cormorants, using hand-captures supplemented by a technique more commonly employed by ornithologists for obtaining data on the food spectrum of such birds (e.g., Seigfried 1971; Jenni 1973; Kushlan 1978). The diet of many egrets and herons consists of various types of insects, along with fishes, amphibians, reptiles, and mammals (Kushlan 1978; Sodhi 1992; Mathew et al. 1997). Especially during the breeding season, 45% of the diet of these species can comprise amphibians and reptiles (Sodhi and Khera 1984). These birds are widely distributed in many parts of the world, including the Indian Subcontinent, and all are colonial breeders. In India, the breeding season more or less coincides with the southwest monsoon (Ali and Ripley 1983), which also is the breeding season of many species of amphibians (Chandra 2002; Das and Dutta 2007) and reptiles (Daniel 2002).

Like other herons and egrets, frightened nestlings of Cattle Egrets will regurgitate food stored in the crop and gizzard

(Hanebrink and Denton 1969; Jenni 1969). Because this is the least invasive method of studying the food consumed by nestlings (Patel 1996), they were frightened by striking a bamboo or lightweight aluminum pole against a tree branch while simultaneously shouting or clapping. Nestlings responded by immediately regurgitating a bolus, which was carefully collected, stored in a plastic bottle, preserved in a 5–10% formalin solution, labeled, and taken to the laboratory for further study.

To test the efficacy of this method for conducting surveys, we made observations and collected boluses during the southwest monsoon (July–September) in 1997, 1998, and 1999 at ten heronries (Fig. 1), four along the margins of protected areas and six in urban areas. Four heronries were mixed-species and six were single-species heronries (exclusively Cattle Egrets). However, even in the mixed-species heronries, Cattle Egrets were the most abundant species (Table 1) and the only one that is largely a terrestrial feeder (Hancock and Kushlan 1984). Cormorants, herons, and other egrets feed primarily in aquatic habitats (Ali and Ripley 1983).

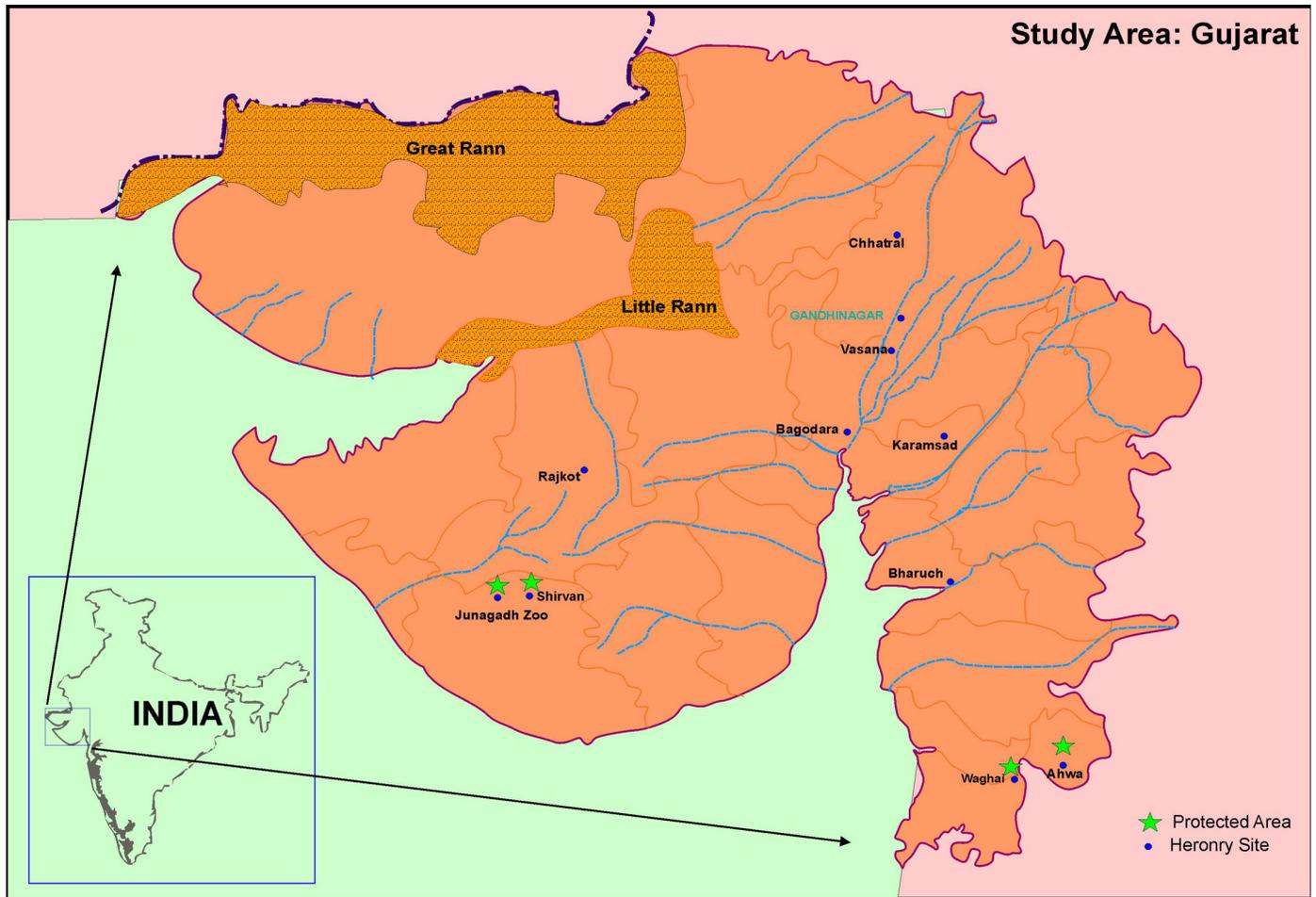


Fig. 1. The study area in Gujarat State showing the location of surveyed heronries (see also Table 1).

Results

We collected 24 species of amphibians and reptiles, including 12 species of frogs and toads, one species of turtle, eight species of lizards, and three species of snakes (Table 2). Twelve species were in regurgitated food boluses, four of which (*Microhyla ornata*, *Euphlyctis hexadactylus*, *Eutropis carinata*, and *Eutropis macularia*) were found in four or more heronries, five (*Polypedates maculatus*, *Lygosoma albopunctata*, *Lygosoma guentheri*, *Amphiesma stolata*, and *Xenochrophis piscator*) in only two heronries, and three (*Ramanella* sp., *Lissemys punctata* hatchlings, and an adult *Echis carinata*) were limited to small areas within a single heronry.

The greatest numbers of amphibian and reptilian species were recovered from large and medium-sized single-species heronries at Waghai (20 species) and Ahwa (19 species), respectively (Table 1). Although both Bharuch and Waghai are large heronries, more species were recovered from the single-species heronry at Waghai than from the mixed-species urban heronry at Bharuch (14). The least number of species was recovered from a small single-species urban heronry in Rajkot (7).

Discussion

Food habits of Cattle Egrets are catholic (Hancock and Kushlan 1984), hence the great diversity of reptiles and amphibians in the diet (Figs. 2 & 3). However, Cattle Egrets are terrestrial and rarely feed in marshy areas, reducing the likelihood of feeding on purely aquatic vertebrates. Consequently, small terrestrial vertebrates dominate their diet. On the other hand, cormorants, herons, and the other egrets feed primarily on aquatic organisms (fishes, occasional amphibians and aquatic snakes like the Buff-striped Keelback, *Amphiesma stolata*). With the exception of the Indian Flapshell Turtle (*Lissemys punctata*), few small reptiles occur in marshy/shallow waters. This presumably accounts for the relatively low number of amphibian and reptilian species recovered from the Bharuch heronry when compared to that at Waghai (mixed-species heronry vs. single-species heronry) despite both being large in size.

The amphibian and reptilian species found in regurgitated boluses were common and widely distributed, except *Ramanella* sp., which is restricted to the Dang Forest south of the Narmada River in Gujarat (Vyas 1998, 2008). In con-

Table 1. Heronries in Gujarat State, India, surveyed during this study. Large heronries (>2,000 nests); medium (2,000–1,000 nests); small (<1,000 nests). Bird species: Indian Pond Heron (*Ardeola grayii*), Cattle Egret (*Bubulcus ibis*), Great Egret (*Casmerodius albus*), Little Egret (*Egretta garzetta*), Intermediate Egret (*Mesophoyx intermedia*), Black-crowned Night Heron (*Nycticorax nycticorux*), and Little Cormorant (*Phalacrocorax niger*).

Site (Year of Survey) Coordinates	Bird Species	Size	Number of Prey Species in Boluses	Remarks
Junagadh Zoo (1997) 21°32'31.79"N 70°27'56.18"E	<i>Bubulcus ibis</i> <i>Egretta garzetta</i> <i>Phalacrocorax niger</i>	Medium	14	Near Protected Forest (now Girnar Wildlife Sanctuary)
Shirvan, Talala (1997)	<i>Bubulcus ibis</i> <i>Egretta garzetta</i>	Small	14	Settlement in Girnar Wildlife Sanctuary
Rajkot City (1997) 22°16'57.22"N 70°49'19.74"E	<i>Bubulcus ibis</i>	Small	7	Urban area
Bagodara (1997) 22°38'17.41"N 72°12'05.59"E	<i>Bubulcus ibis</i>	Medium	13	Urban area
Chhatral (1997) 23°16'49.51"N 72°26'47.74"E	<i>Bubulcus ibis</i>	Medium	12	Rural area
Vasna Village (1997) 22°59'02.14"N 72°33'36.79"E	<i>Bubulcus ibis</i>	Small	11	Rural area
Karamsad (1997) 22°32'32.93"N 72°54'20.89"E	<i>Bubulcus ibis</i> <i>Egretta garzetta</i> <i>Phalacrocorax niger</i>	Medium	16	Urban area
Bharuch City (1997) 21°42'45.53"N 73°00'04.28"E	<i>Ardeola grayii</i> <i>Bubulcus ibis</i> <i>Casmerodius albus</i> <i>Egretta garzetta</i> <i>Mesophoyx intermedia</i> <i>Nycticorax nycticorux</i>	Large	14	Urban area
Waghai, Dangs (1999) 20°46'27.50"N 73°29'46.72"E	<i>Bubulcus ibis</i>	Large	20	Near Vansada National Park
Ahwa, Dangs (1999) 20°45'01.17"N 73°29'46.72"E	<i>Bubulcus ibis</i>	Medium	19	Near Purna Wildlife Sanctuary



Fig. 2. A foraging Cattle Egret (*Bubulcus ibis*) with a Common Asian Toad (*Duttaphrynus melanostictus*). Photographs by Kartik Upadhyay.



Fig. 3. A foraging Cattle Egret (*Bubulcus ibis*) with a juvenile Checkered Keelback (*Xenochrophis piscator*). Photograph by Manoj Thaker.

trast, those species found only in specific heronries either had restricted distributions or were commonly encountered only during the monsoons.

Few of the Indian studies on the diets of nestling Cattle Egrets (Sodhi 1992) or other water birds (Mukherji 1972; Sodhi 1985, 1986, 1989; Sodhi and Khara 1986) attempted to identify amphibians and reptiles at the species level. Hence, this is the first report in which amphibians and reptiles recov-

ered from regurgitated food boluses of Cattle Egrets and other water birds are identified at that level.

Consumption of the Flap-shell Turtle (*Lissemys punctata*) by the Black-necked Stork (Vyas and Thaker 2014) and the Lesser Adjutant Stork (Sivasubramanian and Bhupathy 1991) is well documented. However, smaller birds like the Cattle Egret were not known to feed on these turtles, so this report represents a new record. Similarly, the consumption of a venomous adult Saw-scaled Viper (*Echis carinata*) by a Cattle Egret is noteworthy.

Cattle Egrets usually breed during the southwest monsoon in northwestern India, with slight deviations depending on local conditions (Ali and Ripley 1983; Parasharya and Naik 1990). Considering asynchronous nesting in a given heronry (Parasharya and Naik 1990) or an area (Breedon and Breedon 1982), heronries could be sampled repeatedly over a three-month monsoon period. Repeated sampling would increase the likelihood of encountering amphibian and reptilian species that are less abundant or appear only under specific conditions (rain, agricultural operations, etc.).

Every survey method has advantages and disadvantages. Limitations of this supplementary method include: (1) Specific habitats and microhabitats of amphibian and reptilian species cannot be determined; (2) chances of acquiring intact specimens are reduced; (3) sampling at heronries is possible only during the birds' breeding seasons; and (4) it is useful only for smaller and mostly terrestrial species. Advantages are: (1) It consumes less time and money; (2) it does not require permission to collect specimens (although permission might

Table 2. Species of amphibians and reptiles found in regurgitated food boluses in heronries in Gujarat State, India. Heronries (see also Table 1): Junagadh Zoo (J), Shirvan, Talala (S), Rajkot City (R), Bagodara (B), Chhatral (C), Vasna Village (V), Karamsad (K), Bharuch City (BC), Waghai, Dangs (W), and Ahwa, Dangs (A). Species: Common Asian Toad (*Duttaphrynus melanostictus*), Indian Marbled Toad (*Duttaphrynus stomaticus*), Ornate Narrow-mouthed Frog (*Microhyla ornata*), Balloon Frog (*Uperodon* sp.), Marbled Balloon Frog (*Uperodon systoma*), Indian Skipper Frog (*Euphlyctis cyanophlyctis*), Indian Green Frog (*Euphlyctis hexadactylus*), Indian Bullfrog (*Hoplobatrachus tigerinus*), Indian Burrowing Frog (*Sphaerotheca breviceps*), South Asian Cricket Frog (*Zakerana* sp.), Common Indian Treefrog (*Polypedates maculatus*), Indian Flapshell Turtle (*Lissemys punctata*), Brook’s House Gecko (*Hemidactylus* c.f. *brookii*), Oriental Garden Lizard (*Calotes versicolor*), Fan-throated Lizard (*Sitana* c.f. *ponticeriana*), White-spotted Supple Skink (*Lygosoma albopunctata*), Günther’s Writhing Skink (*Lygosoma guentheri*), Dotted Writhing Skink (*Lygosoma punctatus*), Keeled Indian Mabuya (*Eutropis carinata*), Bronze Mabuya (*Eutropis macularia*), Buff-striped Keelback (*Amphiesma stolata*), Checkered Keelback (*Xenochrophis piscator*), and Saw-scaled Viper (*Echis carinata*).

Family	Species	J	S	R	B	C	V	K	BC	W	A
FROGS (ANURA)											
Bufonidae	<i>Duttaphrynus melanostictus</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	<i>Duttaphrynus stomaticus</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Microhylidae	<i>Microhyla ornata</i>	Y							Y	Y	Y
	<i>Uperodon</i> sp.									Y	
	<i>Uperodon systoma</i>		Y	Y	Y	Y	Y	Y	Y	Y	Y
Dicroglossidae	<i>Euphlyctis cyanophlyctis</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	<i>Euphlyctis hexadactylus</i>	Y	Y					Y		Y	
	<i>Hoplobatrachus tigerinus</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	<i>Sphaerotheca breviceps</i>	Y	Y		Y	Y	Y	Y	Y	Y	Y
	<i>Zakerana</i> sp.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	<i>Zakerana</i> sp.	Y	Y		Y	Y		Y	Y	Y	Y
Rhacophoridae	<i>Polypedates maculatus</i>									Y	Y
TURTLES (TESTUDINES)											
Trionychidae	<i>Lissemys punctata</i>							Y			
LIZARDS (SQUAMATA)											
Gekkonidae	<i>Hemidactylus</i> c.f. <i>brookii</i>	Y	Y		Y		Y	Y	Y	Y	Y
Agamidae	<i>Calotes versicolor</i>	Y	Y		Y	Y	Y	Y	Y	Y	Y
	<i>Sitana spinaecephalus</i>	Y	Y		Y	Y	Y	Y	Y	Y	Y
Sphenomorphidae	<i>Lygosoma albopunctata</i>				Y					Y	
	<i>Lygosoma guentheri</i>									Y	Y
	<i>Lygosoma punctata</i>	Y	Y	Y		Y	Y	Y	Y		Y
Mabuyidae	<i>Eutropis carinata</i>				Y			Y		Y	Y
	<i>Eutropis macularia</i>	Y	Y						Y	Y	Y
SNAKES (SQUAMATA)											
Natricidae	<i>Amphiesma stolata</i>									Y	Y
	<i>Xenochrophis piscator</i>							Y			Y
Viperidae	<i>Echis carinata</i>				Y						

be necessary to salvage dead specimens in protected areas); and (3) it can provide tentative data regarding the population status (abundant/ rare/presumably absent) of amphibians and reptiles within the sampled area.

To date, we have tested this supplementary survey technique only in Gujarat State, which has a moderate amphibian and reptilian species richness, with over 23 species of amphibians (Vyas 2005) and 114 species of reptiles (Vyas 2007). If tested elsewhere on the Subcontinent, we believe it is likely to detect a greater number of species.

Acknowledgements

We thank the Forest Department of Gujarat for permission to conduct research in protected areas. We also thank Karitk Upadhyay (Vadodara) for providing egret photographs. RV is thankful to the late Vijayraj Jadeja, Curator, Sayaji Baug Zoo, Vadodara for support and encouragement. BMP is grateful to the Director of Research, Anand Agricultural University, Anand for encouragement.

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