

# Significant bird records and local extinctions in Purna and Ratanmahal Wildlife Sanctuaries, Gujarat, India

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We carried out fieldwork in Purna Wildlife Sanctuary and Ratanmahal Wildlife Sanctuary in the fragmented eastern forest belt, Gujarat, India, between September 1999 and March 2003, and made occasional observations in the area during 1989–2004. We documented the first records of Brown Wood Owl *Strix leptogrammica* and Large-tailed Nightjar *Caprimulgus macrurus* in Gujarat, and recorded six species new for the reserves and eleven other noteworthy species. We identify eight species that may be locally extinct and 14 other species that may be susceptible to forest loss and degradation owing to their rarity, habitat specificity, foraging guild, body size, endemism, and/or edge-of-range distribution. Hunting and biotic homogenisation may also be contributing to local avifaunal impoverishment.

## INTRODUCTION

Gujarat, the westernmost state of India, owes its rich avifauna to its diverse range of habitats, geographical location along the Indus flyway, and tradition of conservation (Khacher 1996). The diversity of habitats includes deciduous and thorn forests, grasslands, wetlands, marine intertidal areas, scrublands and saline deserts (Singh 2001). The eastern part of Gujarat harbours about 50% of the state's forests. These are mainly found along the four major mountain ranges: the Aravallis, the Vindhyas, the Satpuras and the Western Ghats. These forests contain the westernmost moist deciduous forest patches in the Indian peninsula and they mark the westernmost limits of several species of forest plants (e.g. teak *Tectona grandis*) and animals (e.g. tiger *Panthera tigris* and sloth bear *Melursus ursinus*) in India. In addition, the state also includes the easternmost range limits of several arid and semi-arid zone species (e.g. Asiatic lion *Panthera leo persica*). Ali (1950) suggested that the Satpura mountain range has played an important role in the dispersal of Indomalayan forms to the Western Ghats, a global biodiversity hotspot. Thus, with respect to Indian ornithogeography, eastern Gujarat is an important region. Considering this, relatively few studies have been carried out to document the avifauna of the region (Table 1).

Large-scale habitat change has taken place since the survey of Ali (1954–1955), and once-contiguous forests are today severely fragmented and disturbed by human activity (Khacher 1996, Singh 2001). For many forest

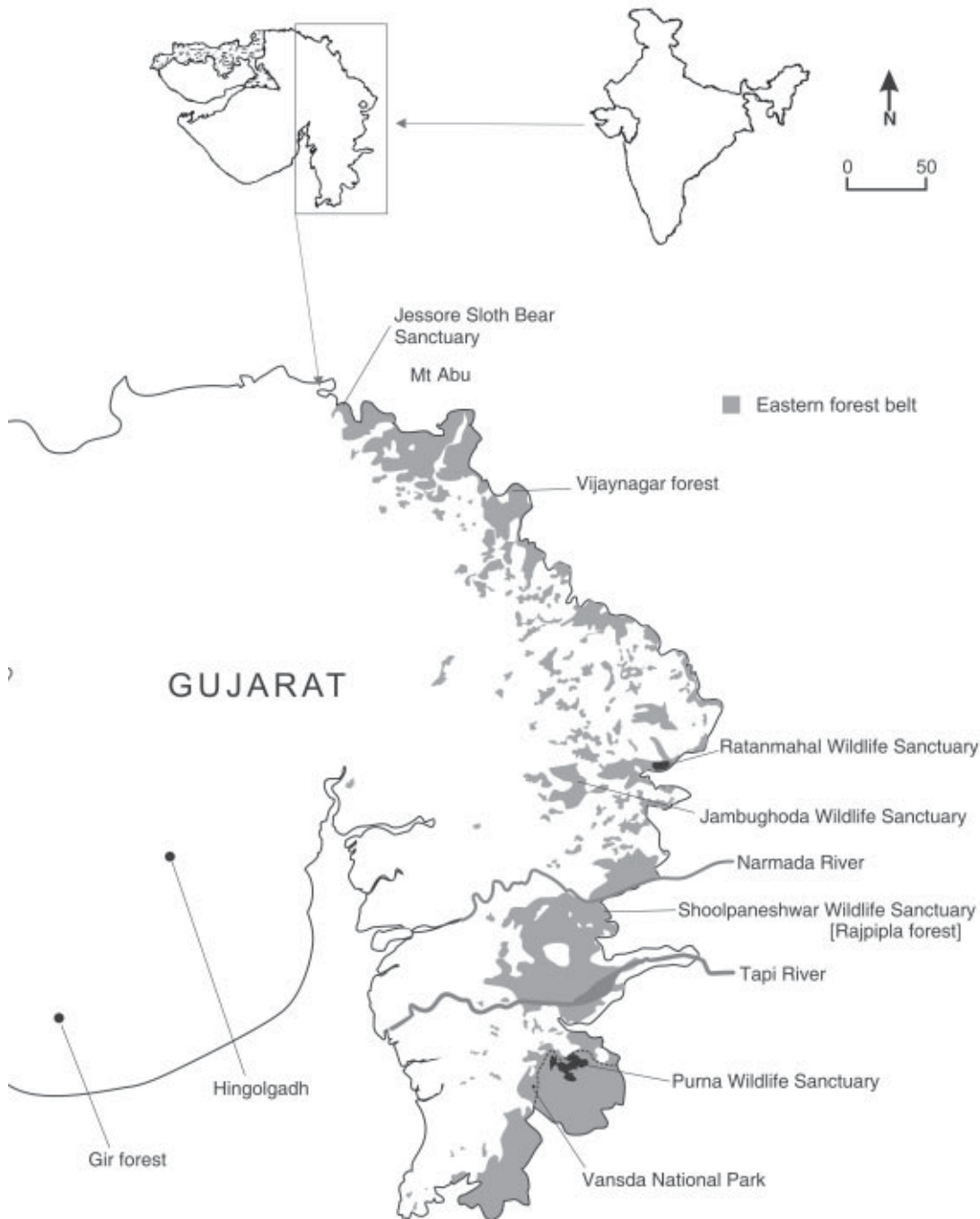
areas in this region, even basic presence/absence data on bird species is unavailable. Such gaps in information hamper the assessment of the status of the forest avifauna and hinder effective conservation planning. This is especially true in the light of documented impacts of habitat loss, fragmentation, degradation and other anthropogenic factors on forest avifauna across the globe in the past two decades (e.g. Simberloff 1985, Newton 1995, Laurance *et al.* 2002). These impacts do not necessarily affect all birds equally: several studies have found that certain groups are more vulnerable than others (see Lindenmayer *et al.* 2002, Henle *et al.* 2004 for reviews). Our study was carried out in part to document the occurrence and abundance of such sensitive forest bird species to facilitate their conservation.

## STUDY SITES

Intensive studies were carried out at Purna Wildlife Sanctuary (hereafter Purna) and Ratanmahal Wildlife Sanctuary (hereafter Ratanmahal). Purna (161 km<sup>2</sup>) is located between 20°51'N 73°32'E and 21°31'N 73°48'E. It lies in Dangs district, located in the northernmost part of the Western Ghats biogeographic zone. The Western Ghats have been identified as a global biodiversity hotspot and an Endemic Bird Area (Stattersfield *et al.* 1998, Myers *et al.* 2000). Purna has moist and dry deciduous forests with bamboo brakes and extensive teak, 'khair' *Acacia catechu* and bamboo *Dendrocalamus strictus* and *Bambusa*

**Table 1.** Avifaunal studies in the eastern forest belt of Gujarat (WLS = Wildlife Sanctuary, NP = National Park).

Area	Survey period	Reference
Dangs (including present Purna WLS and Vansda NP)	1946 and 1948 (1 month each)	Ali (1954–1955)
Jambughoda Forest (now WLS)	1944–1948	Ali (1954–1955)
Rajpipla forests (now partly Shoolpaneshwar WLS)	1944–1948	Ali (1954–1955)
Balaram forest, Palanpur (now Balaram-Ambaji WLS)	1944–1948	Ali (1954–1955)
Rajpipla forests	July 1981–January 1983	Monga and Naoroji (1983)
Shoolpaneshwar WLS	December 1989–March 1992	Desai <i>et al.</i> (1993)
Dangs forests (including Purna)	1988–1990	Worah (1991)
Vansda NP	April 1998–August 2000	Singh <i>et al.</i> (2000)
Ratanmahal WLS	September 1999–January 2001	Present study (Trivedi 2001)
Purna WLS	June 2001–March 2003	Present study (Trivedi 2003)



**Figure 1.** Location of Purna and Ratanmahal Wildlife Sanctuaries, Gujarat, India.

*arundinacea* plantations (Worah 1991). The average annual rainfall is c.2,100 mm (Anon. 2001). Ratanmahal is located between 20°32'N 74°03'E and 20°35'N 74°11'E. It lies at the confluence of the Vindhya Range and Malwa Plateau adjoining the state of Madhya Pradesh. With an average annual precipitation of c.1,000 mm, it harbours dry deciduous forests dominated by teak, and some patches of moist deciduous biotopes with very little or no teak and with luxuriant bamboo brakes (Singh 2001, Trivedi 2001). Ratanmahal also has preponderance of 'mahuwa' *Madhuca indica* trees.

Most of the precipitation in these two protected areas occurs during the south-west monsoon, i.e., June–October, with July and August being the rainiest months. The terrain in both areas is hilly and rugged, with the highest altitude

being 574 m in Purna and 670 m in Ratanmahal. Both areas are rich in their flora (Bedi 1968, Singh *et al.* 2002) and possess high within-habitat heterogeneity (Trivedi 2001, 2003). Purna is free from human habitation (except one village located within the sanctuary), but Ratanmahal has several villages and their crop-fields within the sanctuary. Various other human activities, including moderate-to-heavy livestock grazing, wood cutting, fuelwood collection, collection of leaves (particularly of 'tendu' *Diospyros melanoxylon*), and the harvesting of bamboo and other non-wood forest produce occur in both sanctuaries, as do poaching and fishing (Singh *et al.* 2002, Trivedi 2003). Other areas referred to in the text are either dry deciduous forests with plantations or degraded forests in the eastern forest belt of Gujarat (see Fig. 1).

### Habitat loss and fragmentation

The loss, fragmentation and degradation of habitat caused by humans has been regarded as an important driver of species extinctions and of the impoverishment of regional biota. In the eastern forest belt of Gujarat, both fragmentation and complete loss of forests have been reported. Singh (2001) estimated that 1,782 km<sup>2</sup> of forest area in Gujarat (c.12% of the current total forest area of the state) was lost between 1960 and 2000 as a result of irrigation projects, agriculture, mining, road building, industry and the legalisation of encroachments. Purna has a long (c.100-year) history of systematic forestry (Worah 1991), whereas Ratanmahal has remained virtually free of intensive forestry practices (Singh *et al.* 2002). Worah (1991) reported a patchy distribution of forests in Dangs district (in which Purna is located), with a mean patch size of 28 km<sup>2</sup>. She regarded these forests as 'fragmented' owing to presence of several teak and bamboo monocultures, many of which were fairly young. Organised forestry has opened up the forests of Purna and surrounding regions through roads and associated anthropogenic disturbances. This has also led to habitat fragmentation. In Dangs district, selective felling between the late nineteenth and mid-twentieth centuries eliminated large trees. Between the 1960s and 1980s, several forest patches were clear-felled and converted into teak monocultures (Anon. 2001). Forestry operations of thinning and climber-cutting removed lianas as well as several species of low timber value associated with teak (Anon. 2001). This has changed the composition and structure of several forest patches, especially in accessible areas. Tree felling was stopped with a moratorium in 1987–1988 (Anon. 2001). However, the harvesting of bamboo on a large scale continues even today (Trivedi 2003). The habitat at Purna thus consists of a mosaic of plantations (mainly of teak) of various ages, secondary forests, and few patches of primary moist and dry deciduous forest. Worah (1991) and Singh *et al.* (2000) reported local extinctions of several mammals from Dangs district, including Indian giant squirrel *Ratufa indica dealbata*, tiger, gaur *Bos gaurus*, smooth-coated otter *Lutra perspicillata* and sloth bear.

### METHODS

In total, 70 days were spent in the field at the two sanctuaries (38 at Purna and 32 at Ratanmahal) during all seasons between September 1999 and March 2003. To prepare inventories of bird species we carried out extensive surveys over all terrain and vegetation types within the two sanctuaries. Line transects (without distance estimation) and intensive birdwatching along existing trails were used to obtain information on encounter rates, status and habitat use. For nocturnal species, we noted calls at selected locations by keeping vigil on 3–4 nights in each sanctuary in the dry seasons (winter and summer). Ten transects in Purna and five in Ratanmahal (varying in length from 1 to 3.5 km) were walked. We undertook 64 such walks, covering a total sampling distance of 83 km. The status of birds was determined based both on their encounter rates (individuals/km) on transects and on general observations throughout the study period. After calculating the encounter rates for each species on each transect, mean encounter rates for each species were derived by averaging

these. Thus, sample sizes for mean encounter rates were ten and five for Purna and Ratanmahal respectively. We supplemented our data with information gathered by PT between 1989 and 2004 through intensive birdwatching in the eastern forest belt. Information from the field was supplemented by secondary data collected through interviews with local residents and a survey of the literature.

To assess changes in the status of forest birds over time at Purna, we used two past data sets: Ali (1954–1955) and Worah (1991). There have been no previous surveys at Ratanmahal, so a detailed assessment of avifaunal changes here was not possible. Instead, we depended on secondary information collected from local residents and on previous observations made by PT during 1989–1991. To maximise our chances of detecting rare species, we searched intensively in all habitats and searched specifically for such species. We categorised the distribution (widespread or patchy) and nature of habitat occupancy (forest-interior, edge, open area, etc.) for species using Ali (1969), Worah (1991) and Grimmett *et al.* (1998). Feeding guilds were assigned based on the literature (Ali 1969, Grimmett *et al.* 1998, Raol 1998) as well as our observations in the field. Bird species susceptible to forest alteration and loss were identified primarily based on rarity (mean encounter rates <0.5 individual/km) and habitat specificity (forest-interior species and species preferring moist deciduous forest). This information was compared with published literature documenting susceptible taxa in the Oriental region (e.g. Johns 1986, Worah 1991, Mitra and Sheldon 1993, Raman 1995, Datta 2000, Castelletta *et al.* 2000, Raman 2001).

### RESULTS

A total of 191 species were recorded at the two sanctuaries: 139 at Purna and 147 at Ratanmahal.

#### New records for Gujarat

Two species, Large-tailed Nightjar *Caprimulgus macrurus* and Brown Wood Owl *Strix leptogrammica*, were recorded for the first time from the state. Neither species was recorded by earlier surveys or listed in checklists for Gujarat (Ali 1954–1955, Khacher 1996, ZSI 2000, Khacher and Raol undated).

#### BROWN WOOD OWL *Strix leptogrammica*

This species was seen at Purna in moist deciduous forest consisting of teak, *Adina cordifolia*, *Terminalia crenulata* and extensive brakes of *Bambusa arundinacea* (Trivedi 2003). Three daytime sightings were obtained at Dhulda, Bardipada range, on 22 March 2002 (one sighting) and 30 April 2002 (two sightings). Two sightings involved a pair (presumably the same pair), while the third was of a solitary individual. The pair was found perched in a bamboo clump and, when disturbed, flew a short distance within the middle storey and settled at a low height. The absence of concentric barring on the facial disks and the dark coloration clearly distinguished this species from the congeneric Mottled Wood Owl *S. ocellata*. Ali and Ripley (1983) described the distribution of the species as 'dense moist deciduous to semi-evergreen and evergreen biotopes at suitable locations throughout the country', while Grimmett *et al.* (1998) described it as inhabiting the Himalayas, north-east India, Eastern and Western Ghats. Its northernmost record in the Western Ghats is from the



Sanjay Gandhi National Park (Mumbai), Maharashtra (Prasad 2003). Thus our record is a northerly extension of the known range of this species by over 150 km.

#### LARGE-TAILED NIGHTJAR *Caprimulgus macrurus*

During surveys for nocturnal birds at Ratanmahal, a distinct *chaunk...chaunk...* call was heard on the plateau at the Ratanmahal temple near the Gujarat–Madhya Pradesh border at 19h00–19h30 on 3 and 17 March 2000. Based on the frequency of notes as well as on their long-drawn nature as compared with the *chunk...chunk...* call of the Grey Nightjar *C. indicus*, these calls were identified as belonging to the Large-tailed Nightjar. No visual observations were made. The closest prior records are by D'Abreu (1935), who described this species as breeding in densely shaded ravines of the former Central Provinces (presently Madhya Pradesh and Chhattisgarh states), and by Grimmett *et al.* (1998) from eastern Madhya Pradesh. Our record at Ratanmahal extends the known range of the species considerably to the west.

#### New records for Purna and Ratanmahal

##### BLACK EAGLE *Ictinaetus malayensis*

This species was sighted twice (on 20 August 2001 and 22 December 2001) at Purna (the first records for this site) and was also seen at Jambughoda Wildlife Sanctuary (hereafter Jambughoda) in January 2002, 2003, 2004 and 2005. The species was identified by its characteristic upward-angled primaries in flight, dark coloration, yellow cere and feet and, most notably, its behaviour of gliding low over the forest canopy. In Gujarat, this species has been reported from Jambughoda forest (Ali 1954–1955) and Gir forest (Dharmakumarsinhji 1985). In neighbouring states, Mashru (2004) recorded it from Mt Abu in Rajasthan and D'Abreu (1935) reported it from Madhya Pradesh.

##### ASHY WOODSWALLOW *Artamus fuscus*

We found c.10 individuals of this species at Ratanmahal on 10 September 2000. They were perched on telegraph wires and an adjacent tree while making aerial sallies to hawk insects. This species was not recorded by Ali (1954–1955) from Gujarat, but Khacher (1996) reported a sighting from the Rajpipla area (Narmada district, Satpura mountain range) and Worah (1991) recorded it in the Dangs district. Our record extends the known range of the species by c.75 km north.

##### GREATER RACKET-TAILED DRONGO *Dicrurus paradiseus*

This species was sighted 24 times (involving 29 individuals) in January, March, April, May, July and December at Ratanmahal and on 40 occasions (involving 58 individuals) in January, February, March, April, June and December at Purna. The mean encounter rate of the species was 0.97 birds/km (SD=0.83) at Ratanmahal and 0.91 birds/km (SD=0.69) at Purna. It was found to be a sentinel species (and possibly an 'active-nuclear' species) in mixed-species flocks at both Ratanmahal and Purna, and it probably plays a key role in such flocks. Ali (1954–1955) reported this species to be common in bamboo and mixed deciduous forests south of the Narmada river, while Monga and Naoroji (1983) and Desai *et al.* (1993) recorded it from Rajpipla forests (now Shoolpaneshwar Wildlife Sanctuary), south of the Narmada. Ratanmahal

appears to be the northernmost limit of this species in India and possibly the westernmost boundary of its global range.

##### BLUE-CAPPED ROCK THRUSH *Monticola cinclorhynchus*

We recorded three sightings (of single individuals) of this species: one in Purna (22 March 2002) and two in Ratanmahal (on the plateau at the Ratanmahal temple near the Gujarat–Madhya Pradesh border on 19 and 30 January 2000). These were the first records at Ratanmahal. At Purna the species was not sighted on transects, while at Ratanmahal, it was sighted on one transect once, with a mean encounter rate of 0.03 birds/km (SD=0.08). All three birds were in dense bamboo brakes in moist deciduous forest. The species is reported to overwinter mainly in the Western Ghats (Grimmett *et al.* 1998) and in Gujarat it has been reported from Hingolghadh (Khacher 1996), Rajpipla forests (Monga and Naoroji 1983) and Dangs district (singly or in pairs in very small numbers during February and March: Ali 1954–1955).

##### ORANGE-HEADED THRUSH *Zoothera citrina*

At Ratanmahal, two sightings of this species were made: two individuals on a transect on 23 July 2000 (Trivedi 2001) and one on 22 July 2000, while at Purna it was sighted on nine occasions (involving 11 individuals) on two transects during June of 2002. The mean encounter rate was 0.07 birds/km (SD=0.15) at Ratanmahal and 0.19 birds/km (SD=0.40) at Purna. The race was identified as *Z. c. cyanotus* based on the presence of two vertical black stripes across the white ear-coverts and throat. In Gujarat, the species has been reported previously only from south of the Narmada river (Monga and Naoroji 1983, Ali 1954–1955). Our records from Ratanmahal extend its known range to c.75 km north of the Narmada river. The species appears to be a summer visitor and possibly breeds at both sites.

##### CRIMSON SUNBIRD *Aethopyga siparaja*

This species was sighted at Purna and Ratanmahal, and was fairly common in teak and mixed moist forest with *Bambusa arundinacea*. Five sightings (involving seven individuals) were made at Ratanmahal and 29 sightings (involving 42 individuals) were made at Purna. The mean encounter rate was 0.23 birds/km (SD=0.34) at Ratanmahal and 0.74 birds/km (SD=0.94) at Purna. The race observed at both sanctuaries was *A. s. vigorsii* of the Western Ghats. In Gujarat, Ali (1954–1955) recorded the species south of river Narmada at Rajpipla forest. It has also been reported from Shoolpaneshwar Sanctuary in Narmada district (Monga and Naoroji 1983, Desai *et al.* 1993). Our records at Ratanmahal extend its known range by about 75 km and the site is the northernmost for the species in Gujarat.

#### Noteworthy species

Here we give details of 11 species, most of which are forest-interior species (based on Worah 1991) and show a documented vulnerability to forest fragmentation and alteration.

##### GREY JUNGLEFOWL *Gallus sonneratii*

This galliform was heard in Purna at only two localities, but was seen as well as heard on four occasions (involving eight birds) in Ratanmahal. It appears to have been

persecuted beyond recovery in many areas of its former distribution (e.g. Jessore Sloth Bear Sanctuary: Trivedi 2005). Pheasants have been found to be sensitive to changes in forest composition (Johns 1986, Castelletta *et al.* 2000, Datta 2000) as well as hunting. Hunting may be a particular problem for this species as ground-dwelling birds are vulnerable to passive methods of trapping, and this species depends on concealment rather than flight for escape.

#### RUFIOUS WOODPECKER *Celeus brachyurus*

This woodpecker was encountered only at Purna, where it was uncommon and appeared to be partial to bamboo brakes in moist deciduous forest. It was reported previously from Dangs district and Vansda National Park (Ali 1954–1955, Worah 1991, Bhatt 2004), but not elsewhere from Gujarat; hence Purna appears to be the north-westerly limit of its distribution. The species is peculiar in its habit of nesting in the nests of *Crematogaster* ants (Ali 1969).

#### WHITE-BELLIED WOODPECKER *Dryocopus javensis*

We recorded the species three times in Purna at two localities. Purna is the northernmost site for the species in India and the westernmost limit of its global range. This population of White-bellied Woodpecker is isolated, with the nearest neighbouring population at a distance of c.350 km in Melghat Tiger Reserve, Maharashtra (Prasad 2003). The largest woodpecker of peninsular India, this is a bird of primary moist deciduous forest and secondary forest and is also seen in tropical evergreen and semi-evergreen forests (Ali and Ripley 1983, Grimmett *et al.* 1998). In Gujarat, it was reported earlier from Dangs district and adjoining areas of Navsari district (Ali 1954–1955, Worah 1991, Singh *et al.* 2000, Santharam 2003). In the Western Ghats of Maharashtra, the species is extremely rare and has a fragmented distribution (Prasad 2003). Furthermore, its preferred habitat, primary moist deciduous forest, is rare in Gujarat, having been replaced by either secondary forests or plantations (Worah 1991, Santharam 2003). This has resulted in a reduced availability of suitable nesting trees (Santharam 2003). Ali (1954–1955) reported that this species was hunted by tribal people in Dangs district. These factors suggest that the species may be susceptible to local extinction. A similar conclusion was reached for the species in Singapore, where only one pair was found surviving after the loss of a large area of rainforest (Castelletta *et al.* 2000).

#### HEART-SPOTTED WOODPECKER *Hemicircus canente*

This species was recorded on transects on four occasions (involving seven individuals) in Purna (mean encounter rate: 0.11 birds/km, SD=0.23), where it was confined to moist deciduous forest with bamboo. It has been reported from the same localities in Gujarat as White-bellied Woodpecker, with additional records further north from Rajpipla forests (Monga and Naoroji 1983). Santharam (1995) described it as a specialist based on its foraging mode. Prasad (2003) considered it rare in western Maharashtra.

#### LESSER YELLOWNAPE *Picus chlorophus*

This was a rare species, being sighted on only four occasions at three localities in Purna. It was reported earlier by Ali (1954–1955) and Worah (1991) from Dangs district and from Vansda National Park (Bhatt 2004) and

inhabits moist deciduous forests with bamboo (Trivedi 2003). There are no records of the species from other parts of Gujarat. In western Maharashtra, the species is rare with a restricted range (Prasad 2003).

#### WHITE-CHEEKED BARBET *Megalaima viridis*

The occurrence of this species was confirmed on only one occasion in Purna based on its call. This represents the northernmost extent of the distribution of this Western Ghats endemic. The congeneric Brown-headed Barbet *M. zeylanica* was common at Ratanmahal and Purna.

#### MALABAR TROGON *Harpactes fasciatus*

This species was sighted only in Purna at three localities. While Ali (1954–1955) reported it to be ‘fairly common’ in Dangs district, we considered it to be uncommon. Ali (1954–1955) mentioned one of the locations of the species as Ajwa (in present day Vadodara district), situated more than 150 km north-west of the Dangs district. This appears to be a typographical error with ‘Ajwa’ being printed instead of ‘Ahwa’ (the capital of Dangs district). We suspect this because, although a record at Ajwa would be unusual and noteworthy, Ali (1954–1955) does not refer to this locality or emphasise the importance of this record in his annotations to the sites where this species was collected. Malabar Trogon has also been reported from Vansda National Park (Singh *et al.* 2000). It is found in moist deciduous forest with bamboo and secondary growth (Ali 1954–1955). The species has been found sensitive to forest fragmentation and alteration in the southern Western Ghats in India (Raman 2001) as have congeners elsewhere in the Orient (e.g. Johns 1986, Castelletta *et al.* 2000).

#### CRESTED TREESWIFT *Hemiprocne coronata*

This species was sighted only in Purna (only off transects) and Ratanmahal (eight sightings including 30 individuals on transects). Its mean encounter rate at Ratanmahal was 0.86 individuals/km (SD=1.83). Ali (1954–1955) encountered it only in Rajpipla forests (see also Monga and Naoroji 1983) and Dangs district. It has also been reported from the Gir forest (Khacher 1996). We found it in forest with *Lannea coromandelica*, *Boswellia serrata* and *Anogeissus latifolia* on boulder-studded dry hills. Crested Treeswift may be sensitive to forest loss and degradation, as Castelletta *et al.* (2000) recorded the local extinction of the congeneric Whiskered Treeswift *H. comata* in Singapore.

#### BAR-WINGED FLYCATCHER-SHRIKE *Hemipus picatus*

A rare resident, this species was seen only once on transects (23 June 2002) in Bhenskatri range in Purna. Both Ali (1954–1955) and Worah (1991) reported the species earlier from Dangs district, but Singh *et al.* (2000) did not record it from the nearby Vansda National Park. It is easily overlooked owing to its rarity, inconspicuous coloration and small size. Prasad (2003) reported it as an uncommon, localised resident in western Maharashtra, while placing it among the species affected by loss of forests. Johns (1986) and Castelletta *et al.* (2000) also regarded the genus *Hemipus* to be sensitive to forest degradation.

#### MALABAR WHISTLING THRUSH *Myophonus horsfieldii*

This species was sighted only once, on 24 December 2001 on a stream bank in moist deciduous forest at Purna.

Although it is known for its melodious song, we never heard it during the study period. Ali (1954–1955) recorded it as resident in Dangs district, but not common. It is a terrestrial omnivore, known to forage along streams for a variety of invertebrates, including aquatic insects (Ali 1969). Its rarity could conceivably have resulted from changes in hydrology caused by the building of check-dams, perhaps affecting prey availability.

#### WHITE-RUMPED SHAMA *Copsychus malabaricus*

We saw this species only at Purna where it was confined to moist deciduous forest and bamboo patches, and was usually seen rummaging among leaf-litter in search of insects. It was previously reported in Dangs district by Ali (1954–1955) and Worah (1991) and from Vansda National Park by Singh *et al.* (2000), but not elsewhere in Gujarat. It has a patchy distribution in India (Grimmett *et al.* 1998), and belongs to the terrestrial insectivore guild, which is susceptible to forest fragmentation (Raman 2001).

#### Species susceptible to habitat loss and degradation

We used encounter rates and information from the literature and from personal observations on the habitat specificity of species to identify those that we considered likely to be susceptible to forest loss and degradation at the two sanctuaries. At Purna, we found 64 species that had a mean encounter rate of  $\leq 0.5$  individuals/km, while at Ratanmahal there were 47 such species (with 28 of these occurring at both sites). Of the total of 83 rarely encountered species, we excluded 53 widespread species (including raptors) and 17 migrants. The remaining 13 species comprised Grey Junglefowl, Rufous Woodpecker, Heart-spotted Woodpecker, Lesser Yellowthroat, White-cheeked Barbet, Indian Grey Hornbill *Ocyrceros birostris*, Malabar Trogon, Black Eagle, Bar-winged Flycatcher-shrike, White-throated Fantail *Rhipidura albicollis*, White-rumped Shama, Velvet-fronted Nuthatch *Sitta frontalis* and Black-lored Tit *Parus xanthogenys*. Although Indian Peafowl *Pavo cristatus* is widespread in India, it was

**Table 2.** Possible local extinctions of birds in Purna and Ratanmahal Wildlife Sanctuaries.

Species	Extinct at	Past status	Source
JUNGLE BUSH QUAIL <i>Perdica asiatica</i>	Purna	Common	Ali (1954–1955)
RED SPURFOWL <i>Galloperdix spadicea</i>	Purna	Common	Ali (1954–1955)
INDIAN GREY HORNBILL <i>Ocyrceros birostris</i>	Ratanmahal	Unknown	Local reports
STORK-BILLED KINGFISHER <i>Halcyon capensis</i>	Purna, Ratanmahal	Not uncommon	Ali (1954–1955)
WHITE-THROATED FANTAIL <i>Rhipidura albicollis</i>	Purna	Not stated	Ali (1954–1955)
LARGE WOODSHRIKE <i>Tephrodornis gularis</i>	Purna	Rare? 1 specimen procured	Ali (1954–1955)
VELVET-FRONTED NUTHATCH <i>Sitta frontalis</i>	Ratanmahal	Rare, 1 sighting	PT (personal observations 1989–1991)
BLACK-LORED TIT <i>Parus xanthogenys</i>	Purna	Not uncommon	Ali (1954–1955)

**Table 3.** Species susceptible to forest loss and degradation in Purna and Ratanmahal Wildlife Sanctuaries.

Species	Distribution in India	Guild	Habitat occupancy	Occurrence
JUNGLE BUSH QUAIL <i>Perdica asiatica</i> *	Patchy	GFO	Forest edge	Purna†
RED SPURFOWL <i>Galloperdix spadicea</i> *	Widespread	GFO	Forest interior	Purna†
GREY JUNGLEFOWL <i>Gallus sonneratii</i> *	Widespread	GFO	Forest interior	Purna
INDIAN PEAFOWL <i>Pavo cristatus</i> *	Widespread	GFO	Forest interior	Ratanmahal, Purna
RUFIOUS WOODPECKER <i>Celeus brachyurus</i>	Patchy	BF	Forest interior	Purna
WHITE-BELLIED WOODPECKER <i>Dryocopus javensis</i>	Patchy	BF	Forest interior	Purna
LESSER YELLOWTHROAT <i>Picus chlorolophus</i>	Patchy	BF	Forest interior	Purna
HEART-SPOTTED WOODPECKER <i>Hemicircus canente</i>	Patchy	BF	Forest interior	Purna
WHITE-CHEEKED BARBET <i>Megalaima viridis</i> *	Patchy	AFR	Forest interior	Purna
INDIAN GREY HORNBILL <i>Ocyrceros birostris</i> *	Widespread	AFO	Forest interior	Ratanmahal†
MALABAR TROGON <i>Harpactes fasciatus</i> *	Patchy	FSI	Forest interior	Purna
STORK-BILLED KINGFISHER <i>Halcyon capensis</i>	Widespread	AQC	Forest edge	Purna†, Ratanmahal†
BROWN WOOD OWL <i>Strix leptogrammica</i>	Patchy	C	Forest interior	Purna
LARGE-TAILED NIGHTJAR <i>Caprimulgus macrurus</i>	Patchy	HI	Forest interior	Ratanmahal
BLACK EAGLE <i>Ictinaetus malayensis</i>	Patchy	C	Forest interior	Purna
BAR-WINGED FLYCATCHER-SHRIKE <i>Hemipus picatus</i>	Patchy	FSI	Forest interior	Purna
WHITE-THROATED FANTAIL <i>Rhipidura albicollis</i>	Patchy	FSI	Forest edge	Purna†
LARGE WOODSHRIKE <i>Tephrodornis gularis</i>	Patchy	FGI	Forest interior	Purna†
MALABAR WHISTLING THRUSH <i>Myophonus horsfieldii</i> *	Patchy	GFO	Forest interior	Purna
WHITE-RUMPED SHAMA <i>Copsychus malabaricus</i>	Patchy	GFI	Forest interior	Purna
VELVET-FRONTED NUTHATCH <i>Sitta frontalis</i>	Patchy	BF	Forest interior	Ratanmahal†
BLACK-LORED TIT <i>Parus xanthogenys</i> *	Patchy	FGI	Forest interior	Purna†

\* = endemic to India

Guild: AFO = Arboreal frugivore-omnivore; AFR = Arboreal frugivore; BF = Bark-forager; C = Carnivore; AQC = Aquatic carnivore; FGI = Foliage-gleaning insectivore; FSI = Foliage-sallying insectivore; GFI = Ground-foraging insectivore; GFO = Ground-foraging omnivore; HI = Hawking insectivore

Occurrence: † = locally extinct (see Table 2)



considered to be susceptible owing to its rarity at the two sites and vulnerability to hunting. Two additional species that were only encountered off transects, White-bellied Woodpecker and Malabar Whistling Thrush, were also considered susceptible. Further, we suspect the local extinction of four of these species, plus an additional four species, based on an absence of sightings during our study: six from Purna and two from Ratanmahal (Table 2). Finally, we also included Brown Wood Owl and Large-tailed Nightjar, as susceptible to forest alteration owing to their rarity and habitat specificity (see Ali 1969). In all, we identified 22 species as likely to be 'susceptible' to forest degradation and loss at the two study sites (Table 3).

## DISCUSSION

Inferences about local extinctions require that sufficient effort be expended in searching for species. The species discovery curves obtained for Purna and Ratanmahal (Fig. 2) reached asymptotes roughly at the eleventh visit. At Purna, the four species added on the last two visits included three nocturnal species (two owls and one nightjar) recorded after intensive night monitoring. These two graphs suggest that our sampling effort was adequate, although it is almost impossible to record all species owing to the dynamic nature of forest avifaunas (Johns 1986).

We identified 22 species that we considered to be likely to be susceptible to habitat change (Table 3). The status of most of these has changed from 'common' or 'not uncommon' to rare or locally extinct. For one species, Stork-billed Kingfisher *Halcyon capensis*, there has been no recent record from any part of Gujarat. The six species that appeared to be extinct at Purna were seen by Ali (1954–1955) but not by Worah (1991), supporting our

conclusion. Others, like Large Woodshrike *Tephrodornis gularis*, Black-lored Tit, Stork-billed Kingfisher, White-throated Fantail and Indian Grey Hornbill, are known to be vocal and conspicuous, so these are also likely to be genuinely extinct now at these sites.

Nineteen of the 22 susceptible species are characteristically forest-interior species. Such species show reduced fecundity near forest edges and their populations decline as fragment sizes reduce unless immigration from larger forest patches occurs (Temple and Cary 1988). Terborgh *et al.* (1990) recognised two types of rarity among birds in the Amazon rainforests of Peru: species that were locally rare (i.e. in the surveyed locality or habitat) and species that were constitutively rare. They considered the latter as truly rare and vulnerable to human intervention; these included large birds with low population densities (<1 pair/km<sup>2</sup>) such as raptors, parrots, woodpeckers and a few other species that were among the largest members of their respective guilds. In our study, the White-bellied

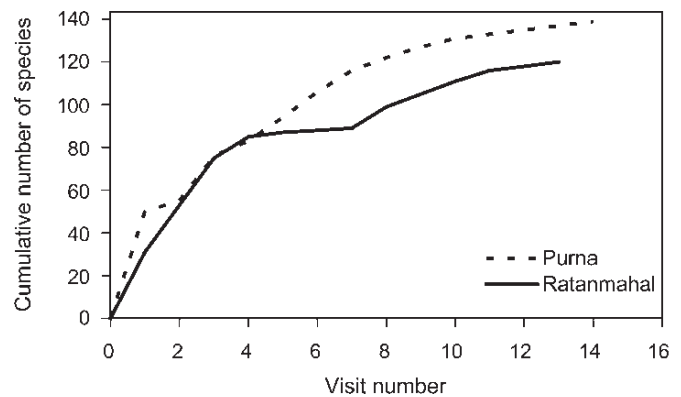


Figure 2. Bird species discovery curves for Purna and Ratanmahal Wildlife Sanctuaries, Gujarat, India.

Table 4. Abundance of species susceptible to forest loss and degradation remaining extant in Purna Wildlife Sanctuary.

Species	Past status		Current status		
	Ali (1954–1955)	Worah (1991) <sup>a</sup>	No. sightings on transects	Relative abundance <sup>b</sup>	Encounter rate <sup>c</sup>
GREY JUNGLEFOWL <i>Gallus sonneratii</i>	Not uncommon	0.036	2	0.001	0.05±0.16
INDIAN PEAFOWL <i>Pavo cristatus</i>	Common in Gujarat	—	1	0.0015	0.06±0.19
RUFIOUS WOODPECKER <i>Celeus brachyurus</i>	Rare?	—	2	0.0015	0.03±0.08
HEART-SPOTTED WOODPECKER <i>Hemicircus canente</i>	Not uncommon	0.024	4	0.0035	0.11±0.23
WHITE-BELLIED WOODPECKER <i>Dryocopus javensis</i>	3 specimens collected in 1 week	0.012	*	*	*
LESSER YELLOWNAPE <i>Picus chlorolophus</i>	Not uncommon	—	1	0.0005	0.03±0.08
WHITE-CHEEKED BARBET <i>Megalaima viridis</i>	Not uncommon	0.012	1	0.0005	0.02±0.05
INDIAN GREY HORNBILL <i>Ocyrocus birostris</i>	Not uncommon	0.012	7	0.0065	0.20±0.29
MALABAR TROGON <i>Harpactes fasciatus</i>	Fairly common	0.145	1	0.0005	0.01±0.04
BROWN WOOD OWL <i>Strix leptogrammica</i>	—	—	*	*	*
BLACK EAGLE <i>Ictinaetus malayensis</i>	—	—	1	0.05	0.05±0.16
BAR-WINGED FLYCATCHER-SHRIKE <i>Hemipus picatus</i>	Not common	0.012	1	0.0005	0.02±0.06
MALABAR WHISTLING THRUSH <i>Myophonus horsfieldii</i>	Not common	0.072	*	*	*
WHITE-RUMPED SHAMA <i>Copsychus malabaricus</i>	Few individuals	0.024	7	0.0035	0.12±0.17
VELVET-FRONTED NUTHATCH <i>Sitta frontalis</i>	Fairly common	—	1	0.0005	0.01±0.04

<sup>a</sup>Relative abundance based on point counts (number of birds in highest count divided by total number of points)

<sup>b</sup>Number of individuals of each species divided by number of individuals of all species recorded on transects (n=10 transects)

<sup>c</sup>Mean±SD individuals/km (n=10 transects)

\*species not detected on transects

Woodpecker as well as some other woodpeckers (see Tables 3 and 4) and the Stork-billed Kingfisher showed the latter kind of rarity, whereas the other susceptible species were locally rare. The replacement of primary moist deciduous forest either by secondary forest or by plantations at Purna has led to fragmentation of the habitat (Worah 1991, Santharam 2003) and is a likely reason for the reduced abundance of such species in this sanctuary (Worah 1991).

Other ecological traits were associated with some of the species we identified as susceptible. These were ground-foraging and bark-foraging guilds, large body size, endemism and edge-of-range distribution. As suggested by Henle *et al.* (2004), these traits probably operate synergistically.

Ground-foraging (six species) and bark-foraging guilds (five species) represented 50% of the susceptible species. These two guilds constituted only 19% (36 species) of the 191 species recorded in either sanctuary. Ground- and bark-foraging guilds were thus significantly more likely to be susceptible ( $\chi^2=15.77$ ,  $df=1$ ,  $P<0.001$ ). Ground-foraging birds have been found susceptible to forest fragmentation in the southern Western Ghats (Raman 2001), and bark-foraging birds are known to be susceptible to changes in micro-climate and foraging substrate resulting from logging (Johns 1986), forest loss and fragmentation (Castelletta *et al.* 2000, Raman 2001).

Stork-billed Kingfisher is likely to be susceptible on account of its large body size. Ali (1954–1955) regarded it as 'not uncommon on forest streams' in the eastern forest belt of the state. However, Khacher (1996) called for a special investigation to ascertain its status in relation to the limnological changes which have taken place in forest streams. The species presumably feeds on relatively large fish as is suggested by its much larger bill (84–93 mm long) and body size compared with the congeneric White-throated Kingfisher *Halcyon smyrnensis* (bill length: 60–67 mm) (Ali 1954–1955). We suspect that degradation of the lotic ecosystems by siltation (Khacher 1996), over-fishing and construction of check-dams has adversely affected the availability of the size and/or species of fish favoured by Stork-billed Kingfisher. In addition, competition with the White-throated Kingfisher, a widespread, open-area species with a varied diet (Khacher 1996) that has colonised Purna in recent years, could also have affected its abundance.

Gaston (1985), Daniels *et al.* (1990) and Raman (2001) showed that endemic bird species in the Indian peninsula and Western Ghats were more vulnerable to habitat loss than non-endemic species. In the Atlantic forest fragments of Brazil, Ribon *et al.* (2003) found that endemic species were more likely to go locally extinct than non-endemics. A total of 23 species (12% of those recorded in either sanctuary) were endemic to the Indian subcontinent. Of the 22 susceptible species, nine (41%; Table 3) were subcontinent endemics, which is significantly higher than expected ( $\chi^2=19.56$ ,  $df=1$ ,  $P<0.001$ ).

Populations found at the peripheries of a species's distributional range tend to occur at lower densities (Hengeveld and Haeck 1982) and hence be more vulnerable to extinction (Lawton 1995) than those in the core parts of its distribution. Of the 22 susceptible species we identified, 14 have their westernmost distributional limits in Gujarat's eastern forest belt (see Grimmer *et al.*

1998). The species for which Purna marks the northern, western or north-western distributional limit are Large Woodshrike, White-bellied Woodpecker, Rufous Woodpecker, Lesser Yellownappe, Brown Wood Owl, Malabar Trogon and White-cheeked Barbet. Ratanmahal is probably the northernmost distributional limit for Velvet-fronted Nuthatch and westernmost boundary for Large-tailed Nightjar. It is notable that Large Woodshrike was also reported locally extinct in Singapore (Castelletta *et al.* 2000), which is near its southernmost range limit.

Poaching may also influence forest avifaunas (Castelletta *et al.* 2000, Henle *et al.* 2004). For example, phasianids are popular game birds and have been hunted to extinction from several areas in Gujarat (Trivedi 2005, personal observations). The effect of hunting on Indian Peafowl is particularly clear. In most parts of Gujarat, where there is a taboo against hunting this species, it is common, occurring in very high abundance at Gir forest (Trivedi 1993) and in several human-inhabited areas. However, in the region populated by tribal groups where Ratanmahal and Purna are located, there is no hunting taboo and the species is extremely rare (Trivedi 2001, 2003).

Forest fragmentation is another possible cause of avifaunal impoverishment, and may act synergistically with anthropogenic activities such as hunting and logging (Laurance *et al.* 2002). We encountered eight widespread species at Purna that are known to favour edges or open areas (Ali 1954–1955, Grimmer *et al.* 1998), but were not recorded by earlier studies: Banded Buttonquail *Turnix suscitator*, Common Hoopoe *Upupa epops*, Black-headed Cuckooshrike *Coracina melanoptera*, Common Myna *Acridotheres tristis*, White-browed Fantail *Rhipidura aureola*, Purple-rumped Sunbird *Nectarinia zeylonica*, Spotted Owlet *Athene brama* and White-throated Kingfisher. Colonisation by these species has possibly been facilitated by the road-building and habitat degradation that accompanied forestry operations (also see Johns 1986). Whether these species have played a role in the impoverishment of the forest avifauna could not be ascertained, although instances of edge-tolerant or edge-favouring competitor species causing a decline of forest-interior or rare species have been reported elsewhere (see Harris 1988, Laurance *et al.* 2002, Henle *et al.* 2004).

## CONCLUSIONS

Gujarat's forest avifauna is in a fragile situation. While intensive surveys are adding species to the state's checklist, there are indications of avifaunal impoverishment and local extinctions. Ratanmahal and Purna are among the last remaining patches of moist deciduous forest in Gujarat and hence mark the global distributional limits for several forest birds. As a result of past forestry operations, the habitat at Purna is more fragmented than that at Ratanmahal, and this has a bearing on future avifaunal impoverishment and conservation. The situation is made worse by the increased isolation of bird populations in forest patches. Intensive surveys should be carried out in all forested regions of the state, including existing and potential forest corridors. Studies on the ecology of susceptible forest birds and the impacts of anthropogenic activities also need to be undertaken.



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