



Figure 1. *a*, Scanning electron micrograph of AnpCh57 showing hyphae and immature ball-shaped vesicle; *b*, View of ball-shaped vesicles and lysed hyphae of AnpCh57. Bar: 10 μ m.

Table 1. Vanadium nitrogenase activity of AnpCh57

Days of growth in DPM* containing 50 nM vanadium	C ₂ H ₂ reduced/mg fr wt/h	
	5°C	28°C
10	4.59 \pm 0.4	2.01 \pm 0.3
15	6.30 \pm 0.5	3.42 \pm 0.2
20	6.20 \pm 0.4	3.46 \pm 0.2

*Na₂MoO₄ was deleted from DPM.

Note: Acetylene reduction activity of spherical vesicles after 15 days at 28°C in DPM containing molybdenum was 6.0 \pm 0.3.

rvation of these colonies under microscope and soft X-rays showed the presence of spherical vesicles after day 30 and both spherical and ball-shaped vesicles after day 45. This and earlier results demonstrate that both vesicles are produced at different times. Thus it could be hypothesized that AnpCh57 produces vanadium nitrogenase during molybdenum deficiency. Vanadium nitrogenase though less efficient at 28°C, would be advantageous since vanadium is less limiting under natural conditions⁴. It is also possible that vanadium nitrogenase is best suited for low temperatures. Thus diverse *Frankia* may expand physiological range of nitrogen fixation by these multiple enzymes.

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Sacred grove relics as bird refugia

Sacred groves are patches of natural vegetation dedicated to certain local deities, from which no harvesting of living matter is permitted by the local communities. Ecologists currently recognize these sacred groves (SG) as a unique cultural institution for conserving local biodiversity¹. Numerous sacred groves are among the last representatives of climax vegetation in the Western Ghats and North East India, whereas SGs in other parts of the country have dwindled due to colonial land use policies^{1,2} and erosion of traditional values regarding natural resource use. Nevertheless, hundreds of relics of SGs

exist in the tribal tracts of eastern India, and much of the tribal cultural life in West Bengal has been reported to be still centred around these relics³.

The observations we report here are a fallout of an ethnobiological survey we conducted from early April to end-June, 1996 in Jamboni, Jhargram, Gidhni, Belpahari and Banspahari Forest Ranges of western Midnapore district. In conformity with our previous study³, we found remnants of SG in almost every tribal village in the region. Most of these groves, locally called Jahiristhan, are relics of ancient SGs, containing 10–20 trees, amidst a denuded lateritic

expanse. The tree species mostly found in these relics include sal (*Shorea robusta*), asan (*Terminalia tomentosa*), karam (*Adina cordifolia*), banyan (*Ficus bengalensis*), aswath (*F. religiosa*), pial (*Buchanania lanzan*), piya-sal (*Pterocarpus marsupium*), neem (*Azadirachta indica*), and mahua (*Bassia latifolia*). All these species are also found in sal forests, albeit mostly in reproductively immature stages.

The sal coppice forest patches in the region under study are highly degraded, and are now regenerating under community protection by villagers' Forest Protection Committees over the past

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Table 1. Habitat preference of birds in West Midnapore

Taxa	Common name	Sal forest	Sacred grove	Settlement area*
Apodiformes				
<i>Apus affinis</i>	House swift	+	-	+
<i>Cypsiurus parvus</i>	Palm swift	+	-	+
Caprimulgiformes				
<i>Caprimulgus asiaticus</i>	Common Indian nightjar	+	-	-
Columbiformes				
<i>Columba livia</i>	Blue rock pigeon	-	+	+
<i>Streptopelia chinensis</i>	Spotted dove	+	+	+
<i>S. decaocto</i>	Ring dove	+	+	-
<i>Treron phoenicoptera</i>	Yellow legged green pigeon	-	+	-
Coraciiformes				
<i>Ceryle rudis</i>	Pied kingfisher	-	+	+
<i>Coracias benghalensis</i>	Indian roller	+	-	+
<i>Halcyon smyrnensis</i>	Whitebreasted kingfisher	-	+	+
<i>Upupa epops</i>	Hoopoe	+	-	-
Cuculiformes				
<i>Centropus sinensis</i>	Crow pheasant	+	-	-
<i>Cuculus varius</i>	Common hawk cuckoo	+	+	-
<i>Eudynamis scolopacea</i>	Koel	-	+	+
Falconiformes				
<i>Milvus migrans</i>	Pariah kite	+	-	+
<i>Gyps bengalensis</i>	Indian white-backed vulture	+	-	+
Galliformes				
<i>Francolinus pondicerianus</i>	Grey partridge	+	-	-
<i>F. francolinus</i>	Black partridge	+	-	-
Gruiformes				
<i>Turnix susciator</i>	Common bustard quail	+	-	-
Passeriformes				
<i>Acridotheres tristis</i>	Indian myna	-	+	+
<i>A. fuscus</i>	Jungle myna	+	+	-
<i>Anthus novaeseelandiae</i>	Paddyfield pipit	+	-	+
<i>Cisticola juncidis</i>	Streaked fantail warbler	+	-	+
<i>Copsychus saularis</i>	Magpie robin	-	+	+
<i>Corvus splendens</i>	Common crow	+	-	+
<i>C. macrorhynchos</i>	Jungle crow	+	-	-
<i>Dendrocitta vagabunda</i>	Indian tree pie	+	-	-
<i>Dicrurus adsimilis</i>	Black drongo	+	-	+
<i>Nectarinia zeylonica</i>	Purple rumped sunbird	-	+	-
<i>Oriolous xanthornus</i>	Black headed oriole	-	+	+
<i>Orthotomus sutorius</i>	Tailor bird	-	+	+
<i>Passer domesticus</i>	House sparrow	-	-	+
<i>Ploceus philippinus</i>	Weaver bird	-	+	+
<i>Pycnonotus cafer</i>	Red-vented bulbul	-	+	+
<i>Sturnus contra</i>	Pied myna	-	+	+
<i>Turdoides striatus</i>	Jungle babbler	+	-	-
Strigiformes				
<i>Athene brama</i>	Spotted owl	-	+	+
<i>Tyto alba</i>	Barn owl	-	+	+
Piciformes				
<i>Dinopium benghalensis</i>	Lesser goldenbacked woodpecker	+	-	-
<i>Megalaima haemacephala</i>	Coppersmith	-	+	-
Psittaciformes				
<i>Psittacula krameri</i>	Rose-ringed parakeet	-	+	+
<i>P. eupatria</i>	Large Indian parakeet	-	+	-

*includes farm fields.
+ = Sighted.

8-10 years^{4,5}. The average crop height of the sal coppice stands is ca. 9 m, with GBH < 30 cm. However, the forest of Belpahari range is composed of a large population of old trees, with an average crop height of ca. 16 m, and GBH of 30-56 cm.

Although most of the SGs are composed of a score of old trees, the Kanak Durga temple grove at Chilkigarh is considerably large (ca. 20 acres), within the premises of the royal estate of Chilkigarh. This grove contains a large floral diversity, and is characterized by old-growth trees, lianas and lichens. The canopy cover of this grove is at least as good as that of the Belpahari forest.

The survey produced, *inter alia*, an inventory of local birds based on direct sighting records, for which we spent an average of 3 days in each of the five ranges during the period 2 April-30 June, 1996, and the duration of sighting effort was from 9 am till 4.30 pm each day. We have also incorporated here the records of bird sightings separately made in June-July 1995 in the same area. Although a number of waterfowl (e.g. pond heron, little cormorant, red wattled lapwing, stone curlew, little egret, cattle egret, white-breasted waterhen, etc.) and migratory land birds (e.g. brown shrike) were recorded, we confine our discussion here to the resident land birds alone. A total of 42 species of resident land birds occur in the region studied. The birds were sighted in the sal forests, SGs, farm fields and vegetations in the settlements (Table 1). Since the original objective of the survey did not concern primarily with avian diversity estimation in SGs, the records of bird occurrences are inadequate for statistical quantification and generalizations. Nevertheless, the data presented here may serve to indicate the apparent habitat preference of the birds with some overlaps. Table 1 shows that 22 land birds are found in the SGs, four of which are occasionally also sighted in the sal forest. The spotted dove was the only species that was found in all the three kinds of habitats. Ten species of birds were found only in sal forests and another 9 in both the sal forest and the settlement area, but not in SGs. A total of 19 birds were recorded to occur outside the sal forests; of these, 14 were found in SGs and human habitations,

and at least four species (yellow-legged green pigeon, purple rumped sunbird, coppersmith and large Indian parakeet) were found only in the SGs. The house sparrow was found only in the human settlement area.

It seems plausible that the unavailability of sufficient quantum of fruits and the poor canopy structure in the regenerating sal forests fail to provide attractive foraging and nesting habitats for the birds occurring outside the sal forest. However, the Belpahari and Banspahari forests contain a good proportion of mature trees with well-developed canopy, yet only 3 out of the 21 birds recorded from SGs were sighted in these forests. The socio-religious girdle of taboos around the SGs prohibiting trapping and hunting of animals, seems to be the only explanation for the 18 birds occurring in the SGs, and not in the sal forests.

An important support to our conjecture that habitat protection is the primary reason for the bird's preference of the SGs, was lent by the local tribal hunters reporting that many birds that are hunted for meat (e.g. magpie robin, coppersmith, orioles, mynas and parakeets) tend to nest in the Kanak Durga temple grove and other SGs. We could not verify these reportings, but were able to notice a small number of nests of the Indian myna and the black-headed oriole in three different SGs in Jhargram, Banspahari and Belpahari Ranges.

An old (abandoned) nest of the weaver bird was also sighted on a palm tree in a derelict SG in Jamboni Range.

Further intensive studies are required to consolidate our findings. Nevertheless, assuming that the probability of sighting a bird species was equal in all three habitats categorized in Table 1, the record of 22 local landbirds from the SGs suggests that these groves served as important sanctuaries for numerous biota in the past when they were of bigger physical dimensions. While it is unknown how many species of other groups of organisms were, or still are, protected by the institution of SG, this study indicates that these dwindling SGs continue to serve as important refugia amidst the landscape of species depletion. The function of SG in providing refuge to a variety of life forms has been appreciated by ecologists, but most studies in SG biodiversity have encompassed little more than floral inventories, thus leaving a considerable gap in the documentation of faunal diversity in SGs. Our qualitative data herein underscores the need for a rigorous study of the current ecological function of the existing SGs. Furthermore, this study reveals the efficacy of tradition in maintaining biodiversity in the face of continuing onslaught of the 'mainstream' economy on the indigenous cultural heritage.

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ACKNOWLEDGEMENT. We are grateful to Dr. Indraneil Das and Mr. Sujjan Chatterjee for helpful discussion and to the two unknown referees for their perceptive criticisms on the manuscript.

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