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Phil. Trans. R. Soc. Lond. B 1979 **286**, 211-224
doi: 10.1098/rstb.1979.0028

Phil. Trans. R. Soc. Lond. B. **286**, 211–224 (1978) [211]
Printed in Great Britain

The ecology and conservation of the Aldabran brush warbler *Nesillas aldabranus*

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The Aldabran brush warbler, *Nesillas aldabranus*, is one of the world's rarest birds. Studies conducted over the course of 2 years indicate that its distribution is probably restricted to one small area of Aldabra Atoll. Within this area it inhabits only one vegetation community, dense 'mixed scrub', and even within this it is very patchily distributed. Only five separate individuals were definitely identified during the study, but these included two pairs which held contiguous territories. Aspects of the ecology and behaviour of the species are described. The extremely rough and densely vegetated habitat in which the brush warblers live prohibits an accurate estimate of total population size, but it is probably below 25 individuals. Possible conservation measures are discussed in the light of the information collected.

Introduction

The Aldabran brush warbler, *Nesillas aldabranus*, is endemic to Aldabra Atoll, Indian Ocean, and was first described by Benson & Penny (1968) from two specimens taken in late 1967 and early 1968. Before I began my studies on the Aldabran land bird fauna in July 1974 the species was known solely from these two birds and one further individual which was mist-netted, ringed and released in April 1974. The aim of this paper is to give details of the behaviour, ecology and population size of the Aldabran brush warbler, together with a consideration of factors of probable importance to its future conservation. Five different species of brush warbler, belonging to two quite distinct genera (Diamond 1979), occur in the southwest Indian Ocean region, and information relating to the evolution and dispersal of *N. aldabranus* will be presented elsewhere in a comparative analysis incorporating all species of both genera.

Study area and methods

I was present on Aldabra for a total of 27 months (July 1974–June 1975 and November 1975–February 1977). Detailed maps, showing all places mentioned in this paper, are contained in Stoddart (1971*a*) and at the end of this volume. Extensive searches revealed that *N. aldabranus* is probably confined to one small area (Gionnet) at the west end of Middle Island (figure 1); almost all the work described below was carried out here. I visited Gionnet on 28 different occasions at roughly monthly intervals, each visit lasting on average for 3 days (table 1). Owing to the density of the scrub, human movement around this area was practicable only where narrow paths had been cleared. All my field work was conducted from on or near such paths which were marked with coded stakes set at 50 m intervals so that observations could be mapped accurately (see figure 1 for details). Before 1974 only the coast path between Anse Coco and Anse Porche (A10–A20) existed, but in April of that year another path was

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cleared between Anse Porche and the lagoon (Z1–Z13). In December 1974 and January 1975 I extended the coast path east (to A48), and cut a further east–west path (B10–B20) which ran roughly along the dividing line between the 'mixed scrub' and '*Pemphis* scrub' vegetation communities (see below). This increased the total path length available in the area to about 3 km.

The habitat at Gionnet comprises rugged pavé and champignon rock (Stoddart, Taylor, Fosberg & Farrow 1971) covered by extremely dense 'mixed scrub' and '*Pemphis* scrub' communities (Fosberg 1971; Hnatiuk & Merton 1979, this volume). The high diversity 'mixed scrub' occurs on a raised ridge of pavé which runs along the north coast and extends on average only 50–100 m inland. The rest of the area is mainly lower-lying, more rugged champignon where '*Pemphis* scrub' is the dominant vegetation. This is a low diversity community, heavily dominated by *Pemphis acidula*, which is composed only of plants which can tolerate conditions of high salinity and little soil. The two communities intergrade along their boundary, and throughout the '*Pemphis* scrub' there are scattered, slightly raised places on which grow some of the species otherwise confined to the north coast ridge.

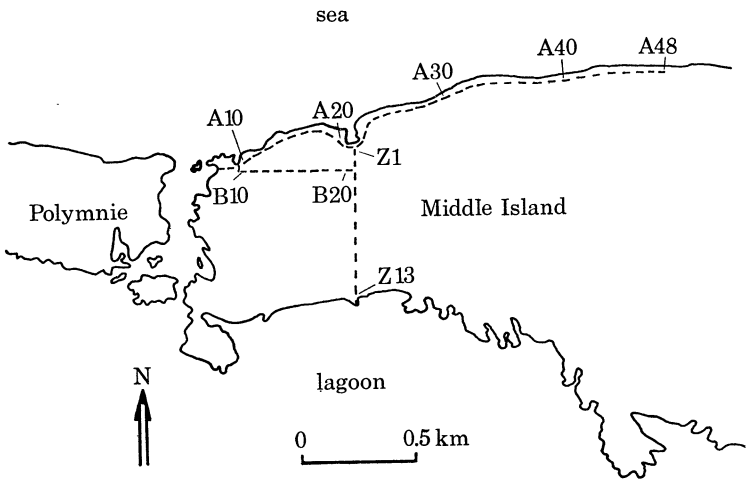

FIGURE 1. The main study area at Gionnet, with paths indicated by dotted lines. Each path was given a different letter ('A', 'B' and 'Z'), and had consecutively numbered stakes set at 50 m intervals along it. Distributional information presented in this paper and referring to this area is pinpointed to a given 50 m sector of path by means of these letters and numbers, e.g. an observation coded A20 would have been made between markers A20 and A21.

In order to permit a closer analysis of brush warbler occurrence in relation to vegetation composition in the Gionnet area, I recorded the distribution of the different species of plant. The data are summarized for each path in appendix 1. It was obtained by noting the identities of all plant species growing within 2 m of different 50 m sectors of path; grasses, sedges and small herbs were excluded as they formed only a very small percentage of the total plant biomass of the closed-canopy shrub communities which I was censusing. As the 'Z' path crossed the main 'mixed scrub'/'*Pemphis* scrub' boundary at right angles, more detailed data are given in appendix 2 for this path alone to illustrate the manner in which plant species diversity changed along it.

Much of the study of the brush warblers themselves depended on the use of tape playback of their vocalizations to attract them. These vocalizations were originally recorded on a Uher 4400 Stero Report IC tape recorder, and were transferred to cassette tape for playback over a Philips 2204 recorder. This playback, supplemented by 'squeaking' (Emlen 1969) to which

brush warblers also are attracted (cf. Forbes-Watson 1969), was vital for field work because the skulking and frequently silent birds were otherwise very difficult to find in the dense vegetation. Once located, the birds showed little fear of man and could be watched from close range without apparent disturbance to them. However, the density of the scrub prohibited attempts to follow a bird far and, in conjunction with their rapid habituation to both playback and 'squeaking', this greatly restricted the amount of direct observation possible on any individual brush warbler.

Results

(*a*) *Numbers*

During the entire study I definitely identified only five different individuals, one of these being the bird (W) that had been colour-ringed before my arrival on Aldabra. Of the other

Table 1. Recorded distribution of brush warblers within the study area at Gionnet, in relation to the dates of my visits

	brush warbler individuals (see text)					
date	W♂	UR♀	Y♂	G♀	R♂	'Unknown'†
Apr. 15–18‡ (1974)	16	—	—	—	—	—
May 10–17‡	—	—	—	—	—	—
Sept. 7–10	—	—	—	—	—	—
Oct. 13–14	—	—	—	—	10, 15–16§	—
Dec. 3–6	—	—	27–28§	27–28§	15–16	—
Dec. 17–18	—	—	27–28	27–28	—	—
Jan. 29–Feb. 2 (1975)	30	30	27–29	27–29	—	—
Feb. 16–17	30–36	30–36	28–29	28–29	—	—
Feb. 21	30–31	30–31	28–29	28–29	—	—
Mar. 10–12	30–32	30–31	28–29	28	—	—
Apr. 9	27	27	26	—	—	—
Apr. 10	—	28	28	—	—	—
Apr. 11	—	27–29	27–29	—	—	—
Apr. 22–23	33	28	28	—	—	—
May 8–9	—	27–28	27–28	—	—	—
June 6–7	—	27–29	27–29	—	—	—
Nov. 26	—	—	—	—	—	—
Dec. 17–18	—	—	27–30	—	—	—
Jan. 6–7 (1976)	—	—	27–28	—	—	—
Jan. 29–31	—	—	28	—	—	—
Feb. 20–22	—	—	28–29	—	—	—
Mar. 30–Apr. 1	—	—	28	—	—	—
May 2–5	(29)‖	—	28–29	—	35	—
June 2–5	—	—	—	—	—	—
July 2–5	—	—	28	—	—	—
Aug. 2–4	—	—	—	—	14	—
Sept. 7–12	—	—	28–29	—	—	—
Nov. 5–8	—	—	—	—	—	—
Dec. 19–21	—	—	—	—	28–29	—
Jan. 23 (1977)	—	—	—	—	29	—
Jan. 29–30	—	—	29–30	—	28	16
Feb. 9–10	—	—	—	—	27–28	15–16

All sightings of brush warblers were made from the coast ('A') path, and the numbers shown refer to the marker stakes on this path (see figure 1 for details).

† Bird never seen clearly enough to check for colour rings.

‡ Data from C. Huxley and R. Wilson (personal communication).

§ Birds not yet colour-ringed so identity not certain.

‖ Very brief sighting which could not be confirmed.

four, I colour-ringed three, and could be fairly certain of the identity of the fourth during a period in which it was paired and territorial. The different individuals are referred to below by their colour-rings (R = red, Y = yellow, G = green, W = white, UR = unringed). Table 1 gives the dates and precise localities at which all sightings were made; no brush warbler was ever seen away from the coast ('A') path.

TABLE 2. BIOMETRICAL AND OTHER DATA TAKEN FROM CAPTURED BRUSH WARBLERS

authority ...	Benson & Penny (1968)	Benson & Penny (1968)	C. R. Huxley & J. R. Wilson (personal communication)	personal observation	personal observation	personal observation
date	11 Dec. 1967	29 Jan. 1968	16 Apr. 1974	5 Dec. 1974	17 Dec. 1974	17 Dec. 1974
ring colour	—	—	W	R	Y	G
sex	♀	♂	♂	♂	♂	♀
mass/g	—	19.5	18	19.7	—	19.4
wing/mm	63	70	67	68.5	69	65
tail/mm	86	91	85	—	—	—
tars./mm	24	24	26.4	—	25.5	23.7
bill length/mm						
tip to feathers	15	15	15.9	14.8	16.0	15.6
tip to skull	18	18	20.2	—	18.9	17.9
brood patch	yes	no	no	no	no	yes
remige moult	no	near start	near end	no	no	no

(*b*) *Biometrics and sexing*

Available biometrical data are summarized in table 2. The sexes are similar in appearance, but of the two pairs observed in the field one member of each was clearly larger, bolder in approaching a source of playback, more vocal, and failed to develop a brood patch in the breeding season; these individuals were assumed to be male, and the other members of the pairs taken to be female. **R** was never seen paired with any other individual but on both mensural characteristics and behaviour appeared to be male.

(*c*) *Voice*

The vocal repertoire of the Aldabran brush warbler consists of only two types of call which I was able to distinguish unequivocally from one another in the field, and analysis on a sound spectrograph (Kay Sonagraph 6061-B) showed that the coarse structure of even these was quite similar. Much the more common of the two was a very brief 'chak' call of wide frequency range (figure 2*a*). This was given by both sexes and in a wide variety of different circumstances, with differences in meaning apparently being conveyed by variation in the number and temporal spacing of calls given and by the loudness with which they were uttered. Single or short groups of soft calls were given every now and again by members of a pair to maintain contact in the dense vegetation, and were also made occasionally by unmated individuals. The male of a pair and, less frequently, unmated males would 'sing', often from a prominent perch, giving a series of loud calls as shown in figure 2(*a*): beginning slow, increasing in tempo, and with a few slower calls at the end. Similar call sequences were given by one or both members of a pair in response to tape playback, and the two birds sometimes 'duetted' although without relating the timing of their calls to those of their partners in any precise manner. With increasing agitation the slower initial and final calls tended to be omitted; when highly excited a bird

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occasionally gave what I termed in my field notes a 'machine-gun chatter', rolling the individual calls together into a long, harsh, extremely rapid stream; e.g. male W gave this response to tape playback on 23 April 1975 after he had apparently been recently dispossessed of his mate by male Y (see table 1 and below). Both the harsh 'chirrr' and 'short, scolding chatter' recorded by Penny and Diamond respectively (in Benson & Penny 1968) probably refer to sequences of these 'chak' calls.

The second type of call was a loud, nasal 'chir' and was always given after one or two preliminary 'chak' calls, producing a di- or trisyllabic 'chak–chir' phrase which must correspond

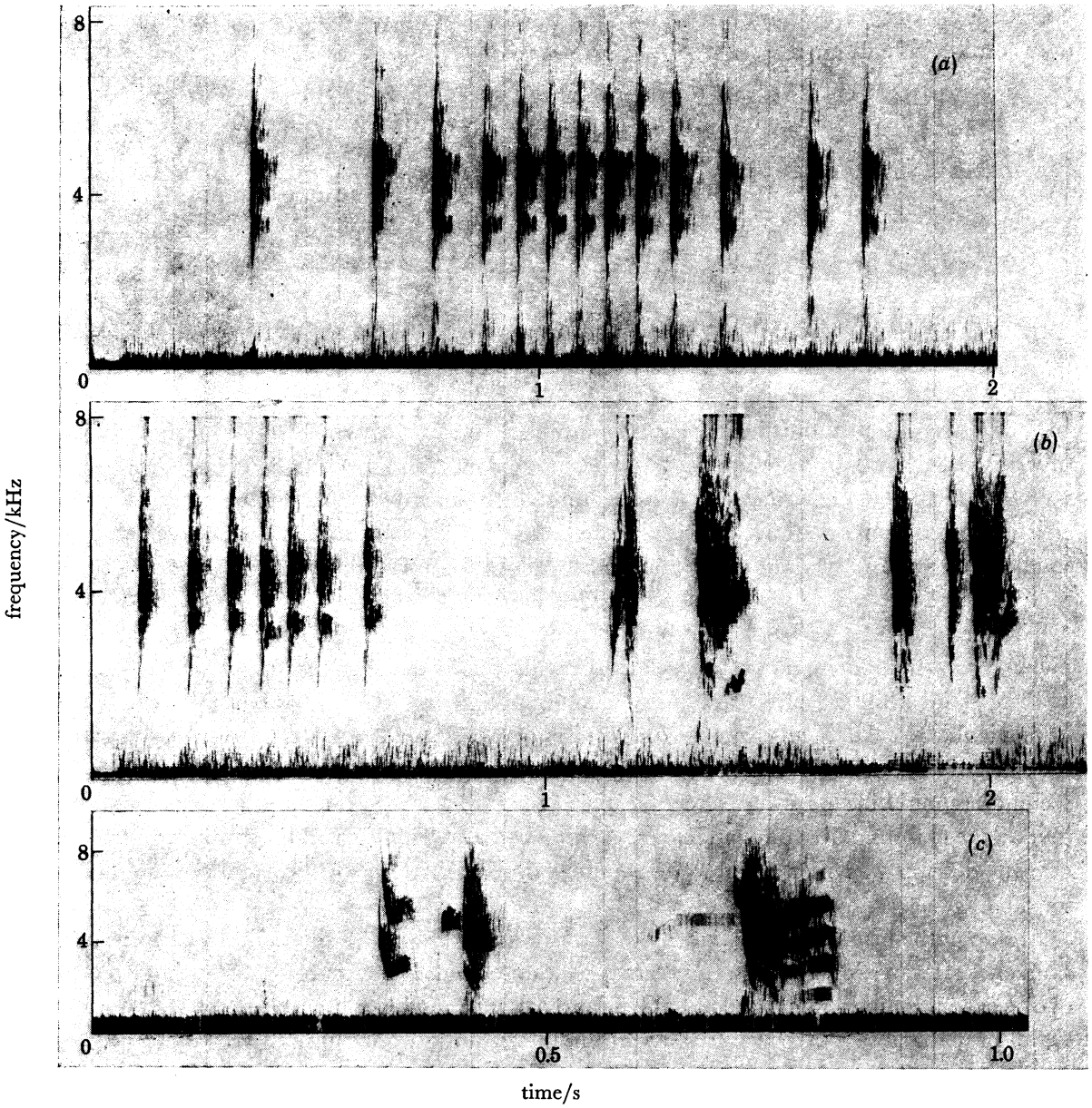

FIGURE 2. Sound spectrograms of brush warbler vocalizations. (*a*) Sequence of 'chak' calls. (*b*) 'Chak' calls followed by two 'chak-chir' phrases. (*c*) Details of a 'chak-chir' phrase illustrating the considerable harmonic structure which some 'chir' calls exhibited. Note that both time and frequency scales are different in (*c*) from those in (*a*) and (*b*).

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to the 'chinkachoy' described by Penny (in Benson & Penny 1968). Figure 2(*b*) shows the end of a sequence of 'chak' calls followed by two 'chak–chir' phrases, the former of which sounded disyllabic and the latter trisyllabic. Although closely resembling the 'chak' call in coarse structure, the 'chir' is slightly more extended in duration and may show considerable harmonic structure (figure 2*c*). Both sexes used the 'chak–chir' phrase but females gave it proportionately more frequently; it was also noted that male Y used the phrase more often when unmated than when paired. However, no clear-cut distinction could be made between circumstances in which the 'chak–chir' phrase was used and those in which 'chak' calls alone were given. The brevity and wide frequency range of both types of call must enable them to be easily located (Nottebohm 1975), and the loudness with which the birds can utter the calls permits communication over considerable distances.

TABLE 3. FORAGING HEIGHT OF BRUSH WARBLERS

height/m	% of total feeding observations
above 1½	17.8
below 1½	53.3
ground	28.9

total observations: 45

(*d*) *Feeding ecology*

Field observation indicated that food consumed by *N. aldabranus* consists entirely of small invertebrates, probably largely insects and spiders (see also Benson & Penny 1968); other members of the genus *Nesillas* are also predominantly insectivorous (Benson 1960). Prey seen clearly ranged from one-third to twice the length of the birds' beaks (*ca.* 5–30 mm), although smaller items were certainly eaten but were swallowed too rapidly for their length to be estimated. Large prey were beaten violently against a branch or the ground before being consumed.

The methods used by brush warblers to capture prey can be grouped into three categories: picking, leap-snatching and probing. Picking means removal of food items from leaves, branches or the ground while the bird still has its feet on a solid surface. Leap-snatching, which was used in particular to take insects from the undersides of leaves and branches, involved a part jump, part brief flight with the prey being captured while the bird was in the air. With both these techniques loud bill snaps were often audible as the bird grabbed the prey. Probing was used to investigate clumps of live or dead leaves, rotten wood and leaf litter on the ground; in the latter case the detritus was often swept aside by a flick of the beak, but the birds did not use their feet for digging.

Although the brush warblers live in dense scrub which is about 4–5 m tall, they are essentially skulkers that move low through the vegetation and seldom fly far. Table 3 shows that over 75% of observed foraging was carried out at heights below 1.5 m, and more than 25% on the ground. Of all prey that I saw taken from above ground level, 75% were captured on only three species of plant (*Dracaena reflexa*, *Pandanus tectorius* and *Pemphis acidula*), but these species were all so common in the area that the brush warblers inhabit that it cannot be concluded from this that the birds were actively selecting particular plant species in which to forage.

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(*e*) *Annual cycle*

Both rainfall and insect abundance on Aldabra are highly seasonal (Stoddart & Mole 1977; Frith 1975), and most of the land bird species have regular annual cycles of breeding and moult (Prŷs-Jones 1979). Data for the brush warbler are very limited, but its breeding season probably begins in October or early November, near the onset of the wet season, and extends until late January. The female that I observed in December had a pronounced brood patch, and Benson & Penny (1968) found a female with a nest containing three eggs in this month. Rand (1936) and Benson (1960) have previously reported that other *Nesillas* species in similar seasonal environments in Madagascar and the Comoro Islands also breed at this time of year. My field observations indicated that the Aldabran brush warblers were certainly engaged in moult between the second half of February and the end of April, although the male taken by Benson & Penny (1968) had begun moulting by late January (table 2); a start this early may be unusual and may have resulted from the loss of his probable mate 6 weeks previously.

(*f*) *Breeding success*

Breeding pairs were located only during the 1974–5 breeding season (table 1), and to minimize disturbance to them I made no attempt to search for their nests. However, had any young survived I should almost certainly have been able to detect them during their post-fledging period of dependence as the paired adults were easy to locate throughout the breeding and early moult seasons. It is probable that no young were produced within the area shown in figure 1 during the entire course of the study.

(*g*) *Territorial behaviour*

The two pairs of brush warblers present in the 1974–5 breeding season held contiguous territories with the boundary separating them running inland from the north coast through marker A30 to a point about 50 m from the sea, south of which neither pair appeared to venture. By simultaneously attracting both pairs with tape playback, and thereby setting up inter-pair confrontations, I found the boundary to be closely delineated with neither pair willing to trespass across it although they would call loudly at each other while only a few metres apart. On the opposite side of their territory, Y and G were never seen to move further west than A27, and thus had a territory size of roughly $\frac{3}{4}$ ha. W and UR were found as far east as A36, indicating a territory size of over $1\frac{1}{2}$ ha, but the area they commonly utilized was similar in size to the territory of Y and G (table 1).

The territorial system altered in April 1975, during the postnuptial moult, when the female G disappeared and female UR subsequently changed both its mate and its territory (table 1). G was last seen on 11 March. On the first day of my next visit to the area, 9 April, both W and UR were found foraging and calling at A27 within what had previously been the territory of Y and G. Prolonged searching revealed a very subdued Y alone at A26, i.e. about 50 m further west than his previous territorial boundary. On the following day, however, W was not present, but Y and UR were found foraging together at A28; they remained paired together in the old territory of Y and G until I left Aldabra for 5 months in June 1975. W was seen again back in his old territory at the end of April so the change of mate by female UR had certainly not been caused by his death.

From November 1975 onwards only unmated males could be found. Y had by then lost his second mate, UR, but nevertheless persisted in his territory until September 1976. No bird

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could be found in this territory in November, but by the following month R had taken up residence. After being ringed in December 1974 this latter bird had vanished for nearly 18 months and then made two reappearances in widely separated places during 1976 before finally taking up a territory in December between A27 and A29 where he remained until the end of the study (table 1). Y, however, was definitely still alive in 1977 as he was seen again in the vicinity of his old territory. Unmated males might thus either remain resident in one place for a long time or move around to a considerable degree, and their disappearance could not be equated with death. During periods when individuals could not be found it is uncertain whether they had moved out of the study area or whether they merely stayed silent, and therefore undetectable, within its bounds.

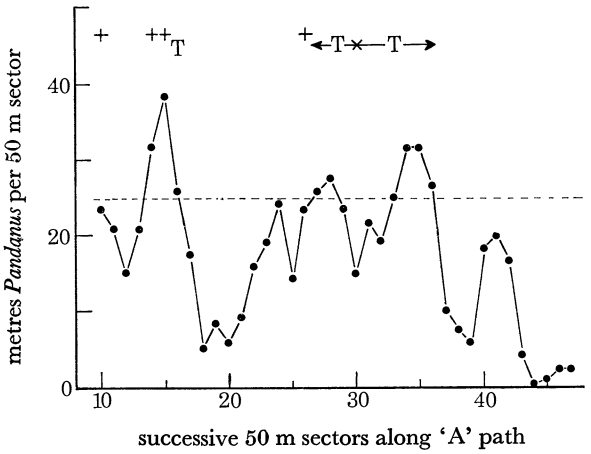

FIGURE 3. The linear abundance of *Pandanus* along the coast ('A') path, with the amount of *Pandanus* being expressed as the running mean of that in three contiguous sectors. T, sectors in which brush warblers were known to have held territories; +, other sectors in which brush warblers were seen. Above dotted line more than half the length of path in a sector was bordered by *Pandanus* on at least one side. Note that the T at A16 refers to where the pair collected by Benson & Penny (1968) had their nest.

(*h*) *Distribution in relation to habitat*

Brush warblers were never found in the low diversity '*Pemphis* scrub' (*contra* Penny 1974). Within the more diverse 'mixed scrub' the distribution of brush warbler sightings was patchy (table 1); in particular the species was found only along the coastal ('A') path although the overall composition of the vegetation bordering this path differed only in limited degree from that bordering the 'B' path (appendix 1). Of the floristic differences which did exist the most pronounced was the virtual absence of *Pandanus tectorius* from the 'B' path whereas it grew in large stands along the coast edge. Brush warblers were frequently sighted in or near these *Pandanus* stands so I investigated the possibility of a positive association between the two. For each 50 m sector along the 'A' path I measured the length which was bordered on at least one side by *Pandanus* plants. Figure 3 shows graphically the close relationship between the distribution of *Pandanus* and that of brush warblers, and statistical analysis confirmed that sectors in which brush warblers were known to have occurred were bordered by significantly greater amounts of *Pandanus* than those in which the birds were not ($\bar{x}$ for *Pandanus* in sectors where brush warblers had been sighted $= 27.7 \pm 7.2$ m, $n = 15$; $\bar{x}$ for *Pandanus* in sectors where brush warblers had not been sighted $= 10.9 \pm 4.9$ m, $n = 23$; $t = 4.08$, $p < 0.001$).

Discussion

The Aldabran brush warbler is clearly an extremely uncommon species, but it is not obvious whether this has always been so or whether environmental alterations in the recent past have caused its present rarity, and may possibly also lead to its future extermination. Changes on Aldabra which may have tended to diminish the numbers of brush warblers and restrict their distribution can be summarized under four headings:

(*a*) '*Natural' alteration in vegetation distribution and abundance*. There is no direct evidence pointing to any specific alteration of this type which might have been detrimental to the brush warbler population. However, considerable change in vegetation cover has certainly occurred during the recent past on some parts of Aldabra (see, for example, Hnatiuk, Woodell & Bourn 1976; Merton, Bourn & Hnatiuk 1976), and the size and composition of the plant communities present are probably very sensitive to alterations in climate, sea level and/or the abundance of the major endemic herbivore, the giant tortoise (*Geochelone gigantea*), the population of which is known to have increased greatly since the beginning of this century (Stoddart 1971*b*).

(*b*) *Introduction of goats* (Capra hircus). The history of this species on Aldabra has been described by Stoddart (1971*b*, 1977). Goats are now common on South Island and the eastern part of Middle Island, and until recently occurred on West Island also. Their introduction has not resulted in the devastating effect on vegetation that similar introductions of goats have had on remote islands elsewhere, but their browsing activity may tend nevertheless to open up areas of dense scrub and thus make them less suitable for brush warblers.

(*c*) *Introduction of rats* (Rattus rattus). Most of the common small passerine species on Aldabra suffer very high nest predation (Frith 1976; Prŷs-Jones 1979), and much of this can be attributed to rats which were introduced at an unknown time in the past and are now ubiquitous on the main islands of the atoll.

(*d*) *Introduction of cats* (Felis catus). Cats have also been introduced to Aldabra (Stoddart 1971*b*) but are so rare on Middle Island that it seems unlikely they could have affected the brush warbler population.

Fosberg (in Benson & Penny 1968) considered that the only apparent ecological peculiarity of the Gionnet region was the abundance of *Dracaena reflexa*, a plant not common over most of Aldabra. However, a number of different factors taken in conjunction make the north coast 'mixed scrub' habitat at Gionnet clearly distinct from any other area of the atoll. These factors are:

(1) extremely dense, closed-canopy vegetation, with a considerable leaf litter/soil layer beneath;

(2) large, dense stands of almost pure *Pandanus tectorius*;

(3) a high abundance of *Dracaena reflexa*;

(4) a total absence of both tortoises and goats.

It seems likely that some combination of the above factors is critical for the presence of brush warblers, although the relative importance of each is still speculative. The exceptionally rich 'mixed scrub', and possibly *Dracaena reflexa* in particular, may be essential for the species to forage in. It is probable that the growth form of *Pandanus* offers higher than average protection for nests from rat predation; the only active nest of a brush warbler which has been found on Aldabra was built in *Pandanus* (Benson & Penny 1968), and other land bird species very frequently select this plant to nest in in places where it is available (personal observation).

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The absence of tortoises and goats from Gionnet may be of considerable importance in preventing the opening up of the 'mixed scrub' habitat and the disturbance and scattering of the leaf litter layer. Both tortoises and goats, but apparently not brush warblers, occur on Middle Island east of Anse Grande Grabeau (which is placed 2 km west of its correct position on the map in Stoddart (1971*a*)), and here the 'mixed scrub' is much more open. However, this is not necessarily a case of cause and effect since tortoises, goats and brush warblers are all absent from rather similar open vegetation on Polymnie Island. From the east end of the Gionnet coast path (A48) to a point somewhat west of Anse Grande Grabeau there is no path of any type, and the vegetation is extremely dense; this is one of the least known areas of Aldabra. The only landing place from the sea in this region is at Opark, and my limited forays in this area revealed no signs of tortoises or goats which thus seem likely to have the westerly limits of their distribution on Middle Island between here and Anse Grande Grabeau. Tortoises tend generally to be absent from dense scrub on Middle Island (Bourn & Coe 1978), but it is more difficult to understand why goats, which elsewhere extensively utilize even dense '*Pemphis* scrub' (M. Gould, personal communication), should not have spread to the Gionnet area.

The known total world distribution of the Aldabran brush warbler is confined to a 50 m wide strip along the north coast of Middle Island running east for 2 km from Passe Gionnet. Its maximum likely distribution is bounded by the same strip extended to about 1 km west of Anse Grande Grabeau, i.e. some 9 km in length or *ca.* 0.45 km^2 in area. Extrapolation, made on the assumptions that the study area contains three potential brush warbler territories, that the unvisited but potentially suitable area contains a proportionately equivalent number of territories, and that the brush warbler occurs nowhere else on Aldabra, gives a maximum population size of about 25 birds. In fact there is no reason to believe that the population even approaches this figure as the suitability of all the included habitat is uncertain (I found no brush warblers at Opark), and there is also no evidence that even three pairs of brush warblers have ever tried to breed simultaneously within the Gionnet study area.

Aside from rat eradication, which is not now and may never be a feasible proposition, no 'active' conservation measures appear possible. 'Passive' conservation measures should include the total protection of all 'mixed scrub' lying to the west of Anse Grande Grabeau on Middle Island. In particular, no east–west paths should be cut in the intervening region between the Gionnet study site and Anse Grande Grabeau as this might permit goats and/or tortoises to infiltrate past any vegetational barriers that exist. Despite the great difficulty of coastal landings, further investigation of this region should be performed only along paths cut on a north–south axis, and these should be both very narrow (to permit rapid regeneration) and few in number. The creation of further suitable areas for brush warblers is almost certainly impracticable, but other places where it might conceivably exist undetected should be investigated further, e.g. the densely vegetated, little-known region in the southwestern corner of South Island.

The Aldabran brush warbler population is in a critical condition. This state is not directly man-induced, however, and the only feasible conservation measure at present is total protection of both it and its very restricted habitat.

Alec Forbes-Watson, Gary Hill, Chris Huxley, Oliver Prŷs-Jones and Marilyn Walker assisted me at different times in the field. Jenny Horne and Chris Huxley lent me Uher tape recorders. Tony Diamond, Gary Hill, Oliver Prŷs-Jones, David Snow and David Stoddart commented on a draft of this paper. The Royal Society provided facilities at the Aldabra

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Research Station, and the Natural Environment Research Council provided financial support. To all of the above I am grateful.

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Appendix 1. Plant species distribution along the paths in the Gionnet study area

plant species	% of 50 m sectors in which species occurred		
	'A' path	'B' path	'Z' path
Capparidaceae			
Capparis cartilaginea Decaisne	0	10	0
Maerua triphylla A. Rich.	0	0	8
Flacourtiaceae			
Flacourtia ramontchii L'Herit.	5	0	0
Malvaceae			
Abutilon angulatum (Guill. & Perr.) Mast.	32	30	0
Thespesia populnea (L.) Solander ex Correa	11	0	8
Erythroxylaceae			
Erythroxylum acranthum Hemsley	42	60	0
Simaroubaceae			
Suriana maritima L.	5	0	0
Ochnaceae			
Ochna ciliata Lam.	11	40	0
Meliaceae			
Malleastrum leroyi Fosberg	32	0	8
Icacinaceae			
Apodytes dimidiata E. Mey. ex Arn.	63	20	0
Celastraceae			
Maytenus senegalensis (Lam.) Exell	100	100	100
Mystroxylon aethiopicum (Thunb.) Loes.	100	100	58
Rhamnaceae			
Scutia myrtina (Burm. f.) Kurz	32	100	83
Sapindaceae			
Allophylus aldabricus Radlk.	79	100	25
Leguminosae			
Abrus precatorius L.	26	10	0
Caesalpinia bonduc (L.) Roxb.	5	0	0
Dicrostachys microcephala Renv.	42	70	0
Rhizophoraceae			
Rhizophora mucronata Lam.†	0	0	17
Combretaceae			
Terminalia boivinii Tul.	95	70	17
Lythraceae			
Pemphis acidula Forst.	100	100	100
Passifloraceae			
Passiflora suberosa L.	68	30	25
Rubiaceae			
Canthium bibracteatum (Bak.) Hiern	53	60	0
Polysphaeria multiflora Hiern	95	100	33
Tarenna trichantha (Baker) Bremek.	42	40	8
Tarenna supra-axillaris (Hemsley) Bremek.	95	90	33
Tricalysia sonderana Hiern‡	95	60	17
Compositae			
Vernonia grandis (DC.) Humb.	5	60	50
Goodeniaceae			
Scaevola taccada (Gaertn.) Roxb.	11	0	0
Plumbaginaceae			
Plumbago aphylla Bojer ex Boiss.	5	0	0

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plant species	% of 50 m sectors in which species occurred: 'A' path	'B' path	'Z' path
Sapotaceae			
Sideroxylon inerme L.	100	100	100
Oleaceae			
Jasminum elegans Knobl.	59	40	8
Salvadoraceae			
Azima tetracantha Lam.	68	20	0
Asclepiadaceae			
Pleurostelma cernuum (Decaisne) Bullock	100	100	58
Sarcostemma viminale (L.) R. Br.	+	40	0
Secamone fryeri Hemsley	11	0	0
Boraginaceae			
Cordia subcordata Lam.	5	0	8
Convolvulaceae			
Ipomoea macrantha Roem. & Schultes	63	10	25
Ipomoea pes-caprae (L.) R. Br.	16	0	0
Solanaceae			
Solanum indicum L. var. *aldabrense* (Wright) Fosberg	74	70	58
Verbenaceae			
Clerodendrum glabrum E. Meyer	11	10	0
Premna obtusifolia R. Br.	+	0	0
Nytaginaceae			
Pisonia grandis R. Br.	5	0	0
Amaranthaceae			
Achyranthes aspera L.	16	50	58
Deeringia polysperma (Roxb.) Moq.	11	10	0
Loranthaceae			
Bakerella clavata (Desv.) S. Balle	0	0	8
Euphorbiaceae			
Acalypha claoxyloides Hutch.	100	100	100
Euphorbia pyrifolia Lam.	100	100	25
Phyllanthus casticum Soy.-Will.	5	20	0
Margaritaria anomala (Baill.) Fosberg var. *cheloniphorbe* (Hutch.) Fosberg	11	0	0
Moraceae			
Ficus nautarum Baker	21	10	8
Ficus avi-avi Bl.	16	30	25
Ficus reflexa Thunb.	59	100	67
Liliaceae			
Lomatophyllum aldabrense Marais	100	50	17
Asparagus umbellulatus Bresler	11	0	0
Dracaena reflexa Lam.	100	100	8
Orchidaceae			
Acampe rigida Buch.-Han. ex J.E.Sn. (P. F. Hunt)	5	0	0
Pandanaceae			
Pandanus tectorius Parkinson§	95	10	0
total no. of sectors censused	19	10	12

Notes: Each sector on the 'B' and 'Z' paths was censused, but only every alternate sector on the longer 'A' path. + refers to species present along the 'A' path but not occurring within the censused sectors. Grasses, sedges and small herbs were excluded from the censuses.

† May also have included some *Bruguiera gymnorrhiza* (L.) Lam. and *Ceriops tagal* (Perr.) C. B. Robinson.

‡ May also have included some *Coptosperma nigrescens* (Hook. f.) Hiern.

§ *Sensu* Fosberg (1977).

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Appendix 2. Occurrence of plant species in successive 50 m sectors along the 'Z' path at Gionnet

plant species	50 m sectors (see figure 1) 1	2	3	4	5	6	7	8	9	10	11	12	% occurrence
Acalypha claoxyloides	+	+	+	+	+	+	+	+	+	+	+	+	100
Maytenus senegalensis	+	+	+	+	+	+	+	+	+	+	+	+	100
Pemphis acidula	+	+	+	+	+	+	+	+	+	+	+	+	100
Sideroxylon inerme	+	+	+	+	+	+	+	+	+	+	+	+	100
Scutia myrtina	+	+	+	+	+	+	.	+	.	+	+	+	83
Ficus reflexa	+	+	+	+	.	+	.	+	.	.	+	+	67
Achyranthes aspera	+	.	.	+	.	.	+	+	+	+	+	.	58
Mystroxylon aethiopicum	+	+	+	+	.	+	+	+	.	.	.	.	58
Pleurostelma cernuum	+	+	+	+	+	+	.	.	.	.	+	.	58
Solanum indicum	+	.	.	+	.	+	+	.	.	+	+	+	58
Vernonia grandis	+	+	+	.	+	+	+	.	.	.	.	.	50
Polysphaeria multiflora	+	.	+	+	.	.	.	.	.	.	+	+	33
Tarenna supra-axillaris	+	+	.	+	.	.	.	.	.	.	+	.	33
Allophylus aldabricus	+	+	+	.	.	.	.	.	.	.	.	.	25
Euphorbia pyrifolia	+	+	+	.	.	.	.	.	.	.	.	.	25
Ficus avi-avi	.	.	+	.	.	.	.	+	.	.	+	.	25
Ipomoea macrantha	+	.	.	.	.	.	.	+	+	.	.	.	25
Passiflora suberosa	+	+	+	.	.	.	.	.	.	.	.	.	25
Lomatophyllum aldabrense	+	+	.	.	.	.	.	.	.	.	.	.	17
Rhizophora mucronata	.	.	.	.	.	.	.	.	.	.	+	+	17
Terminalia boivinii	+	.	.	.	.	.	.	.	.	.	+	.	17
Tricalysia sonderana	+	.	.	.	.	.	.	.	.	.	+	.	17
Bakerella clavata	.	.	.	+	.	.	.	.	.	.	.	.	8
Cordia subcordata	+	.	.	.	.	.	.	.	.	.	.	.	8
Dracaena reflexa	+	.	.	.	.	.	.	.	.	.	.	.	8
Ficus nautarum	.	.	.	.	.	.	.	.	+	.	.	.	8
Jasminum elegans	+	.	.	.	.	.	.	.	.	.	.	.	8
Maerua triphylla	.	.	.	.	.	.	.	.	+	.	.	.	8
Malleastrum leroyi	+	.	.	.	.	.	.	.	.	.	.	.	8
Tarenna trichantha	.	.	.	.	.	.	.	.	.	.	+	.	8
Thespesia populnea	+	.	.	.	.	.	.	.	.	.	.	.	8
number of species	25	14	14	13	7	10	8	10	8	7	16	8	

+, Present; points indicate absence. Grasses, sedges and small herbs were excluded from the census.

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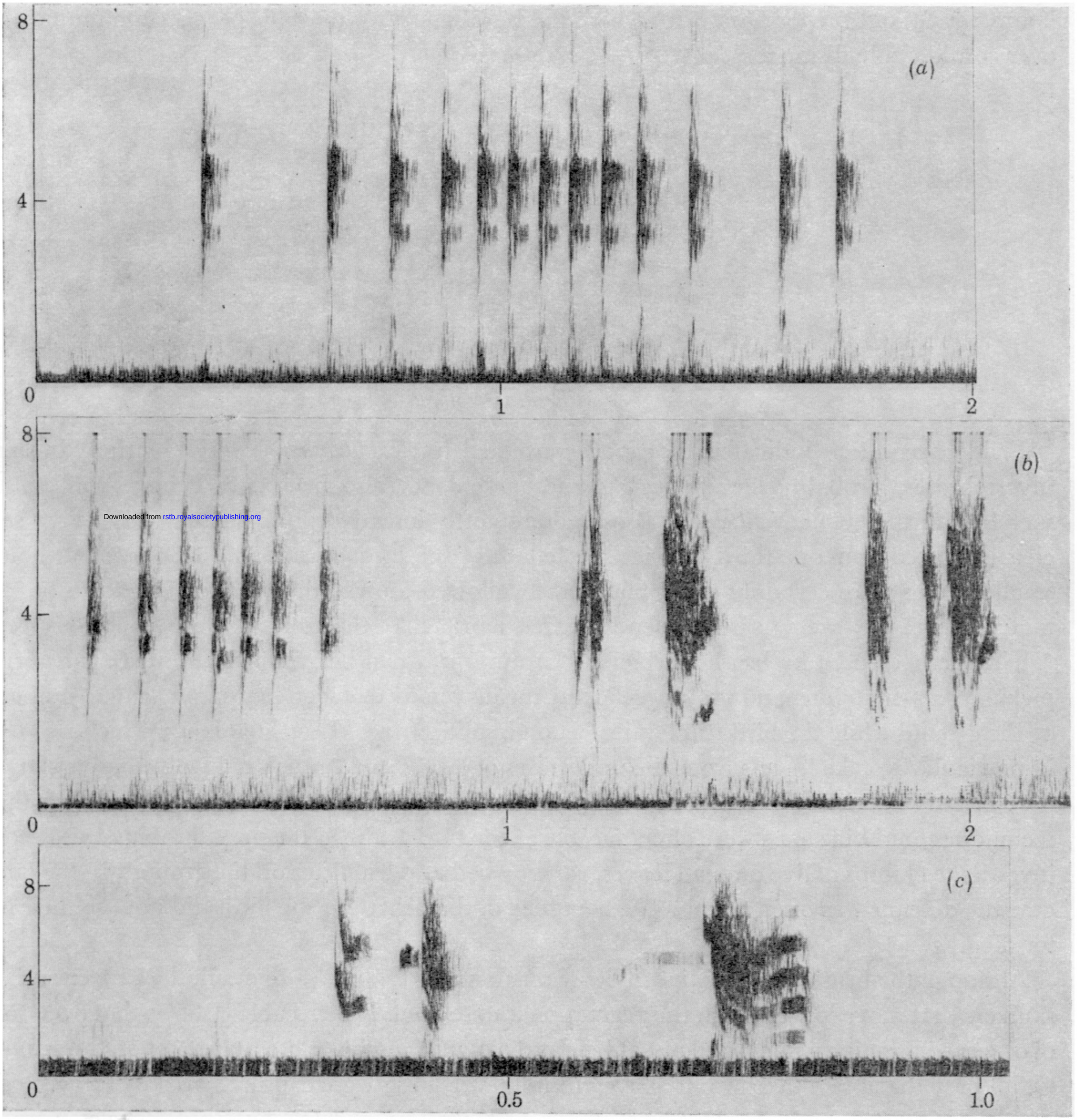

FIGURE 2. Sound spectrograms of brush warbler vocalizations. (*a*) Sequence of 'chak' calls. (*b*) 'Chak' calls followed by two 'chak-chir' phrases. (*c*) Details of a 'chak-chir' phrase illustrating the considerable harmonic structure which some 'chir' calls exhibited. Note that both time and frequency scales are different in (*c*) from those in (*a*) and (*b*).