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Surveying *Rhynchocyon* elephant-shrews in tropical forest

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Summary

A survey for *Rhynchocyon* elephant-shrews, based on the abundance of nests along strip transects, was developed and calibrated using data from a detailed study of the ecology of the Golden-rumped Elephant-shrew *Rhynchocyon chrysopygus*. Using this method, the density of Golden-rumped Elephant-shrews in three different habitats within Arabuko–Sokoke Forest, Kenya was determined, and was found to range from 23 to 75 animals per square kilometre.

Key words: Survey methods, *Rhynchocyon*, elephant-shrews, habitat choice

Résumé

On a réalisé une étude des rats à trompe (*Rhinchocyon*) basée sur l'abondance de nids le long de bandes transects et on l'a calibrée en se servant de données provenant d'une étude détaillée de l'écologie du rat à trompe à croupe dorée, *Rhynchocyon chrysopygus*. Grâce è cette méthode, on a déterminé la densité de cette musaraigne dans trois habitats différents de la forêt Arabuko-Sokoke, au Kenya, et elle est évaluée entre 23 et 75 animaux par km^2.

Introduction

Determining the density of mammals in tropical forest poses a considerable problem for ecologists. Strip census techniques provide a relatively quick means by which density estimates can be obtained for some species, particularly primates (Eberhardt, 1978; Whiteside *et al.*, 1988). For species that are sighted rarely, the relative abundance of indirect signs, such as faecal pellet groups, can be used (Jachmann & Bell, 1984; Barnes & Jensen, 1987; Koster & Hart, 1988). These can only be converted to density estimates, however, if suitable population abundance data are available with which to calibrate them in the same or similar habitat to that being surveyed. In this paper, we describe a method for determining the density of *Rhynchocyon* elephant-shrews using the abundance of nests along fixed width transects.

The three species of elephant-shrew in the genus *Rhynchocyon* are small, shy animals (weighing 500–600 g), generally inhabitating forest habitat in Eastern and Central Africa (Kingdon, 1974; Nicoll & Rathbun, 1990). They are diurnal and entirely insectivorous, tending to feed in deep leaf litter. Only one detailed study of their behaviour and ecology has been carried out (Rathbun, 1979) and, due to the difficulty of obtaining reliable density estimates, little information is available concerning their distribution or status (Nicoll & Rathbun, 1990).

The Golden-rumped Elephant-shrew *Rhynchocyon chrysopygus* Günther, which forms the focus of this study, has the most restricted range of all the elephant-shrews, only being reported from the coastal forests of the north Kenya coast (Corbet, 1971). Although much of Kenya's coastal plain was once covered in dry deciduous forest, it is now limited to a few patches, of which by far the largest is Arabuko–Sokoke (area of 372 km^2; Collar & Stuart, 1988). Many of the forests that remain on the coast are under pressure from tree and pole cutting, and from agricultural encroachment. Consequently, the Golden-rumped Elephant-shrew is ranked as the most endangered member of its family by IUCN's Insectivore, Tree-shrew and Elephant-shrew Specialist Group (Nicoll & Rathbun, 1990), although the lack of information concerning the status of all three species makes it difficult to determine their conservation status. Obtaining reliable density estimates for this and other *Rhynchocyon* species is therefore essential.

All three *Rhynchocyon* species create leaf nests on the forest floor, which cover a small depression in the soil, and are about 50 cms in diameter (Kingdon, 1974; Rathbun, 1979). Each individual uses a number of nests at any one time. Although the Four-toed Elephant-shrew *Petrodomus tetradactylus* occurs in similar habitat to *Rhynchocyon*, the former species does not build nests, sheltering instead in hollow logs and under dense vegetation (Kingdon, 1974). Unlike the elephant-shrews themselves, the nests of *Rhynchocyon* elephant-shrews are relatively conspicuous and easy to detect, and could provide indirect estimates of abundance. A number of assumptions have to be met, however; that nests are equally visible in all habitats, that elephant-shrews maintain the same number of nests in different habitats, that the abundance or visibility of nests does not vary according to the season and that nests degrade at the same rate in different habitats. Our aims in this study were to test these assumptions to determine whether sightings of nests could provide a means of reliably assessing elephant-shrew densities, and then to use the method to determine the densities of Golden-rumped Elephant-shrews in three different habitat types within Arabuko–Sokoko Forest, Kenya.

Methods

The study was carried out in Arabuko–Sokoke Forest, Kenya, between January and March 1992. The forest, positioned close to Malindi on the Kenya coast, covers 372 km^2 and consists of three main habitat types: (1) woodland dominated by *Brachystegia spiciformis*, on loose sandy soils; (2) *Cynometra–Brachylaena* woodland, on red soils; (3) *Afzelia* forest (Kelsey & Langton, 1984). Annual rainfall is dominated by a long rainy season in April, May and June. Mean rainfall ranges from below 600 mm to more than 1000 mm per annum.

Straight narrow transect lines, just wide enough to walk along, were cut through the area to be sampled, and the perpendicular distance from the transect to the centre of each nest sighted was recorded, to the nearest 0·5 m. All transects were checked twice, once by a local tracker who marked all the nests he saw, and again by the senior author, ensuring that virtually all visible nests were sighted. Nests varied in their state of repair and were categorized as 'in use' (IU) or 'not in use' (NIU). Nests that were no longer used were distinctive in that their 'roofs' had fallen in so that a depression was obvious over the hole in the soil.

Although standard line transect methods record all the animals (or nests, dung piles, etc.) sighted from the transect line, allowing use of all the data, there are problems with determining the effective sample width (Burnham, Anderson & Laake, 1980). In this study, we decided to use a fixed sample width of 6 m (3 m on each side) for a number of reasons. Although nests were abundant, and were easily detected close to the transect line, a pilot study showed that the probability of detection dropped off rapidly at distances greater than 2–3 m due to the nature of the vegetation, particularly in certain habitats. Nests were rarely sighted more than 5 m from the transect line. Nests were also less visible in certain habitats, and the transect area had to be searched thoroughly to ensure that all nests, particularly the older ones, were detected. It was therefore easier to concentrate on searching a fixed area more thoroughly, rather than scanning a wider area less intensively. Care was taken to ensure that all nests within 3 m of the transect line were sighted and that nests whose centre was outside the 3 m distance were not included.

Transects varied in length for logistical reasons but were usually 400 m long; sufficiently long that all transects included at least one nest, even where the elephant-shrew density was low, and most transects included many more. A large number of relatively short transects ensured that as many habitat types as possible could be surveyed in the time available, and for a given total length of transect, a large number of short transects will give a lower sample error than a small number of long transects (Norton-Griffiths, 1975). Sample error was also reduced by stratifying the census area into three zones, based on the main habitat types (see above). A total of 26·2 km of transects was carried out in Arabuko–Sokoke Forest; 7700 m in the *Afzelia* forest, 9400 m in the *Cynometra* forest, and 9100 m in the *Brachystegia* woodland. Transects were randomly positioned through the forest, did not overlap, and, to take into account any variation caused by human disturbance, at least a third of the transects in each habitat were positioned near the forest edge, where the level of disturbance was likely to be higher. Densities were calculated separately for each habitat and then multiplied by the estimated area of that habitat, as determined from aerial photographs (Kelsey & Langton, 1984).

Calibration of nest abundance data

To calibrate the survey method we determined the true Golden-rumped Elephant-shrew density in the main study area of 450 m × 500 m by catching and marking all the individuals, and then carried out ten trial transects through this area. The study site was located in the *Afzelia* forest, and a grid of paths was cut every 50–60 m through it. The elephant-shrews were caught using 25 m–30 m long 3″ fishing nets strung along these paths (Rathbun, 1979). Each individual was marked with coloured plastic rings placed around the hind leg (Rathbun, 1979), ear clipped, and released. Trapping continued until no new individuals were caught for two weeks.

Radiotracking was used to determine the mean home-range size of elephant-shrews in the main study area, to correct for edge effects (Seber, 1982), and also to compare nest use between the different habitats. Eleven elephant-shrews were radiotracked in the main study site in the *Afzelia* forest, and a further 8 in both the *Cynometra* and *Brachystegia* habitats. Elephant-shrews were fitted with radiocollars weighing 6–10 g, and were tracked continually for 6–8 h periods, the position of the animal on a map of the study area being determined every 10 min by triangulation. A grid of paths was cut at 50–60 m intervals through each study site to facilitate accurate locations which were made to an accuracy of 10 m. Radiotracking continued until further data did not increase the home-range estimate. On average, home-range size versus cumulative fix number (Harris *et al.*, 1990) reached an asymptote after approximately 200 fixes (excluding those where the animal was in a nest) and an average of 315 fixes was made for each animal (n=27). Radiotracking was usually completed within 2–4 weeks for each individual to reduce variation caused by gradual shift in home-range positions over time. Radiotracked individuals were usually sighted once every 1–2 h, enabling us to check the accuracy of the triangulations regularly. Elephant-shrews remain in their nests until approximately 0630 h and by starting radiotracking before this time each morning, we could determine the location of nests.

Results

Density of Golden-rumped Elephant-shrews in the main study area

A total of 37 animals was caught in the main study area, of which eight were immature. Since some of these animals would have had ranges extending outside the boundary of the study area, the trapping area was greater than 450 × 500 m. On average elephant-shrews in this area had home ranges of 3·1 ha (n=11, determined using restricted polygon method with all fixes included—Harris *et al.*, 1990), mean diameter 200 m, so an extra band of half this width (100 m) was included on three sides of the study area. The whole diameter was not used since it was unlikely that all the peripheral elephant-shrews were caught, since trapping was only carried out on average in half their range. The study site was bounded on one side by a road which appeared to form an effective barrier. The trapping area was thus 650 m × 600 m (39 ha) and the total density of elephant-shrews estimated to be 37/39=0·95 animals/ha. Since eight of the elephant-shrews caught were immatures, the density of mature individuals was 29/39=0·74/ha.

An alternative estimate of density can also be obtained from radiotracking data. Golden-rumped Elephant-shrews are monogamous and pairs defend their home ranges (Rathbun, 1979). While the total home range size in the main study area averages 3·1 ha, this includes an area of overlap with neighbouring ranges. The exclusive core area (restricted polygon method, 90% of fixes) that is defended and includes minimum overlap with neighbours averages 2·7 ha. Thus using this estimate, the density of mature animals was 2/2·7=0·74 animals/ha, the same as that obtained from the trapping data.

Calibrating the survey method

Ten short, trial transects (of total length 1800 m) through the area of known density produced a mean nest abundance (IU & NIU nests combined) of 1·94 nests/100 m of transect (SE=0·41). To check how accurate the survey method was across different habitats, the density of nests was compared with elephant-shrew abundance in two other sites where independent estimates of elephant-shrew density were available from trapping data combined with radiotracking

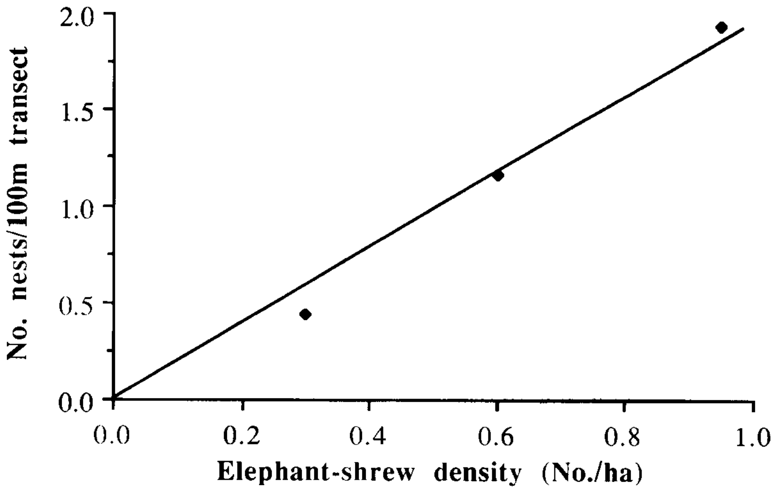

Fig. 1. The relationship between nest abundance and elephant-shrew density in three habitats within Arabuko–Sokoke Forest (line fitted by eye).

data (as described for the main study site), but over a smaller area of 400 × 400 m. The results suggested that nest abundance is positively correlated with elephant-shrew density and that the relationship is linear (Fig. 1).

In order for the relationship between nest abundance and elephant-shrew density to be linear, elephant-shrews must use the same number of nests when in different habitats and at different densities, and the nests must degrade at the same rate. Radiotracking was used to test the first of these assumptions. In Arabuko–Sokoke forest, the mean number of nests used by elephant-shrews to sleep in overnight did not vary significantly between the three different habitats (ANOVA, $F=1{\cdot}41$, df=2, NS; *Afzelia*: 6·5. *Cynometra*: thicket: 6·1, *Brachystegia*: 6·5). On average, elephant-shrews used 6·1 nests, similar to the number estimated for two elephant-shrews (12 'in use' nests for the pair) occupying another habitat type, Coral Rag forest, at Gede Ruins (Rathbun, 1979).

To determine whether nests degraded at the same rate, the ratio of 'in use' and 'not in use' nests found during the survey transects in the three main habitat types was compared. No significant differences were found (% of 'in use' nests in *Afzelia*: 32%, $n=126$; *Brachystegia*: 33%, $n=46$; and *Cynometra*, 28%, $n=142$; Chi-square=4·51, df=2, NS).

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The average number of nests found per 100 m of transect was 1·08 (SE=0·11), 0·33 (SE=0·05) 'in use' nests and 0·75 (SE=0·08) 'not in use' nests, using data from all transects. A histogram of nest frequency against distance from the central transect line shows that nests were equally likely to be found at 2–3 m as at 0–1 m (Fig. 2); Chi-square=1·11, df=2, NS). Nest abundance indices were converted to density estimates using the correction factor of 0·95/1·94 (the density of elephant-shrews in the main study area/the number of nests per 100 m of transect in the same area), densities varied from 23 to 75 elephant-shrews km^{-2} according to the habitat (Table 1). Golden-rumped Elephant-shrews were

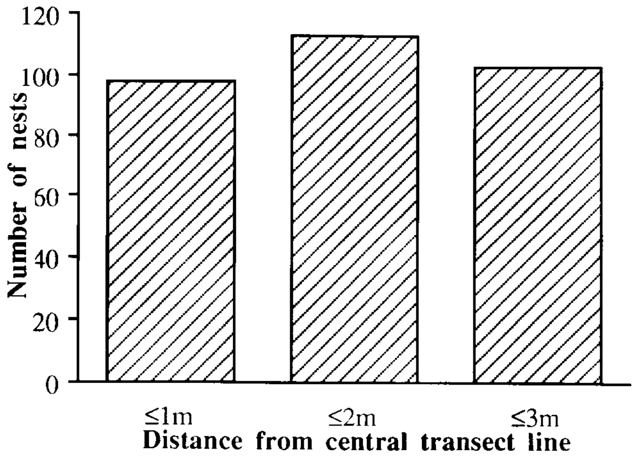

Fig. 2. The number of nests sighted at different distances from the central transect line (all transects combined).

Table 1. The density of Golden-rumped Elephant-shrews in the three main habitats of Arabuko–Sokoke Forest, Kenya

Habitat	Nests/100 m of transect ± SE	Density no/km^2 ± SE
Afzelia forest	1·54 ± 0·22	75 ± 11
Cynometra woodland	1·39 ± 0·17	68 ± 8
Brachystegia woodland	0·47 ± 0·10	23 ± 5

more abundant in the *Cynometra* and *Afzelia* habitats than in the *Brachystegia* woodland (ANOVA, df=2·87, F=13·9, P<0·001).

Discussion

The abundance of nests as determined from strip transects was a reliable indicator of elephant-shrew abundance in three habitats within Arabuko–Sokoke Forest, providing a relatively quick and easy means of surveying this small, rarely seen species. The strip census method makes a number of assumptions, however, which need to be tested:

1 That all nests are sighted within the 6 m total transect width and that nests are equally visible in all habitats. By checking all transects twice with two different observers, the probability of locating all nests in different habitats was increased. The histogram of nest sightings against distance from the central line suggests that nests at the edge of the strip were as likely to be detected as those positioned more centrally.

2 That elephant-shrews maintain the same number of nests in different habitats. This was confirmed by radiotracking; elephant-shrews in four different habitats all used about 6 nests.

3 That the abundance of nests does not vary according to the season. Rathbun (1979) reports a peak in nest building activity at the end of the dry season, in September and October, when the deciduous trees lose their leaves and nests will obviously be most abundant just after this time. By collecting most of the data

over a relatively short period (January–March 1992) after the main nest building peak, this problem of seasonal differences is reduced.

4 That the relative frequency of 'in use' and 'not in use' nests is similar in different habitats, i.e. that nests degrade at the same rate. The finding that the percentage of 'in use' nests does not vary between habitats suggests that nests do degrade at the same rate.

5 That nests are distributed at random with respect to the survey path. Transects were cut at random, irrespective of vegetation or geographic features so this assumption was not violated. In addition, since elephant-shrews are monogamous and defend exclusive home ranges, elephant-shrews and their nests tend to be fairly evenly distributed over the habitat, although, on a finer scale, nests within a territory may be partly clustered (Rathbun, 1979).

Using the survey method, it was possible to estimate the density of Golden-rumped Elephant-shrews in three different habitats within Arabuko–Sokoke Forest. The densities were considerably greater than expected and it is clear that reliable survey data are essential for such small animals that are rarely seen. The survey method could provide a quick and easy way to determine the relative abundance of *Rhynchocyon* elephant-shrews in other areas. However, it has not been calibrated for the two other species of *Rhynchocyon* elephant-shrews and, since it is possible that the number of nests used by individual elephant-shrews may vary in different species and in different habitats, these factors need to be tested before converting abundance indices to population densities using the data presented here.

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