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EFFECTS OF OBSERVERS USING DIFFERENT METHODS UPON THE TOTAL POPULATION ESTIMATES OF TWO RESIDENT ISLAND BIRDS

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ABSTRACT.—During a 5-week study of the Nihoa Millerbird and Nihoa Finch, we censused birds using these techniques: two line transect methods, a variable-distance circular plot method, and spot-mapping of territories (millerbirds only). Densities derived from these methods varied greatly. Due to differences in behavior, it appeared that the two species reacted differently to the observer. Millerbirds appeared to be attracted to a moving observer, perhaps to forage on insects; finches appeared to be attracted to a stationary observer in order to feed on seabird eggs temporarily abandoned during the count. Although these behaviors may be unusual, they dramatically demonstrate that no single census method will suffice for all species. The method that assures the least observer effect will provide the most accurate population estimate.

The ornithological literature contains few serious attempts to determine total species populations; the few cases are of very rare or insular populations, usually both. Because of the lack of immigration and emigration geographically inherent in island environments, the census of resident island bird populations can provide important insights into many questions of avian biology. We discuss here two such species' populations and demonstrate the potential of different census methods that result in quite different population estimates.

Nihoa Island, a volcanic high island remnant, is the easternmost of the Northwestern Hawaiian Islands, which largely make up the Hawaiian Islands National Wildlife Refuge. The island is 63.2 ha in area, rising to 273 m, with an average southward facing slope of 45°. The east, west, and north coasts are sheer cliffs, and the south coast consists of low (10–20 m) cliffs skirted by rock benches. There is one nearly inaccessible beach. The vegetation is very low, rarely exceeding 0.75 m high, and is largely made up of three shrub species (*Sida fallax, Solanum nelsoni,* and *Chenopodium oahuense*).

Nihoa is one of the only two sizable high islands (Necker is the other) of the Northwestern Hawaiian Islands. As such, it supports a biota that is unique in several ways, as compared to the refuge's atolls. Nihoa has endemic plants (Herbst *in* Clapp et al. 1977), several arthropod taxa (Beardsley 1966) and a very dense population of seabirds (including large numbers of shearwaters, petrels, and terns). Nihoa also has two endangered, endemic passerines, the Nihoa Millerbird (Sylviidae: *Acrocephalus familiaris kingi*) and the Nihoa Finch (Drepanididae: *Psittirostra ultima*). The Laysan Millerbird (*A. f. familiaris*), now extinct, was the only other native Hawaiian sylviid. The Nihoa Finch and its close relative the Laysan Finch (*P. cantans*), are two of the only four extant finch-billed drepanidids, all of which are endangered (USFWS 1980). Survival of these two finches on two tiny islands will be dependent on management programs that successfully prevent introduction of exotic biota and other forms of human disturbance.

The difficulty of successfully landing on Nihoa (approximately 50% of all attempts succeed), and the rigorous field conditions, explain why so little is known of the biology of the millerbird and the finch. Aside from a 12-day field expedition in 1969 by John Sincock of the U.S. Fish and Wildlife Service and Ernest Koska, then of the Hawaii Division of Fish and Game, only about 70 days have been spent in the study of the biota of Nihoa (Clapp et al. 1977). Periodic, usually annual, visits by USFWS biologists have rarely entailed more than a brief census of the two land birds. As a result, population estimates for the millerbird and finch have fluctuated greatly, in part no doubt a result of sampling intensity, as well as a reflection of population trends. Estimates of millerbirds have varied from as low as 41 to as high as 592. Estimates of finches have ranged from 1318 to 6686 (Sincock *in* Clapp et al. 1977). Recent (1977–1979) millerbird estimates by Sincock (pers. commun.) range from 127 ± 119% (95% confidence limits) to 490 ± 60%. Sincock's finch estimate for 1979 was 3612 ± 40%.

Obtaining total population estimates of these two resident island birds is desirable for at least two reasons: (1) knowledge of the total population size would enhance our understanding of population dynamics and limiting factors for these species, and (2) development and implementation of management plans would be aided by accurate information on total population numbers.

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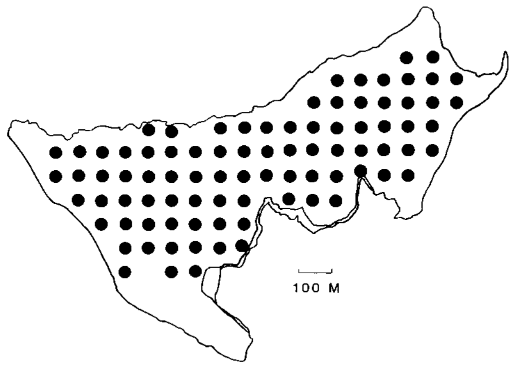

FIGURE 1. Map of Nihoa showing location of the 87 variable-distance circular plot stations.

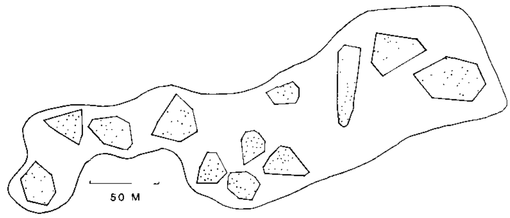

FIGURE 3. Map of 12 millerbird territories within an area thought to have no other resident birds.

The structural simplicity of the ecosystem and the extremely small and defined species' distributions contribute to the attractiveness of Nihoa as an experimental setting. It is possible here to test several methods of estimating avian population numbers, including the important variable, observer effect.

METHODS

Conant and Collins spent 31 May to 6 July 1980 on Nihoa. They censused using three methods: (1) 87 variable-distance circular plot stations (Reynolds et al. 1980), 82 of which were sampled twice for a total of 169 stations (Fig. 1); (2) 49 strip transects 76.2 m (250 ft) long (Fig. 2) were each sampled once in late June, using a variable-distance method (J. T. Emlen 1971); and (3) a fixed-distance strip method based upon that used previously by Sincock (pers. commun.) involving a total count of all birds within 3 m on either side of the observer along the 49 transects. The transects used in the last two methods were randomly established by Sincock in 1968 and have been censused annually since that time.

During studies of millerbirds' breeding behavior, Conant spot-mapped 20 breeding territories, 12 of which were within an area she thought to contain no resident birds other than the 12 breeding pairs (Fig. 3). Locations of either color-marked or behaviorally paired individuals were mapped over a 4-week period. A minimum of 14 observations of one of the pair members was required before we calculated the territory size. The range of registrations was 14 to 31. Two density estimates were derived from spot-map data using: (1) the average size of single territories, and (2) the total area occupied by the 12 territories and the immediately adjacent unoccupied areas (Fig. 3). Both values for territory size were extrapolated to the total island area and multiplied by two to arrive at a total population estimate. We judge that virtually the entire island has habitat suitable for breeding.

We calculated 95% confidence limits for all of the population estimates by the following formula:

$$\text{C.I.} = \hat{N} \pm \sqrt{\frac{d}{a}} \times 1.96$$

where $\hat{N}$ is the estimate of the total population, d is the density per ha, and a is the area surveyed in ha. This latter figure was derived directly in strip censuses, and calculated in variable-distance counts from the effective detection distance (Ramsey and Scott 1979). Significance levels between densities at different distances from the observer were calculated by the method of Ramsey and Scott (1979).

RESULTS

Total population estimates varied depending on which method was used (Fig. 4). Estimates

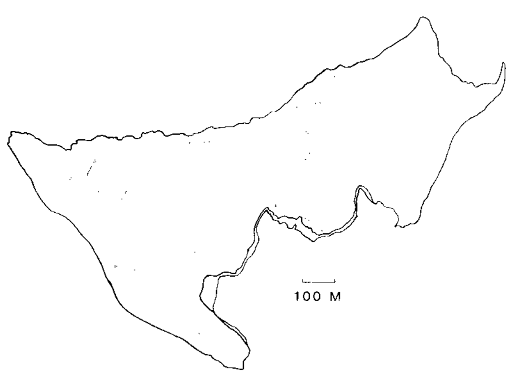

FIGURE 2. Map showing locations of the 49 strip transects.

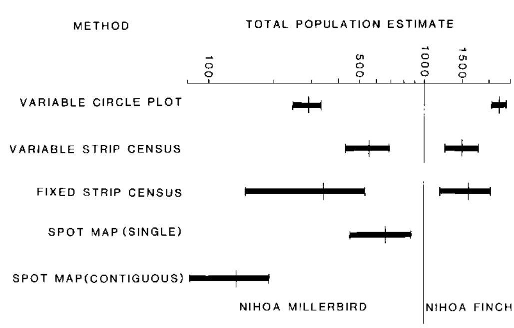

FIGURE 4. Total population estimates with 95% confidence limits for millerbirds and finches.

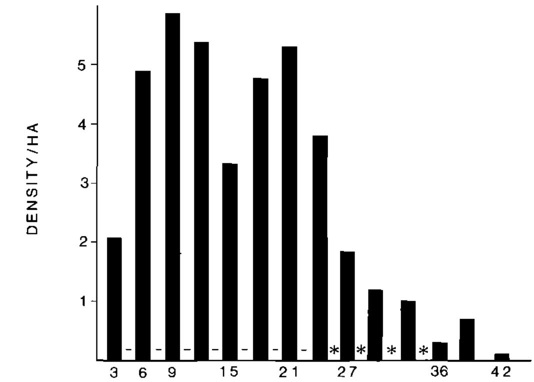

FIGURE 5. Millerbird densities resulting from variable-circular plot method. Distance measurements are the outer limit of each band in 3 m intervals. (* indicates a significant difference in densities between the band farther out and all those closer to the observer.)

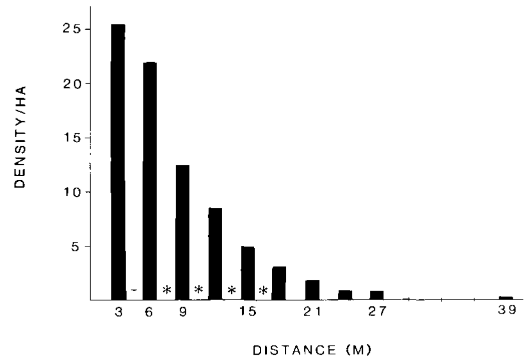

FIGURE 6. Finch densities resulting from variable-distance strip transect method. (*—see Fig. 5.)

of millerbirds varied from 133 to 659, and estimates of finches varied from 1499 to 2219 (Table 1). For the millerbird, highest total population estimates resulted from the variable strip and the variable-circle stations. For the finch, the highest density was from the variable-circle stations, and the lowest from the variable distance strips and the fixed-distance strips. The 95% confidence intervals calculated were smallest for the circular-plot stations and largest for the fixed-distance strips.

The variable-distance methods (circular-plot stations and variable-strip transects) provided data allowing us to identify different types of observer effects. The strip censuses were conducted by a moving observer, while in the station counts the observer was stationary. A species that is unaffected by the presence of an observer would show a reasonably flat distribution of individuals per ha out to the "basal radius" (see the "no attraction" curve in Figure 9). From this point outward fewer birds are detected, as some are overlooked. If birds are, for instance, repulsed by an observer, there would be significantly fewer close to the observer. With this in mind, we examined the patterns of abundance by the different methods.

With two census methods there appeared to be no observer effect: variable-circular plots of millerbirds (Fig. 5) and variable-strip censuses for the finch (Fig. 6). In both cases there was no significant increase in density out to the basal radius, which was 24 m in the millerbird and 9 m in the finch. In contrast, the variable-circle

TABLE 1

RESULTS OF VARIOUS CENSUS METHODS USED TO ESTIMATE DENSITIES AND TOTAL POPULATIONS OF THE NIHOA FINCH AND THE NIHOA MILLERBIRD

Method	No. of samples	No. birds in count	Effect. detect. dist. (m)	Size of plot (ha)	Area of plots (ha)	Dens. per ha	Total pop. est.	95% confid. limits (±)
Nihoa Finch								
Var.-dist. circle	169	597	18.6	0.11	18.3	32.6	2060	165
Var.-dist. strip	49	172	7.8	0.12	5.8	22.8	1443	247
Fixed-dist. strip	49	57	—	0.05	2.2	25.4	1608	418
Nihoa Millerbird								
Var.-dist. circle	169	187	27.8	0.24	41.1	4.5	287	41
Var.-dist. strip	49	91	11.4	0.17	8.5	8.5	537	124
Fixed-dist. strip	49	12	—	0.05	2.2	5.4	338	192
Spot map (single)	20	—	—	0.19[1]	3.8	10.4	659	205
Spot map (contig.)	12	—	—	0.95[1]	11.4	2.1	133	53

[1] Mean size of territory.

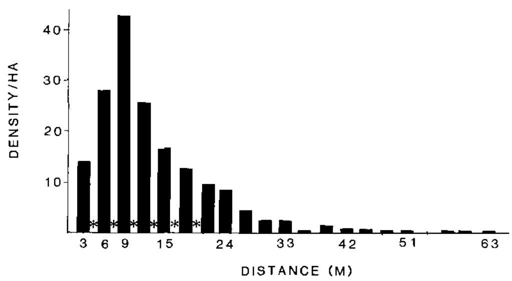

FIGURE 7. Finch densities resulting from variable-distance circle plot method. (*—see Fig. 5.)

plot censuses of finches with a stationary observer (Fig. 7) and the variable-strip censuses of millerbirds with a moving observer (Fig. 8) suggested an observer effect. In both cases, there are significantly ($P \leq 0.05$) fewer birds closer to the observer than at greater distances (peaking in the 6–9 m band). At first glance, it might appear that in both methods the birds were repulsed by the observer. However, we suggest that birds are actually attracted to the observer. The crucial point in arriving at this conclusion is that *the two censuses with probable observer effects both yielded the highest density estimates* of the species censused (Fig. 4). These results argue that the birds were attracted to the observer.

DISCUSSION

We hypothesize that the two patterns of density are derived as in Figure 9. When there is no

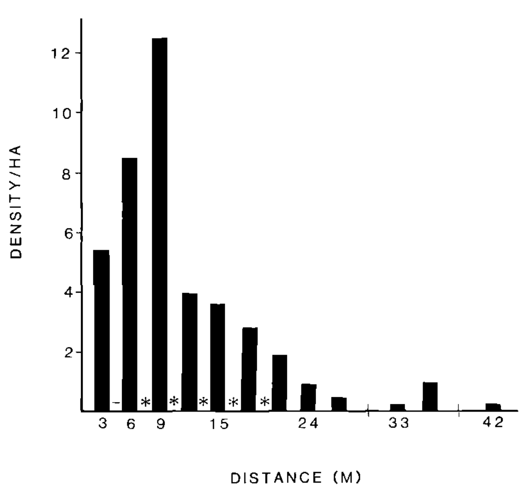

FIGURE 8. Millerbird densities resulting from variable-distance strip transect method. (*—see Fig. 5.)

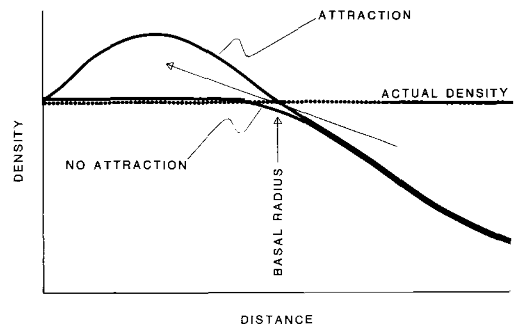

FIGURE 9. Hypothetical detection curves showing expected patterns with and without observer effect (attraction). Basal radius occurs at the effective detection distance.

observer effect, the detection curve should be without significant changes from the observer out to the basal radius, where it begins to drop off (see "no attraction" curve, Fig. 9). When birds are attracted to the observer, as we suggest, they approach the observer from an area near and beyond the basal radius (see "attraction" curve, Fig. 9). The question may be raised: What are the causes of the attraction? We suggest that it is a response to food resources.

The millerbird is an insectivorous bird, gleaning insects primarily from foliage, but also from stems, from litter, and on the soil surface. The finch is omnivorous, eating a considerable variety of vegetable material as well as the eggs of seabirds. The strong attraction of finches to exposed seabird eggs has been noted by several observers (e.g., Sincock, pers. commun., Clapp et al. 1977).

Based on observations of feeding behavior, and on examination of the lateral distribution of birds in relation to observers, we developed hypotheses to explain the apparent attraction of millerbirds to a moving observer and of finches to a stationary observer. We suggest that the millerbird is perhaps attracted to the insects flushed by a moving observer; hence the variable strip transects yielded the higher densities. The finch, on the other hand, should be attracted to a stationary observer because seabirds on nests near the observer will have left their eggs temporarily exposed during the count; thus the variable-circle plots yield the highest finch estimate. Finches may also be attracted to a moving observer, but are likely to be attracted to the area behind the observer, where seabirds are off the nest, so that birds drawn in behind the observer's path will not be counted.

Based on our interpretation of the data, we feel that the best population estimates for the two species result from the censuses without significant observer effect; that is, the variable-circle plot in the millerbird (287 ± 42 birds), and from the variable-strip census in the finch (1499 ± 250 birds). The fixed width strip census yielded densities with too large a variance to be useful because of the narrow area (6 m wide) surveyed. Spot-mapping is inadequate because: (1) it is extremely time-consuming relative to the sample size obtained; (2) it cannot document adequately "floaters" or those pairs that are relatively inconspicuous because of their stage of nesting; and (3) it is difficult to assign an accurate figure to the area surveyed (cf. "single" and "contiguous" spot-mapping in Fig. 4).

A major conclusion of this study is that the effects of an observer in bird censuses may be profound. Additionally, it is evident that the responses of birds to observers may vary depending on the species. An understanding of the birds' behavior permits the application of the least biased method to arrive at population estimates.

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