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Census Methods for Caribbean Land Birds

Joseph M. Wunderle, Jr.

SUMMARY

Different census methods can be used to survey the distribution of a terrestrial bird species or to monitor population changes. The appropriate method depends on whether the objective is simply to document the presence of a species or to quantify its relative abundance, population density, population trends over time, habitat use, survivorship, or the physical condition of individuals. Once the objective is defined, consideration should be given to selecting a study site, the number of sampling units, the time of day, the time of year, and the experience of field personnel. The various census techniques, and their advantages and disadvantages in the Caribbean Islands, discussed in this paper are: point counts without distance estimation, variable-radius point counts, fixed-radius point counts, point counts for parrots, line transects without distance estimates, variable-distance line transects, strip transects, spot mapping, territory mapping of color-banded birds, mist petting, and use of tape-recorded playback to enhance detectability. For most studies of land birds in the Caribbean, the fixed-radius point count method is recommended.

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INTRODUCTION

In the Caribbean Islands, 37 species of resident birds are currently threatened with extinction; 34 of these are terrestrial species (Collar and Andrew 1988). In addition, the Caribbean is visited by thousands of North American migrants each winter, and many of these may be threatened by habitat disturbance on the breeding grounds or on their wintering areas in the Caribbean. In most cases, little or nothing is known of the basic population biology necessary to prevent extinction of these island residents or visitors. Our ignorance frequently includes a lack of essential information on habitat distribution, natural population fluctuations, and population response to a variety of natural and human-caused disturbances. This ignorance could prove tragic to some of the region's threatened species, particularly on islands where human disturbances and frequent natural events, such as droughts and hurricanes, could drastically reduce bird populations. Thus, there is a need to encourage and assist Caribbean biologists in surveying and monitoring bird populations on their islands.

Ornithologists have used a variety of techniques to survey the abundance and distribution of Caribbean bird populations. For example, some surveys have involved observers who remained stationary for a fixed-time interval and counted all birds detected at a point (Cox and Ricklefs 1977, Rivera-Milan 1992, Wunderle 1985) or counted only those birds within a given distance from the observer (Wunderle and others 1992) before proceeding to the next point. In other cases, an observer counted and tallied all birds while walking slowly along a transect line (Lack 1976, Lack and Lack 1973, Lack and others 1973). In some cases, in addition to counting the birds, the observer noted the distance between the birds and the transect (Cruz and Delannoy 1984, Emlen 1977a, Faaborg and Arendt 1985) or counted only the birds within a given distance from the transect line (Vilella and Zwank 1987). Some surveys have involved playing back tape-recordings of songs or other vocalizations of specific secretive species to elicit a response from them in order to document habitat distribution and abundance (Blockstein 1988, Varty 1991, Wunderle 1992). Birds captured in mist nets have also provided an indication of abundance (Diamond 1974, Faaborg and Arendt 1985, Terborgh and Faaborg 1973, Terborgh and others 1978, Wunderle and others 1987). Finally, density estimates (birds per unit area> have been obtained by mapping the positions of unmarked territorial birds (Recher 1970) or by more intensive methods requiring that birds be captured with mist nets and be given unique combinations of color-bands. After banding, the birds are released; then the observer maps their territories (Holmes and others 1989).

In only a few cases have bird populations been monitored for long time periods in the Caribbean. Long-term monitoring with mist nets in the dry forest of Puerto Rico has documented population changes in resident species in relation to rainfall over 9 years (Faaborg and others 1984) and declines in wintering North American migrants over 16 years (Faaborg and Arendt 1991). Christmas bird counts, sponsored by the National Audubon Society headquartered in New York, have been consistently held (for over 15 years in some areas) throughout the Caribbean. Although Christmas counts have numerous weaknesses, they have enabled investigators to detect some general patterns in distribution and abundance (Pashley and Martin 1988). In some instances, monitoring efforts have focused on endangered species such as the Puerto Rican parrot (*Amazona vittata*). With this species, censuses involving numerous observers situated in widespread lookouts in trees, on ridge tops, or in towers are made at sunrise or sunset as the birds move from or to roost sites (Snyder and others 1987). These systematic parrot counts have been made since 1968 and continue today.

To the uninitiated it appears that a bewildering variety of methods have been used to sample terrestrial bird populations in the Caribbean. Yet, in the examples cited previously, the method used was generally appropriate for the question or questions posed by the investigators. Thus, the selection of a particular sampling method is dependent upon the question of interest to the investigator and the time and resources available to conduct the sampling.

Joseph M. Wunderle, Jr., is a research wildlife biologist at the International Institute of Tropical Forestry, U. S. Department of Agriculture, Forest Service, Rio Piedras, PR 00928-2500. In cooperation with: University of Puerto Rico, Rio Piedras, PR 00936-4984.

In this review, some of the most appropriate bird census methods suitable for sampling Caribbean land birds, particularly songbirds (Passeriformes), on the Caribbean Islands are summarized. The census methods described here can be used for surveys of abundance and habitat distribution. For example, censuses might be conducted in a variety of different habitats to determine in which habitat the species of concern is most abundant. Locating the threatened species and its appropriate habitat is the first stage of any conservation effort. Once the appropriate habitat is identified, regular systematic censuses should be conducted to monitor the populations over a long time period. Consistent long-term population monitoring enables the observer to examine how bird populations change in response to natural or human-induced events. The benefit of long-term monitoring was illustrated by recent hurricane studies in which census data collected before a hurricane were available and could be used to provide a baseline for comparison with data collected after a hurricane (Askins and Ewert 1991, Waide 1991, Wauer and Wunderle 1992, Wunderle and others 1992).

A variety of publications have described sampling methods and techniques for songbirds, and some have provided the basis for much of this review (Pyle and others 1987; Ralph and others, 1993; Verner 1985). Because these previously published census methods focus on temperate zone species, methods most appropriate to the Caribbean based on 15 years of sampling bird populations in both the Greater and Lesser Antilles are emphasized in this review. The purpose of this review is to encourage Caribbean bird watchers to adopt widely accepted census methods to routinely survey and monitor bird populations on their islands.

CENSUS REQUIREMENTS

General Requirements

All census methods must satisfy the following basic requirements as listed in Manuwal and Carey (1991):

1. Birds must be accurately identified.
2. Sampling efforts must be adequate to detect the presence of species.
3. Sampling efforts must be adequate to obtain estimates with desired precision.
4. Differences among observers should be slight or accounted for.
5. Differences in detectability among species should be slight or accounted for.
6. Differences in detectability among habitats should be slight or accounted for.
7. Differences in detectability among years should be slight or accounted for.

Selecting Sample Sites

The selection of a site or sites for counting depends on the purpose of the counts. If the counts are intended to describe the distribution and abundance of specific threatened or endangered species, then initial surveys should be made in a variety of different habitats and possibly along habitat "edges." However, for long-term monitoring purposes, it is generally best to sample uniform habitat types. If the study is designed to sample uniform habitats, then counts should be made at least 25 m, and preferably 50 m (Hutto and others 1986), from a habitat border, at least where conditions permit.

Factors Affecting Census Results

Time of Day. -The best time for conducting a census is in the morning from sunrise until about 10 a.m. in the lowlands and until 11 a.m. at high altitudes (> 400 m). It is best if censuses are begun within 15 min of dawn. Mist netting can be done throughout the day, although captures tend to decrease at midday in hot, sunny, lowland habitats.

Time of Year. -Both counting and mist netting can be done in any season of the year. However, if the intent is to monitor population changes, counting or netting should be done every year at roughly the same time. Comparisons of counts in the breeding period with those in the nonbreeding period are difficult because of changes in the behavior of birds. For example, birds are easier to detect during censuses in the breeding season when they are most vocal, but they are often easier to capture in the nonbreeding period when they wander more. Thus, the time and season of sampling must be standardized.

Periodic droughts can be a serious problem for censuses standardized to fixed dates during the breeding season in many lowland areas, particularly in the subtropical dry forest life zone. Droughts involving delays in the onset of early wet season rains (normally in April or early May) delay breeding and thus reduce census detections. For example, counts scheduled for early May might normally show an abundance of breeding birds, but breeding may be delayed until early June in a drought year, thereby causing fewer detections than normal. One solution to this problem is to time the censuses with the arrival of the early wet season rains in dry forests. However, in moist and wet forests most breeding occurs at the end of the wet season. Therefore, the best solution is to count birds only after breeding activity has been detected. Censuses normally scheduled for nonbreeding periods (i.e., November through January) are less likely to encounter this problem.

Weather. -Conducting a census or capturing with a net should never be done when it's windy, rainy, foggy, or too hot or when there is direct sun on the net.

Record Keeping

Maintaining a field journal is an essential requirement for all field studies. It is valuable to routinely record date, time, location, weather conditions, personnel involved, the number and type of censuses made, all birds seen or heard, and plant phenology (which plants are flowering or fruiting). Additional observations on behavior, nesting, and predation can be valuable. Standardized data sheets should be used for all censuses; examples are shown in the appendix.

Equipment Care

Binoculars of 7 x 35 or higher magnification are most suitable for census work. The greatest problem faced by Caribbean bird watchers is keeping fungal growth off binocular lenses, which occurs under warm, humid conditions. Thus, it is essential to store binoculars in a dry location, such as a wooden box with small holes in the top and a small light bulb set inside the bottom for heating and drying the binoculars. The bulb should be illuminated when the binoculars are in the box.

Binoculars can also be stored in an airtight plastic or metal box (some cracker or cookie containers are ideal) with a cloth bag or an old sock containing silica gel, which will absorb moisture from the container and the binoculars. The silica will turn pink when saturated with moisture and can be dried in an oven to return it to its normal blue coloration. Silica gel can be purchased commercially from a variety of photography stores.

CENSUS METHODS

Selecting a Census Method

Once the objectives of a study are defined, an appropriate method can be selected to take a census of bird populations (table 1). Any of a variety of methods can be used to detect the presence of a species in a habitat. If the species of concern is particularly rare or secretive, use of a tape-recorded playback of vocalizations may enhance the likelihood of detection. If the objective of the study is to obtain a measurement of relative abundance (e.g., number of individuals per point, percentage of points with one or more individuals, number of individuals per kilometer of transect, etc.), then a variety of methods are also available. Measurements of relative abundance are useful for comparative purposes, such as comparing habitats or comparing years. Population trends can be monitored using the same methods for sampling relative abundance. Only a few methods are adequate to measure population density (e.g., number of individuals per hectare), but fortunately most measurements of relative abundance are adequate for most other purposes. Finally, if the objective requires measurements of the physical condition of the birds (fat or lean) or measurements of survival, mist netting will be required.

Point Counts

Point counts are one of the most popular methods for surveying bird distributions and monitoring population changes in Caribbean land birds. This method can be

Table 1. -*Summary* ***of census*** *methods and their appropriateness for specific objectives in the Caribbean (adapted from Manuwal and* Carey *1991)*

Method	Objective*						
	Species presence	Relative abundance	Population		Habitat use	Physical condition	Survival
			Trends	Densitv			
Point counts							
Without distance estimate	R	X	X		X		
Variable-radius	X	X	X		X		
Fixed-raduis	X	R	R		X		
Transects							
Without distance estimate	X	X	X				
Variable-distance estimate	X	X	X	X			
Strip transects	X	X	X	X			
Spot mapping	E	E	E	R	X		
Mapping color-banded birds	E	E	E	X	X		R
Mist netting			X			R	X

*X= adequate to achieve objective.
E = excessive, provides more detail than necessary to achieve objective.
R= recommended for the Caribbean.

used to study yearly changes in bird populations at fixed points, differences in species composition between habitats, and abundance of different species at a specific location. This method is particularly appropriate for Caribbean habitats in which rugged terrain or dense, scrubby vegetation makes walking difficult. Point counts involve an observer standing in one location for a fixed time period and recording all birds detected, whether by sight or by sound. Each point count site should be at least 100 m apart, and preferably 150 to 200 m apart. A single observer can complete 12 to 15 point counts per morning, depending on the terrain. At least 30 counts should be conducted, depending on the abundance of the species and the purpose of the counts. Point counts can be conducted once or many times at a given site.

The time spent at each point should represent the minimum time needed to sample at least 80 percent of the species present at a point. For example, preliminary studies by Waide and Wunderle[1] in a Puerto Rican rain forest and a dry forest indicated that, in a point count, 35 to 46 percent of the species are sampled in the first 5 min, 79 to 83 percent of the species are detected in 10 min, and 85 to 88 percent of the species are detected in 15 min, assuming that 100 percent of the species are detected in 20 min. These results, and those of Askins and Ewert (1991), suggest that a point count of 10 min duration may be adequate for most Caribbean surveys. However, observers might wish to conduct some initial experiments to establish the appropriate time period needed to sample a point.

The point count method, because of its simplicity and practicality in rough terrain and thick vegetation, is well suited for most songbird survey and monitoring work in the Caribbean. Unfortunately, point counts are not very accurate for estimating population densities, particularly for species with low densities. For instance, Burnham and others (1980) have shown that a minimum of 40 point counts must contain the species of concern to accurately estimate population density, so that density estimates for a rare species might require 100 or more point counts. However, for most conservation purposes, a density estimate may not be required, and the results from point counts can provide a reliable index of abundance. In fact, Verner (1985) argues that point counts are the preferred method for monitoring long-term population trends because "... the time spent counting can be absolutely controlled, and more sites can be sampled, permitting more representative sampling." However, several factors must be considered to obtain accurate point counts. Because estimates of distance must be made in both the variable-radius and fixed-radius point count methods, it is essential that all participants practice estimating distances with known references in the appropriate habitat. An optical range finder can be very useful for practicing distance estimates. Practice should continue until all observers obtain consistent levels of accuracy for distances within 25 m.

The accuracy of point counts (as well as the accuracy of most other methods) in different habitats is likely to vary. Visual census methods (point counts, transects, spot mapping, etc.) detect most species in open areas and areas with low vegetation, but not in areas with thick vegetation. Furthermore, as the vegetation heights increase, the ability to detect certain species in the canopy decreases. This deficiency was illustrated in a point count study by Waide and Narins (1988) using a 22-m canopy tower in the El Verde rain forest in Puerto Rico. Here they discovered that two of three canopy-singing species were underestimated by 33 to 46 percent in ground point counts. Species that sang softly or at high frequencies were most likely to be missed by observers at ground level. To counter this problem, they suggested using a small, 20-m, fixed-radius point count (or small, fixed band for transects), because this tended to minimize the bias against certain canopy-singing species. Care also should be used in estimating the distance to singing or calling individuals (those not observed) because this method is most vulnerable to error.

Point counts can be classified into three major types depending on how the observer treats information on distance from the birds (fig. 1) and classified into a fourth type when modified for counting parrots:

Point Counts Without Distance Estimation. — Detected birds are counted without regard for distance from the observer. These counts cannot be used for estimating density, but they are useful for measuring species richness. Examples of the use of this method can be found in Cox and Ricklefs (1977) and Wunderle (1985).

Variable-Radius Point Counts. -***The*** observer estimates the distance to the detected birds. Analysis, by species, can include data either grouped into concentric rings of similar radii about the point or data in an ungrouped form (Reynolds and others 1980).

Fixed-Radius Point Counts. -***Detections*** are recorded for birds within a fixed-radius circle around the observer separately from all detections beyond the radius. The size of the radius is dependent on the thickness of the vegetation and the observer's ability to detect all birds. Therefore, the observer should select the largest radius in which all birds can be detected. For most habitats, with the exception of dense vegetation, 25 m is commonly used as the standard radius.

This method can be used to calculate three indices of bird abundance, any of which can be used to test for

[1]Waide, Robert B.; Wunderle, Joseph M., Jr. 1987. Changes in habitats available to migrant land birds in the Caribbean. Unpublished interim report submitted to the World Wildlife Fund-U.S., Washington, DC 20037 U.S.A.

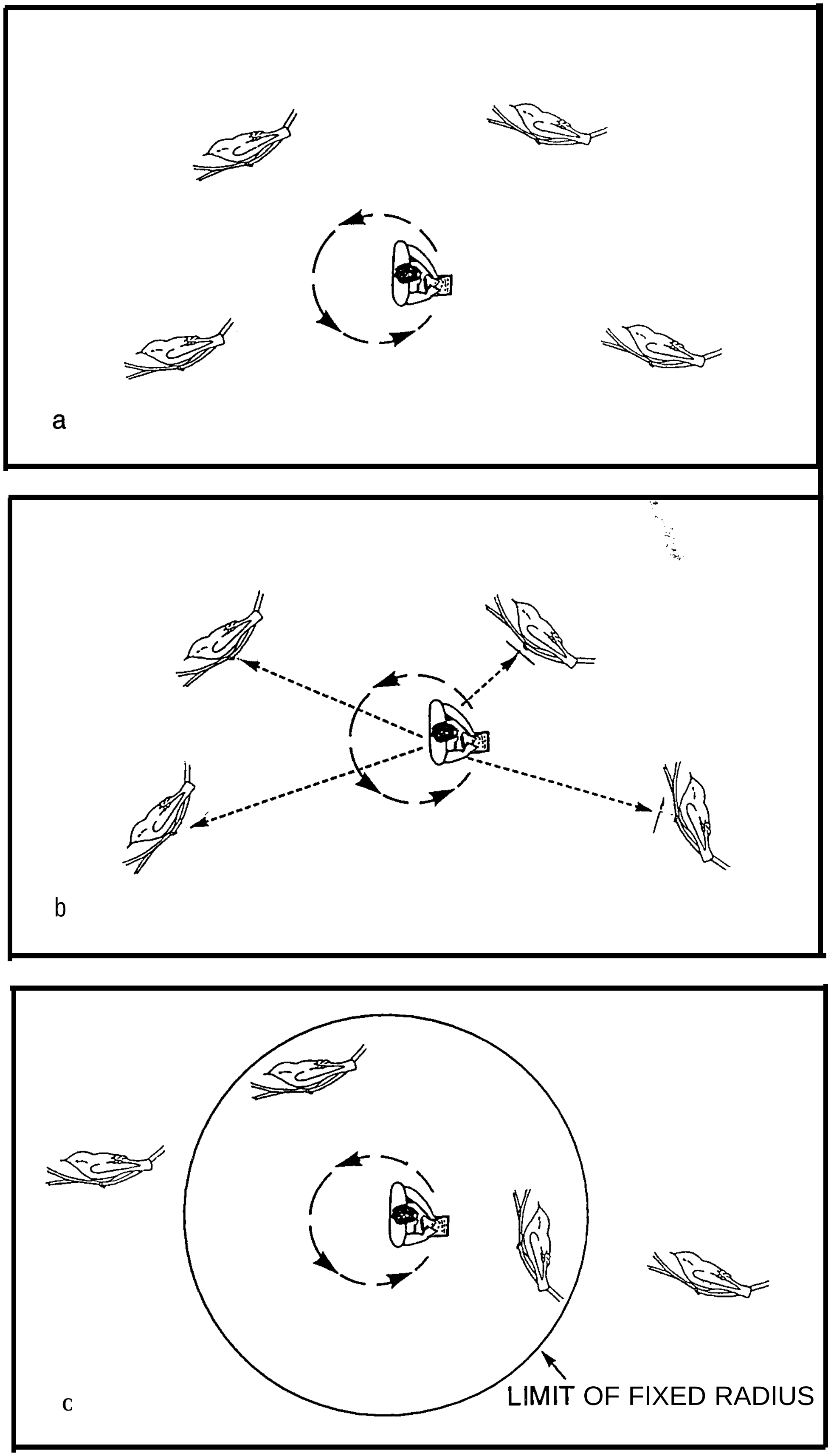

Figure 1.—*A stationary observer making bird observations: (a)* a *point count without distance estimation; (b) a variable-radius point count where the observer estimates the distance to all birds; and (c) a fixed-radius point count in which birds are tallied both within and outside a predefined distance* (radius) *from the observer.*

differences in community composition among sites or for differences in the abundance of a given bird species among sites or among years. These indices are (1) the mean number of detections within 25 m of the observer, (2) the percentage or proportion of points with one or more detections within 25 m of the observer, and (3) the percentage or proportion of points with one or more detections, regardless of the distance from the observer. These indices allow comparisons with standard statistical tests (Hutto and others 1986). Because species differ in their detectability, it is sometimes valuable to calculate a detection ratio for each species, particularly when comparing different species, but also when comparing the same species at different times of the year (such as breeding vs. nonbreeding periods). For example, vocal species, such as scaly-naped pigeons (ramiers, *Columba squamosa)*, have high detection ratios, whereas quiet species, such as hummingbirds (doctorbirds), have low ratios. The detection ratio represents the number of point counts at which a given species was recorded only beyond the 25 m radius divided by the total number of counts at which the species was recorded, whether within or beyond 25 m.

Examples of the calculation of the different indices derived from point counts are shown in table 2.

Hutto and others (1986) recommend fixed-radius point counts because they have fewer assumptions than most other methods of estimating population density and can be used in both the breeding and nonbreeding periods. For examples of different ways in which the method has been used in the Caribbean, see Askins and Ewert (1991) and Wunderle and others (1992).

Point Counts for Parrots. -Because of their elusive behavior, parrots require special census techniques designed to obtain counts as they move to their roost sites before sunset or as they depart from their roost sites after sunrise (Snyder and others 1987). Parrots

Table 2. -Example *of* calculations *of different indices derived from 25-m fixed-radius point counts of 10 minutes duration each (Calculations are based on only 5 point counts for illulstrative purposes, but normally* **would** *involve 30 or more independent points)*

A. From original data sheet (see appendix):

Species	Time 6:04 ≤25m	>25m	Time 6:19 ≤25m	>25m	Time 6:31 ≤25m	>25m	Time 6:45 ≤25m	>25m	Time 7:06 ≤25m	>25m
Bananaquit	2	1	3	1	2	2	4	1	2	0
P.R. Emerald	1	0	1	0	2	0	0	0	1	0
Scaly-n. Pigeon	0	3	0	2	0	1	1	1	0	3
P.R. Tanager	3	2	4	1	6	2	5	2	4	1

B. Summary of indices calculated from field data above:

Species	Mean detections within 25 m	Mean detections unlimited radius	Percentage of points with detections within 25 m	Percentage of points with detections unlimited radius	Detection ratio
Bananaquit*	2.6	3.6	100	106	0.8
P.R. Emerald Hummingbird†	1.0	1.0	80	80	0.0
Scaly-n. Pigeon ‡	0.2	2.2	20	100	1.0
P.R. Tanager §	4.4	6.0	100	100	1.0

*For bananaquits (*Coereba flaveola*), the mean detection within 25 m would be the most appropriate index of abundance.

†For Puerto Rican emerald hummingbirds *(Chlorostilbon maugaeus)*, both the mean detections within 25 m and the percentage of points with detections within 25 m provide equivalent measures of abundance because the mean detection within 25 m is equivalent to one. Note the low detection ratio, indicating the absence of detection beyond 25 m.

*For scaly-naped pigeons *(Columba squamosa)*, the most appropriate index would be either the mean detections per unlimited radius or the percentage of points with detection at points of unlimited radius because this species is rarely detected within 25 m of the observer. (This species is easily disturbed by human presence.) Because of the very high detection ratio of this species, point counts should be widely separated (at least 200 m).

§For Puerto Rican tanagers (*Neospingus speculiferus)*, the appropriate measure would be either the mean detections within 25 m or mean detections at points of unlimited radius. The percentage of point measurements would be inappropriate for this species because of its tendency to occur in flocks.

are best counted simultaneously by several observers situated at different vantage points (ridge tops, tree tops, cleared hillsides, etc.). Each observer counts the passing parrots and records the time of their passage and their compass bearing as they fly out of sight. Because observers at different locations are likely to see and count some of the same birds, information on group size, time, and direction of flight can be used after the census to eliminate duplication.

Snyder and others (1987) have found that counts made during the parrot breeding period need not involve any lookout points other than those covering the nesting areas. During the breeding period (February through May), most parrots, including nonbreeders, roost in the nesting areas where they may be consistently counted. Counts are best conducted from sunrise to about 8 a.m. or from 3:30 p.m. until dark. Lookout sites should have a wide view of the landscape and be spaced so that all flying birds are visible from at least one site. Counts made within forests under the canopy are likely to miss many birds. For this reason, treetop lookouts are particularly valuable for counting parrots in forested regions. Information on construction of treetop platforms for parrot counts can be obtained by writing the Wildlife Program, Caribbean National Forest, USDA Forest Service, P. 0. Box B, Palmer, PR 00721 U.S.A.

Transects

Transects involve slowly walking through a habitat and, therefore, should be conducted only in areas where the observer can concentrate on birds instead of worrying about footing or dodging spiney or poisonous plants. It is important that the observer traverse the transect at a fixed speed (e.g., 100 m in 10 min). Transect censuses can take many forms; three are shown in figure 2.

Line Transects Without Distance Estimates. – This is the simplest form of transect census and can enable the observer to generate a list of species present in a habitat. By walking slowly for a given distance or time period, the observer is able to obtain a list of species that can be compared between habitats. Lack (1976) effectively used this method in Jamaica. It cannot be used for estimating densities, but it does provide information on the presence or absence of species in a habitat.

Variable-Distance Line Transects. -Here the observer must estimate the perpendicular distance to the bird from the transect line. This can be done directly or indirectly by recording the distance from the observer to the bird and the sighting angle between the transect line and the bird. Using this method, transect counts are made in which all detections, visual and aural, out to the distance limit of detectability are recorded. The count for each species is then multiplied by a conversion factor (coefficient of detectability) representing the percentage of the population that is normally detected. Conversion values for each species are derived directly from distribution curves of detection points located laterally from the observer's transect line. Obviously, this technique is difficult to conduct and is recommended only if density estimates are required and only for habitats or terrains where transects can be easily run. For a detailed explanation and examples of the method see Burnham and others (1980) and Emlen (1971, 1977a, 1977b).

Strip Transects. -In this type of transect, fixed boundaries are set on both sides of the transect, and all detected birds within the boundaries (the strip) are tallied. Boundaries are usually set at 25 to 50 m on each side of the transect line, depending on the density of the vegetation. These transects are simpler to run than variable-&stance line transects because the observer estimates only one distance (to the outer boundary) rather than distance estimates for each bird. In addition, density estimates are considerably simpler, requiring only that the total for each species be divided by the area of the strip. However, it is often difficult to be certain whether an individual bird is just inside or outside the boundary.

Although a strip transect is simpler to conduct than the variable-distance line transect, it does not allow the observer to correct the count for differences in species detectability. Because species differ in the ease with which and distance at which they are detected, it is inadvisable to make comparisons among different species. Therefore, a strip transect is best used for making comparisons of one species in different habitats or sites, but with the realization that detectability can vary with habitat and that the derived densities are crude estimates. Vilella and Zwank (1987) provide an example of the proper use of this method for counting calling nightjars at night.

Spot Mapping

This method involves mapping the positions of territorial birds. Detailed field maps and repeated visits (at least 10) to the site are required before the observer is able to determine the territories on the study site and the population density. It is used primarily during the breeding season because it is based on observations of territorial males who are actively displaying on their territories. It is often assumed that all males are paired with a female, which can sometimes be verified during the field visits. Some workers report only the number of territorial males per unit area. Obviously, the method works best with territorial species and is not effective for colonial, highly social, or nonterritorial species. Because spot mapping is done in the main period of breeding, it is most effective for those species with a

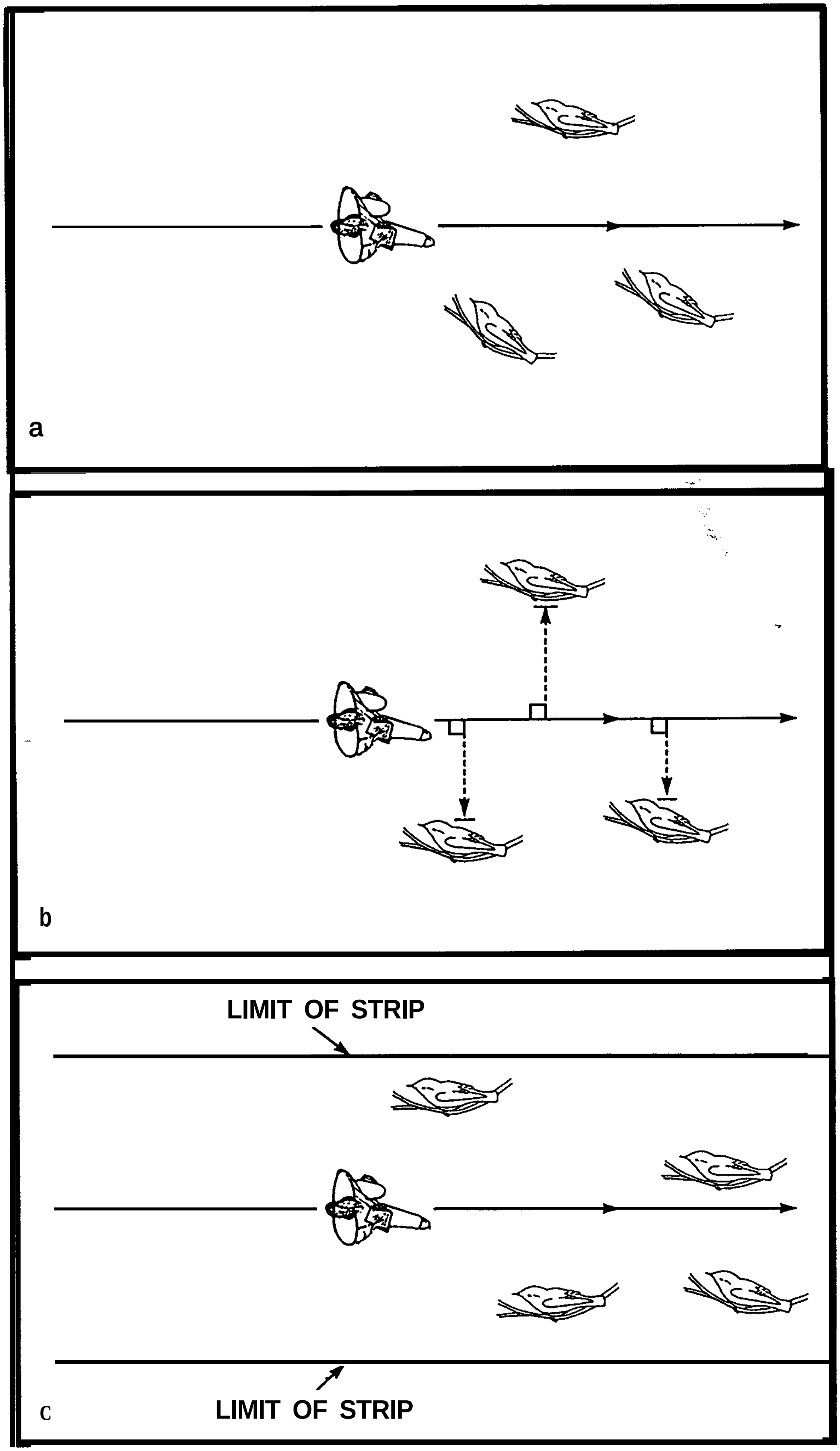

Figure Z.-A slowly moving observer making bird observations while walking a transect line; the observer may: (a) simply record all birds regardless of distance (line transect without distance estimate); (b) record all birds and estimate theirperpendicular distance to the transect line (variable-distance line transect); or (c) record all birds observed within a fixed distance of either side of the transect (strip transect).

short, well-defined breading season. For an example of the use of this method in a Puerto Rican rain forest see Recher (1970).

The method is intensive and is not appropriate for broad-scale monitoring of land birds, but it is appropriate when reasonably precise pair numbers and density estimates are required from small habitat patches or study sites. One or two observers in a single morning can sample 10 to 30 ha in a wooded area or 50 to 100 ha in an open area. The minimum size of the study site depends on the bird density, with the requirement that at least 50 and preferably over 100 pairs be present to obtain sufficient data-at least 10 ha in forests and 50 ha in open habitats. The study site should be as round or square as possible to limit border length, which can influence bird densities. Before the census begins, a detailed map (scale at 1:2,000) is needed, showing landmarks such as trails, streams, forest edges, ridges, roads, etc. If few landmarks are available, it is advisable to place a grid with flagging or metal tags at 25-m intervals throughout the site. It is important that the map show sufficient detail to enable precise plotting of the positions of all birds.

A clean map is used for each census, and different symbols are used for different species and individuals. Each visit should cover the area as evenly as possible, and no part of the site should remain farther than 25 m off the route. The most difficult task is to separate different individuals and not count the same individual two or more times on a visit. This requires walking with moderate speed through the study area and recording birds on the map at the same time. The observer should stop frequently to search for simultaneous observations of different individuals of the same species. If uncertain as to whether one or two individuals are present, the observer should return to the area later the same morning to verify the actual number.

This method is time consuming, particularly if all species on the site are to have their territories mapped. For example, in a forest it usually takes 10 mornings to census 30 ha by the accepted lo-visit version of the method (about 50 to 60 hours of field work). The observer should allow 40 hours (4 hours per morning) to prepare the species maps and approximately 5 to 10 hours to analyze them. Thus one can expect to spend 100 hours to census 30 ha of forest during the breeding season.

The method described here is the standard method used by the Cornell Laboratory of Ornithology in its resident bird counts (known as Breeding Bird Censuses). The counts have been conducted throughout North America, and the organizers welcome participation and publish the results of each plot annually in the "Journal of Field Ornithology." Participation by Caribbean residents is encouraged; contact the Cornell Laboratory of Ornithology, Resident Bird Counts, 159 Sapsucker Woods Road, Ithaca, NY 14850, U.S.A. (telephone 607-254-2441).

Territory Mapping of Color-Banded Birds

By capturing birds in mist nets, leg banding them with unique color combinations, and then mapping their locations after release, an accurate estimate of density can be obtained. In fact, this method provides the best measure of density, even though nonterritorial individuals (floaters) are not accurately counted. If the study is continued for a sufficient time period (4 to 10 years), the method has the added benefit of allowing a measurement of survival of known individuals on their territories. Unfortunately, the method is highly labor-intensive because it requires both the amount of time and effort of spot mapping (e.g., mapping the site followed by numerous visits for mapping individual birds), plus an additional amount of time for capturing and banding the birds. Because the method is so intensive, it is usually used for studying only one or two species at a time (fig. 3).

Mist Netting

Standardized mist netting enables biologists to monitor population changes and provides information about the health of a population. Captured birds can provide detailed information on sex, age, weight, and fat condition, all of which can assist in evaluating the condition of a population. For example, the sex ratio of a population can be used to assess differential survival in the previous year and the potential for population increases. The proportion of juveniles captured can provide a measure of a population's productivity in the previous months (Baillie and others 1986). Weight and fat condition, when related to anatomical measurements (such as wing length), can provide an estimate of the health of individuals in the population. Careful inspection of captured individuals can enable workers to determine the reproductive condition of individuals and the pattern of molt-all basic information needed to determine the annual cycle of reproduction and molt as illustrated by Diamond's (1974) studies in Jamaica. Finally, marking individuals (particularly with color-bands) can aid in studying dispersal and survivorship among years. Examples of Caribbean mist net studies on distribution and long-term population trends can be found in the works of Faaborg and Arendt (1985, 1991), Faaborg and others (1984), Terborgh and Faaborg (1973), and Terborgh and others (1978).

Caribbean land birds have been captured with 6-, 9-, 12-, and 18-m nets; net size depends upon the goals of the project and the source of the nets. Because the capture efficiency for different sized birds varies with the net mesh size (Pardieck and Waide 1992), it is important to consistently use the same mesh size for

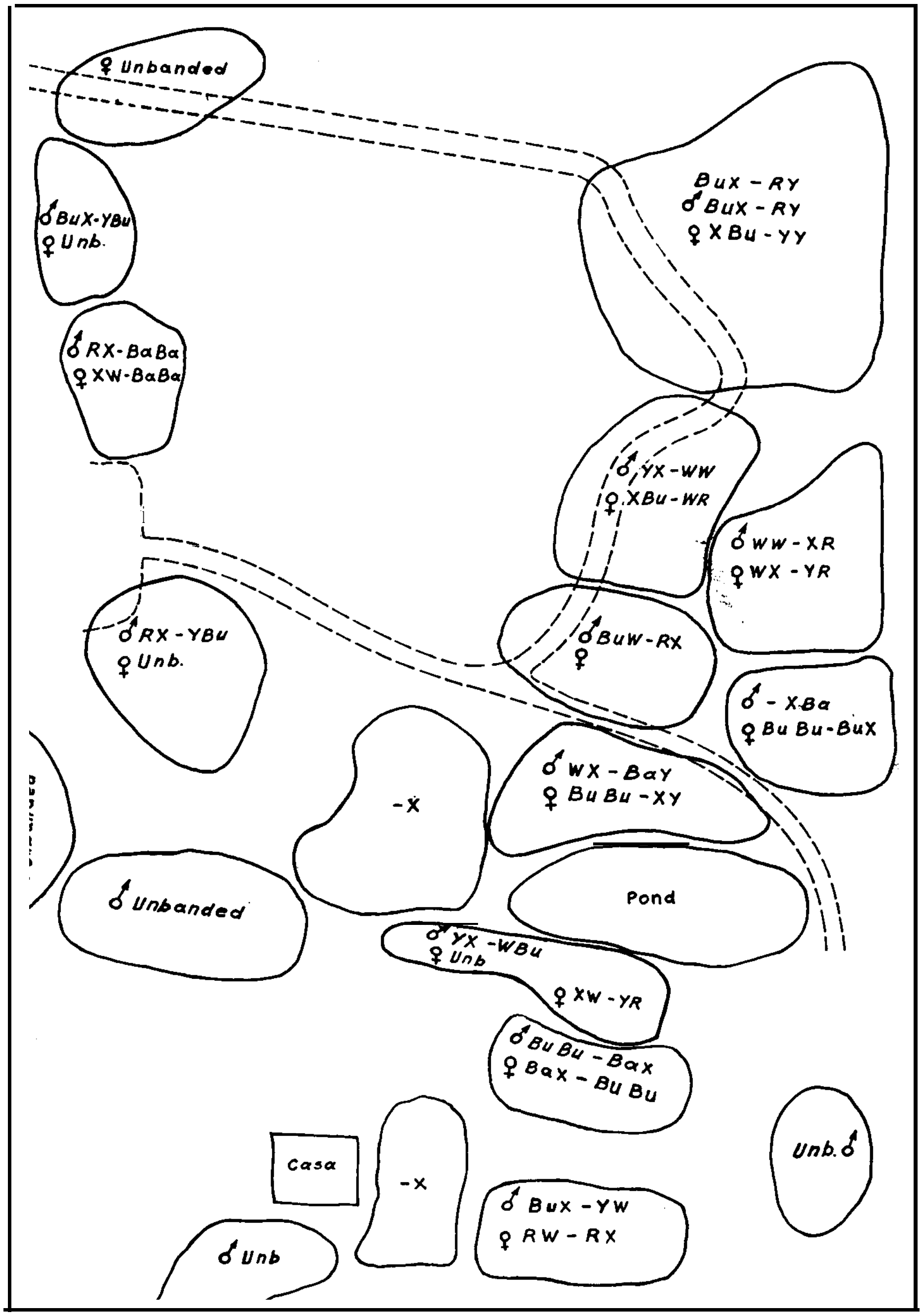

Figure 3.-A *field sketch map of territories of color-banded bananaquits* (**Coereba** flaveola), *in* ***Cayey,*** *PR, on 11 March 1989. Letter* ***code*** *refers to color-band combinations* ***(R.*** *red;* ***Bu.*** *blue; Ba. black;* ***W.*** *white;* ***Y.*** *yellow;* ***X.*** *metal). Band* ***code*** *is read from top to bottom, left to right, with bird facing the observer. Birds with the code* ***-X*** *are individuals with no color-bands and only a metal band on their left leg.*

long-term studies. Generally, nets with a mesh of 30 or 36 mm are used for small- to medium-sized songbirds. Nets can be set between two upright 3.0- to 3.7-m poles braced with two nylon cords at each end. Metal electrical conduit tubes (1.3 cm in diameter) or polyvinyl chloride tubes of the same diameter are readily available in most building supply stores in the Caribbean and can serve as net poles in areas where bamboo poles are unavailable. Supporting cords can be tied to the base of available shrubs or to stakes placed in the ground. Before net placement, a 1.5- to 2.0-m wide strip of vegetation should be cleared along the length of the net to prevent entanglement in the vegetation.

Nets are most effective in areas with no wind and low light levels and where the maximum vegetation height is equal to or only slightly above the top of the net. Nets are less effective in forests with tall trees where canopy dwellers are poorly represented in net samples. This problem can sometimes be alleviated by use of nets strung in the canopy, involving a complex of cords, pulleys, and poles to raise the nets high off the ground. However, in most instances, capture rates with canopy nets are so low that it is rarely worth the effort required to set and operate them.

The most efficient means of operating nets is to place a line of nets end-to-end, so that each net shares a pole with the preceding net. These net lines can be placed on unused trails or abandoned roads that pass through the appropriate habitat. Nets placed on ridges, on habitat edges, near streams, or in mesic sites in dry habitats can have very high capture rates, but samples may not be representative of uniform habitats. Nets should be set up the afternoon before sampling and furled for the evening. On the following morning, nets should be opened at the first sign of light and left for at least 6 hours-and preferably until sundown-for 2 or 3 complete days to obtain an adequate sample. Nets placed in the shade should be checked about every 30 minutes and at least once each hour. Nets should be checked more frequently during light showers and closed during heavy downpours. Nets in the sun in lowland areas should be routinely checked and cleared of birds every 10 minutes . The need for frequent net inspections and the capture rate sets the limit on how many nets can be safely operated at a site. Generally, 2 experienced people can operate 10 to 12 full-length nets, assuming that capture rates are moderate and that only a small amount of information is obtained from each captured bird. However, nets require almost constant vigilance in areas with mongooses or feral cats.

The number of birds captured in mist nets decreases with time, primarily because birds learn where nets are located. Forest bird captures did not decrease when netting intervals were spaced with nonnetting intervals of 2 to 3 weeks (Wunderle and others 1987). However, this procedure may not work in other habitats and with other species; biologists must first experiment to determine the appropriate interval between netting efforts.

Handling and Freeing Captured Birds. — Re- moving birds from mist nets is a fine art that requires hours of practice and is best learned from an experienced person. In fact, a beginner should not operate nets without supervision and assistance until he or she has considerable experience in removing entangled birds. The principal concern in netting should always be the life and health of the captured birds, and a netter should never hesitate to close down nets and immediately release birds when overwhelmed with numerous captures or severe weather conditions. The methods used by most netters to remove birds have been described by Bleitz (19701, Ralph (1967, 1988), and Shreve (1965). Although several different removal techniques have been recommended, the most widely used method is that of Ralph and others (1993):

1. The first and most important step is to determine from which direction the bird entered the net. This requires finding the opening of the pocket caused by the weight of the bird.

2. Once the opening of the pocket is determined, move to the side in which the bird entered the net, and grasp both tibiae- the tibia is the part of the leg above the bare tarsus. If the person removing the bird is right handed, both tibiae should be grasped with the left hand, so that the fingers point towards the bird's head. Both thumb and fingers should hold the tibiae as close to the bird's body as possible, leaving the right hand free to remove net strands from the entangled bird.

3. The process of disentanglement should begin by making certainthat all threads are pulled down and off the tibiae and thighs below the heel joint (the prominent joint between the tibia and tarsus). Note that threads can often be high up on the thigh at the flank.

4. Toes should be untangled by pulling strands gently. A blunt probe, crochet hook, forceps, or pencil can often be useful. Sometimes, if the heel joint is straightened out, the bird's toes will relax and release the netting. Toes can frequently be extracted by first freeing the opposable toe (the "thumb") by sliding threads over it and lifting it away from the other toes. Next, the other three toes should be straightened and the netting slid over these toes, thereby freeing the feet.

5. Once the feet have been freed, the bird should be pulled up and away from the net, still holding the legs on the uppermost part of the tibiae. Pull the bird away from the net creating a small amount of tension, so that when wings and other body parts are freed, the net pulls away from the bird. Next, the netting should be removed from the bend of the wings by working from the underside. Often a badly entangled wing can be freed by carefully opening the wing and sliding the threads off the wing. At this stage, it is useful to pull gently on any exposed threads to free them or to see where they are caught.

6. When the wings are freed, the head should be disentangled by gently pulling threads from the neck, working from the back of the head forward. The bill should be secured by placing the thumb against the tip while pulling the net over the head.

7. In some species, particularly thrushes, thrashers, and woodpeckers, the tongue can be badly entangled in the net. In this situation, the bird's head should be held between the index and second finger, while the third and fourth fingers and thumb can hold the net near the side of the mouth and relieve pressure on the tongue. A probe, such as a pencil, pointed twig, or crochet hook can be manipulated with the free hand to remove the

thread from behind the cleft of the tongue. This method requires considerable skill, and until it is mastered, a small pair of scissors is useful. Often, just clipping a single strand of netting will free the tongue.

8. Birds that are badly entangled and in distress may be extracted by use of a fine knife or scissors. If threads are to be cut, first find the area with one layer of netting, or the area with the fewest layers. As few threads as possible should be cut, and the bird should be pulled through the net. The bird should then be removed from the net in the normal manner. Finally, check to see if any threads remain on the bird, particularly in its wings or bill.

9. Once removed from the net, birds should be placed in small cloth bags for transportation and temporary holding at the processing site. Ideally, birds should each be placed in a separate holding bag, but small nonaggressive species (e.g., warblers or grassquits) can be placed together for short periods of time. It is better to temporarily "store" captured birds in suspended holding bags in the shade rather than hanging in the nets, particularly when processing is delayed. To properly hold a songbird in the hand requires that the bird's head be held between the knuckles and base of the fingers so that its back rests firmly against the palm of the hand. Held properly in this manner the bird should be unable to flap its wings, thereby reducing the risk of injury.

Banding. -If mist netting is used for survey work (e.g., to locate the habitat in which a particular species occurs or is most abundant), then it may not be necessary to band the birds. In this case, simply cutting a small portion of the end of a tail feather will suffice to discriminate between new and recaptured birds during a short netting session (1 to 4 days). It will also save the time and effort required for banding, which would be wasted if a long-term study is not contemplated. Banding is useful only if it will answer a specific question and is not recommended as a routine practice.

Banding is essential for studying long-term survival or for mapping territories at a later date. Banding and banding supplies are tightly regulated by the U.S. Fish and Wildlife Service, and prospective banders are required to work with an established bander before obtaining a banding permit. Numbered aluminum bands and information on methods, equipment, and record-keeping can be obtained from the Bird Banding Laboratory, Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708, U.S.A. Information regarding banding supplies and equipment can also be obtained from AVINET, Inc., P.O. Box 1103, Dryden, NY 13053-1103, U.S.A.

For most studies involving color-banded individuals, it is useful to use four bands (two on each leg), which allows a variety of unique color combinations-three plastic color-bands and a U.S. Fish and Wildlife Service aluminum band. A simple code, which involves reading the band combinations from top to bottom and left to right (with the bird facing the observer, starting with the observer's -not the bird's -left) can be used. For example, the code RY-XW can be used to indicate an individual with a red above a yellow band on the bird's right leg and an aluminum band (X) above a white band on the bird's left leg. Therefore, color type and position, above or below as well as left or right, provide many unique band combinations. The colors red, yellow, blue, and white are easiest to distinguish in the field.

Colored plastic coil bands are attached to the leg by placing the outer end of the band next to the leg and uncoiling the band so that the inner end finally resides on the outside and helps hold the band in place. Although these bands rarely come off the bird, they do require practice to properly place them on the bird's leg. A coat hanger Can be used to practice placing the coil bands. High-quality coil bands of several different sizes and colors that resist fading in the tropical sun can be obtained from AVINET, Inc. or the National Band & Tag Co., 721 York St., Newport, KY 41072, U.S.A. Split-ring plastic color-bands for land birds can be obtained from A. C. Hughes, Ltd., 1 High Street, Hampton Hill, Middlesex TW12 1 NA, UK.

Record Keeping and Data Collection. -Records should be kept of the location, size, type, and number of nets and the hours and weather conditions during which nets are open.

Capture rate per net hour has commonly been used as a unit for standardizing netting effort. The net hour unit simply represents the product of the number of standard-sized nets that are open multiplied by the number of hours the nets are open. For instance, 1 net open for 1 hour represents 1 net hour, whereas 10 nets open for 2 hours represents 20 net hours of netting effort (assuming all nets are of equivalent size, usually 12 m long). The total bird captures are divided by the total net hours, providing a capture rate per net hour that enables comparison of captures obtained from different netting efforts. It is often convenient to convert the capture rate to 100 net hours, as opposed to having to deal with decimal points of a bird! Unfortunately, for most resident species in the Caribbean, captures decrease with netting effort; therefore, capture per net hour is not a useful measurement of effort. For a discussion of the appropriate measurement see Terborgh and Faaborg (1973). The best way to solve this problem, at least when using mist netting for long-term monitoring purposes, is to standardize the number of nets, net placement, hours of operation, and time when nets are opened and closed. For example, Faaborg and others (1984) have always used 3-day samples, usually with a 16-net line, once a year for their long-term studies.

The date, location, species, and (if possible) sex and age should be recorded for each captured individual.

Sex and age are important data, but unfortunately are difficult to determine in many species due to the highly variable nature of size, plumage, and molt patterns in each species. It is important to realize that it is not possible to reliably sex, age, and/or identify all live individuals. In the Caribbean, in particular, reliable methods for aging and sexing have not been determined for many species, and this subject represents an area in which Caribbean ornithologists could make major contributions. Thus, it is better to be cautious than inaccurate when determining age and sex, and there will be many birds for which these determinations will remain unknown.

Aging Birds by Skull Ossification. -The best method for aging songbirds is by determining the extent of ossification (defined below) in the postbreeding period (April through December in most Caribbean habitats). Unfortunately, the method allows the determination of only two age classes -juvenile (hatching year) and adult (after hatching year).

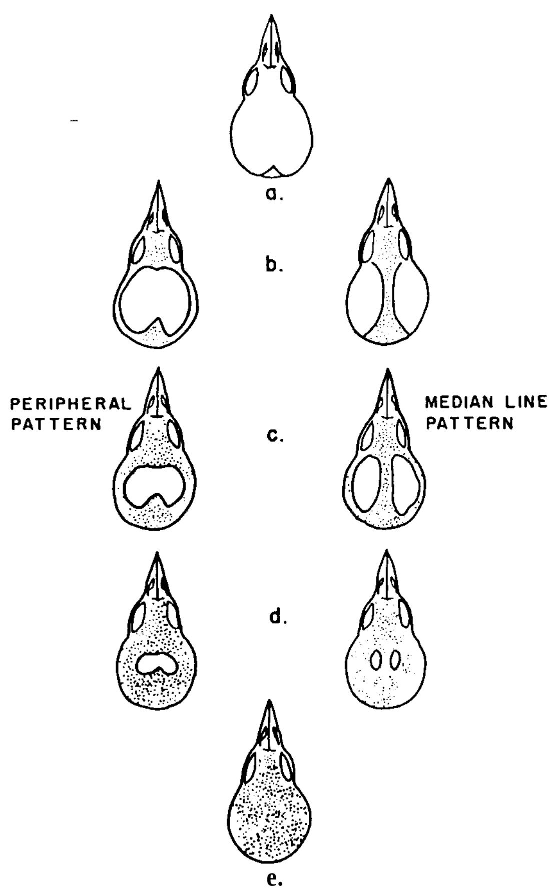

Figure 4. *– Two major patterns of skull ossification proceeding from a very young bird with an unossified skull (a) to a mature adult with a completely ossified skull (e) (adapted from Pyle and others 1987).*

This method is based on the fact that, when a fledgling leaves the nest, the upper section of the skull (parietals and frontals) consists of only a single layer of bone. However, as the fledgling matures (until 4 to 12 months old, depending on the species) a second layer of bone develops below the first layer. As this second layer grows, a series of tiny bone supports is produced (very much like the struts in an airplane wing), which extends through the air space between the two layers. This process is called "ossification" or "pneumatization." When these tiny bone supports are viewed from above, they appear as tiny white dots (ossified) on the skull surface in contrast to the unspotted (unossified) skull of a very young bird.

Although the progression pattern of ossification varies among species, two major patterns are evident (fig. 4). The peripheral ossification pattern is more common in small species, whereas the median line pattern is more common in large species. However, considerable individual variation exists, and in some species either pattern may occur. The speed at which this process occurs varies among species. Unfortunately, the rate of ossification has not been studied in Caribbean birds; therefore, it must be assumed (correctly or incorrectly) that patterns found in North American species are also typical of some Caribbean species. In most North American songbirds, the skulls of the earliest hatching-year birds (hatched in May through early June) may be completely ossified by October or November, but later hatching-year birds (hatched late June through July) may not be completely ossified until November, December, or January. This pattern appears to apply generally to Caribbean birds, at least in Grenada and Puerto Rico. However, it is possible to find birds with incompletely ossified skulls at any time of the year in the Caribbean.

To age birds by the extent of skull ossification requires that the observer first wet the feathers on top of the skull just behind the eyes. Then the feathers must be carefully parted to allow an area of the skull to be viewed through a small area of bare skin. Fortunately, the skin on the skull is very thin and almost transparent. Thus, with sufficient light, one should be able to see the extent of ossification by moving the area of bare skin over the skull. If the skin is thick on the crown, it is often helpful to make the opening in the feathers on the side of the skull or neck where the skin is more transparent. Unossified areas of the skull are pinkish and have no white dots (i.e., have no bone supports), in contrast to the ossified areas with white dots that may have an overall white, pinkish-white, or gray appearance.

The observer's main goal is to locate areas without white dots (unossified), requiring that the bare wet skin be moved over much of the skull in search of unossified regions. By moving the skin over the skull surface, the observer should be able to differentiate between white dots on the skin (which move with the skin) and ossified white dots on the skull (which are stationary when the skin is moved). Except for the youngest fledglings, at least some white dots should be present along the crown midline or the posterior base of the skull (fig. 4). With "advanced" juveniles, the observer must be careful to look for small unossified "windows" on the crown behind the eyes. Care should always be taken to look for these small windows because they are easy to miss. It is often useful to sketch the position and relative size of the unossified windows on the data sheet or in the field notebook. These sketches can contribute to badly needed information on the development of aging criteria for Caribbean species. Some Caribbean species, such as thrashers, may be difficult to age by skull condition because fat on the skull makes it almost impossible to see the skull.

Sex ***Determination. -Birds*** without sexual differences in size or plumage can usually be sexed by the presence of either a brood patch (mostly females) or cloacal protuberance (males only) during the breeding period. The presence of a brood patch or cloacal protuberance can generally be used to reliably identify the appropriate sex, whereas the absence of either structure cannot be used to determine sex, particularly in the Caribbean where breeding and nonbreeding individuals of many species can be found at any time of the year.

Brood Patch. -To transfer body heat effectively to the eggs, females develop a highly vascularized, featherless area on the lower breast and abdomen known as a brood or incubation patch. This enables her to place her bare skin directly on the eggs or young, thereby facilitating heat transfer. Because females do most, if not all, of the incubation and brooding, they have the most highly developed brood patches. Thus, the presence of a substantial brood patch indicates that an individual is a female in most songbirds.

Brood patches begin to form with the loss of abdominal down feathers, 3 to 5 days before the first eggs are laid (Blake 1963). Afterwards, the blood vessels of the area begin to expand, and fluid collects under the skin giving a puffy or swollen appearance, often described as edematous (for the presence of an edema or fluid buildup). Females with this edematous condition are actively incubating eggs or brooding newly hatched young (fig. 5). However, once the nestlings leave the nest, a decrease in vascularization and edema occurs, although the patch may remain defeathered for as long as a month or more (until the initiation of prebasic molt). In this postbreeding condition, prior to molt, the female's brood patch skin-often appears grayish and wrinkled. If the female begins another clutch, the process is repeated.

The brood patch can be located by blowing softly to part the feathers on the lower part of the breast and abdomen where the skin condition can be examined.

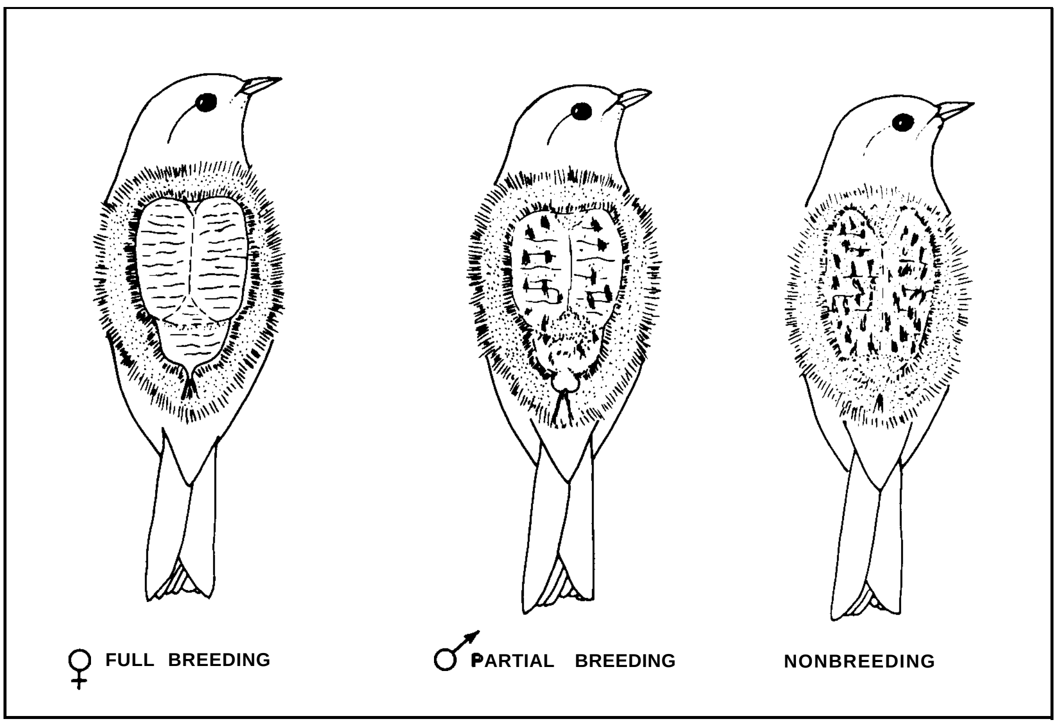

Figure 5. -Different *stages of brood patch development (adapted fmm Pyle and others 1987).*

Care should be taken in looking for a brood patch because the unwary observer can be easily misled. For example, in hummingbirds and many juvenile songbirds, little or no down occurs on the abdomen. Therefore, they might initially look like females with a brood patch; however, the abdomen is quite smooth with a pink or red coloration. Also, males of some songbird species (e.g., ***Myiarchus*** flycatchers, vireos, mimids, and a few others [Pyle and others 19871) will incubate or brood and partially develop a brood patch. However, in these cases, male brood patch development is usually incomplete, and may involve slight to moderate feather loss, vascularization, and swelling that rarely reaches the extent developed by females of the same species. The following categories can be used for classifying the brood patch condition:

1. No Brood Patch – Breast and abdomen with down feathers or with traces of down feathers; skin smooth and not puffy or wrinkled.
2. Smooth Skin-Breast and abdomen with down feathers missing; skin smooth and dark red.
3. Edematous -Breast and abdomen without down feathers and skin puffy or swollen with fluid and increased vascularization evident; represents the peak of incubation.
4. Wrinkled-Breast and abdomen without feathers and skin not swollen; skin has a wrinkled or scaly appearance.

Cloaca1 Protuberance. -With the onset of breeding, male songbirds develop external cloaca1 protuberances, or bulbs, which store sperm and facilitate its transfer during copulation. The protuberance is usually apparent from several weeks to several months depending on the species and the number of clutches produced during the breeding period. The protuberance is absent in nonbreeding males.

The cloacal protuberance can be inspected by blowing the feathers apart in the vent region. A well-developed protuberance in the male forms at a right angle to the abdomen and tends to be larger at the tip than at the base (fig. 6). Although females may occasionally show a small protuberance or at least some swelling in the vent region, it rarely attains the size of the male protuberance. For instance, a female in breeding condition may have a swelling that forms a gradual slope on the abdomen (in contrast to the right angle formed in the male) ending with the cloacal opening directed towards the tail. However, females in this condition are usually in full breeding condition with an active brood patch.

With experience, an observer should be able to identify differences in the size of the cloacal protuberance in the male and may wish to describe the size with subjective categories (i.e., none, small, medium, large).

Molt. -Very little is known about the sequence and timing of molt (feather replacement) in Caribbean birds, yet this information can be useful for determining age and sex in many species. A common molt pattern in northern temperate songbirds and some Caribbean species involves two molts per year, just before and just after the reproductive period. These molts produce two plumages, the basic plumage (nonbreeding) and the alternate plumage (breeding). The molts that bring about these plumages are the prebasic

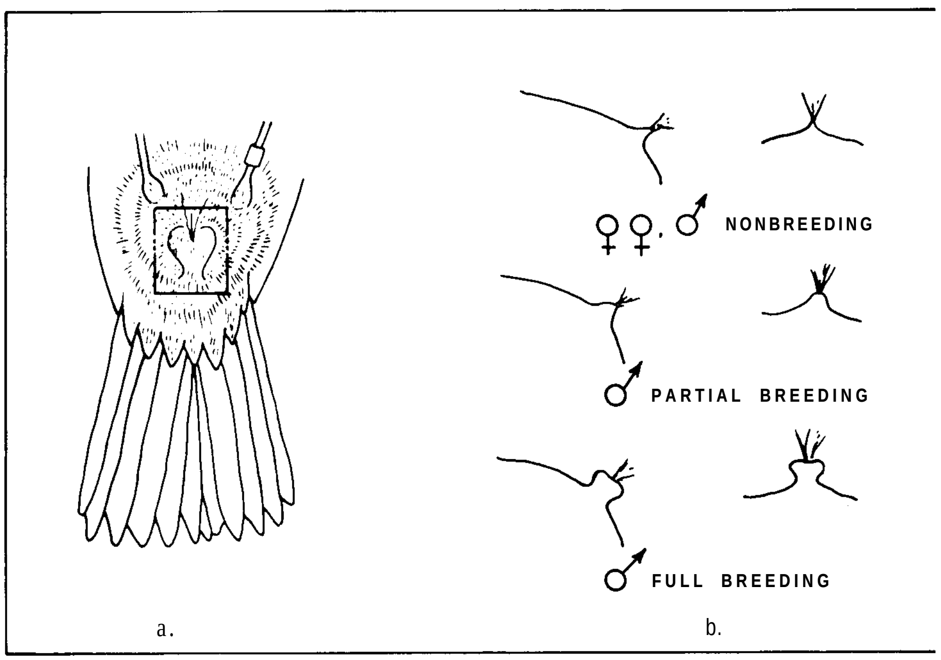

Figure 6. —*Cloacal protuberances at different stages of development in songbirds: (a) a cloacal proturberance at the peak of breeding (boxed); (b) different stages of cloaca1 protruberance development shown in profile (adapted from Pyle and others 1987).*

molt, which produces the basic plumage at the end of the breeding period, and the prealternate molt, which produces the alternate plumage at the end of the non-breeding period. All North American songbirds have a prebasic molt, whereas slightly over half have a pre-alternate molt. Whether this pattern exists for Caribbean species remains to be documented.

Close inspection of a bird's skin, made possible by blowing apart the body feathers, will indicate molting feathers by the presence of a cylindrical sheath around the base of each new feather. The sheath surrounding the molting feather is finally preened off when the feather is fully mature. Thus, the documentation and quantification of body molt simply requires an evaluation of the extent and location of sheathed feathers on a bird's body.

The quantification of body molt usually involves a subjective evaluation of the amount of down or contour feathers sheathed on the body, excluding the wings and tail. A simple three-category scale can be used to quantify this body molt as none, moderate, or heavy. However, the molt of wing and tail feathers (designated as flight feathers) can be evaluated with more precision because the pattern of flight feather molt is usually systematic. Also, it is usually easy to distinguish between new and old flight feathers on a molting individual. To understand and document the pattern of flight feather molt first requires knowledge of the terms used to describe and number these feathers.

Two major groups of flight feathers are recognized on the wing (fig. 7), the primaries and the secondaries ("remiges"). The primaries are the long, outermost feathers attached to the bones of the "hand" and are numbered consecutively from the innermost at the bend of the wing ("wrist-joint") outward to the end of the wing.' Depending on the species, 9 or 10 primary feathers occur on the wing. Pyle and others (1987) summarize the songbirds with 9 and 10 primary feathers per wing. The pattern of primary molt proceeds one feather at a time from the innermost primary (primary number 1) to the outermost primary (primary number 9 or 10, depending on the species) and is symmetrical, occurring simultaneously at the same primary position on both wings. Therefore, primary molt can be recorded by simply noting the primary feather number(s) missing or growing during molt. However, care should be taken to check both wings because feathers are often accidently lost and replaced by an adventitious molt, which is not symmetrical and obviously does not occur seasonally.

The secondaries are the long feathers, on the inner part of the wing, attached to the skin covering the bone of the forearm ("ulna"). The secondaries are numbered in ascending order from the bend of the wing (wrist-joint) inward toward the body. Molting of the secondaries also follows this sequence, one feather at a time, except for the three innermost secondaries ("tertials"), which tend to be molted concurrently with the longer

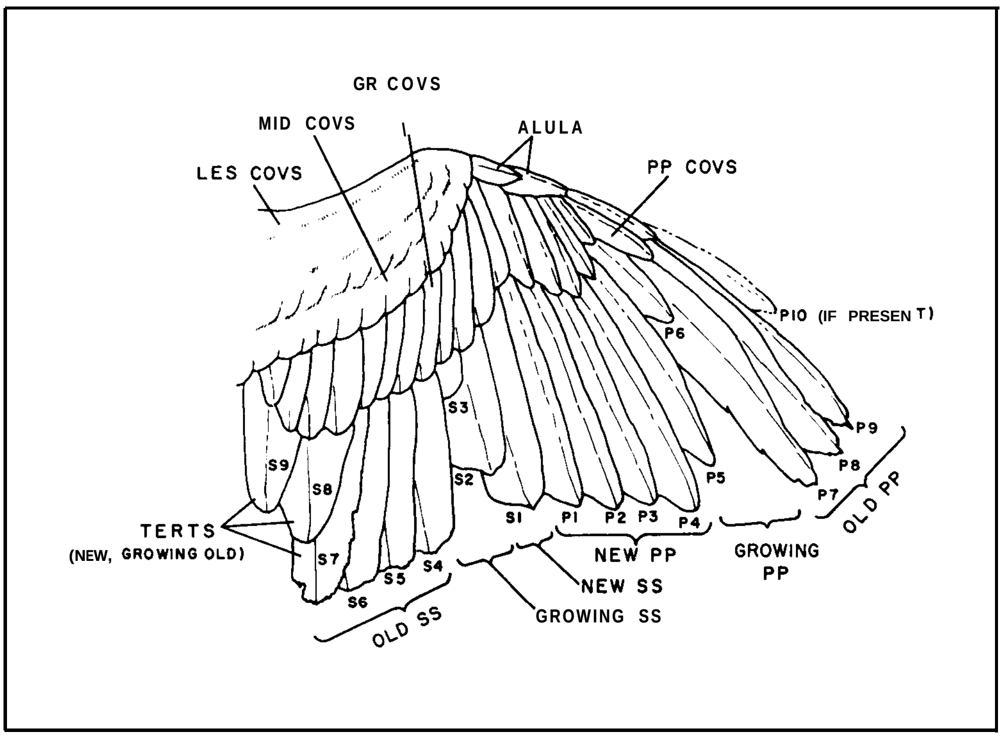

Figure 7. -*An example of a wing during molt, with p indicating primary feather (pp for primaries), s for secondary feather (ss for secondaries), terts for tertials. In this example, primary number 6 and secondary number 3 are molting (adapted from Pyle and others 1987).*

secondaries. As with the molt of the primaries, molt of secondaries can be recorded by noting the number of the molting secondary feather, with a check to see if the molt is symmetrical.

The tail feathers ("rectrices") are numbered in pairs, beginning with the innermost pair (designated as number 1) and proceeding outward in both directions to number 5 or number 6, depending on the species. In other words, the numbering is symmetrical from the innermost pair of feathers ascending to the outermost feathers. The pattern of tail molt varies among species, with the innermost (number 1) feathers sometimes molting simultaneously with the body molt in some juveniles. The remaining rectrices molt symmetrically from the innermost (number 2) to the outermost feathers (number 5 or number 6). Tail molt can be quantified by recording the number of the molting feather.

In summary, molting can be recorded by evaluating the extent and amount of molting feathers on the body and the feather number of the molting flight feathers. More details on molting and its quantification can be found in Ginn and Melville (1983). Not only is basic information needed on molt patterns by age and sex for many Caribbean species, but information on the timing of molt will contribute to the understanding of the annual cycle of the bird species, as demonstrated in the Jamaican avifauna by Diamond (1974).

Body Fat. -An evaluation of the amount of body fat on a bird can provide an indication of the bird's condition. Low fat levels may reveal periods of stress, low food supplies, and other conditions that indicate the viability of an individual. Fat levels vary most in migratory species and are at their highest levels just before migration. Fat, when present, is visibly deposited in the abdomen and the furcula ("wishbone"). Fat deposits can range in color from orange white, yellow white, to off white and generally contrast with the deep red of the pectoral muscle or the dark-colored viscera of the abdomen.

Fat in the furcula region can be inspected by parting the feathers in the region where the neck protrudes from the body. A depression (furcular or interclavicular region) is formed between the attachments of the breast (pectoralis) muscles to the furculum and the coracoids, forming a "V" running toward the spinal cord. Fat in this region can be subjectively ranked into categories from some to a lot. A scale of 0 to 4 is adequate for most Caribbean birds, which would modify the fat categories as described in Ralph and others (1993) (table 3).

Other Measurements. -A diversity of measurements can be made from captured birds as described in detail by Pyle and others (1987) and summarized in figures 8 through 11. Some measurements can be especially valuable in helping to determine the age or sex of certain species. For example, in many birds, the males of a particular population will tend to be larger

Table 3.—*Fat categories for Caribbean birds (adapted from Ralph and others [1993])*

Fat Class	Furculum	Abdomen
0	No fat, region concave	No fat
1	Trace of fat in scattered patches, region deeply concave, furculum less than 5 percent tilled	None or a trace of fat
2	Thin layer of fat, furculum less than 33 percent tilled	Trace or thin layer of fat
3	Fat in small patches, furculum 50 percent tilled	Small patches of fat, not covering some areas
4	Fat level with clavicles, furculum 66 percent filled	Covering pad of fat, slightly mounded
5	Region slightly bulging	Region well mounded

than females of that population. Thus, measurements of wing length, tarsal length, and weight can be quite useful. When these measurements are included with estimates of fat, the body size of the bird can help to provide an indication of its health.

It is important that measurements be taken in a standardized way, particularly when used to determine the age and sex of individuals. Weight is probably the simplest measurement and can be taken with a Pesola® spring scale and a light cloth bag of known weight for holding the bird while suspended. For other standard measurements, refer to either Svensson (1984) or Pyle and others 0987); at least one of these publications should be a standard part of all netting and banding kits, even in the Caribbean.

Tape-Recorded Playback

To attract quiet or secretive species, it is often useful to play a tape-recording of their songs or call notes in the appropriate habitat. This technique is particularly valuable for counting a particular rare species. The tape-recorded playback can be combined with point counts or transects, although censuses that use playback cannot be compared with censuses that do not use playback. One simple playback design involves playing a tape of the vocalizations at the natural rate for 5 minutes followed by 5 minutes of silence in which individuals are counted. This technique could be used at each individual point count or while walking slowly on a transect. If playbacks are done in a consistent manner, they can be used for both survey and monitoring purposes because they provide an index of abundance (but not an actual measurement of density). In the Caribbean, tape playback has been used to survey the

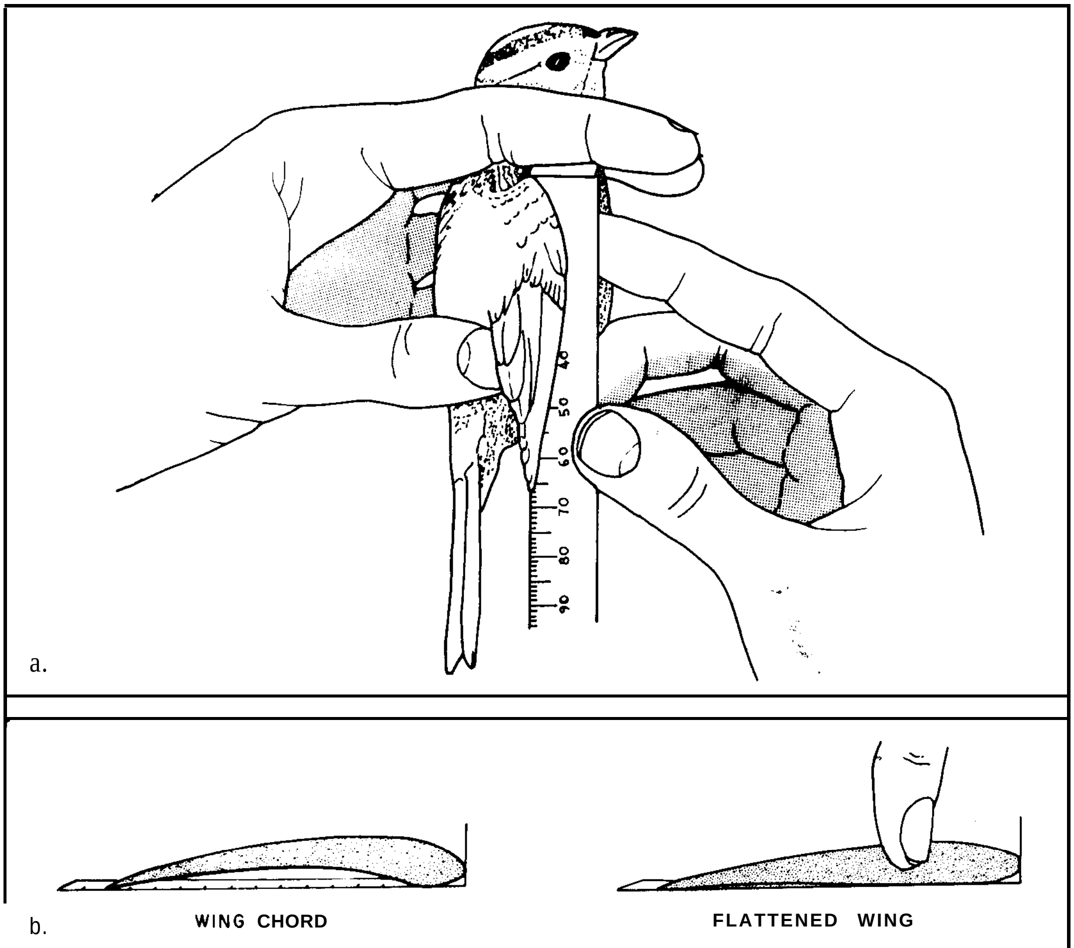

Figure 8. -Methods of measuring wing length: a. *an appropriate hold for obtaining the measurement; b. two different techniques for obtaining wing measurements (wing chord on left; flattened wing on right). The wing chord is the most commonly used measurement (adapted from Pyle and others 1987).*

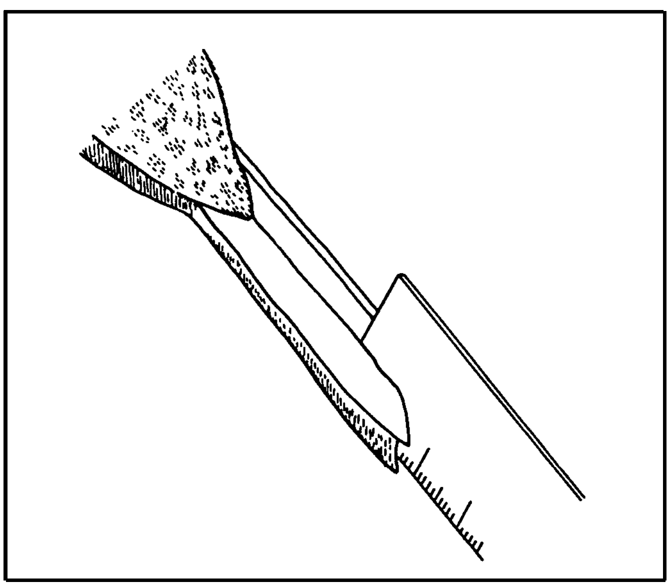

Figure 9. -*An accepted method of measuring the tail involves inserting a ruler between the central tail features (rectrices) and guiding the ruler up against the body surface to obtain the maximum reading of tail length (adapted from Pyle and others 1987).*

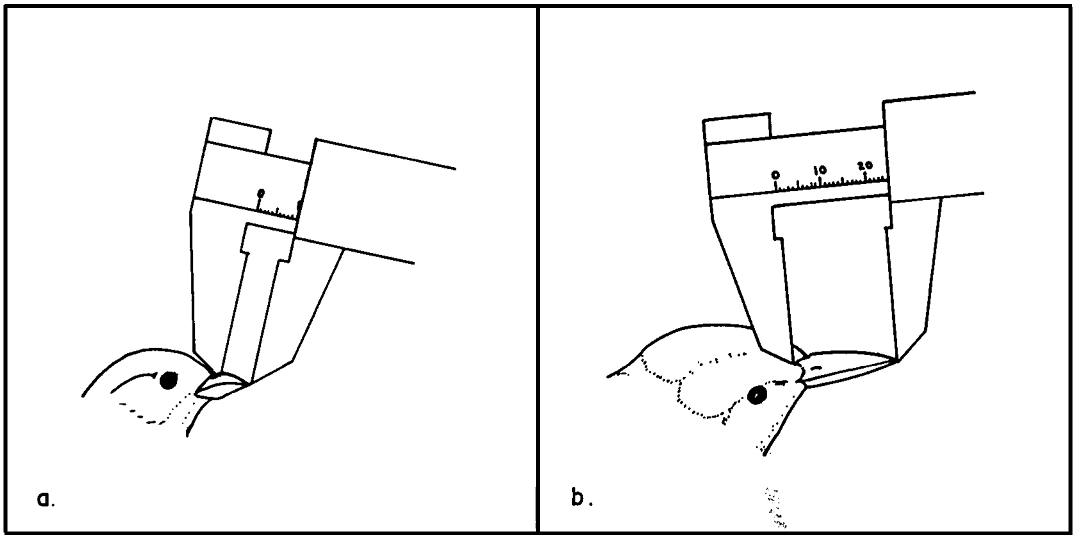

Figure 10.-*The culmen and **exposed culmen** are two standard measures for bill length The culmen (a.) is measured from the anterior end of the nostril to the end of the bill, whereas the exposed culmen (**b.**) is measured from the edge of the feathering at the base of the **bill** to the bill tip (adapted from Pyle and others 1987).*

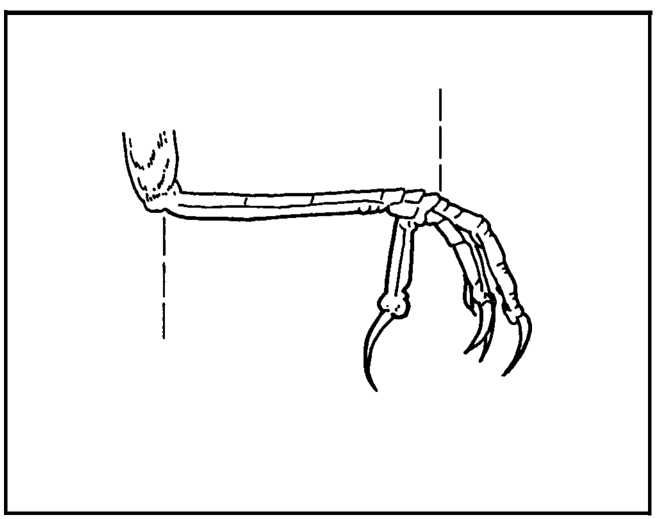

Figure 11. -*Ends of the tarsus used to obtain* a *measurement of tarsal length, which is best done with calipers (adapted from Pyle and others 1987).*

distribution of the endemic Grenada dove, *Leptotila wellsi,* (Blockstein 1988) and to assess the populations of several endemic bird species on Jamaica in the aftermath of a major hurricane (Varty 1991).

Playback can often be used to capture territorial birds. For example, a portable speaker can be placed beneath a net and used to attract an individual into the net. This method requires a speaker attached to a long cable that runs to a tape recorder operated by a hidden observer several meters from the net. As described by Holmes and Sherry (1989), the method was very effective for capturing wintering migrants in Jamaica.

Tape-recorded songs of many Caribbean species can be obtained from the acoustical lab of the Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, NY 14850, U.S.A. (telephone 607-254-2441) Information and equipment for field recordings and playback can be obtained from Saul Mineroff Electronics, Inc., 946 Downing Road, Valley Stream, NY 11580, U.S.A. (telephone 516-825-4702).

LITERATURE CITED

Askins, Robert A.; Ewert, David N. 1991. Impact of Hurricane Hugo on bird populations in Virgin Islands National Park. Biotropica. 23: 481-487.

Baillie, S.R.; Green, R.E.; Boddy, M.; Buckland, S.T. 1986. An evaluation of the constant efforts sites scheme. Hertshire, UK: British Trust for Ornithology; report of the constant effort sites review group to the ringing committee of the British Trust for Ornithology. [Number of pages unknown].

Blake, C. 1963. The brood patch. Eastern Bird Banding Association Workshop Manual. 2: 8-9.

Bleitz, D. 1970. Mist nets and their use. Inland Bird Banding News. 42: 1-15.

Blockstein, David. 1988. Two endangered birds of Grenada, West Indies. Caribbean Journal of Science. 24: 127-136.

Burnham, K.P.; Anderson, D.R.; Laake, J.L. 1980. Estimation of density from line transect sampling of biological populations. Wildlife Monographs. 72: 1–202.

Collar, N.J.; Andrew, P. 1988. Birds to watch. ICBP Tech. Pub. No. 8. Cambridge, UK. Page Brothers (Norwich), Ltd. 303 p.

Cox, George W.; Ricklefs, Robert E. 1977. Species diversity and ecological release in Caribbean land bird faunas. Oikos. 28: 113-122.

Cruz, Alexander; Delannoy, Carlos A. 1984. Ecology of the elfin woods warbler (*Dendroica angelae*). 1: Distribution, habitat usage, and population densities. Caribbean Journal of Science. 20: 89-96.

Diamond, Anthony W. 1974. Annual cycles in Jamaican forest birds. Journal of Zoology. 173: 277-301.

Emlen, John T. 1971. Population densities of birds derived from transect counts. Auk. 88: 323-342.

Emlen, John T. 1977a. Land bird communities of Grand Bahama Island: The structure and dynamics of an avifauna. Ornithological Monographs. 24: 1–129.

Emlen, John T. 1977b. Estimating breeding season bird densities from transect counts. Auk. 94: 455-468.

Faaborg, John R.; Arendt, Wayne J. 1985. Wildlife assessments in the Caribbean. Rio Piedras, PR: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Institute of Tropical Forestry. 220 p.

Faaborg, John R.; Arendt, Wayne J. 1991. Long-term declines in winter resident warblers in a Puerto Rican dry forest. American Birds. 43: 1,226–1,230.

Faaborg, John R.; Arendt, Wayne J.; Kaiser, Mark S. 1984. Rainfall correlates of bird population fluctuations in a Puerto Rican dry forest. The Wilson Bulletin. 96: 575-593.

Ginn, H.B.; Melville, D.S. 1983. Moult in birds. Guide No. 19. Hertfordshire, UK: British Trust for Ornithology. 26 p.

Holmes, Richard T.; Sherry, Thomas W.; Reitsma, Leonard. 1989. Population structure, territoriality and overwinter survival of two migrant warbler species in Jamaica. Condor. 91: 545-561.

Hutto, Richard L.; Pletschet, Sandra M.; Hendricks, Paul. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk. 103: 593-602.

Lack, David. 1976. Island biology. Cambridge, UK: Cambridge University Press. 445 p.

Lack, David; Lack, Andrew. 1973. Birds on Grenada. Ibis. 115: 53-59.

Lack, David; Lack, Edward; Lack, Paul; Lack, Andrew. 1973. Birds on St. Vincent. Ibis. 115: 46-52.

Manuwal, David A.; Carey, Andrew B. 1991. Methods for measuring populations of small, diurnal forest birds. Gen. Tech. Rep. PNW-278. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 p.

Pardieck, Keith; Waide, Robert B. 1992. Mesh size as a factor in avian community studies using mist nets. Journal of Field Ornithology. 63: 250-255.

Pashley, David N.; Martin, Robert P. 1988. The contribution of Christmas bird counts to knowledge of the winter distribution of migratory warblers in the Neotropics. American Birds. 42: 1,164–1,176.

Pyle, Peter; Howell, Steve N.G.; Yunick, Robert P.; DeSante, David F. 1987. Identification guide to North American Passerines. Bolinas, CA: Slate Creek Press. [Number of pages unknown].

Ralph, C. John. 1967. Taking data at a banding station. In: Western bird-banding workshop manual. Bolinas, CA: Western Bird-banding Association, Point Reyes Bird Observatory. [Number of pages unknownl.

Ralph, C. John. 1988. A brief guide to banding birds. In: Western bird-banding Association workshop manual. Arcata, CA: Western Bird-Banding Association, Humboldt Bay Bird Observatory. [Number of pages unknown].

Ralph, C. John; Geupel, Geoffrey R.; Pyle, Peter [and others]. 119931. Field methods for monitoring landbirds. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 41 p.

Recher, Harold F. 1970. Population density and seasonal changes of the avifauna in a tropical forest before and after gamma irradiation. In: Odum, H.T.; Pigeon, R.F., eds. A tropical rainforest. Springfield, VA: U.S. Department of Commerce, National Technical Information Services: E69-E93.

Reynolds, R.T.; Scott, J.M.; Nussbaum, R.A. 1980. A variable circular-plot method for estimating bird numbers. Condor. 82: 309-313.

Rivera-Milan, Frank F. 1992. Distribution and relative abundance patterns of Columbids in Puerto Rico. Condor. 94: 224-238.

Shreve, A. 1965. Preventing net casualties. Eastern Bird Banding Association Workshop Manual. 4: 1–22.

Snyder, Noel F.R.; Wiley, James W.; C.B. Kepler, Cameron B. 1987. The parrots of Luquillo: natural history and conservation of the Puerto Rican Parrot. Los Angeles: Western Foundation of Vertebrate Zoology. 384 p.

Svensson, L. 1984. Identification guide to European Passerines. Stockholm: Svensson. 279 p.

Terborgh, John; Faaborg, John. 1973. Turnover and ecological release in the avifauna of Mona Island, Puerto Rico. Auk. 90: 759-779.

Terborgh, John; Faaborg, John; Brockmann, Jane. 1978. Island colonization by Lesser Antillean birds. Auk. 95: 59-72.

Varty, Nigel. 1991. The status and conservation of Jamaica's threatened and endemic forest avifauna and their habitats following Hurricane Gilbert. Bird Conservation International. 1: 135-151.

Verner, Jared. 1985. Assessment of counting techniques. Current Ornithology. 2: 247-302.

Vilella, F.; Zwank, P.J. 1987. Density and distribution of the Puerto Rican Nightjar in the Guayanilla Hills. Caribbean Journal of Science. 23: 238-242.

Waide, Robert B. 1991. The effect of Hurricane Hugo on bird populations in the Luquillo Experimental Forest. Biotropica. 23: 475-480.

Waide, Robert B.; Narins, Peter M. 1988. Tropical forest bird counts and the effect of sound attenuation. Auk. 105: 296-302.

Wauer, Roland H.; Wunderle, Joseph M., Jr. 1992. The effect of Hurricane Hugo on bird populations on St. Croix, U.S. Virgin Islands. The Wilson Bulletin. 104: 656-669.

Wunderle, Joseph M., Jr. 1985. An ecological comparison of the avifauna of Grenada and Tobago, West Indies. The Wilson Bulletin. 97: 356-365.

Wunderle, Joseph M., Jr. 1992. Sexual habitat segregation in wintering black-throated blue warblers in Puerto Rico. In: Hagan, J.; Johnston, D.P., eds. Ecology and conservation of Neotropical migrant landbirds. Washington, DC: Smithsonian Institution: 299–307.

Wunderle, Joseph M., Jr.; Díaz, Ariel; Velasquez, Iris; Scharron, Rafael. 1987. Forest openings and the distribution of understory birds in a Puerto Rican rainforest. The Wilson Bulletin. 99: 22-37.

Wunderle, Joseph M., Jr.; Lodge, D. Jean; Waide, Robert B. 1992. The short-term effects of Hurricane Gilbert on terrestrial bird populations on Jamaica. Auk. 109: 148-166.

FOR FURTHER INFORMATION

Publications cited here are part of the library collection at the International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Call Box 25000, Rio Piedras, PR 00928-2500, U.S.A.

Appendix

Examples of field data sheets are shown for fixed-raduis point count (25 m), strip transects (25 m on each side of transect), and banding data.

FIXED-RADIUS POINT COUNT DATA SHEET

Date____________ Location_________________________ Weather______________

Observer_______________

Species	Time		Time		Time		Time	
	≤25m	>25m	≤25m	>25m	≤25m	>25m	≤25m	>25m

STRIP TRANSECT DATA SHEET

Date__________ Location____________________ Weather___________

Observer____________

	Transect # ___ Length________ Time ________		Transect # ___ Length________ Time________		Transect # ___ Length________ Time________	
Species	≤25m	>25m	≤25m	>25m	≤25m	>25

BANDING RECORD - Individual Species

Scientific Name ____________________ AOU Number ______ Location ____________________

Common Name ____________________

Band Number	Color Com.	Age	Sex	Wing	Tail	Tars.	Bill	Wgt.	Fat	Molt	Date

Wunderle, Joseph M., Jr. 1994. Census methods for Caribbean land birds. Gen. Tech. Rep. SO-98. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 26 p.

Various census methods for Caribbean land birds are presented. The method used depends upon the objective of the study. For most studies of Caribbean land birds, the fixed-radius point count method is recommended.

Keywords: Color-banding, mist netting, point counts, populations, spot mapping, territory mapping, transects.

United States
Department of Agriculture

Forest Service

Southern Forest
Experiment Station
701 Loyola Ave., Rm.T-10210
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