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INVENTORY METHODS FOR AMPHIBIANS AND REPTILES

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ABSTRACT--Amphibians and reptiles are important in the energy flow of many ecosystems. In some communities, they predominate over birds or small mammals in terms of the number of species and individuals or biomass. For example, forest salamanders may exceed 3,000 individuals per ha. There is a clear need for intensive study of herpetological communities to obtain more accurate measurement of their relative importance in ecosystems. Methods of sampling herpetological communities include mark-recapture studies, opportunistic collecting, line transects, nocturnal observations, road-cruising, leaf-litter samples, removal methods, pitfall arrays, and special techniques (e.g., turtle traps). Merits of these sampling schemes are briefly compared. We recommend pitfall arrays combined with time-constraint collecting as the most effective pair of methods for sampling terrestrial forest herpetofaunas. Such inventories provide information on species richness, relative abundance and biomass of amphibians and reptiles related to macro- and microhabitat differences.

INTRODUCTION

Amphibians and reptiles should be included in monitoring programs for several reasons. First, inventories of all components of the vertebrate fauna are necessary for the wisest implementation of multi-resource decisions. Amphibians and reptiles are a major part of the fauna (excluding fishes) of North America (Bury et al. 1980). Second, amphibians and reptiles may constitute the largest proportion of vertebrates in certain ecosystems. Reptiles predominate in some aridlands, outnumbering mammals and resident birds both in species diversity and individuals present. Salamanders dominate in certain forests. In eastern deciduous forests, for example, Burton and Likens (1975) found about 3,000 salamanders per ha (biomass of 1.7 kg/ha), greater than the number of individuals or biomass for birds or small mammals. In redwood forests, Bury (in press) estimated about 400 salamanders per ha (1.4 kg/ha). Local aggregations of some species can reach 5 individuals per m^2 (Jaeger 1979, Bury unpubl. data), the highest known density of any terrestrial vertebrate. Third, reptiles and amphibians are important prey and predators in food webs. For example, the Pacific giant salamander (*Dicamptodon ensatus*) in streams of northwestern U.S. is a major predator (up to 99% of the predator biomass), sometimes exceeding fishes in importance (Murphy and Hall 1981). Amphibians and reptiles are important wildlife resources and warrant serious consideration in management evaluations.

When properly applied, species diversity indices are useful measures in population studies (see Pielou 1975, James and Rathbun 1981). However in herpetological research, it is especially difficult to record species occurrence and relative abundance because many amphibians and reptiles are highly seasonal in activity, secretive, occur in patchy distributions, or are specialized in their habits (fossorial, arboreal, etc.).

Inventoring and monitoring herpetofaunas are also challenging because in the past these taxa have been neglected by resource managers and their inventory technology lags behind that available for birds and mammals. Recently, however, a variety of approaches and techniques for sampling herpetological communities have become available (see Scott 1982 and below). Here, we will review some of these techniques.

MARK AND RECAPTURE TECHNIQUES

Some populations of amphibians and reptiles can be sampled by using a variety of mark and recapture techniques (Ferner 1979). For example, diurnal lizards and freshwater turtles are two taxa in which recapture of marked individuals is usually feasible. These methods are adequately described elsewhere (see Otis et al. 1978, Seber 1982, White et al. 1982). Such techniques are usually most applicable to intensive sampling schemes or long-term studies and consequently are more expensive than some other methods (see below).

OPPORTUNISTIC METHODS

General searches at different times of the day and year should be employed to reveal the richness of local herpetofaunas. Experienced herpetologists seize opportunities to discover animals, e.g., after thunderstorms. Collecting with a potato rake (to turn over objects) is a basic means to locate animals. Road-cruising at slow speeds often is the most effective way to locate snakes; night-driving is particularly useful in aridlands. Wire or mesh funnel traps catch freshwater turtles. These and other general methods to collect a diverse sample are discussed by Stebbins (1966), Conant (1975), and Nussbaum et al. (1983).

LEAF-LITTER PLOTS

Thorough searches of relatively small plots usually entail raking through all surface matter. Lloyd et al. (1968) searched 402 plots (each 2.3-m^2) in Borneo; Scott (1976, 1982) cleared all litter from 58-m^2 plots in Costa Rica and Cameroun; Inger and Colwell (1977) examined 652 quadrats varying from 58 to 231-m^2 in Thailand; Liebermann-Jaffe (1981) searched 64-m^2 plots in Costa Rica; and Raphael et al. (1982) examined many 20-m^2 subplots in northern California. Campbell and Christman (1982) collected intensively on 1,000-m^2 plots in Florida, and Bury (in press) sampled 1,250-m^2 plots in northern California. Captures were normally high enough for comparative studies, but these searches often require large investments of labor and time. However, Raphael et al. (1982) found that capture rates were only one-tenth as successful in litter plots than in general opportunistic collecting for the same investment of time (2 h per plot). Leaf-litter plots can be useful in forest stands where species are known to be restricted to litter or duff.

REMOVAL METHOD

The removal method is effective for highly visible or easily captured species (see Bury 1981, 1982). It is best adapted to open terrain such as aridlands. Plots can be 1 ha or larger; all animals are removed by hand-capture, shooting (.22 dust) or other means. Sampling is of short duration (2-5 days), which permits coverage of many plots. This is a cost-efficient technique when it can be employed.

TIME-CONSTRAINT COLLECTING

Time-constraint (T-C) collecting is a plotless sampling technique that provides relative abundance and species richness data. T-C work involves staying within a specific habitat type (e.g., wet old-growth forest) with collectors searching under prime cover sites (e.g., logs, bark, etc.) favored by amphibians and reptiles. It cannot reveal density or biomass per unit area. This method is highly efficient as collectors focus attention on the best available cover sites rather than searching less productive areas.

Campbell and Christman (1982) reported that T-C collecting at 6 person-h per site repeated 3 times a year was twice as efficient in terms of species and individuals taken than was collecting in fixed-area plots. One of us (MGR) has used T-C to estimate relative abundance of reptiles and amphibians in Douglas-fir forests of California (Table 1); 84 plots were sampled once in the fall and again in the spring (2 person-h per site per season). Average capture was 17.3 salamanders and 0.8 lizards per plot. All species known to occur in this study area (Marcot 1979) were encountered.

TABLE 1.

COMPARISON OF SALAMANDER AND LIZARD CAPTURE RATES FROM TIME-CONSTRAINED (T-C) SEARCHES (N=84) AND PITFALL ARRAYS (N=166) IN SUCCESSIONAL STAGES OF DOUGLAS-FIR FOREST, NORTHWESTERN CALIFORNIA. $\bar{X}$=MEAN FOR EACH SITE.

	T-C Search		Pitfalls	
Species	Total	$\bar{X}$	Total	$\bar{X}$
Ambystoma gracile	2	<0.1	2	<0.1
Dicamptodon ensatus	5	0.1	16	0.1
Rhyacotriton olympicus	3	<0.1	1	<0.1
Taricha granulosa	18	0.2	33	0.2
Plethodon elongatus	196	2.3	54	0.3
Ensatina eschscholtzi	1095	13.0	1234	7.4
Aneides flavipunctatus	32	0.4	4	<0.1
A. ferreus	100	1.2	6	<0.1
Sceloporus occidentalis	22	0.3	252	1.5
S. graciosus	14	0.2	91	0.6
Eumeces skiltonianus	15	0.2	272	1.6
Gerrhonotus coeruleus	17	0.2	334	2.0
G. multicarinatus	1	<0.1	31	0.2
Total salamanders	1451	17.3	1350	8.1
Total lizards	69	0.8	980	5.9

PITFALL ARRAYS

Buried pitfall traps and funnel traps with fences to direct animals into traps are highly effective to sample herpetofaunas. There are several designs with fences (see Storm and Pimental 1954, Gibbons and Semlitsch 1981, Jones 1981, Campbell and Christman 1982, Vogt and Hine 1982, Bury unpubl. data) or without fences (see Fitch 1951, Banta 1957, Medica et al. 1971, Lillywhite 1977, Raphael in prep.). Some of these are shown in Fig. 1. Pertinent considerations in design are the ability to install traps and fences (e.g., short fences of 5-m length are best in forest habitats where there are many logs and trees), catchability (e.g., small-size pitfall traps may be too shallow to catch some animals), convenience, costs, effort required to check arrays, and need to sample different taxa.

With some experimentation, pitfall arrays can be highly effective and efficient techniques to sample amphibians, reptiles, and other taxa (e.g., shrews). Vogt and Hine (1982) stated that because of seasonal activity, the catch of all species over months of trapping showed many periods of low or no success. Several short sampling periods (especially during and after rains) staggered throughout the season should give a better estimate of species composition and populations than a longer period at any one time.

Raphael (in prep) used pitfalls (7.6 ℓ size) arranged in a 2 x 5 grid (20-m spacing without drift fences) to estimate salamander and lizard abundance on 166 sites in Douglas-fir forests of California. A total of 1,350 salamanders and 980 lizards were captured after 18 months of continuous sampling (Table 1). Pitfalls captured the same species as T-C but the capture rate for salamanders was only about half whereas the lizard capture rate was about 7 times that of the T-C technique. Some salamanders were rarely caught in pitfalls but were fairly abundant in T-C samples. The clouded salamander (Aneides ferreus), for example, was captured about 30 times as often in T-C as in pitfall traps. In contrast, the 2 species of alligator lizard were rare in T-C samples but common in pitfall arrays.

Initial installation and annual costs of pitfall arrays are high. Raphael and Rosenberg (in press) estimated that their arrays cost $57.00 per plot to install and $216.00 per plot per year to monitor and maintain. T-C collecting, on the other hand, was estimated to cost about $76.00 per plot with no set-up costs. It is apparent from our comparison of the methods, however, that neither one alone is sufficient for a reliable estimate of relative abundance of the herpetofauna.

CONCLUSION

For most inventory purposes, relative abundance and species richness indices are suitable for management decisions. Two or more applicable techniques can provide needed information on patterns and trends in species richness, abundance, and biomass. We recommend the use of the combination of forest time-constraint collecting and pitfall arrays for one of the best inventories of terrestrial herpetofaunas. Density estimates are possible using mark and recapture techniques, but these studies are usually expensive; they are best for single species or a few species that can be recaptured. Using recently developed techniques, amphibians and reptiles can be inventoried, revealing their importance in ecosystems and allowing valid judgements of their value as resources.

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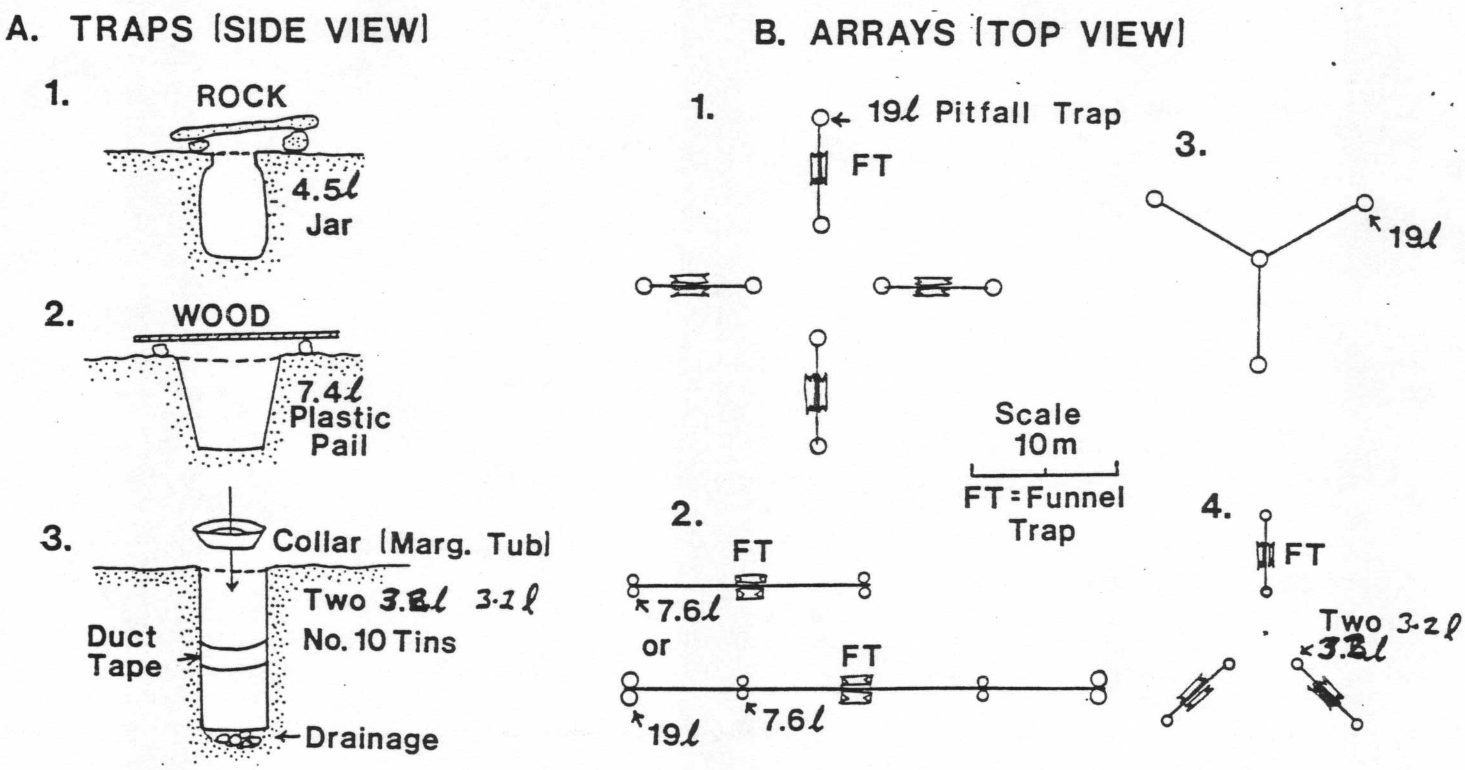

FIGURE 1. Selected designs. A. Pitfall traps without fences: 1. Lillywhite (1977); 2. Raphael (in prep.); and 3. Bury (in prep.). Pitfall arrays with fences 0.4-0.5 m tall (Aluminum Valley): 1. Campbell and Christman (1982); 2. Vogt and Hine (1982); 3. Jones (1981); and 4. Bury (in prep.).