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Lack of effect of herpetological collecting on the population structure of a community of *Anolis* (Squamata: Dactyloidae) in a disturbed habitat

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Abstract. Collecting of herpetological specimens is critical for documentation and survival of species, but removal of individuals from wild populations is often cited as a cause of population declines. Collecting or hunting has had undeniable negative effects on some turtle and crocodylian species, but the effects of typical herpetological collecting on populations of small species such as lizards and frogs are largely unknown. Here we test whether an instance of intense herpetological collecting—removal of all observed individuals of a community of abundant *Anolis*—has short-term effects on species abundance, sex ratio, body size distribution, or perch use. We found that the removed community was replaced in relative species abundance and that sex ratio, body size distribution, and nocturnal perch occupation were duplicated in the most abundant species, *A. kemptoni*, within 24 hours. This result demonstrates a lack of effect of herpetological collecting on measured population variables in this case. Additional studies are necessary to assess the generality of this finding, but it is possible that many reptile and amphibian populations are resilient to standard herpetological collecting.

Keywords. Conservation, disturbance, intensive collecting, Panama, population recovery.

Introduction

Species of reptiles and amphibians face numerous threats to their survival due to recent rapid global change (Hoffman et al., 2010). Habitat destruction and alteration by humans is probably the most effective driver of species decline (Alford and Richards, 1999; Gibbons et al., 2000; Cushman, 2006). Diseases, particularly *Batrachochytrium dendrobatidis* in frogs, have become well-established causal factors in herpetological declines (Berger et al., 1998). Invasive species may negatively impact native populations through competition, hybridization, or predation (Case and Bolger, 1991). The decline and extinction of herpetological species is multicausal, and synergistic effects appear to be common (Wake and Vredenburg, 2008).

Collection or hunting of animals is often cited with the above examples as a major cause of population declines (e.g., Gibbons et al., 2000; Bohm et al., 2013). Probably this concern is the reason for widespread and often restrictive regulations regarding herpetological collecting (see e.g., Levell, 1997). There are prominent cases where a causal link between collecting or hunting and population decline seems clear (e.g., crocodylians in the United States; Brazaitis, 1989). But such examples are few, and highly taxon- and technique-specific. Virtually all documented cases of decline due to removal of animals involve either large vertebrates or destruction of habitat (references in Gibbons et al. [2000]; experimental evidence in Goode et al. [2004]). Study of one notorious case of intensive and repeated collecting, rattlesnake roundups, has produced inconclusive results regarding negative population effects (Fitzgerald and Painter, 2000; Means, 2009). And although there is considerable evidence that over-harvesting can harm populations, there are exceptions. For example, aboriginal hunting and land management may benefit populations of some lizard species by increasing habitat and thus population sizes (Bird et al., 2013). The effect of typical herpetological collecting—as defined here, visual surveys to secure individual specimens by hand—is not well studied.

Evidence presented for the effects of collecting on populations of small ectotherms such as lizards and frogs is generally anecdotal. Quantitative studies assessing

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collecting impacts are needed (Schlaepfer et al., 2005). Here we test whether an instance of intense simulated herpetological collecting—the removal of all observed individuals—taffects species abundance in a community of *Anolis* and sex ratio, body size distribution, and perch use of the most abundant species in this community in a disturbed area in Panama.

Materials and Methods

Study area

Our study site is a 95-meter segment of road north of Boquete, Chiriqui, Panama, along the Bajo Mono Loop road (8.82992, -82.48028 to 8.82979, -82.47943; WGS-84; 1,580 m a.s.l.). We surveyed both sides of this transect. The area is disturbed and, like most road cuts, this habitat represents a well-defined edge between the road and adjacent habitats. The western side of the road is a pasture bordered by tall grasses and some trees; the eastern side overlooks a stream with thicker vegetation. Secondary forest occurs within 100 meters of the site. We collected eight species of *Anolis* within 5 km of the site, at varying elevations: *A. polylepis, A. biporcatus, A. kemptoni, A. magnaphallus, A. benedikti, A. ginaelisae, A. datzorum,* and *A. salvini*.

Specimen collection

The most effective technique for collecting large numbers and high species diversity of *Anolis* is to search for sleeping individuals at night (pers. obs. of SP based on collection of 242 species of *Anolis* in 15 countries). We walked along each side of the road segment and collected each *Anolis* individual we observed. For each individual collected, we recorded data on species, perch height (m), perch type (grass/leaf, twig/branch), sex, and body length (mm).

On 11 June 2013 we surveyed and removed all *Anolis* detected. On 12 June 2013 we returned and recorded the same data for observed individuals, but released all captures. Each survey took approximately 90 minutes. The individuals that were collected on 11 June were released at the site five days after initial collection, except voucher individuals of each species were preserved.

Analyses

We compared species diversity, number of individuals, perch height, body length, and perch type between the two surveys, in total and with data separated by sex, graphically and using a Mann-Whitney U test for continuous variables and a chi-square test for perch type. We present detailed results for *Anolis kemptoni* (by far the most abundant species) and summary results for the other observed species.

Results

The surveys produced very similar results (Table 1). During the initial survey we removed 18 anoles, 17 *Anolis kemptoni* (six male, 11 female) and one *A. ginaelisae* (male). During the post-removal survey we recorded 21 anoles, 17 *A. kemptoni* (six male, 11 female), one *A. ginaelisae* (male), two *A. magnaphallus* (male), and one *A. salvini* (male).

Only *A. kemptoni* was present in large enough numbers to analyze trends within species. Removal of all observed *Anolis* during the first sampling period had no discernible effect on abundance of lizards during the second sampling period. Population numbers of each species were comparable, as both surveys were dominated by *A. kemptoni*, and only one or two individuals of each other species were found in each survey. Behavior (i.e., sleeping perch) and sex and body size distributions were approximately unchanged between surveys for the most abundant species, *A. kemptoni* (Figure 1, Table 1). Figure 2 shows the body size distribution of observed *A. kemptoni*. Male perch height was marginally statistically different between surveys (P = 0.04); all other comparisons were nonsignificant.

Table 1. Comparison of perch parameters and body length of *Anolis kemptoni* in surveys before and after removal of all observed *Anolis*.

	Before	After	P-value
All	n = 17	n = 17	
perch height (m)	1.6	1.3	0.12
perch type (% leaf)	65	82	
body length (mm)	45.9	44.6	0.93
Males	n = 6	n = 6	
perch height (m)	2.1	1.1	0.04
perch type (% leaf)	67	100	
body length (mm)	44.7	41.5	0.75
Females	n =11	n = 11	
perch height (m)	1.3	1.3	0.95
perch type (% leaf)	64	73	
body length (mm)	46.6	46.4	0.75

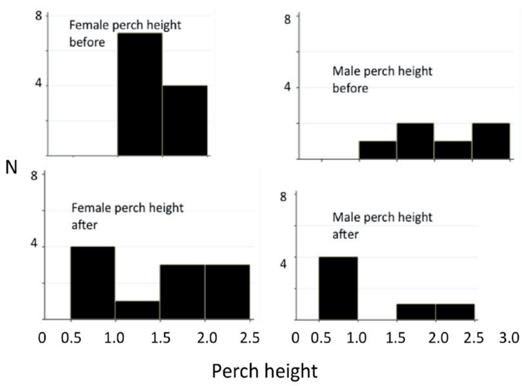

Figure 1. Comparison of perch heights used by *Anolis kemptoni* before and after all observed specimens were removed.

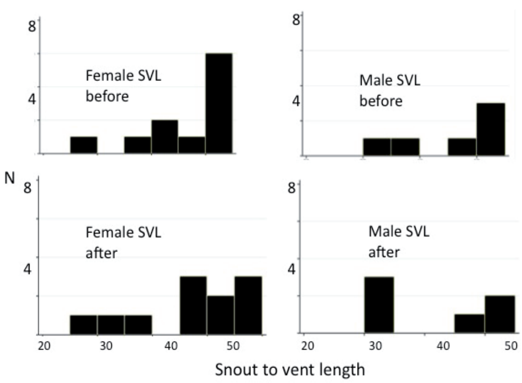

Figure 2. Comparisons of body lengths of *Anolis kemptoni* before and after all observed specimens were removed..

Discussion

Although clearly limited in scope, our results are compatible with the idea that short-term, intensive collecting of small lizards is not harmful to local abundances. The immediate replacement of the population was striking. We expected to find fewer lizards on the second survey because we removed 18 lizards during the initial survey. Instead, we observed 21 new lizards—a complete recolonization of observable perches within 24 hours. We expected abundance to decline and then recover quickly and thus we planned multiple surveys. But the extraordinarily rapid recovery of the community obviated additional surveys.

The recolonization of perches mirrored the initial survey in relative species abundances and in all measured population variables for the most abundant species, *A. kemptoni*. This replicated recovery suggests a similar population segment of *A. kemptoni* is waiting to occupy roadside or edge perches. The lack of a significant increase in abundance of any other species to 'replace' the removed *A. kemptoni* may indicate lower local abundances of these species and/or that the majority of surveyed habitat is most suitable for *A. kemptoni* and not *Anolis ginaelisae*, *A. magnaphallus*, or *A. salvini.* The latter contention appears likely for *A. ginaelisae,* which prefers larger higher perches than the grass blades that dominated our study site, and *A. magnaphallus*, which prefers lower bushy vegetation (pers. obs.). However, we found *A. salvini* to be highly abundant in some other grassy disturbed areas similar to our study site. Thus, some other factor besides habitat is likely to be affecting population levels in this species at our site.

Conclusions from this study are necessarily preliminary, but results are compatible with the view that nightly specimen collecting has negligible impact on nightly abundance and population structure of small lizards. We expect that this result applies only to restricted conditions that are species, community, and/or habitat specific.

Caveats to results: Current study

The study site is highly disturbed and thus represents an unnatural arena. The area apparently is subject to pulse disturbance via roadside cutting, which likely causes high mortality and may help explain the ability of lizards to recolonize after a large number of animals have been removed. Most lizard habitats are unlikely to be subject to such constant perturbation.

We selected this area for study because anoles are highly abundant here (as in several undisturbed and edge-habitat areas; Schlaepfer and Gavin, 2000; pers. obs.). Anoles are more detectable and perhaps more abundant in sparse, disturbed or edge habitats. Older successional habitats are more complex, anoles have more places to hide, and herpetologists are less likely to see them in such places. Much more work remains to be done, but disturbed communities offer a useful venue for examining population issues. We note that we found the four species of our study in lower numbers in less disturbed habitat at comparable elevations close to our study site, and that each species was found at extremely high levels at other disturbed areas. For example, we observed 18 *A. salvini* in 22 minutes at the Volcan Baru trailhead, Boquete, Panama. And we found *A. magnaphallus* to be more abundant than *A. kemptoni* in less grassy disturbed areas immediately adjacent to our study site.

In addition to the unnatural study area, we note that the removal of all observed individuals from a single area was intense, but could have been designed for even greater effect. For example, we could have collected all individuals over multiple consecutive nights. Collecting effort and quality of habitat would be fruitful variables to include in future studies of the effects of collecting on populations.

Caveats to results: First study attempt

Our initial attempt at this study, at a site within 100 meters of the study area, was foiled by habitat destruction. We briefly review these results below.

We surveyed *Anolis* on 31 May 2013 at a similar site to our study area and found 47 *Anolis* specimens (*A. kemptoni*, *A. magnaphallus*, and *A. ginaelisae*) in approximately 1.5 hours of searching; we removed all discovered specimens. We returned the next night and found 18 specimens. On the fourth night after the initial survey, one of us (SP) returned and noted an apparent 100% recovery of the population, but no rigorous specimen counts/measurements were taken because a detailed survey was planned for the following night. Upon return the next night, however, the entire study area was found to be razed of grasses and small plants. We surveyed and found an extreme reduction in specimen count (catch and release of 10 individuals of *Anolis*). A survey performed two days after this second survey found similar results (seven individuals observed).

Results are not straightforwardly interpretable due to conflation of collecting and habitat removal effects. However, these observations suggest two testable possibilities for future work: First, the result of this paper of complete population recovery in 24 hours may be exceptional rather than general. Complete recovery of anole populations after collecting is usual, in our opinion, but more than 24 hours may be needed for this recovery to occur. Second, habitat destruction has a greater effect than herpetological collecting on populations. The anole population recovered quickly from our collections, but flatlined when its (disturbed) habitat was removed.

Implications

There are precious little data on the effects of typical herpetological collecting on populations (Schlaepfer et al., 2005), yet restrictions on collecting become ever more stringent. We suggest additional studies to attempt to duplicate or refute the patterns seen here, and to expand such studies to additional herp clades and communities and varying degrees of collecting effort. Results from such studies may influence collecting permit requirements. For example, duplication of our results—which we view as rapid short-term population recovery following a brief bout of intense herpetological collecting--could suggest that restrictions on species and specimen numbers should be relaxed for many small vertebrates.

We close by noting that the generality of our results remains to be determined. There are taxon, technique, and habitat-specific factors that affect a population's ability to recover following removal of individuals. Population factors such as abundance, habitat availability, fragmentation of range, and reproductive rate, among others, are expected to influence the effects of collecting on population health. Collector factors, such as techniques used (e.g., destructive vs. observational) and degree of collecting effort are likely to affect population risk as well. Field experiments such as this one should be an invaluable tool for assessing these variables.

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