Long-term population estimates and synchronous variation in two populations of black rat snakes (*Elaphe obsoleta*) in Eastern Ontario

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Abstract

*Synchronous variation describes the pattern that occurs when variables, such as population size, from several separate populations increase or decrease together. It is common in animal populations and is relevant when studying species of conservation interest because synchrony prevents population rescue. We used 23 years of mark-recapture data to test for the presence of synchronous variation in population size for two separate populations of the threatened black rat snake (*Elaphe obsoleta*) in Eastern Ontario. The Jolly-Seber method was used to estimate population size. The population sizes tended to vary synchronously from 1982 to 2005. Synchronous variation in population size can be attributed to the Moran effect, where two separate populations become synchronous due to common environmental perturbations. Evidence of synchrony has serious conservation implications; this population of black rat snakes is more vulnerable to environmental perturbations because all subpopulations would become rare simultaneously.*

Introduction

Long-term population monitoring plays an essential role in conservation. Examining population trends is the only means to assess species status and to evaluate the efficacy of management actions.

Synchronous variation is common in animals (Ranta *et al.* 1995; Hudson and Cattadori 1999). Subpopulations that vary asynchronously can rescue neighbouring populations through dispersal (Koenig, 1999), lessening the risk of local extinctions. In contrast, subpopulations that vary synchronously may cause the entire population to be more susceptible to extinction. We used 23 years of mark-recapture data to test for population size synchrony among two genetically distinct populations of the threatened black rat snake (*Elaphe obsoleta*) in Eastern Ontario, thus extending the work of Weatherhead *et al.* (2002).

The black rat snake is limited in Canada to a few disjunct populations along the north shore of Lake Erie and one continuous population on the Frontenac Axis of Eastern Ontario.

Methods

Study sites

Two sites in Eastern Ontario were compared in this analysis, St. Lawrence Islands National Park (SLINP) and Queen's University Biological Station (45º 37'N, 76º13'W). Sites are separated by a major 4-laned highway and the St. Lawrence River.

Data collection

The biology station captures were limited to areas near the biology station (1.8 km^2) while the SLINP captures were limited to a study site (2.0 km^2) on Hill island, a large island (5.6 km^2), almost entirely owned by Parks Canada. Mark-recapture data were collected from 1982 to 2005 at Hill Island and from 1981 to 2005 at the biology station. Male, female, and juvenile snakes were captured opportunistically and at hibernation enclosures in all years.

Population size estimates

Population sizes were estimated using the Jolly-Seber method, which makes the following assumptions: (1) populations are open (birth, death, immigration and emigration occur) (2) every individual has the same probability (α_t) of being captured (3) every individual has the same probability of survival (Φ_t) from time t to time t+1 and (4) individuals do not lose their marks. This method enables us to calculate the proportion of animals marked (α_t), the size of the marked population, and population size (N_t) (Krebs, 1998). Population estimates were then log-transformed to normalize their distribution (Koenig, 1998). We regressed, by site, estimated population sizes on year to test for significant temporal trends. To determine if population size was synchronous between populations, we used the Pearson moment correlation between the two time series. Instead of using the log transformed data directly, correlations were tested using the difference between logs of two successive observations. This detrends the data and puts the emphasis on synchrony (Koenig and Knops 1998; Bjørnstad *et al.* 1999).

Results

The St. Lawrence Islands National Park population shows a non significant increase from 1981 to 2005 ($r = 0.23$, $P = 0.30$) (Figure 1) while the biology station population shows a significant trend, decreasing from 1983 to 1993 and increasing from 1994 to 2005 ($r = 0.73$, $P < 0.001$) (Figure 1). A quadratic regression was fit to the biology station data since a linear regression was non significant and there was clear evidence of curvature. The synchrony between estimated population sizes was positive, but non significant ($r = 0.28$, $P = 0.22$) (Figure 2).

Figure 1. Annual trends in estimated population size (log-transformed) from the Jolly-Serber model for black rat snakes (*Elaphe obsoleta*) at Hill Island and the Queen's University Biology Station

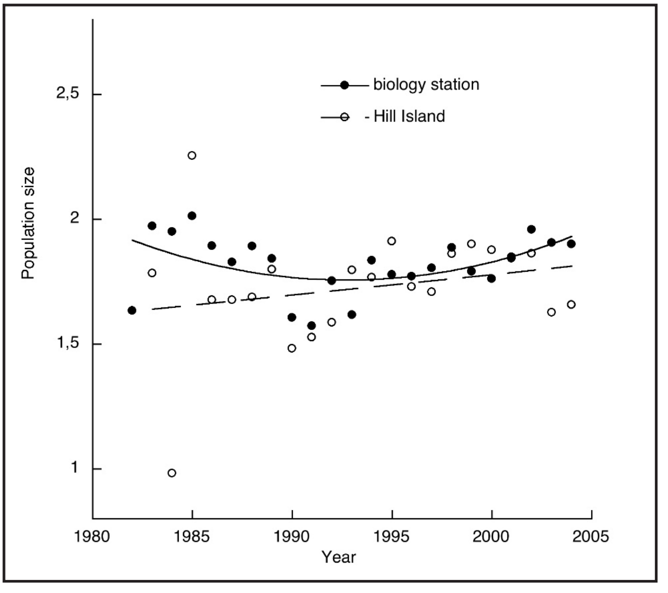
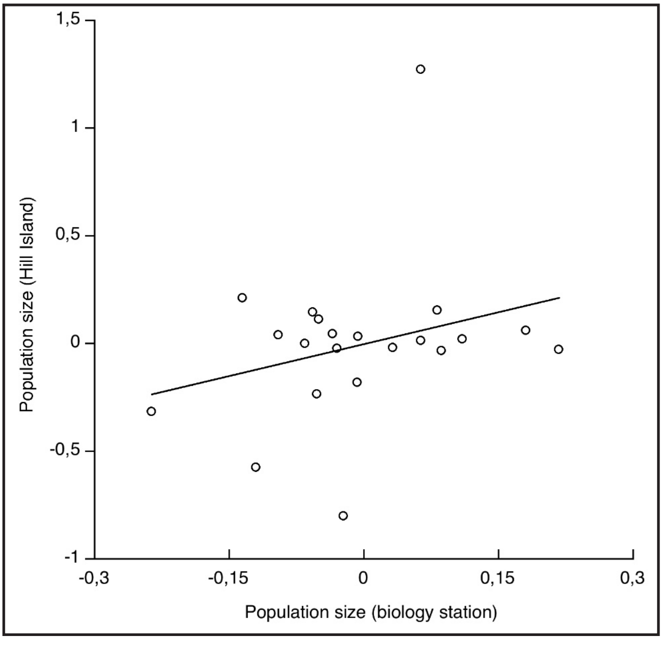


Figure 2. The first difference time series of log-transformed annual population size



Discussion

These additional years of mark-recapture data have shed light on interesting long-term trends. Weatherhead *et al*. (2002) found a significant decrease in the population size at the biology station while our new data show that this pattern is changing. Our analysis was limited to estimates in population size, while Weatherhead *et al*. (2002) examined other parameters such as probability of survival, recruitment and age structure. They were able to associate the population decline to a decrease in recruitment, which in turn had shifted the age structure of the population to more mature individuals. If this trend remains true, increased recruitment may be largely responsible for the population increase at the biology station. Much black rat snake research has been accomplished at the biology station in recent years (Blouin-Demers *et al*. 2002; Blouin-Demers and Weatherhead 2002; Blouin-Demers *et al*. 2003; Weatherhead *et al*. 2003), promoting stewardship with local cottagers and possibly increasing recruitment through the use of experiments that require the protection of clutches by means of laboratory hatching (Blouin-Demers *et al*. 2005). In addition, northern populations, particularly ectotherms, can also be seriously influenced by changes in climate (Post and Stenseth 1999; Willette *et al*. 2005). Recruitment as well as other important ecological processes are affected by fluctuations in climate and in turn influence the internal dynamics of populations (Stenseth *et al*. 2002; Ciannelli *et al*. 2005). Examining the effects of climatic variation on key internal dynamics, such as recruitment and sex-ratios may enable us to better interpret what is happening to our northern populations.

Similar to Weatherhead *et al.* 2002 we found some evidence of population synchrony. Since these populations are separated by over 30 km and are genetically distinct (Lougheed *et al.* 1999), this synchrony is attributable to common stochastic environmental factors, the Moran effect (Engen and Sæther, 2005). As mentioned above, these two populations are found in this species' northern range (Prior and Weatherhead, 1998) and are thus submitted to similar stresses, such as a 6 month hibernation period (Blouin-Demers *et al.* 2000). Such stresses, combined with other environmental factors play an important role in synchronizing nearby populations.

Other parameters such as recruitment, percent of mature individuals and sex-ratios must be investigated with this new data to permit us to closely examine the individual dynamics of these populations. As recommended by Weatherhead *et al.* in 2002, although population sizes have a tendency to vary synchronously, indicating that the black rat snakes' Canadian population may be susceptible to overall decline, internal dynamics are essential to examine before employing similar conservations strategies for both populations.

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