ABUNDANCE AND AGE DISTRIBUTION OF THREE SPECIES OF RANID AMPHIBIANS IN ALGONQUIN PROVINCIAL PARK, ONTARIO, CANADA

1997 Final Report

Are amphibians declining in undisturbed habitats?

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ABSTRACT

Since 1985, the population dynamics of three species of Ranid amphibians
(Rana catesbeiana, Rana clamitans and Rana septentrionalis) have been
investigated using intensive mark-recapture techniques. The focus of this
ongoing, long-term study is to test whether these ranids are experiencing a decline
in abundance, and thereby determine if the proposed phenomenon of global
amphibian declines is occurring in the relatively pristine environment of the
Wildlife Research Area of Algonquin Park. More broadly, the study endeavours
to establish the basic parameters of population dynamics and life history in long-
lived Anurans. To date, the study indicates that population sizes of all three
species do fluctuate significantly from year to year at a local scale, but that the
study population as a whole has shown no significant changes in abundance over
the entire sampling period. This suggests that broad environmental factors, such
as increased UV or global warming, are not contributing to amphibian declines in
this region in a way that can be detected by our study.
INTRODUCTION

There is global concern that many of the world's species of amphibians are experiencing a general decline in population numbers (Barinaga 1990, Wake and Morowitz 1990, Pechmann et al. 1991, Wake 1991, Blaustein and Wake 1995). Habitat loss, normal climatic fluctuations, natural population fluctuations, or collecting/harvesting (Barinaga 1990, Wyman 1990, Brooks et al. 1995) may account for many of these declines. However, other declines seemed to have occurred in areas where there has been little disturbance or climatic change. These general declines in undisturbed habitats may be due to more subtle causes such as increased UV radiation, pollutants, or even global warming (Barinaga 1990, Wyman 1990, Wake 1991, Berrill et al. 1992, Bishop and Pettit 1992). Because amphibians are a significant element of many different ecosystems, there might be a potential for serious disruptions of ecosystems as consequences of amphibian declines arising from environmental changes.

In Ontario, there have been reports that several species of frogs have undergone recent declines in abundance, with the bullfrog (*Rana catesbeiana*) and Blanchard's cricket frog (*Acris crepitans blanchardi*) cited as notable examples (Bishop 1990, Berrill et al. 1992, Coleman and Cholmondeley 1995). In 1995, responding to concerns that bullfrog populations are in serious decline, the Ontario Ministry of Natural Resources (OMNR) eliminated the commercial harvest of bullfrogs in the districts of Tweed and Kemptville (harvesting pressure has traditionally been greatest in these districts). In 1996, the OMNR eliminated both the commercial and sport harvest of bullfrogs in all of southeastern and parts of south central Ontario. Also, the OMNR hopes to establish a
monitoring program to evaluate the status and growth of the remaining bullfrog populations.

However, even given this increasing concern for Ontario's amphibian populations, it is difficult to assess these concerns beyond the obvious effects of habitat loss because, except for this present study, there exists no long-term published research on amphibian numbers in Ontario. Without long-term studies on amphibian numbers, we are in no position to draw any firm conclusions regarding the status of amphibian populations in Ontario (Brooks 1992), nor can we make effective decisions about the management and conservation of these important species (e.g. Howard 1978, 1981, Bury and Whelan 1984).

In the Algonquin Provincial Park Wildlife Research Area, we have been using mark-recapture techniques to study the population dynamics of *Rana catesbeiana*, *R. clamitans*, and *R. septentrionalis* (bullfrogs, green frogs and mink frogs respectively) over the past 12 years. This study provides a baseline estimate of population levels of all three species, and now represents the most extensive long-term study of amphibian population changes in Canada. We are addressing the question of whether or not these three species are experiencing a long-term decline in numbers in the relatively undisturbed environment of the Algonquin Park Wilderness Zone. Investigation of this question will not only provide insights into factors affecting these ranid populations but may also shed light on reasons for the amphibian declines. For instance, evidence indicating that our populations are not declining would suggest that an intact, relatively undisturbed environment is sufficient for healthy metapopulations of amphibians regardless of proposed global occurrence of increased UV, acid rain, warming trends, etc. If this is the
case, perhaps our focus on maintaining amphibian diversity and abundance should be aimed at preservation of habitats that contain the features necessary for vital population processes, i.e. metapopulation dynamics. On the other hand, evidence indicating that even these relatively undisturbed populations are declining would suggest that there are other overriding factors causing amphibian declines, such as increases in UV radiation or subtle increases in specific environmental contaminants.

For a study such as this, the Wildlife Research Area is ideal in that it meets all of the criteria as a potential site for intensive long-term monitoring as set out at a recent symposium on declining amphibian populations in Canada. Such monitoring sites should be chosen on the basis of location of key species, logistics, and strong evidence for long-term protection of the site as a relatively undisturbed research venue (Brooks 1992).

**OBJECTIVES**

The 1997 long-term study continued to use established mark-recapture techniques to estimate abundance, age and sex distribution, and growth rates of the three species of Ranid frogs. These data were then compared to similar data collected from previous years (1985-1996) to investigate the dynamics of the frog populations. We had established a replicable and adequate sampling system in earlier years to allow us to continue to assess and monitor changes in abundance in the future and to establish the degree of variation typical of these species in a relatively pristine northern environment. The data also allow us to test the hypothesis of long-term decline in an area with minimal human impact. This 1997 Report outlines the study methodology, provides preliminary
results regarding population sizes and age distributions, and briefly discusses possible trends.

For the 1998 field season, we have several specific objectives:

1. Continue the collection of the long-term abundance data following the established sampling methodology, which allows for comparison of population abundance estimates across years.

2. Continue to collect samples that will be used to determine the effectiveness of skeletochronology as an aging technique for the bullfrog.

3. Establish replicable protocol for estimating abundance of the chorusing populations, which will be useful not only in conjunction with the long-term data but also in comparison/contrast of our populations with other chorusing populations in Ontario.

4. Sample surrounding populations within the Sasajewun watershed to investigate the importance of metapopulation dynamics to the persistence and stability of these undisturbed populations.

MATERIALS AND METHODS

Location

The 1997 study was conducted from May 10 to August 22 in the Wildlife Research Area (45° 35' N, 78° 30' W) of Algonquin Provincial Park, Ontario. Frogs were captured in Lake Sasajewun, an artificial impoundment covering approximately 63 hectares and dating from the early 1900s (Obbard 1977, 1983), and in the adjacent bogs (Figure 1).
Figure 1. Lake Sasajewun and surrounding bodies of water. Letters indicate areas of population concentration.
Sampling

Lake Sasajewun was divided into three sections for sampling because logistic considerations precluded sampling the entire lake on any single day. Each sampling area contained a single region of population concentration as well as a portion of the lake where breeding sites were located. During one complete capture session of the entire lake, each of the areas was sampled within one 6 to 8-day span. Five capture sessions were completed in 1997.

All frogs were captured using dip nets during diurnal capture sessions, which lasted approximately 7 hours. Sampling effort in any one capture session ranged from 10 to 21 people hours but averaged approximately 12 people hours. Diurnal capture sessions focused on the areas of population concentration within each sampling area (i.e. the bogs). The shorelines were scanned on the way to and from the areas of high population density. The motivation behind this unequal sampling effort was an attempt to maximize the number of frogs captured and therefore the numbers of recaptured individuals. In the past the lack of sufficient recaptures has hampered the calculation of population estimates. Since hand-capturing of animals is inherently biased towards areas of high numbers of individuals and due to the nature of the present study (i.e. monitoring population fluctuations), it was felt that concentrating capture effort in areas with dense populations would serve to reduce the error surrounding population estimates.

Processing

Frogs were sorted according to size and species in order to prevent cannibalism and predation, and were transported to the laboratory for processing. Frogs were kept in
holding tanks (1m X 1m X 1m) with a continuous flow of water. Processing involved recording species’ identity and sex, measuring mass and snout-urostyle length (SUL) and marking each individual. All frogs captured during the 1997 field season were marked by the excision of the distal two phalanges of the fourth digit of the left forefoot. All newly metamorphosed frogs, identified by their distinctive body shape, extremely small size and the presence of a tail bud, were also marked by the additional excision of the distal two phalanges of the fourth digit of the right forefoot. This two-digit toe clip will permanently identify these individuals as members of the newly recruited 1997 cohort, but will not allow for individual recognition. It was not necessary to individually identify newly metamorphosed individuals, as they were not used in the population estimates. All bullfrogs at least one year post-metamorphosis were implanted with a Passive Integrated Transponder (PIT) tag which provided a unique 10-digit alpha-numeric identification code when each frog was passed under a scanner. Each green frog and mink frog larger than maturation size (60mm and 50mm SUL respectively) was marked with a unique 3-digit alphanumeric tattoo. Each green frog and mink frog smaller than maturation size (60mm and 50mm SUL respectively) was marked only with the year’s toe clip. These individuals were not tattooed because it was found previously that, due to their size, they did not respond well to the stress of tattoo application.

Statistics

Population size was estimated separately for each species in each area using Jolly’s stochastic method (Krebs 1989). This method was selected because there is too much movement between areas to assume a closed population (a necessary assumption
when using Petersen, Schnabel, etc.). Only a model that allows for immigration (e.g. Jolly’s Stochastic, Bailey’s Triple Catch, Fisher-Ford, etc.) can provide an accurate estimate of population size under the given sampling conditions. We settled on Jolly’s Stochastic method because it provides an estimate of standard error, and therefore allows comparisons among samples (i.e. years). Population size estimates were considered significantly different if their standard error bars did not overlap and were considered not significantly different if there was overlap.

RESULTS

Captures and Recaptures

During the 1997 field season, a total of 1199 frogs were caught (not including recaptures). This number included 267 R. catesbeiana which were greater than one year post-metamorphosis, and 332 R. clamitans and 439 R. septentrionalis which were greater than maturation size (see above). Of these, 111 R. catesbeiana, 31 R. clamitans and 29 R. septentrionalis were recaptured at least once. The maximum number of total captures for any one individual was 5 for R. catesbeiana (9 individuals), 3 for R. clamitans (3 individuals) and 4 for R. septentrionalis (1 individual). Also captured were 161 R. catesbeiana, 67 (of 207 individuals which were smaller than maturation size) R. clamitans and 39 (of 269 individuals which were smaller than maturation size) R. septentrionalis which had transformed from tadpoles in 1997. In comparison to the previous nine years of the study, the fourth most R. catesbeiana were marked for identification on Lake Sasajewun in 1997 (Figure 2). Also, the second largest number of
R. clamitans and the fifth largest number of R. septentrionalis were marked in 1997 (Figures 3 and 4 respectively).

Population Size Estimates

For Area 1, the estimated population sizes of R. catesbeiana for the months of June, July and August were 96, 57 and 52 (SE = 11, 6 and 8) individuals older than one year post-metamorphosis respectively (Figure 5). Likewise for Area 2, the population sizes were 32, 35 and 22 (SE = 4, 8 and 6) for June, July and August respectively (Figure 6). There were insufficient recaptures of R. catesbeiana in Area 3 to estimate the population size for the month of June, however, the population size estimates for July and August were 88 and 156 (SE = 37 and 116) individuals respectively (Figure 7). The population size estimates for Areas 1 and 2 combined for the months of June, July and August were 128, 92 and 74 (SE = 15, 14 and 14) individuals older than one year post-metamorphosis (Figure 8). The population size estimates for all three areas combined for July and August were 180 and 230 (SE = 51 and 130) individuals (Figure 9).

For Area 1, the estimated population size of R. clamitans for June, July and August were 36, 8 and 12 (SE = 3, 2 and 14) individuals larger than maturation size respectively. The Area 1 population size estimates of R. septentrionalis larger than maturation size for June, July and August were 46, 5 and 42 (SE = 47, 2 and 116). Recapture rates of R. clamitans and R. septentrionalis in Areas 2 and 3 were too low to calculate population size estimates. The total number of individuals marked in all three areas (Figures 3 and 4 for R. clamitans and R. septentrionalis respectively) is presented as a measure of relative population abundance for these two species.
Population size estimates for all three species were lower than the total number of individuals marked during 1997 (Figures 2 – 9 and Table 1).

**Age Distribution**

In 1997, 38% of the total number of *R. catesbeiana* marked were newly transformed individuals (Table 1). Also, 62% of all marked *R. clamitans* and 61% of all marked *R. septentrionalis* were individuals that were smaller than maturation size (Table 1).

The mean SUL of mature *R. catesbeiana* females increased continuously from 92.6mm in 1991 to 109.0mm in 1996 (Table 2). However, in 1997 the average SUL of mature female *R. catesbeiana* decreased dramatically to 93.7mm. Mature female *R. clamitans* increased in SUL from 62.6mm in 1991 to 80.7mm in 1994, decreased to 75.2mm in 1996 and in 1997 increased to 78.1mm (Table 2). The mean SUL of mature female *R. septentrionalis* has remained consistent from 1991 to 1997 ranging from 57.6mm (1991) to 60.0mm (1996) (Table 2).
Figure 2. Numbers of bullfrogs marked on Lake Sasajewun over the course of the long-term study using a standardized sampling technique. Open, light grey and dark grey columns represent total numbers of bullfrogs, bullfrogs greater than one year post transformation and neonate bullfrogs respectively.
Figure 3. Numbers of green frogs marked on Lake Sasajewun over the course of the long-term study using a standardized sampling technique. Open, light grey and dark grey columns represent total numbers of green frogs, mature adult green frogs and juvenile green frogs respectively.
Figure 4. Numbers of mink frogs marked on Lake Sasajewun over the course of the long-term study using a standardized sampling technique. Open, light grey and dark grey columns represent total numbers of mink frogs, mature adult mink frogs and juvenile mink frogs respectively.
Figure 5. Bullfrog population size estimates for Area 1. Open, light grey and dark grey columns represent population estimates for the months of June, July and August respectively. Bars represent one standard error above and below the estimate.
Figure 6. Bullfrog population size estimates for Area 2. Open, light grey and dark grey columns represent population estimates for the months of June, July and August respectively. Bars represent one standard error above and below the estimate.
Figure 7. Bullfrog population size estimates for Area 3. Open, light grey and dark grey columns represent population estimates for the months of June, July and August respectively. Bars represent one standard error above and below the estimate.
Figure 8. Bullfrog population size estimates for Areas 1 and 2 combined. Open, light grey and dark grey columns represent population estimates for the months of June, July and August respectively. Bars represent one standard error above and below the estimate.
Figure 9. Bullfrog population size estimates for Areas 1, 2 and 3 combined.

Open, light grey and dark grey columns represent population estimates for the months of June, July and August respectively. Bars represent one standard error above and below the estimate.
Table 1. Total number of individual ranid amphibians marked in all three areas in Lake Sasajewun, Algonquin Provincial Park.

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a number of neonates / total number of individuals * 100

b number of juveniles / total number of individuals * 100
Table 2. Snout-urostyle lengths of mature female ranid amphibians captured in Lake Sasajewun, Algonquin Provincial Park.

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DISCUSSION

Both *R. septentrionalis* and *R. clamitans* had a lower percentage of recaptured individuals than *R. catesbeiana* in 1997 as in all previous years. This could indicate larger population sizes for both *R. septentrionalis* and *R. clamitans*, however, there are other explanations for the lower recapture rates. As aquatic vegetation (mainly water shield, *Brasenia schreberi*) spreads across the lake during the summer months, *R. septentrionalis* move into deeper water from the edges of the lake with the spreading vegetation. This makes later season captures more difficult as there is a relatively larger surface area over which individuals may disperse as the summer progresses. There are two possible explanations for the low recapture rate of *R. clamitans*. Adult *R. clamitans* tend to hide in dense vegetation along the shoreline, which makes the location and capture of individuals difficult. Also, *R. clamitans* is the most terrestrial of the three species and may spend most of the summer months away from the lake. However, *R. catesbeiana* tends to occupy the same type of habitat throughout the year and individuals that are captured early in the year have a better chance of being recaptured throughout the summer than either *R. clamitans* or *R. septentrionalis*.

The physical characteristics of Area 3 enabled frogs to escape into deep water or dense vegetation relatively easily, therefore sampling efficiency and recapture rates were lower in this area than in Areas 1 and 2. However, for the fourth consecutive year recapture numbers were large enough to allow an estimate of *R. catesbeiana* population sizes in all three areas. Comparisons of the 1997 population size estimates with the population estimates of previous years indicate no evidence of a long-term decline in *R. catesbeiana* numbers in any of the areas monitored (Figures 5 to 9). Short-term
population fluctuations were observed in all areas, however these fluctuations were never correlated in their direction or magnitude (Figures 5 to 9).

We did not capture every individual in the study area, therefore we expected the estimate of population size to exceed the number of individuals marked in any year. However, population estimates for all species were lower than expected on the basis of the total number of individuals marked. An assumption of Jolly's stochastic method is random dispersal between sampling periods or equal catchability. The violation of the assumption of equal catchability can cause the population size to be underestimated, with magnitude of the bias being proportional to the magnitude of the variation in catchability (Begon 1979). This assumption was probably violated as *R. catesbeiana* tend to be territorial and would return to the same location when released. This may have increased the chance of recapture since the person catching the frogs would also become familiar with these territories. Juvenile *R. catesbeiana* were repeatedly recaptured in the same location even though they were sometimes released up to 200 metres from the capture location. Bias due to differences in catchability should not invalidate our population estimates to monitor trends in population size provided that the sampling bias is consistent across years.

There does not seem to be any directional trend in the total numbers of *R. clamitans* and *R. septentrionalis* captured over the past few years. However, without population size estimates, no conclusions can be drawn from these results. Since 1997 was the first year in which population size estimates were calculated for Area 1, no between year comparisons can be made. However, the ability to calculate these estimates partially validates the concentration of sampling effort within the areas of population concentration (see Methods, Sampling).
This long-term investigation into the population dynamics of three species of ranid amphibians indicates that the populations of *R. catesbeiana* on Lake Sasajewun are not declining. However, the data concerning the abundance of *R. clamitans* and *R. septentrionalis* do not reflect any obvious directional trends. If some broad environmental factor, such as increased UV, were contributing to local as well as global declines, these populations would likely show some evidence of decreasing abundance as reflected by the population estimates of *R. catesbeiana* and the total captures of *R. clamitans* and *R. septentrionalis*.

Although periodic reassessment may be adequate for monitoring long-term trends in population size, it is not sufficient for revealing patterns of cyclic population change. Continuous long-term studies are required to determine whether variation in population parameters is cyclic and predictable enough to be useful in designing conservation strategies. We believe that long-term studies such as this will be most useful in designing future monitoring programs, evaluating population trends and developing conservation strategies.
LIST OF PUBLICATIONS


RELATED CONFERENCE TALKS


MacDonald, J.C. and R.J. Brooks. 1996a. A real world look at statistical power (i.e. by non-statisticians) as it applies to amphibian declines. Sixth Annual Meeting of the Task Force on Declining Amphibian Populations in Canada. University of Calgary, Calgary, Alberta.


LITERATURE CITED


