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Breeding Ponds Colonized by Striped Newts after 10 or More Years

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Many amphibian populations are thought to be structured as metapopulations across a landscape (but see Smith and Green 2005), particularly those species breeding in isolated temporary ponds (e.g., Gill 1978, Hecnar and M'Closkey 1996, Skelly 2001). In terms of Levins' (1969) classic metapopulation concept, isolated wetlands could serve as demes or subpopulations in a larger metapopulation context. This also includes the uplands surrounding isolated wetlands for those species that migrate between upland refuges and isolated breeding sites. Because of variable hydroperiods or presence of predators (e.g., some fishes), certain ponds may be subject to prolonged periods without sufficient hydroperiod to allow metamorphosis (e.g., Semlitsch et al. 1996), whereas others may persist through time and allow the production of metamorphs to maintain populations (sources). A prolonged period of metamorphic failure could lead to a local extinction event. Should conditions change, sites from which populations had been extirpated might be recolonized via dispersal of individuals from source populations. This dynamic interplay of occupancy, colonization and local extirpation thus produces a mosaic of occupation scenarios at any point in time. As Marsh and Trenham (2001) point out, however, this model is somewhat simplistic since there are many variables which affect landscape occupancy by pond-breeding amphibians, including various deterministic factors, the distribution of terrestrial habitats, and the isolation of the pond "patches."

Despite the general acceptance of the metapopulation model, few studies have demonstrated amphibian colonization of a former breeding site after a long absence (see Taylor et al. 2006 for a possible example involving *Eurycea quadridigitata* after 8 years) or colonization of previously unsuitable sites. Here, we report on the colonization of aquatic breeding sites by the Striped Newt (*Notophthalmus perstriatus*) in north-central Florida after a period of 10 years or more with no water, or under previously unsuitable conditions, and suggest that Striped Newts may form metapopulations. Metapopulation dynamics have important implications for the conservation and management of this imperiled species (Dodd et al. 2005). For example, for Striped Newts to persist as metapopulations it is crucial to protect a suite of wetlands with a diversity of hydroperiods and to properly manage uplands to facilitate dispersal among ponds.

For five years, Breezeway Pond on the Ordway-Swisher Biological Station, Putnam County, Florida was monitored five days per week using an encircling drift fence-pitfall trap sampling procedure (see Dodd 1992 for details of this study). Hydroperiod was monitored daily. From 1985 to 1990, > 2500 Striped Newts were marked as they entered and exited the 0.16 ha pond. During the latter half of the study (1988 - 1990), a prolonged drought affected north-central Florida (Franz 1991) and Breezeway Pond went dry on 23 December 1988. Captures of Striped Newts declined accordingly, from 744 in 1987 to 16 in 1990 (Dodd 1993). After October 1990, Breezeway Pond was periodically checked for the next 10 years, especially after substantial rain events, to monitor its hydroperiod. It did not refill until January 1998. During this period the pitfall traps were closed and the drift fence was opened in numerous places to allow animals to move freely in the dry pond basin. On 8 May 1998, a larval Striped Newt was collected from the pond (UF 133756). Despite rigorous dip-net sampling of the pond, which was less than 0.1 hectares in extent at the time, only four larval newts were captured. Although we cannot be sure, this could indicate that very few adults, which migrate to Breezeway Pond in the winter (Dodd 1993), recolonized the pond.

Smith Lake is a 7.55 ha clear-water lake located 350 m N of

Breezeway Pond. It had been stocked with fish when the station was a private hunt club (prior to 1980). In 1983, fish surveys documented the presence of *Etheostoma fusiforme*, *Gambusia holbrooki*, *Lepomis macrochirus*, and *Micropterus salmoides* (R. Franz, pers. comm.). During aquatic surveys prior to 1990, no Striped Newts were collected in the lake, which was not surprising since Striped Newts do not inhabit ponds with predatory fishes (Dodd et al. 2005). However, a small isolated wetland (Smith Lake Pond #1, ca. 425 m east of Smith Lake) had Striped Newts on 9 April 1993 (UF 91485). Smith Lake dried on 29 May 1990 because of a severe drought that affected many lakes and wetlands on and near the Ordway-Swisher Biological Station (Franz 1991) and remained dry for several years before refilling. No fishes have been found in the lake since it dried completely in the early 1990s. Striped Newts were collected from Smith Lake for the first time on 1 February 1997 (UF 133789), again on 2 November 1997 (UF 125759), and most recently on 20 April 2005 (no voucher collected).

A similar situation occurred at a neighboring wetland, Blue Pond (0.71 ha basin), on the Ordway-Swisher Biological Station. Prior to the mid-1980s, when the Station was in private ownership, Blue Pond was a popular fishing site. In the spring of 1985, approximately 100 largemouth bass were caught in Blue Pond (S. Scaife pers. commun.). Blue Pond dried completely in 1989 during the same severe drought that caused Smith Lake and Breezeway Pond to dry. No fish have been found in Blue Pond since the drought. Striped newts were first documented in Blue Pond on 9 February 1997 (UF 128031), and most recently on 11 November 2006 (no voucher taken). They have been documented in Blue Pond numerous times during the interim between these dates. Because Striped Newts only breed in fishless ponds, and thus to our knowledge did not occur in Blue Pond prior to the drought, this is another example of colonization of previously unsuitable habitat by the species.

Salamanders are known to colonize breeding sites after the extinction of predatory fish. Funk and Dunlap (1999) conducted surveys for introduced trout and native Long-toed Salamander larvae in high elevation lakes in 1978 and again in 1997/1998. They found evidence to suggest that Long-toed Salamanders were able to colonize lakes in which trout went extinct. This is similar to our findings with Striped Newts at the Ordway-Swisher Biological Station. Population estimates at known Striped Newt breeding ponds on the Biological Station vary. Dodd (1993) documented 2521 individuals over a 62.5 month period (1985–1990) at Breezeway Pond. During a two-year period (1996–1998), Johnson (2002) counted 8127 Striped Newts entering and exiting One Shot Pond. However, Johnson (unpubl. data) only found 32 individuals at neighboring Fox Pond during a 270-day period from Nov 1997 to Aug 1998. Drift fences encircled both of these ponds. Despite herpetologists working on the Biological Station for the past 25 years and sampling many of the Station's wetlands, this was the first time Striped Newts were documented in Fox Pond and thus may represent a colonization or recolonization event. Fox Pond is very isolated from other wetlands and likely never supported predatory fishes naturally.

Striped Newts have been found in 12 ponds on the Ordway-Swisher Biological Station, all of which have dried for varying lengths of time during the last three decades. The larger wetlands (Smith Lake, Blue Pond, Clear Pond) and two deep but small ponds (Berry, One-Shot) have the longest hydroperiods, but even at these locations drought may completely eliminate or severely limit the duration and timing of suitable conditions for Striped Newt breeding. At such times, Striped Newts may attempt to disperse to other wetlands if available. Striped Newts have been found terrestrially 700 m from the nearest possible breeding site (Dodd 1996), and an inter-pond movement of ca. 685 m (movement of a marked newt from One Shot Pond to Fox Pond) was recorded on the Ordway-Swisher Biological Station (Johnson 2003). Johnson (2003) suggested that 16% of a Striped Newt breeding population may migrate > 500 m from non-breeding terrestrial habitats to reach an isolated breeding pond. Although they have the ability to migrate hundreds of meters into upland habitats, there appears to be strong philopatry to natal breeding ponds, and inter-pond dispersal is a relatively rare event. This supports our supposition that Striped Newts form metapopulations because it means that recruitment is more likely to come from within a patch (e.g., breeding pond and surrounding uplands) rather than via immigration from nearby patches (Harrison and Taylor 1997).

Understanding the synchrony of local population dynamics is important for differentiating between patchy populations and true metapopulations (Harrison and Taylor 1997; Hecnar and M'Closkey 1996). Unfortunately, details of the synchrony of pond occupancy (e.g., extinction and recolonization rates) by Striped Newts across all potential breeding ponds on the Ordway-Swisher Biological Station are unknown. Long-term studies among multiple patches (ponds) are required to collect such data. Nonetheless, we believe our data support the hypothesis that Striped Newts on the Station persist as a metpopulation. Because of environmental stochasticity (e.g., drought, predator colonization), local extinctions are likely over time for Striped Newt breeding ponds on the Station. Variation in pond hydroperiods leads to variation in the synchrony of extinction events.

The source of the individuals that recolonized Breezeway Pond after 10 years, as well as the source of animals that colonized Smith Lake and Blue Pond following the drought, remains unknown. They likely originated from another breeding pond as part of a metapopulation at the Ordway-Swisher Biological Station, as suggested above. Alternatively, it is possible that in some situations individual Striped Newts may wait out short-term droughts in terrestrial refugia. Eastern Red-spotted Newts (*N. viridescens*) may live > 8 years (Forester and Lykens 1991; Gill 1985), although attempts to age Striped Newts have been unsuccessful (G. Zug, pers. comm.). A single individual *N. perstriatus* from the Ordway-Swisher Biological Station has been kept in captivity since 1991, a period of 15 years (L. LaClaire, pers. comm.). Thus, it is possible that wild Striped Newts are long lived.

Like *N. viridescens* (Gill 1978), *N. perstriatus* seems to fulfill the criteria (patchy occupancy through time of a series of breeding ponds in close proximity; periodic extinction and recolonization due to stochastic environmental fluctuation; potential for long distance dispersal; inter-pond movement) for having a metapopulation structure. Surveys for this declining species need to take into consideration the extent to which individuals and populations are dispersed across a landscape over time. What appears to be an unoccupied or unsuitable site during a short-term survey may be an important location for metapopulation dynamics during optimal environmental conditions.

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The Diets of Three Sympatric Barred River Frogs (Anura: Myobatrachidae) from Southeastern Australia

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There are five species of large (7–10 cm) ground-dwelling myobatrachid frogs of the genus *Mixophyes* found along the coast and adjacent ranges of eastern Australia (Cogger 2000). This genus is of some conservation interest because three species (*M. balbus, M. iteratus,* and *M. fleayi*) have had major declines in numbers and ranges in recent years, presumably due to the chytrid fungus, *Batrachochytrium dendrobatoides*, and habitat loss (Ehmann 1997; Hines et al 1999). Advancing knowledge of their basic biology is imperative for their long-term conservation.

The diet of the *Mixophyes* has been poorly documented. Cogger (2000) notes that they generally feed on "insects and smaller frogs." However, the only specific published report of any kind is Wotherspoon's (1980) note of Leaf Green Tree Frogs (*Litoria phyllochroa*) in the stomach of a *M. fasciolatus*. We document the gut contents of three of the species of barred river frogs (*M. balbus, M. fasciolatus,* and *M. iteratus*) to determine if there is any obvious dietary specialization that might be of importance in the declines of *M. balbus* and *M. iteratus*.

Preserved specimens from each of the three species were obtained from the collections of the Australian Museum, Melbourne Museum and Australian Wildlife Collection. These specimens come from a wide range of sites and span more than 100 years in time. Each specimen was sexed and the contents of the gut cavity removed and placed into a separate specimen tube along with the corresponding museum identification number. Each was examined later in order to identify the number of food items present and, as far as possible, the identity of the prey items. Where an item could be clearly distinguished, it was identified to the family level for insects and order for the other items. Initially, we attempted to estimate the volumes of each food item, but the inconsistent nature of digestion made useful comparisons impossible and this approach was abandoned. Individuals were assigned a sex based on obvious secondary or internal sexual characteristics and were considered sub-adults if less than 5 cm snout–urostyle length (SUL) and showed no distinct sex.

We described diet composition, but did not attempt statistical data analysis because of the small number of individuals containing food items. Furthermore, exploratory analysis (using Principle Component Analysis and Analysis of Variance) revealed that the gut contents of a few individuals with much larger numbers of