CONSUMPTION OF EGGS OF THE ENDANGERED FOUNTAIN DARTER (*ETHEOSTOMA FONTICOLA*) BY NATIVE AND NONNATIVE SNAILS

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Abstract—We examined the percentage of consumption of eggs of the endangered fountain darter, *Etheostoma fonticola*, by native and nonnative snails from the San Marcos River, Hays County, Texas. Although all snails consumed eggs, non-native *Marisa cornuarietis* (Prosobranchia: Ampullaridae) and native *Helisoma anceps* (Pulmonata: Planorbidae) consumed a significantly greater percentage of eggs than non-native *Tarebia granifera* and *Melanoides tuberculatus* (Prosobranchia: Thiaridae) and the native *Physella virgata* (Pulmonata: Physidae). Dramatic increases in *M. cornuarietis* in the San Marcos and Comal springs may have an adverse affect on populations of fountain darters.

Resumen—Comparamos los porcentajes de huevos consumidos del pececito en peligro de extinción, *Etheostoma fonticola*, por caracoles nativos y no nativos del río San Marcos, condado de Hays, Texas. Aunque todos los caracoles consumieron huevos, el caracol no nativo, *Marisa cornuarietis* (Prosobranchia: Ampullaridae), y el caracol nativo, *Heliosoma anceps* (Pulmonata: Planorbidae), consumieron porcentajes significantamente mayores que los no nativos, *Tarebia granifera* y *Melanoides tuberculatus* (Prosobranchia: Thiaridae), y el nativo, *Physella virgata* (Pulmonata: Physidae). Aumentos dramáticos de *M. cornuarietis* en los manantiales San Marcos y Comal podrían afectar adversamente las poblaciones de *E. fonticola*.

The spring-fed San Marcos and Comal rivers of central Texas are home to a rich diversity of aquatic organisms including eight species on the federal list of threatened and endangered species. Exotic species of snails also have become abundant in the springs (Bowles and Bowles, 2001) and these snails have caused a decline in communities of native gastropods (Murray, 1971; Horne et al., 1992; Cauble, 1998). Two introduced species of snails, *Terebia granifera* and *Melanoides tuberculatus* (Prosobranchia: Thiaridae) were discovered in Bexar and Comal

counties in the mid 1960s (Murray, 1964). These thiarid snails at times dominate the malacofauna of the Comal River, and whether this is due to out-competing native species of snails, as suspected by Murray (1971) and Cauble (1998), or to changes in the flow regime (T. M. Brandt, pers. comm.) is not known. The striped ramshorn snail, *Marisa cornuarietis* (Prosobranchia: Ampullaridae), was first detected in the Comal River in 1984 (Neck, 1984) and is suspected to negatively impact and cause decline in growth of freshwater macrophytes through direct consumption (Horne et al., 1992). In general, the ecological impacts of these introduced snails are unknown. Due to the presence of fishes and salamanders in the San Marcos and Comal systems that are on the federal list of threatened and endangered species, there is concern that predation (indirect or direct) by these exotic snails could affect the listed populations.

Like various species of gastropods, the endangered fountain darter, *Etheostoma fonticola*, which resides in both the San Marcos and Comal rivers, relies on aquatic macrophytes for habitat (Schenck and Whiteside, 1976; Linam et al., 1993) and, in particular, for deposition of eggs (Strawn, 1956). Due to overlap in use of habitat between snails and fountain darters, we assessed whether native and nonnative snails consume eggs of fountain darters, and if so, are there differences in rates of consumption among the snails?

We collected native and nonnative snails three times from the San Marcos River, San Marcos, Texas, measured their widths and lengths from apex to basal lip (Burch, 1982), and placed each species into each of seven static treatment aquaria with air stones. Three native snails from different families and three common and problematic nonnative snails were selected as representatives. Treatments included a control with no snails and only fish eggs, nonnative species (*M. tuburculatus*, *T. granifera*, and *M. cornuarietis*), and native species (*Elimia comalensis*, *Helisoma anceps*, and *Physella virgata*). Snails were fed a diet of algal flakes prior to each weekly trial. Per trial, we placed ca. 10 snails in each tank with a total of 10–15 eggs of fountain darters deposited on pieces of polyvinyl chloride (a 100-mm polyvinyl chloride, PVC, pipe halved longitudinally) to simulate macrophytes that are used as sites for deposition of eggs. We recorded number of eggs on the PVC prior to placement in the tank and then once a day for the following 4 days. We also recorded any larvae of darters that hatched. The above test was repeated four times. Replicate week 5 for *M. cornuarietis* did not occur as not enough snails were collected that week. All snails were preserved in ethanol following completion of the study. The percentage of eggs remaining after 5 days was calculated and a one-way analysis of variance (ANOVA) with Fisher's least-significant-difference test was performed to examine differences in consumption. All statistical analyses were conducted using the SYSTAT version 10 software package (Systat Software, Inc., San Jose, California).

TABLE 1—Percentage of eggs of *Etheostoma fonticola* (fountain darter) consumed by native and nonnative snails and coefficient of variation.

Snails	Percentage of eggs consumed	*n*	Coefficient of variation
Native			
Elimia comalensis	33.2	5	87.9
Helisoma anceps	60.8	5	64.7
Physella virgata	9.8	5	112.7
Nonnative			
Melanoides tuburculatus	19.0	5	79.8
Terebia granifera	25.3	5	102.6
Marisa cornuarietis	74.7	4	27.8
Control	0	5	—

Mean body size for each snail was 11 mm (range, 5–16 mm) for *E. comalensis*, 10 mm (2–20 mm) for *H. anceps*, 5 mm (3–9 mm) for *P. virgata*, 28 mm (14–53 mm) for *M. tuberculatus*, 17 mm (10–24 mm) for *T. granifera*, and 27 mm (10–40 mm) for *M. cornuarietis*. Both nonnative and native snails consumed eggs of fountain darters (Table 1). For the native snails, *E. comalensis* consumed 33.2% of eggs, *H. anceps* consumed 60.8% of eggs, and *P. virgata* consumed 9.8% of eggs. For non-native snails. *M. tuburculatus* consumed 19.0% of eggs, *T. granifera* consumed 25.3% of eggs, and *M. cornuarietis* consumed 74.7% of eggs.

Percentage of consumption of eggs differed significantly among species of snails ($F = 4.5$, $df = 5$, $P = 0.005$). However, the post hoc tests revealed that only *M. cornuarietis* and *H. anceps* consumed significantly more eggs than *P. virgata*, *M. tuberculatus*, and *T. granifera*. *Marisa cornuarietis* also had significantly higher rates of consumption than *E. comalensis*.

The large consumption of eggs by *M. cornuarietis* may be attributed to the functional morphology of this species, which includes a radula with long canine-like teeth that is efficient at consuming macrophytes (Horne et al., 1992), and unlike the other species of snails examined, *M. cornuarietis* primarily resides on macrophytes (Horne et al., 1992) where eggs presumably are deposited. The native snail *E. comalensis*, which did consume eggs of fountain darters, typically is found in flowing water (Tolley-Jordan and Owen, 2008). Although larger fountain darters can occur in fast-flowing water (C. T. Phillips, pers. obser.), it is not known if eggs of fountain darters are deposited in lotic waters. Most larvae of fountain darters have been collected in low-flow environments (unpublished data) where *E. comalensis* would not pose a threat.

The native snail *H. anceps* consumed a higher percentage of eggs of fountain darters than nonnative thiarid snails, but a slightly smaller percentage than *M. cornuarietis*. The nonnative snails *M. tuberculatus* (Wiley, 1972) and *M. cornuarietis* (pers. obser.), and the native snail *H. anceps* (Lindholm and Huffman, 1979), were in lentic waters where larval fountain darters (and presumably the eggs) can be abundant. However, Cauble (1998) surveyed the Comal River and reported that the native *H. anceps* consisted of <1% of the diversity of snails. There may be a similar composition in the San Marcos River, and although *H. anceps* may consume eggs, it may never be present in large enough numbers to have any effect on the population of fountain darters. The nonnative snail *M. cornuarietis* is not adapted to these spring runs and has been documented to fluxuate drastically in number (Horne et al., 1992). Given this information, if populations of *M. cornuarietis* in the San Marcos and Comal rivers were to dramatically increase, especially in times of drought where the fountain darter may already be susceptible, there may be an adverse effect on populations of fountain darters. Future studies will need to examine habitat specificity for deposition of eggs by the fountain darter to know if invasive snails like *M. cornuarietis* are a serious threat.

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