

## Management and Ecological Note

# Effects of visible implant elastomer mark colour on the predation of red shiners by largemouth bass

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Visible implant elastomer (VIE) marks are an effective method for marking small-bodied fishes including brown trout, *Salmo trutta* (Linnaeus) (Olsen & Vollestad 2001), darters, *Etheostoma* spp. and *Percina* spp. (Roberts & Angermeier 2004) and shiners, *Notropis* spp. (Bouska & Paukert In press). Laboratory studies have shown that Colorado pikeminnow, *Ptychocheilus lucius* (Girard), bluegill, *Lepomis macrochirus* (Rafinesque), and largemouth bass, *Micropterus salmoides* (Lacepède), marked with VIE have lower marking mortality and higher mark retention rates than fish marked with other methods (Haines & Modde 1996; Catalano *et al.* 2001; Roberts & Angermeier 2004). However, the effects VIE marks may have on the vulnerability to predation of marked fish have received limited investigation.

The few experiments investigating the effect of colour and location of VIE marks on predation had conflicting results. Colorado pikeminnow marked with VIE exhibited the same vulnerability to predation as unmarked control fish (Haines & Modde 1996). Similarly, Roberts and Kilpatrick (2004) found no increase in predation by largemouth bass and rock bass, *Ambloplites rupestris* (Rafinesque), on fantail darters, *Etheostoma flabellare* (Rafinesque), marked with green and yellow VIE compared with unmarked fish. Reeves and Buckmeier (2009) found no difference in predation of orange-, red-, blue- and green-marked largemouth bass, channel catfish, *Ictalurus punctatus* (Rafinesque), and blacktail shiners, *Cyprinella venusta* (Girard), by largemouth bass, flathead catfish, *Pylodictis olivaris* (Rafinesque) or white bass, *Morone*

*chrysops* (Rafinesque). Conversely, other studies have shown that bluegills marked with blue and pink injectable phototonic dye were more susceptible to predation by largemouth bass than fish marked with cryptically coloured marks (opaque marks visible to trained observers; Catalano *et al.* 2001).

Information is needed on the effects of VIE marking on predation so better informed decisions can be made on how to mark small-bodied fishes. Previous laboratory studies of predation on VIE-marked fish have only been conducted on a few freshwater species (Haines & Modde 1996; Roberts & Kilpatrick 2004; Reeves & Buckmeier 2009). The objectives of this study were to determine the effects of two colours of VIE marks in two body locations on the predation of a common stream fish, the red shiner, *Cyprinella lutrensis* (Baird & Girard), by a common predator, the largemouth bass; both species commonly coexist in lakes, streams and reservoirs throughout much their range.

The effects of VIE mark colour on the predation of red shiners by largemouth bass were tested in an indoor experimental stream at Kansas State University from 9 September through 21 October 2008. The experimental stream consisted of two pools, each 130-cm diameter and 56-cm deep, connected by two J-shaped riffles 40-cm wide and 16-cm deep (Knight & Gido 2005). Pools were equipped with electric agitators for aeration and overflow drains maintained water levels. Water visibility remained >0.5 m Secchi depth throughout all experiments. Natural rock substrate was placed in the bottom of the pools and riffles

and each pool contained a 30-cm long, 15-cm diameter black plastic corrugated pipe with a 40 cm by 40 cm plastic tile placed on top to simulate cover found in a natural stream. Water temperature was 19–21 °C among all treatments, and water flow was negligible.

Largemouth bass were collected by boat electric fishing and red shiners were collected by seining from streams and ponds near Manhattan, Kansas, USA where both fish coexist. All fish were held in holding tanks for at least 4 days prior to the experiment. Red shiners were marked with yellow or red (two colours commonly used in field studies conducted on small stream fish, Olsen & Vollestad 2001; Bouska & Paukert *In press*) 5-mm long VIE at two different body locations: on the right side of the body below the skin between the dorsal fin and head, or on the right side between the dorsal fin and caudal peduncle. Control fish were handled and sham injected with an empty injection needle so that they would have the same handling procedures and duration as marked fish. Fish were monitored in their holding tanks for 3 days after VIE injection to document mark retention and marking-related mortalities. Mark retention was 100% and marking-related mortality was <1%. The recovery time of 3 days was found to be sufficient to recover from handling stress (Catalano *et al.* 2001; Roberts & Kilpatrick 2004). Red shiners were fed a diet of commercial flake food daily until the experiment began but were not fed during the experiment.

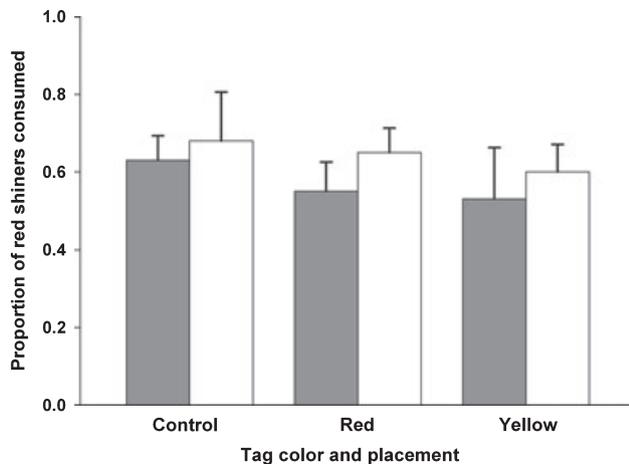
Total lengths (mm) of red shiners and largemouth bass were measured and used to ensure similar lengths for each species in all treatments. Red shiners were moved to the experimental pool 12 h before the predator was introduced to acclimate (Reeves & Buckmeier 2009). Each trial consisted of 20 marked fish (10 fish marked with each colour) and 10 unmarked control fish for a total of 30 red shiners and one predator per trial. Four trials were run with fish marked in each of the two locations for a total of eight trials. Prey and predator fish were only used once.

Largemouth bass were held in tanks and fed unmarked red shiners before the experiments. Prior to the start of the trials, the largemouth bass were not fed for 3 days, and were placed in the sectioned-off riffles of the experimental stream to acclimate for 12 h prior to the experiment. At the start of the trial, one largemouth bass was introduced into each pool. Red shiners were counted three times daily. Trials were concluded when 50–75% of the red shiners had been consumed (Catalano *et al.* 2001; Roberts & Kilpatrick 2004; Reeves & Buckmeier 2009). A two-way analysis

of variance (ANOVA) with interactions was used to determine if mean length of red shiners differed by mark colour (yellow, red, or unmarked control fish) or by trial for each mark location. An ANOVA was also used to determine if the mean proportion of red shiners consumed by largemouth bass differed for yellow marks, red marks and unmarked control fish for each mark location. Proportion data were arcsine square-root transformed to better meet the assumptions of ANOVA.

Mean red shiner total length did not differ among mark colours (red VIE, yellow VIE and unmarked fish;  $F_{2,119} = 2.46$ ,  $P = 0.090$ ) or trials ( $F_{3,119} = 0.76$ ,  $P = 0.516$ ) and the mark colour–trial interaction was not significant ( $F_{6,119} = 0.36$ ,  $P = 0.902$ ) for fish marked near the head or for fish marked near the caudal peduncle (mark colour:  $F_{2,119} = 0.79$ ,  $P = 0.456$ ; trial:  $F_{3,119} = 0.86$ ,  $P = 0.466$ ; colour–trial interaction:  $F_{6,119} = 1.22$ ,  $P = 0.302$ ). Red shiner total length ranged from 44 to 69 mm with mean total length for each trial ranging from 48 to 53 mm. Largemouth bass used in each trial were of similar length (mean 265 mm; range 241–285 mm). Trial duration ranged from 2 to 11 days before 50–75% of red shiners were consumed, with six of eight trials lasting 4–7 days. The mean proportion of red shiners consumed by largemouth bass did not differ for fish marked with yellow VIE, red VIE or controls for fish marked near the head ( $F_{2,11} = 0.31$ ,  $P = 0.740$ ) or for fish marked near the caudal peduncle ( $F_{2,11} = 0.18$ ,  $P = 0.835$ ; Fig. 1). The proportion of red shiners consumed by largemouth bass averaged 0.56 of yellow-marked fish, 0.60 of red-marked fish and 0.65 of control fish.

This study corroborates previous studies that found no difference in predation among VIE marked and unmarked fish (Haines & Modde 1996; Malone *et al.* 1999; Roberts & Kilpatrick 2004; Reeves & Buckmeier 2009). Further, this study demonstrated no difference in predation of red shiners marked with either red or yellow VIE, regardless of the mark location on the fish. Lack of differences in predation among colours and no marks probably was not related to visual detection and discrimination as largemouth bass recognise both red and yellow (Miller & Janzow 1979; Kawamura & Kishimoto 2002). Catalano *et al.* (2001), however, observed increased largemouth bass predation on bluegills marked with brightly coloured injectable phototoxic dye (blue or pink) compared with cryptic marks when the bluegills had access to vegetation for cover. Under conditions where concealment was possible, brightly marked fish may have been more visible to predators, whereas fish with cryptically



**Figure 1.** Mean proportions of red shiners marked near the head (gray bars) or tail (open bars) with red or yellow visible implant elastomer and unmarked controls consumed by largemouth bass for red shiner marked near the head or near the caudal peduncle. Vertical lines represent one standard error.

coloured marks were better able to blend in with the vegetation.

The results of this and other studies indicate that VIE marks do not alter the vulnerability of small fish significantly to predation unless they interfere with the prey's ability to conceal itself. Further research to identify whether different mark colours or locations affect concealment from predators will help assess the implications of marking small-bodied fishes for research and management studies.

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