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MANAGEMENT BRIEF

Short-Term Passive Integrated Transponder Tag Retention in Wild Populations of Bluehead and Flannelmouth Suckers

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Abstract

Passive integrated transponder (PIT) tags, commonly used to individually identify fish, are assumed to not hinder survival or alter the behavior of the fish and to be retained throughout the duration of the study. While these assumptions have been verified for many species, other species have exhibited poor retention or survival, or altered behavior. In this study, we evaluated short-term PIT tag retention and recapturability of PIT-tagged fish in wild populations of migrating and spawning Bluehead Sucker *Catostomus discobolus* and Flannelmouth Sucker *C. latipinnis*. We trapped fish as they entered a spawning tributary of the Gunnison River near Delta, Colorado, USA. We abdominally injected 12.5 × 2.1 mm PIT tags and externally marked 2,645 fish; another 2,660 fish were given an alternative external mark but were not PIT-tagged. When we recaptured fish as they exited the tributary, we found a PIT tag retention rate >99% and recaptured a greater proportion of PIT-tagged fish than of control fish for both species. We did not identify any tag loss in females, suggesting that tags were not expelled with eggs while spawning. Abdominally injected PIT tags are an effective way of marking these species.

Passive integrated transponder (PIT) tags have been widely used for several decades as a cost-effective method of individually marking fish, having few physiological effects and generally high retention rates (Prentice et al. 1990; Hammer and Blankenship 2001; Gries and Letcher 2002). Many large-scale population monitoring and movement studies are conducted using PIT tags (Nunnallee et al. 1998; Paukert et al. 2006). Such studies assume that tag loss is nonexistent and that the ability to recapture fish is not affected by tags. Violating these assumptions often results in substantial bias in parameter estimates (e.g., population size or survival; Williams et al. 2002). While these assumptions have been verified for many fish species (Clugston 1996; Gries and Letcher 2002; Ward et al. 2008), in some cases tag retention has been poor (Baras and Westerloppe 1999; Acolas et al. 2007) and survival has been negatively affected (Ficke et al. 2012). Therefore, tag retention and the ability to recapture fish should be evaluated independently for different species and applications before PIT tag–related data are considered unbiased.

Many PIT tag retention and survival studies use controlled laboratory or caged conditions (Moore 1992; Ward and David 2006; Ward et al. 2008; Ficke et al. 2012; Gardunio and Myrick 2012). In a laboratory setting, effects on recapture rates cannot be tested, and fish do not typically experience the stresses associated with natural habitats. Laboratory and caged studies also fail to account for natural behaviors such as spawning. Tags inserted into the abdomen of gravid fish can be expelled with eggs during spawning, but studies directly addressing short-term tag retention during spawning have been limited to very few fish species, such as Rainbow Trout *Oncorhynchus mykiss*, Brown Trout *Salmo trutta*, Brook Trout *Salvelinus fontinalis*, and Largemouth Bass *Micropterus salmoides* (Harvey and Campbell 1989; Pierce et al. 2005; Bateman et al. 2009; Dieterman and Hoxmeier 2009; Meyer et al. 2011).

Retention of PIT tags in Bluehead Sucker *Catostomus discobolus* and Flannelmouth Sucker *C. latipinnis* has not been thoroughly evaluated, but numerous studies rely on PIT tag data to assess populations and monitor movement of these species throughout the Colorado River drainage (Compton

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et al. 2008; Walters et al. 2012; Van Haverbeke et al. 2013). Bluehead and Flannelmouth suckers are thought to be extirpated from approximately half of their historic range (Bezzerides and Bestgen 2002), so unbiased PIT tag data are especially important for conservation purposes. Previous PIT tagging evaluations for these two species have involved caged conditions or observational recapture data in wild populations (Ward and David 2006; Compton et al. 2008). Additionally, Ficke et al. (2012) found that PIT tagging decreased survival of a similar species, White Sucker *C. commersonii*. Therefore, experimental data on the suitability of PIT tag use in these two species under field conditions are needed.

Our primary objective was to examine short-term PIT tag retention in wild Bluehead and Flannelmouth sucker populations over the spawning period. We PIT-tagged and externally marked Bluehead and Flannelmouth suckers as they entered a spawning tributary. Upon their out-migration, we looked for marked fish without PIT tags to assess tag loss. Our secondary objective was to determine whether PIT tagging decreased recapture rates, which we addressed by externally marking an additional group of fish. All data were collected as part of a large PIT tag–based study examining Bluehead and Flannelmouth sucker movement and tributary use.

METHODS

All fish were marked and recaptured in Cottonwood Creek near Delta, Colorado. Cottonwood Creek is an ephemeral tributary of Roubideau Creek, which flows into the Gunnison River. The hydrograph is primarily snowmelt driven, with flowing water being present usually only during March through the end of June and after sporadic rainfall events. Catostomid suckers use the stream for spawning.

To capture and recapture fish, we installed a weir approximately 130 m upstream from the confluence of Cottonwood Creek with Roubideau Creek. The weir consisted of two stream-spanning aluminum fences (with 2.22 cm spaces between vertical bars) that funneled fish into two traps. One trap (the upstream trap) captured upstream migrants, and one trap (the downstream trap) captured downstream migrants. The traps were aluminum box frames (76.2 × 76.2 × 152.4 cm) with 2.54 × 1.27 cm polyvinyl chloride–coated 14-gauge wire mesh panels and funneled entrances 7–7.5 cm wide. We placed the weir and traps in Cottonwood Creek on April 5 but were forced to remove them on May 6 due to high flows and debris. We reinstalled and operated the downstream weir and trap during out-migration from May 23 through May 25.

We weighed and measured the total length (TL) of all trapped fish, checked for external marks (hole punches in caudal fin), and scanned for a PIT tag using a hand-held portable reader. We also checked for signs of sexual maturity, including nuptial tubercles and the expression of milt or eggs to identify the sex of each individual. We either injected unmarked and untagged Bluehead and Flannelmouth suckers with a 12.5 × 2.1 mm, 134.2 kHz full-duplex PIT tag (Biomark, Boise, Idaho) and gave them a hole punch in the dorsal lobe of the caudal fin (dorsal caudal punch), or we gave them only a hole punch in the ventral lobe of the caudal fin (ventral caudal punch). To inject the PIT tags, we used a handheld implant gun (MK-25; Biomark). The needle was inserted posterior to the left pelvic fin in an anterior direction. Most tags were inserted fully into the body cavity, but some were known to have come to rest in abdominal musculature or fatty tissue. Ten people with various levels of experience implanted the tags, but all had been instructed and supervised by one of several experienced taggers. We made caudal fin hole punches with a standard 6.35-mm-diameter handheld single-hole paper punch. Because PIT tagging fish was the primary objective of the associated movement study we were conducting, we first implanted all available PIT tags (April 8–April 21) before we began applying only ventral caudal punches (April 22–May 6). After tagging and marking, we released upstream Bluehead and Flannelmouth sucker migrants in calm water approximately 50 m above the weir and downstream migrants directly below the weir.

We determined the total number of PIT tags lost from recaptured fish by counting the number of fish with dorsal caudal punches only, then calculated a retention rate in recaptured fish by dividing the total number of recaptured fish with a PIT tag and a dorsal caudal punch by the total number of dorsal caudal–punched recaptured fish. We evaluated retention rates by species and by sex to determine whether gravid females were prone to expelling tags with eggs. We considered individuals that expressed milt on any handling occasion to be males and individuals that expressed eggs on any handling occasion to be females. Individuals possessing nuptial tubercles but not expressing gametes on any handling occasion were considered suspected males, and individuals without nuptial tubercles and not expressing gametes on any handling occasion were considered suspected females.

To determine whether PIT-tagging fish decreased our recapture rates of Bluehead and Flannelmouth suckers, we compared the percentage of captured PIT-tagged fish (including fish with a dorsal caudal punch that had shed their PIT tag and individual fish recaptured multiple times) with the percentage of ventral caudal–punched fish recaptured.

RESULTS

We PIT-tagged and dorsal caudal–punched a total of 2,249 Bluehead and 396 Flannelmouth suckers. Bluehead Suckers TL ranged from 204 to 505 mm (mean = 360.1 mm; SE = 0.62) and Flannelmouth Suckers from 182 to 535 mm (mean = 454.3 mm; SE = 1.64). We recaptured 730 individual dorsal caudal–punched fish. Only one Bluehead Sucker had lost a PIT tag, resulting in an overall retention rate of 99.9% (99.9%

TABLE 1. Numbers of Bluehead and Flannelmouth suckers PIT tagged and given a hole punch in the dorsal lobe of the caudal fin (dorsal caudal punch), and the numbers of suckers recaptured with both a PIT tag and dorsal caudal punch, or with a dorsal caudal punch only (indicating a lost PIT tag). Retention is the ratio of recaptured fish that retained PIT tags to the total number of recaptured fish. Multiple recaptures of the same PIT-tagged fish were excluded.

	Marked	Recaptured		
	PIT tag and dorsal caudal punch	PIT tag and dorsal caudal punch	Dorsal caudal punch only	Retention
Bluehead Sucker				
Male	1,208	432	1	0.998
Female	67	1	0	1.000
Suspected male	58	23	0	1.000
Suspected female	916	216	0	1.000
Total	2,249	672	1	0.999
Flannelmouth Sucker				
Male	219	31	0	1.000
Female	34	12	0	1.000
Suspected male	6	1	0	1.000
Suspected female	137	13	0	1.000
Total	396	57	0	1.000
All fish	2,645	729	1	0.999

and 100% for Bluehead and Flannelmouth suckers, respectively; Table 1).

We gave a total of 2,660 (2,026 Bluehead Suckers and 634 Flannelmouth Suckers) ventral caudal punches (Table 2). The TL of Bluehead Suckers given ventral caudal punches ranged from 187 to 451 mm (mean = 361.1 mm; SE = 0.72), and that of Flannelmouth Suckers ranged from 344 to 564 mm (mean = 448.9 mm; SE = 1.32). We recaptured 593 fish (534 Bluehead Suckers and 59 Flannelmouth Suckers), or 22.3% (26.4% of Bluehead Suckers and 9.3% of Flannelmouth Suckers) of all fish that had been given ventral caudal punches. Considering all recaptures (including multiple recaptures of individual fish) of fish with PIT tags, we recaptured a higher proportion of PIT-tagged fish (29.5% total; 32.1% of Bluehead Suckers and 14.14% of Flannelmouth Suckers) than of ventral caudal–punched fish.

Of the Bluehead and Flannelmouth suckers we marked, 3.0% and 8.6%, respectively, were confirmed females, and 40.7% and 34.6%, respectively, were suspected females. No confirmed or suspected females lost PIT tags. The only tag loss occurred in a confirmed male Bluehead Sucker (Table 1).

Both Bluehead Suckers and Flannelmouth Suckers began entering Cottonwood Creek on April 8, and we stopped trapping on May 27. The mean ± SE time to recapture (number of days between tagging and the final recapture) was 36.7 ± 0.277 d for Bluehead Suckers and 35.5 ± 1.270 d for Flannelmouth Suckers. We excluded several PIT-tagged Bluehead (n = 6) and Flannelmouth (n = 2) sucker recaptures from analyses because they were found impinged on the upstream weir fence less than 24 h after being tagged. We treated these individuals as tagging and handling mortalities.

DISCUSSION

We found that abdominally injected 12.5 × 2.1 mm PIT tags are an effective way of marking spawning Bluehead Suckers and Flannelmouth Suckers for short-term field studies. This method resulted in almost no tag loss (<0.1%) and

TABLE 2. Numbers of Bluehead and Flannelmouth suckers PIT tagged or given a hole punch in the ventral lobe of the caudal fin (ventral caudal punch), and the numbers of suckers recaptured with a PIT tag or ventral caudal punch. Recapture rates compare the total number of PIT tag or ventral caudal punch recaptures (including multiple recaptures of individual PIT-tagged fish) vs. the total number of PIT tags or ventral caudal punches given.

	Marked		Recaptured		Recapture rate (%)	
	PIT tag	Ventral caudal punch	PIT tag	Ventral caudal punch	PIT tag	Ventral caudal punch
Bluehead Sucker	2,249	2,026	722	534	32.1	26.4
Flannelmouth Sucker	396	634	57	59	14.4	9.3
All fish	2,645	2,660	779	593	29.5	22.3

no apparent decrease in recapture rates for both species. In fact, we recaptured PIT-tagged fish at a higher rate than we did ventral caudal-punched-only fish. While this is most likely because we did all PIT tagging before we ventral caudal–punched any fish, and PIT-tagged fish were therefore present for a greater amount of time, the higher PIT tag recapture percentage suggests that PIT tagging did not decrease recapture rates. Though we were unable to evaluate survival of tagged fish, we found only eight PIT-tagged fish (0.30% of all tags implanted) and no known caudal-punched fish that were incapable of continuing upstream immediately after initial handling. Some studies have looked directly at survival of captive PIT-tagged adult catostomids and have found uniformly high survival rates (Burdick and Hamman 1993; Ward and David 2006; Hewitt et al. 2010; Booth et al. 2014), except for Ficke et al. (2012), who found that survival was less than 44% for juvenile White Suckers under 172 mm TL . At least a portion of the fish in all those studies were tagged in a similar body location to ours, but some were tagged with PIT tags twice the size (23.1 × 3.9 mm) of the ones we used. Given that we were using smaller, less invasive tags on adult fish, our findings of negligible tagging-related mortality and high retention agree with the findings of other studies. However, our results should not be used to support tagging assumptions when using larger tags, or juvenile fish.

The validity of our results depended on our ability to detect both tags and hole punches. Although we did not know how quickly hole punches would heal and become undetectable, even by the end of the study, hole punches on all recaptured PIT-tagged fish were still clearly visible. We also did not capture any PIT-tagged fish that lacked a dorsal caudal punch. Therefore, we do not think that we missed ventral caudal punches, which would have biased our comparisons of recapture rates.

While we did not observe any differences between species in tag loss or tagging-affected recapture rates, we did have noticeably lower recapture rates of both PIT-tagged and ventral caudal–punched Flannelmouth Suckers than of similarly treated Bluehead Suckers. However, we believe this did not identify any tagging-related species differences, but instead was due to behavioral differences between the species. Data from a submersible PIT tag antenna deployed in Cottonwood Creek downstream of the weir as part of an associated movement study detected a significantly higher proportion ($\chi^2 = 21.57$; df = 1; $\alpha = 0.5$; $P < 0.001$) of individual PIT-tagged Flannelmouth Suckers than of Bluehead Suckers during the time the weir and traps were removed during high flows (May 6–May 22). Therefore, the different recapture rates were probably the result of a greater proportion of Flannelmouth Suckers than Bluehead Suckers exiting the stream before the trap was reinstalled on May 23.

A concern with abdominally implanting PIT tags immediately before fish spawn was that females would expel tags with eggs, as has been seen in salmonids (Bateman et al. 2009). However, out of the 242 confirmed and suspected female Bluehead and Flannelmouth suckers recaptured, none shed a tag. We observed very few PIT-tagged fish expressing eggs but saw many that appeared to be spent females during the out-migration period, so we are confident that females had spawned but retained their tags. Expulsion of PIT tags with gametes, as seen in salmonids, has not been directly assessed or incidentally observed in other catostomid species.

Another concern was that despite high PIT tag retention rates in Bluehead and Flannelmouth suckers after more than 37 d, our methods did not allow us to address long-term PIT tag retention. However, Burdick and Hamman (1993) found that 245 Razorback Sucker *Xyrauchen texanus* held in an experimental pond and raceway all retained PIT tags inserted either abdominally or into the dorsal musculature for 511 d. Razorback Suckers are related to Bluehead and Flannelmouth suckers and have similar physiology and behavior. We suspect that long-term tag retention among Bluehead, Flannelmouth, and Razorback suckers is similarly high. Additionally, during the course of this project we recaptured both Bluehead and Flannelmouth suckers that had been PIT tagged in years previous to this study, some having retained tags for up to 10 years.

Even under natural conditions, we found support for the assumptions of minimal tag loss and unaffected recapture rates for adult Bluehead and Flannelmouth suckers tagged with abdominally injected 12.5-mm-long PIT tags. These tags are a cost-effective, simple tool for identifying individual fish and building large data sets on population trends and movement patterns. Data generated through the use of PIT tags are valuable for guiding effective conservation strategies for declining fish species. However, the suitability of the tag used should always be evaluated for the species studied, and preferably under natural conditions.

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