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Research Article

Retention of Passive Integrated Transponders (PIT) Tags in Juvenile Rainbow Trout and Brown Trout

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Abstract: Retention and mortality rates of 243 Rainbow Trout Oncorhynchus mykiss (73-119 mm) implanted with 8, 9, and 10 mm Passive Integrated Transponder (PIT) tags and 173 Brown Trout Salmo trutta (71-86 mm) implanted 8 and 10 mm PIT tags were examined in a hatchery setting. Retention rates were 95.9% for Rainbow Trout and 100% for Brown Trout over the study period. Only six Rainbow Trout ejected tags. With the 8 mm tags, two ejections occurred in the first seven days, one occurred between days nine and 15, and one occurred between days 22 and 50. One Rainbow Trout ejected a 9 mm between days 22 and 50, and another Rainbow Trout ejected a 10 mm tag in the first seven days. There were no significant differences in weight or length of fish that ejected their tags. Over the course of the study, survival was 100% for both species. This study documents that Rainbow Trout can be successfully tagged at a minimum TL of 73 mm and Brown Trout at minimum TL of 71 mm with no adverse effects on tag retention or survival.

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Introduction

Individually marking fish to gather specific data is often necessary during fisheries studies (Guy et al. 1996). Passive Integrated Transponders (PIT) tags are a popular tagging method. PIT tags are small, highly-retained injectable tags with unique individual alphanumeric codes that are easily read by a hand-held scanner, thereby allowing in situ collection with minimal, if any, handling of the organism (Acolas et al. 2007; Prentice et al. 1990). Additionally, PIT tags can potentially last for the life of the fish, making them particularly useful in mark-recapture studies (Hewitt et al. 2010; Barbour et al. 2011). They also have been used to evaluate fish movement, habitat use, growth, and mortality (Cucherousset et al. 2005; Ombredane et al. 1998; Teixeira and Cortes, 2007). Their ease of use increases efficiency while marking large samples of individuals, and they can be a tool to access individual fish performance within a population (Bryson et al. 2013; Ward et al. 2008).

One of the primary assumptions of fish marking is that the tag does not negatively impact the fish (Nielson, 1992). One primary consideration with PIT tags is the minimum size a fish needs to be in relation to the size of tag (Columbia Basin Fish, Wildlife Authority 1999) as fish Total Length (TL) at the time of tagging has been shown to be important for both PIT tag retention (Acolas et al. 2007) and tagged fish survival (Baras et al. 1999). Unfortunately, juvenile and small-bodied fish typically fall below the minimum size for tagging. This is problematic because information on survival (Skalski et al. 2009) and growth (O'Donnell and Letcher, 2017) of juvenile fish may be needed to make population inferences.

While the retention rates with larger versions of PIT tags (12-32 mm) has been well documented, the use of smaller PIT tags on juvenile salmonids has been largely untested. As such, the objective of this study was to evaluate long-term tag retention in juvenile Rainbow Trout *Oncorhynchus mykiss* and Brown Trout *Salmo trutta*, using 8, 9, and 10 mm PIT tags.

Methods

Common to both trials

All experimentation occurred at McNenny State Fish Hatchery, Spearfish, South Dakota, USA using well water (11°C; total hardness as CaCO3, 360 mg/L: alkalinity as CaCO3, 210 mg/L; pH, 7.6; total dissolved solids, 390 mg/L). Passive Integrated Transponder (PIT) tags (Biomark, Boise, Idaho, USA) were injected into the peritoneal cavity of fish using a handheld injector (Biomark, Boise, Idaho, USA). Prior to being injected, fish were anesthetized using tricaine methanosulfate (MS-222; Argent Chemical Labs, Ferndale, Washington, USA), to stage 4 anesthesia, described by (Hikasa et al. 1986). After injection, fish were measured to the nearest millimeter for TL, weighed to the nearest 0.1 gram, and scanned with a GPR Plus universal reader (Biomark, Boise, ID) to obtain the unique 12-digit alphanumeric identification number. After tagging, the fish were all pooled into a single 1.8 m diameter circular tank and fed once daily (1.5 mm floating PROTEC FW, Skretting North America, Tooele, Utah, USA) at a rate at or above satiation.

Rainbow trout

On February 11, 2019, juvenile Rainbow Trout were implanted with one of three different-sized tags. Fish were randomly selected, anesthetized and injected with either half-duplex 8 mm (n=98; range TL=80-119 mm; mean TL=100 mm; SD=8; range weight=5-20 g; mean weight=12 g; SD=3), 9 mm (n=82; range TL 73-117 mm; mean TL=100 mm; SD=9; range weight=4-19 g; mean weight=12 g; SD=3) or 10 mm (n=63; range TL=78-118 mm; mean TL=99 mm; SD=8; range weight=6-21 g; mean weight=12 g; SD=3) PIT tags. To evaluate tag retention, the fish were anesthetized and scanned weekly for the first three weeks after tagging and then monthly there-after during the seven-month trial. If a PIT tag was not retained, TL (mm) and weight (g) of the fish was recorded and it was removed from the tank.

Brown trout

On April 1, 2019, juvenile Brown Trout were implanted with one of two different-sized PIT tags. Fish were randomly selected, anesthetized and injected with either a half-duplex 8 mm (n=88; range TL: 71-83 mm; mean TL=76 mm; SD=3; range weight 4-7 g; mean weight=5 g; SD=1) or 10 mm (n=89; range TL=71-86 mm; length TL=76 mm; SD=3; range weight=4-8 g; mean weight=5 g; SD=1) PIT tags. After recovery, the fish were pooled into the tank containing the prior tagged Rainbow Trout and feeding rates were adjusted to maintain satiation. Fish were scanned to check for tag retention at seven and 14 days post-tagging and then at monthly intervals there-after for the five-month trial.

Statistical analysis

Data was analyzed using the SPSS (24.0) statistical analysis program (IBM, Chicago, Illinois, USA). We used Pearson's chi-square tests (α=0.05) to test for differences in retention rates, and t-tests (α=0.05) were conducted where possible to compare the mean lengths and weights of Rainbow Trout that either did or did not retain tags. Percentage data were log transformed prior to analysis of variance to stabilize the variances (Warton and Hui, 2011).

Results

The retention rate for both sizes of PIT tags in Brown Trout was 100% **(Table 1)**. Retention rates for PIT-tagged Rainbow Trout were 95.9% using 8 mm tags, 98.8% with 9 mm tags and 98.4% using 10 mm tags. Throughout the 176-day experimentation, a total of six Rainbow Trout did not retain their tags **(Table 2)**. There was no significant difference in length or weight between fish that either retained or ejected their tags (α=0.05). Of the 8 mm tags ejected, two were ejected between days one and eight, with the third ejected between days nine and fifteen, and the fourth ejected between days 22 and 50, post-tagging. The 9 mm tag was ejected between days 22 and 50, and the 10 mm ejection occurred between days one and eight. There was no significant difference in Rainbow Trout tag retention rate among the three sizes of tags **(Table 3)**. No mortalities were observed during the study period.

Table 1: Mean (SD) initial total lengths and weights, and retention rates for three different size Passive Integrated Transponder tags in Rainbow Trout over seven months and Brown Trout over five months.

Species	Tag Size	Length (mm)	Weight (g)	Retention (%)	N
Rainbow Trout	8	100 (8)	12 (3)	95.9	98
	9	100 (9)	12 (3)	98.8	82
	10	99 (8)	12 (3)	98.4	63
Overall		100 (8)	12 (3)	97.5	243
Brown Trout	8	76 (3)	5 (1)	100	88
	10	76 (3)	5 (1)	100	89
Overall		76 (3)	5 (1)	100	177

Table 2: Mean (SD) initial total lengths and weights of Rainbow Trout that retained or ejected three different sized Passive Integrated Transponders over seven months.

Tag size	Ejected	N	Length (mm)	Weight (g)
8 mm	Yes	4	100 (3)	12 (2)
	No	94	100 (1)	12 (1)
9 mm	Yes	1	117	19
	No	81	100 (9)	12 (1)
10 mm	Yes	1	110	15
	No	62	99 (8)	12 (3)

Table 3: Pairwise comparisons of juvenile Rainbow Trout tag retention rates with 8, 9 and 10 mm Passive Integrated Transponder tags.

Tag size	Tag size	X^2	p-value
8 mm	9 mm	1.3542	0.2445
8 mm	10 mm	0.7929	0.3732
9 mm	10 mm	0.0354	0.8507

Discussion and Conclusion

The results of this study indicate that juvenile Brown Trout (≥ 71 mm) and Rainbow Trout (≥ 73 mm) can be safely tagged with 8-10 mm PIT tags and successfully retain tags for at least five months. With all sizes of tags, the retention rate exceeded 95% in Rainbow Trout and was 100% for Brown Trout.

Our results were similar to the 96.7% retention rate observed by O'Donnell et al. (2017), who used 8 mm PIT tags in Brook Trout *Salvelinus fontinalis* (35-55 mm fork length) at 64 days post-tagging. Similarly, (Tiffan et al. 2015) documented retention rates ranging from 93 to 99% in Chinook Salmon *Oncorhynchus tshawytscha* at two body lengths (40-49 mm and 60-69 mm) injected with 8, 9, and 12 mm PIT tags in a 28-day period. During a nine month mark-recapture study, (Cary et al. 2017) noted a 99.4% retention rate in six species (Bluehead Chub *Nocomis leptocephalus*, Creek Chub *Semotilus atromaculatus*, Yellowfin Shiner *Notropis Lutipinnis*, Mottled Sculpin *Cottus bairdii*, Northern Hog Sucker *Hypentelium nigricans*, and the Striped Jumprock *Moxostoma rupiscartes*) ranging from 39 to 101 mm in length using 8 mm PIT tags, with body length being a predictor of tag retention. Body length also affected PIT tag retention in Southern Redbelly Dace *Chrosomus erythrogaster*, with 8 mm tags suitable for fish longer than 50 mm and 9 mm tags only suitable for fish over 60 mm (Pennock et al. 2016).

While TL has been found to be a predictor of tagging survival, our results indicated no adverse effects on either Rainbow and Brown Trout. This was similar to the 100% survival rates in age-0 Burbot Lota lota observed by (Ashton et al. 2013) when using 9 mm PIT tags. Additionally, (Tiffan et al. 2015) found little to no impacts on survival when tagging juvenile Chinook Salmon, with 8 and 9 mm PIT tags with survival rates exceeding 99% for both tag sizes. Conversely, Ward et al. (2015) found TL to be a significant predictor of mortality for Humpback Chub *Gila cypha* when using 8 mm PIT tags, with small fish exhibiting the highest mortality rates. However, their results still indicated that fish could be effectively tagged to sizes as small as 65 mm with little to no impacts on survival.

Tag-to-body ratios have been used to determine minimum fish size for tag implantation. The 2% tag-to-body ratio recommended by Winter (1983) is often considered to be the upper threshold. However, Brown et al. (1999) observed ratios up to 12% had no impact on swimming performance of juvenile Rainbow Trout. Similarity, (Richard et al. 2013) found that the ratio could be extended to 6% with juvenile Brown Trout for PIT tags. In our study, tag-to-body ratios never exceeded 2%.

The experience of the individual conducting the tagging may impact both retention and survival. While not quantified, (Dare, 2003) suggested that retention rates were linked to the experience of the tagger during a long-term PIT tag retention study on juvenile spring Chinook Salmon. Additionally, Meyer et al. (2011) found that PIT tags implanted by experienced taggers had significantly higher short-term retention rates than did inexperienced taggers. (Richard et al. 2013) found that in small Brown Trout (<55 mm), retention differed between taggers, but found no differences with fish above this length. The use of only a single tagger will reduce any bias that may be associated with multiple taggers (O'Donnell and Letcher, 2017). In this study, only one individual tagged during the trial. However, each trial had a different tagger. In both trials, the tagger had extensive experience with PIT tagging, but no previous experience with tags smaller than 12 mm. Because retention rates exceeded 95% in all cases and fish survival was 100% in this study, a lack of experience with tags less than 12 mm was not problematic.

It is possible that the tag retention rates observed in this study were influenced by the hatchery setting. The rearing tank environment precluded exposure to potentially-deleterious impacts on tag retention, such as changing water temperatures, flooding, and spawning activities (Dieterman and Hoxmeier, 2009). However, fish in the circular tank still exhibited the normal swimming behavior (e.g. sustained and burst swimming and surface feeding) of stream-dwelling trout, suggesting that the observed retention rates are representative of field conditions (Ombredane et al. 1998). Additionally, the controlled hatchery environment allowed for an accurate determination of tag retention and survival.

Certain situations require large numbers of fish to be tagged (Isely et al. 2004). Additionally, a range of sizes of fish may be encountered while sampling, and the ability to tag all of these sizes may be necessary for growth and survival assessments. Given the retention and survival rates observed in this study, further experimentation to establish species-specific minimum TL thresholds for successful PIT tagging would be extremely beneficial.

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