Evaluation of Carlin Dangler Tags in Hatchery-reared Channel Catfish

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Abstract: Long-term tagging studies require a tag that has high retention and does not cause significant mortality. Retention and induced mortality were determined for advanced fingerling channel catfish (*Ictalurus punctatus*) tagged with Carlin dangler tags. We stocked three replicate 0.10-ha ponds with 100 tagged and 150 untagged channel catfish. Mean length ± SD of fish stocked was 232 ± 20 mm (range: 179–282 mm). Mean annual tag loss was 10% and ranged from 4% to 19% among ponds. Annual survival was 9% lower for tagged (mean = 52%) than unmarked control fish (mean = 61%). Annual growth of tagged fish was 58 mm and 376 g less than that of unmarked fish. Overall, results of this study indicated that long-term tag loss of Carlin dangler tags was acceptable for most applications (i.e., 10% per year), but investigators should be aware that tagged advanced fingerling fish, with an associated adipose fin clip, may have reduced survival and growth.

Key words: tag loss, mortality, retention, growth, channel catfish

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Channel catfish (*Ictalurus punctatus*) are one of the most popular sport fishes in Arkansas; in 2006, 36% of Arkansas anglers targeted catfishes (USFWS and USDC 2008). Stocking programs for channel catfish are popular with anglers, and in the late 1990s, 33 states had stocking programs for catfish (Michaletz and Dillard 1999). Exploitation studies have been used to evaluate stocking programs (e.g., Michaletz et al. 2008). These studies require an external reward tag that anglers can easily observe and read, and it is important that tags have excellent retention (e.g., 365 days) without causing significant mortality.

Carlin dangler tags (hereafter Carlin tags) and anchor tags have both been used for exploitation studies with channel catfish. Anchor tags are commonly used (Guy et al. 1996), relatively inexpensive, and can readily be observed by anglers. Hale et al. (1984) reported 97% retention and high survival (86%) of white catfish (*Ictalurus catus*) and channel catfish tagged with Floy FD-68B anchor tags after 184 days. Buckmeier and Irwin (2000) found that anchor tag retention was 100% after 100 days, but declined to 70% after 270 days. In contrast, Timmons and Howell (1995) reported 74% retention of anchor tags at 540 days.

Guy et al. (1996) indicated that Carlin tags have a long retention time as a transbody and transstructural tag. Michaletz et al. (2008) estimated that tag retention for advanced fingerlings was 100%, 90%, and 77% for 1, 2, and 3 years post stocking, respectively, in a hatchery pond. However, two-thirds of the fish died, likely due to predation from large blue catfish and flathead catfish that were also stocked in these ponds because of hatchery space limitations Channel catfish tagged with a Carlin tag and stocked in a 0.4-ha pond experienced 10% tag loss with 70% survival after 5 months. (Shrader et al. 2003). Though unreplicated, these studies indicated that survival of channel catfish could be impacted by tagging and further investigation of the Carlin tag for use in channel catfish was warranted. Thus, the goal of this study was to evaluate Carlin tags for long-term exploitation studies with channel catfish. The primary objective of this study was to determine tag retention and mortality of advanced fingerling channel catfish tagged with Carlin tags. The second objective was to assess the possible effects of tagging on growth.

Methods

A replicated experiment with control fish was used to investigate tag loss and mortality of channel catfish tagged with Carlin tags at the University of Pine Bluff (UAPB) Aquaculture Research Station. Three replicate 0.10-ha ponds were drained completely and limed with hydrated lime for dero worm control (prevention of hamburger gill disease) prior to filling. We decided to stock fish at 2,500 fish/ha, which was the lowest density needed to reduce aggressive behaviors (Lochmann et al. 1998). Our budget allowed us to tag 100 fish per pond. Thus, each pond was stocked with 250 fish (100 tagged and 150 untagged control fish) with mean length of 232 mm (SD = 20) and 86 grams (SD = 23). The adipose fin was clipped on tagged fish to identify tag losses. The tags used (2009 U.S. $1.23 each) were 100 mm long to the twist eye or U (i.e., 50-mm longer than the standard tag), had a single 20–25-mm trailer wire attached to the twist eye, and 4.8-mm wide by 15.9-mm long yellow numbered oval disk tags were attached to the trailer wire. Tags were implanted beneath the dorsal fin using 8–10 twists, leaving 25-mm of excess wire for growth. Excess wire was removed with side cutting pliers. We manufactured needle holders to apply the tags from hollow, square aluminum tubing with a wood insert that had two channels routed into them to insert the bases of the hypodermic needles. The needle holders had fixed widths between the needles of 8–10 mm (mean = 8.5), except one holder had a 6-mm gap. Fish were tagged at the Joe Hogan State Fish Hatchery in Lonoke, Arkansas, held overnight in raceways to check for short-term tag loss, and stocked in the UAPB ponds on 4 April 2011. Tanks on the fish hauling truck were checked for shed tags following stocking. Observed mortalities were recorded throughout the study.

Fish were fed with a 32% protein pelleted (6.35-mm) commercially available floating feed every three days during the summer and fall with feed applications ranging from 1.58 to 1.8 kg per pond per day during the summer and 0.9 to 1.36 kg per pond per day during the spring and fall. Water temperature and dissolved oxygen (DO) were measured twice daily with an YSI 550A hand-held DO meter (Yellow Springs Instrument, Yellow Springs, Ohio). Aeration was provided with a 0.37-kW floating electric paddle-wheel aerator per pond set to run from 2000 h to 0800 h using a timer. In addition, UAPB personnel spot checked ponds throughout the night to ensure that aerators were functioning and that fish were not subjected to low DO conditions.

Water samples were collected monthly (from both ends of each pond) at approximately 0800 h using a 1-m column sampler to obtain a composite sample. Total ammonia nitrogen (TAN:salicylate method), nitrite-N (diazotization method), and pH were analyzed using a HACH DR 4000 spectrophotometer (HACH Company, Loveland, Colorado). Chloride concentration was determined by titration using a HACH aquaculture water quality test kit. Total alkalinity (digital tritration using sulfuric acid) and total hardness (digital titration using EDTA) were measured as ppm $CaCO_3$ with the HACH kit.

Tag loss and tagging mortality were determined on 6 July 2011, 9 November 2011, and 9–10 April 2012, corresponding to 96, 216, and 368 days post stocking, respectively. At 96 and 216 days post stocking, fish were captured using three-pass removal seining after drawing down the ponds. Fish were held in separate live cages for each pass. The number of fish in the pond was estimated using program CAPTURE (jacknife estimator Mbh, Pollock and Otto 1983) to determine interval mortality rates. The ponds were drained completely 9–10 April 2012 to collect all remaining fish. After ponds were drained, they were inspected for dead fish or shed tags lying on the surface of the ponds. All fish collected were checked for a tag, an adipose fin clip, physical signs of tag loss, infection, or other tag issues. At each examination of the channel catfish population, a subsample of 25 tagged and 20 control fish from each pond were measured (total length, mm) and weighed (g) after being anesthetized with Tranquil (Quinaldine).

Tag loss was determined as the number of fish that lost tags divided by the total number of tagged fish recovered, and this proportion was multiplied by 100 to obtain percent loss (Mourning et al. 1994). Survival was calculated for each pond as the number of fish alive at a given sample date divided by the number stocked. Differences between survival of the tagged and control groups were assigned to tagging-induced mortality. Mean annual survival was compared between tagged and control fish with a paired t-test after arcsine transformation. Annual growth, mean length at stocking, and mean length at 368-days were compared between tagged and unmarked control fish using paired *t*–tests. A significance level of $P \leq 0.05$ was used for all tests.

Results

Mean annual tag loss (i.e., 368-days) was 10%, but tag loss was variable and ranged between 4% and 19% among ponds (Table 1). At 96 days post stocking, mean tag loss was < 1% (1 of 207 fish); however, mean tag loss increased to 8% after 216 days, and 10% after 368 days. Thus, most tag loss occurred between 7 July and 11 November (96 to 216 days post stocking), corresponding to the time period when fish growth was fastest.

Annual survival of fish was 9% higher for unmarked than tagged fish in the three ponds (range: 7%–10%, $t = -57$, df = 2, $P < 0.001$, Table 2). Annual survival for all fish averaged 58%. Survival was similar between tagged (70%) and control (74%) fish after 96 days ($t = -1.69$, df = 2, $P = 0.23$), but higher for untagged fish (66%) than tagged fish (59%) after 216 days ($t = 8.36$, df = 2, $P = 0.01$).

The annual growth rate (g/day) of unmarked control fish was roughly double that of tagged fish (Table 2). Annual growth of

Table 1. Carlin dangler tag loss for channel catfish in three ponds at 96, 216, and 368 days post stocking.

	Tag loss (% of marked fish)			
Time	Pond 71	Pond 74	Pond 75	Mean
96 d	0%	<1%	0%	<1%
216 d	15%	4%	6%	8%
368 d	19%	8%	4%	10%

Table 2. Survival, mean length, and growth of Carlin dangler tagged (T) and unmarked (U) channel catfish among three 0.10-ha ponds during 2011–2012. Overall means are shown ± SE.

	Pond 1		Pond 2		Pond 3		Overall mean		
	T	U	T	U	T	U	T	U	*P*-value
Survival (%)	63	71	48	58	45	55	52 ± 6	61 ± 5	<0.001
Mean length at stocking (mm)	225	230	232	234	227	245	228 ± 2	236 ± 4	0.240
Mean length after 368 d (mm)	377	437	375	447	376	442	376 ± 1	442 ± 3	0.003
Annual growth (mm)	151	206	143	213	150	197	148 ± 2	206 ± 5	0.014
Mean weight at stocking (g)	80	83	84	88	79	99	80 ± 5	90 ± 5	–
Mean weight after 368 d (g)	505	860	485	912	455	828	482 ± 15	867 ± 25	–
Annual growth (g)	426	777	401	824	375	728	401 ± 15	776 ± 28	0.004
Annual growth rate (g d^{-1})	1.2	2.1	1.1	2.2	1.0	2.0	1.1 ± 0.0	2.11 ± 0.1	–

tagged fish was 57 mm (paired *t*-test, $t = -8.45$, df = 2, $P = 0.014$) and 376 g ($t = -15.74$, df = 2, $P = 0.004$) less than that of unmarked fish. Mean length was similar between tagged and untagged fish at the start of the study (mean difference = 8 mm, df = 2, $t = -1.655$, $P = 0.24$, Figure 1); however, by the end of the study, mean lengths were 66 mm greater for untagged (442 mm) than tagged fish (376 mm; paired *t*-test; $t = -18.117$, df = 2, $P = 0.003$). At 368 days, mean length of fish that lost tags was 372 ± 13 mm ($n = 10$; range: 311–450 mm).

Mean daily DO values (± SE) measured across ponds were 7.2 ± 0.3 in the morning and 10.7 ± 0.4 in the afternoon. Average monthly morning DO concentrations were greater than 5 ppm during the summer months, except in Pond 75 during July (mean = 4.5 ppm). The lowest DO measurement recorded was 3.6, 3.4, and 2.5 ppm for ponds 71, 74, and 75, respectively. Only 0.5%, 1%, and 6.7% of morning DO measurements were less than 4 ppm for the three ponds. The highest temperature recorded was 38.2 C. Mean monthly values (± SE) of other water quality parameters measured across ponds were: total alkalinity 179 ± 19, total hardness 149 ± 11, chlorides 129 ± 15 ppm, TAN 0.13 ± 0.10, nitrite-N 0.05 ± 0.04, and pH 8.3 ± 0.4.

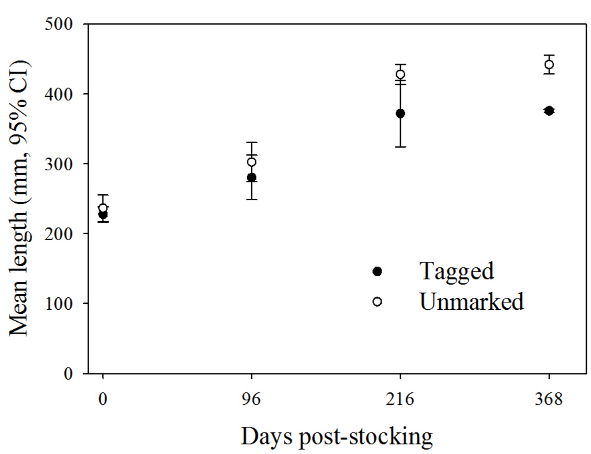

Figure 1. Mean length over time of channel catfish tagged with Carlin dangler tags and unmarked fish among three 0.10-ha hatchery ponds.

Discussion

Tag loss rates of Carlin dangler tags for long-term tagging studies with channel catfish and other species of Ictalurids are usually low, typically ranging between 0% and 16% per year (Graham and DeiSanti 1999, Shrader et al. 2003, Michaletz et al. 2008, Sullivan and Vining 2011). Unlike our study, Michaletz et al. (2008) reported an annual tag loss of 0% for channel catfish in small Missouri impoundments, but their tags did not have trailer wires that can get tangled up when the fish are crowded. The annual tag loss and survival rates for our study were generally comparable to those found by Shrader et al. (2003) for catchable channel catfish > 305 mm TL in an Idaho reservoir (10% loss and 70% survival at 5 months). Sullivan and Vining (2011) reported 100% survival and 16% tag loss for large catchable blue catfish (*Ictalurus furcatus*; 482–995 mm TL) held in a 0.4-ha pond after 5 months. Travnichek (2011) reported 1% tag loss and 8% mortality for flathead catfish (*Pylodictis olivaris*; >305 mm TL) held for one year in a pond. Holly et al. (2009) suggested that field results using Carlin for both channel catfish and blue catfish >300 mm TL in an Alabama reservoir indicated high tag retention. Annual loss of Carlin tags appears to be lower in Ictalurids than some species, including white sturgeon (*Acipenser transmontanus*; 22% loss; Rien et al. 1994), rainbow trout (*Oncorhynchus mykiss*; 23%–35%; McAllister et al. 1992), and walleyes (*Sander vitreus*; 24%; Kallemeyn 1989). Because tag loss rates are variable, Kallemeyn (1989) and Isermann and Knight (2005) stressed that tag loss rates should be monitored during tagging studies as a standard procedure.

We performed dissections on seven channel catfish (range of lengths, 238–524 mm) and found that usually 2–3 pterygiophores were encompassed by the tag wires. X-ray images showed that pterygiophores on channel catfish slant anterior towards the head of the fish (Smith and Smith 1994). Researchers using Carlin tags should be careful not to apply the tag too far back posteriorly to avoid missing the pterygiophores (i.e., towards the caudal fin). Sullivan and Vining (2011) suggested that tag losses may be caused by not spanning across at least one pterygiophore with the tag. Careful dissection of a sample of tagged fish would be helpful for understanding potential causes for tag loss.

Tags that are too short may lead to high tag loss rates (e.g., Greenland and Bryan 1974), and we recommend that future studies use a Carlin tag length of 100 mm past the eye or U. We observed unusually high annual tag loss of 30% in a pilot study pond (unpublished data) that may have been related to the combined effects of using a short tag length (50-mm past eye or U), growth of the small fish (mean TL = 175 mm, SE = 1.2 mm) and a temporary problem with pond vegetation catching the tags.

Our study appears to be the first to document that Carlin dangler tagging resulted in reduced survival and growth of advanced fingerling channel catfish. Carlin tags have also been shown to reduce survival and growth in artic charr (*Salvelinus alpinus*; Strand et al. 2002) and growth in striped bass (*Morone saxatilis*; Chadwick 1963). The size of fish we studied (mean length = 232 mm) were similar to the size of fish most state agencies stock in small impoundments to escape predation by largemouth bass (175–250 mm TL; Michaletz and Dillard 1999). It is unknown if tagging larger catchable channel catfish would produce results similar to our study. Although our study would have benefited from more replicate ponds, reductions in growth and survival from tagging were consistently found among all three ponds. Mortalities were not noticed during the study and we did not attempt to document sources of natural mortality, including aggressive biting (Lochmann et al. 1998), handling stress, diseases, and predation. Most tagged fish we observed did have minor sores at the tagging sites.

We are unaware of any studies concerning the effects of adipose fin clips on the survival and growth of channel catfish, so our treatment was the combined effects of both the tag and adipose clip. Studies have shown that removal of spines and fins have both little influence on survival and growth of channel catfish (Albaugh 1969, Stevenson and Day 1987, Michaletz 2005), and negative effects of survival (Hale et al. 1984). Studies indicate that adipose fin removal in salmonids does not affect growth, but the results for survival are conflicting (Nicola and Cordone 1973, Mears and Hatch 1976, Gjerde and Refstie 1988, Zerrenner et al. 1997). We used adipose fin clips for this study to document tag loss because our pilot study indicated that tag losses were not always identifiable without a secondary mark.

Reduced survival and growth of tagged channel catfish in our study was not likely influenced by water quality because both tagged and control fish were stocked in the same ponds. Also, water quality values remained within levels known to be acceptable for good survival and growth of channel catfish throughout the study (Boyd and Tucker 1998, Tucker and Hargreaves 2004). Channel catfish mortality is expected in ponds with DO less than 1 – 1.5 mg L^{-1} (Moss and Scott 1961, Tucker and Hargreaves 2004), and prolonged exposure to DO less than 2.5 – 3 mg L^{-1} may reduce growth (Andrews and Matsuda 1975). Piper et al. (1982) noted that fish do well in ponds with dissolved oxygen concentrations above 4 mg L^{-1}.

Our study was performed under controlled hatchery conditions, so the results of this study may not be directly applicable to wild populations. Our stocking rate of 215 kg/ha is higher than levels seen in natural waters (<65 kg ha^{-1}; Aggus and Lewis 1978, Quinn and Limbird 2008) but is much lower than densities in commercial culture ponds (Tucker and Hargreaves 2004). We recommend further study of the performance of Carlin tags in wild populations.

Exploitation studies for put-grow-and-take stockings of advanced fingerling channel catfish should account for tagging effects on growth and survival, otherwise effectiveness of stocking programs may be underestimated. If tagged fish exhibit lower feeding rates, it could reduce their likelihood of capture by anglers, leading to biased estimates of angler exploitation. Tag-induced reductions in survival and growth have the potential to influence management decisions concerning the appropriate size of fish to stock. Therefore, tag loss rates should be monitored during tagging studies as a standard procedure.

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