Fisheries Research 186 (2017) 337–344

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Tracking juvenile sturgeon in the wild: Miniature tag effects assessment in a laboratory study on Siberian sturgeon (*Acipenser baerii*)

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ARTICLE INFO

Article history:
Received 1 August 2016
Received in revised form 21 October 2016
Accepted 24 October 2016
Handled by George A. Rose

Keywords:
Acoustic transmitters
Survival
Growth
Swimming behavior
RFID microtags
Stress

ABSTRACT

Acoustic telemetry is commonly used to study movements of fish within their natural environment. Telemetry studies on sturgeons have focused mainly on large individuals; research on juveniles is scarce and tagging-effect studies on young-of-the-year are needed considering the species threatened status and their poorly known freshwater ecology. To study the feasibility of acoustic tagging in juveniles, a trial on Siberian sturgeon (*Acipenser baerii*) was carried out. The purpose of our study was to assess the effects of intraperitoneal acoustic tagging on survival, growth, swimming behavior and tag retention in young-of-the-year sturgeons. Fifty fish were tagged with dummy-acoustic transmitters (1.07 × 0.54 × 0.31 cm, 0.28 g) and compared to 55 control individuals that were handled and anesthetized but not tagged. Fish ranged between 14 and 19.1 cm in total length (TL) and the tag burden for implanted fish was 1.3–2.6% body weight. Fish growth was estimated 15 and 30 days after tagging. Swimming behavior was assessed at 2, 7, 12, 21 and 26 days post-tagging using video tracking. All fish were also tagged with Radio Frequency Identification microtags (RFID microtags) to allow individual recognition during the trial. After one month of rearing, survival and tag retention rate of dummy-tagged fish were both 98%. Tag implantation had no effect on length or weight either 15 or 30 days after tagging. Specific growth rate was influenced positively by fish initial weight 15 days after tagging but this influence disappeared by day 30. Under stress, swimming performance was influenced by tagging: during stressful swim treatments, dummy-tagged fish moved greater distances and had higher swimming speeds at 12 days after tagging. Also, their swimming paths were straighter at 21 days after tagging compared to the pre-stress behavior. RFID microtag loss probability was 22.6% for control and 46.9% for dummy-tagged fish; RFID microtag loss was influenced by surgeon on dummy-tagged fish. These results suggest that loss rate of RFID microtags is acceptable when applied alone on juveniles of this species but the tagging procedure should be improved. Implantation of miniature acoustic transmitters can be successfully applied to young sturgeons as small as 14 cm TL and 10.7 g taking into account a possible higher sensitivity to stress during the first 21 days after surgery.

1. Introduction

Sturgeons constitute a group of 25 species and most of them are considered to be under threat (IUCN, 2015). Their conservation status and the lack of information in many aspects of their biology, life and evolutionary history make them a priority for research, management and conservation actions (Birstein 1993; Waldman and Wirgin 1998; Billard and Lecointre 2001; Williot et al., 2011). Improvement of species basic knowledge in their natural environment can be obtained by telemetry techniques. This approach is

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http://dx.doi.org/10.1016/j.fishres.2016.10.017
0165-7836/© 2016 Published by Elsevier B.V.

one of the most common and reliable means to study fish spatial ecology (Lucas and Baras 2000; Cooke et al., 2004; Bégout et al., 2016). Telemetry has previously been used for sturgeon species, mainly on large juveniles and adults, to characterize behavior such as movement patterns (Hall et al., 1991; Dionne et al., 2013), habitat use (Auer 1999; Erickson et al., 2002; Taverny et al., 2002; Sulak et al., 2009; Peterson et al., 2013), dispersal and migration (Foster and Clugston 1997; Neufeld and Rust 2009; Brevé et al., 2013). In order to obtain information through telemetry techniques, fish need to be identified individually and this lead to the development of a variety of transmitters and tagging procedures (Bridger and Booth, 2003). Studies have revealed that fish physiological, behavioral and growth responses to tagging procedures are influenced by transmitter size and attachment technique and seem to be species-specific (Cooke et al., 2011; Crossman et al., 2013). In view of this, preliminary tests are needed to adapt the transmitters and tagging method to a particular species and life stage (Jepsen et al., 2002) in order to minimize adverse effects on the animal being studied. In sturgeons, surgically implanted transmitters with external antennas can injure the fish as the transmitter migrates inducing tag loss (Collins et al., 2002). Externally attached transmitters can reduce sturgeon swimming performance (Counihan and Frost, 1999) and result in poor growth and survival (Johnson et al., 2014). Internal implantation of tags without anchoring has a highly variable retention rate depending on the sturgeon species (Crossman et al., 2013). Gastric implantation has shown high rates of expulsion as well as mortality (Neely et al., 2009). Finally, peritoneal implantation is the most recommended method (Neely et al., 2009; Crossman et al., 2013; Miller et al., 2013) because it causes fewest adverse long-term effects (Mulcahy, 2003). Up to now, due to transmitter design, the smallest sturgeons tracked in the wild have been restricted to individuals of 9 months of age of 27–38 cm with transmitters weighing 2.9 g in the air (Acolas et al., 2012). To our knowledge, the smallest sturgeon successfully tagged in laboratory with telemetry transmitters (0.2 g in the air) were age-0 pallid sturgeon (*Scaphirhynchus albus*), 17–26 cm, which were either given surgical or external attachments (Johnson et al., 2014). Recent reductions in the size and weight of telemetry transmitters, as seen for the Juvenile Salmon Acoustic Telemetry System (JSATS) tags (McMichael et al., 2010), may enable monitoring smaller sturgeons movements for approximately 30 days (tag expected life). JSATS have been successfully used, without effects on growth and survival, on juvenile salmon species of 9–9.9 cm and 6.8–12.4 g (Brown et al., 2010) but its feasibility and effects in young sturgeons is unknown. Miniaturization has been also developed on radio frequency identification tags (RFID). These tags have been successfully used on several taxa from small species to young individuals of larger ones, allowing long term individual identification studies (Moreau et al., 2010; Cousin et al., 2012; Ferrari et al., 2014; Ouedraogo et al., 2014; Podgorniak et al., 2015) without any impact on growth or survival for fish as small as 1.6–4.2 cm and 0.14–0.78 g (Cousin et al., 2012).

In Western Europe, the last remaining wild sturgeon population, the European sturgeon (*Acipenser sturio*), is strictly protected and subject to a European restoration action plan (Rosenthal et al., 2007). Fish are usually stocked at a young stage in rivers and means to assess the efficiency of the stocking program are required (IUCN reintroduction specialist group, 1998). Most of the current knowledge on the species traits concerns their estuarine life phase i.e. 3 to 7 year-old fish (Rochard et al., 2001; Brosse 2003). The ecology of the young-of-the-year in rivers is largely unknown (Acolas et al., 2011) and it's a priority to improve the species conservation efforts (Gross et al., 2002; Acolas et al., 2011). Considering the protected status of this species and the low number of specimens available, assessing the tagging impact directly on European sturgeons is not suitable and a model species must be used. For our study, Siberian sturgeon (*Acipenser baerii*) was used as it has anatomical and physiological similarities to other sturgeon species (Boone et al., 2013), as well as being available in local hatcheries. This species is not protected under French regulations. The aim of the present study was to evaluate the feasibility of intraperitoneal tagging and effects on survival, growth, and swimming behavior in young-of-the-year Siberian sturgeons to be able to transfer the results onto protected sturgeon species. In the present study, also RFID microtags were used to identify individual fish reared in common garden conditions to assess individual growth.

2. Methods

2.1. Fish rearing

The fish specimens used in this experiment were 2-month old hatchery-reared Siberian sturgeons obtained from a local commercial hatchery. The fish ranged from 14 to 19.1 cm TL (16.3 ± 1.0 cm, mean ± SD) and 9.9–22.1 g (15.0 ± 2.5). The fish ($n = 105$) were raised between February and March 2014 at the Irstea experimentation station of Saint-Seurin-sur-l'Isle (Southwest France). Fish were reared in 2 cylindrical tanks of 471L capacity (100×60 cm; diameter*height) under common garden conditions (half dummy-acoustic tagged fish and half control fish in each tank considered as replicas). Tanks were indoors under 12L:12D photoperiod but covered with mesh to reduce brightness (light under cover = 10 lx). Tanks were supplied with a 5 l min^{-1} flow-through system of underground water and temperature was recorded automatically (Tinytag®) every half hour and maintained constant at 17.4 ± 0.5 °C (no significant differences between tanks, Wilcoxon test = 475, $p = 0.16$). Additionally, ammonium (<0.05 mg/L) and nitrites (0.01–0.025 mg/L) levels were kept below toxic levels (JBL® *kit*) and oxygen over 95% saturation (WTW™ multi 3430). Fish were fed at 2.5% body weight twice per day using 0.2 cm pellets (Coppens International® *kit*, Steco Pre Grower-14). Tanks were cleaned once a day by scraping the bottom and food leftovers were flushed away twice per day.

2.2. Fish tagging

Dummy acoustic tags (0.28 ± 0.2 g in air) were made-up using fishing lead immersed in molded epoxy resin that aimed to replicate the JSATS L-AMT-1.416 acoustic tags (Lotek®) which are $1.07 \times 0.54 \times 0.31$ cm (length*width*depth) and 0.28 g in air. Fish had one week of acclimation period and were food-deprived for 24 h before tagging which occurred on February 26, 2014. Sedation was done using clove oil (0.5 ml L^{-1} of clove oil diluted in 5 ml of ethanol 75% per 10L of water). Once anesthetized, fish were measured (TL ± 0.1 mm) and weighed (W ± 0.1 g). Control fish were 14.2–19.1 cm TL (16.4 ± 1.1) and 9.9–20.8 g (15.1 ± 2.6); dummy-tagged fish were 14–18.9 cm TL (16.1 ± 1.0) and 10.7–22.1 g (14.9 ± 2.5). Transmitters represented 1.3–2.6% of the tagged fish body mass in air. Fish were then placed on their backs in a V-shaped ruler and gills were regularly irrigated with water containing a half dose of anesthetic to maintain an anesthetized condition and keep gills moisted as described in Acolas et al. (2012) for older sturgeons. To allow fish individual recognition during the trial, RFID microtags (Nonatec™, diameter = 0.1 cm, length = 0.6 cm, weight ≈ 0.01 g) were inserted in all individuals (control + dummy-tagged). All equipment used during the tagging process was autoclaved and sterilized before surgery and disinfected between each fish. Tags were cleaned in ethanol and air-dried before use. Fish skin was disinfected before any incisions with a sterile pad with 10-time diluted hydrogen peroxide. Implantation was done by piercing the abdominal cavity, slightly left of