

First observation of fouling of externally attached radio transmitters in an African river

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Fouling of externally attached tags is an important consideration in long-term tagging studies as it may affect fish behaviour and well-being. Two externally attached radio transmitters on African tigerfish *Hydrocynus vittatus* were covered with short green algae, after the fish were recaptured 49 and 64 days after tagging in the Kavango River, Namibia. This is the first observation of fouling on external radio transmitters from any African river which highlights the importance of conducting studies that evaluate the various health or behavioural effects resulting from tagging.

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INTRODUCTION

Electronic tagging and tracking of fishes (i.e. telemetry) can provide valuable information on the spatial ecology, migration and response to environmental changes, making it one of the preferred methods to study freshwater fishes worldwide (Thorstad et al., 2013; Jepsen et al., 2015). External transmitters are commonly used in telemetry studies; however, tissue damage, reduced growth, increased mortality and decreased swimming performance are associated potential negative effects (Jepsen et al., 2015). Externally attached transmitters change the stream-line body shape of fishes, and reduced swimming performance from additional drag has been experimentally demonstrated for relatively small (120–200 mm in length) Atlantic salmon *Salmo salar* smolts (McCleave and Stred, 1975; Moore et al., 1990), juvenile rainbow trout *Oncorhynchus mykiss* (Mellas and Haynes, 1985) and juvenile white sturgeon *Acipenser transmontanus* (Counihan and Frost, 1999). In adult *S. salar*, however, Thorstad et al. (2000) reported no difference in swimming performance between fish with externally attached transmitters vs. untagged controls. Interestingly, during a different study by Thorstad et al. (2001) the relatively poor condition factor of an adult farmed *S. salar* fitted with an externally attached transmitter was attributed to additional drag resulting from transmitter fouling with green algae, mussels, seaweed and *Balanus* sp.

In southern Africa, external radio tags to monitor freshwater fish movement behaviour are increasingly being used in a range of environmental monitoring, conservation and research programmes (O'Brien et al., 2012; O'Brien et al., 2013; Burnett et al., 2018; Roux et al., 2018; Burnett et al., 2020). External radio tags are generally preferred over surgically implanted transmitters as the latter have been shown to cause 100% mortality or tag loss in a Namibian reservoir (Økland et al., 2003). To date, however, there have been no studies on the possible effects of external radio transmitters, nor has there been a recapture of any radio-tagged fish (Eva et al., 2005; Økland et al., 2005; Thorstad et al., 2005; O'Brien et al., 2012; O'Brien et al., 2013; Jacobs et al., 2016; Burnett et al., 2018; Roux et al., 2018; Burnett et al., 2020) that could provide evidence of potential negative effects of using this method.

Here we report on the first observed fouling of external transmitters attached to African tigerfish *Hydrocynus vittatus*, Castelnau 1861, in the Kavango River, Namibia. These fish were part of a larger study involving the movement behaviour of 49 tigerfish (Jacobs et al., 2020). The standardized tagging procedures were as follows: Tigerfish were anaesthetized using 2-phenoxy-ethanol (0.3 mL/L) and fitted with external radio transmitters (Model F2120 Advanced Telemetry Systems, Inc., Isanti, MN, USA) that are encapsulated in 3M Scotchcast and the antenna was nylon coated, weigh 16 g in the air and measure 55 × 20 × 11 mm. Transmitters were attached with orthopaedic wire (0.65 mm diameter), threaded horizontally through the pterygiophore bones in the dorsal musculature. The external transmitters were secured by twisting and locking the ends of the wire against a flat plastic back-plate on the opposite side of the transmitter. The tags were attached tightly to the body of the tigerfish to minimize the risk of snagging or fouling, and to minimize possible drag. After tagging, fork length (L_F) was measured to the nearest mm and total body mass (g) recorded, and all fish were released at their capture site.

Two tigerfish, with L_F 510 mm and 588 mm, and weight 2 800 g and 3 530 g, were recaptured by anglers, 49 and 64 days after being radio-tagged. The first tigerfish was recaptured in the Mahangu Game Park by angling scientists 6.34 km downstream from its tagging location. At recapture, the tigerfish measured L_F 515 mm and weighed 2 890 g. The second tigerfish was recaptured 80.6 km downstream from the tagging location by a professional angling guide in the Okavango Panhandle, Botswana.

No physical measurements were recorded for the second recaptured tigerfish and information regarding the growth on the tag was based on a verbal report from the angler. In both cases, however, the transmitter, antenna, attachment wire and plastic back-plate were overgrown by green algae (Fig. 1). In addition, both tigerfish had signs of some dermal abrasion, approximately one scale row below the position of the transmitters (Fig. 2). Although no clear infection was observed, redness of the dermis probably resulted from irritation between the transmitter and the dermis, which can be expected with externally attached transmitters (Herke and Moring, 1999). The second recaptured tigerfish increased in length and weight over the study period, which suggests that the general health of the fish was not noticeably negatively influenced by the tag.

This is the first documented observation of fouling of externally attached radio transmitters in any African freshwater river. Although reduced swimming performance from additional drag has been experimentally demonstrated for juvenile and small fish species, we were studying adult specimens (Jacobs et al., 2020). Based on the survival and growth demonstrated by one fish, the distances travelled and the fact that the transmitter weight combined with additional weight from algal fouling remained far less than the recommended 2% tag weight to body weight 'rule' (Winter et al., 1996), we conclude that the observed growth on the transmitter may not have significantly influenced adult tigerfish behaviour. This suggests that this approach is suitable for behavioural ecology experiments on tigerfish. In severe cases irritation may lead to infections that could result in mortality of the

tagged fish (Økland et al., 2003). As a result, alternative attachment methods such as the silicone-mound method (Crook, 2004) that has been used successfully on golden perch *Macquaria ambigua* and common carp *Cyprinus carpio* could be evaluated. Although the weight of the fouled tag was less than 2% of body weight, external tags can impart additional drag and the use of internal radio transmitters could be considered in future studies. Anti-fouling paints on the exterior surface of transmitters are common in marine telemetry studies and may be advantageous to reduce fouling (Balmer et al., 2011); however, caution must be taken to ensure that the chemicals utilized in anti-fouling paints do not have negative effects on the tagged fishes. Baras et al. (2002) reported no negative effects from internal tagging of tigerfish over a one-month period and the application of this method may be explored.

While the observed fouling was less severe than the green algae, mussel, seaweed and *Balanus* sp. fouled tags reported to influence *S. salar* behaviour (Thorstad et al., 2001), our observations nevertheless suggest that tag fouling and its potential effects on the behaviour of smaller fish require further research. Future research under controlled conditions is required to document effects of external radio tagging, including fouling, injury, and to better understand long-term effects on reproduction, survival and health. We recommend that studies using external radio tags in African freshwater rivers should consider tagging effects in their methodology, monitoring and sampling design, and address practices used to minimise the impact of external radio tags on fishes.

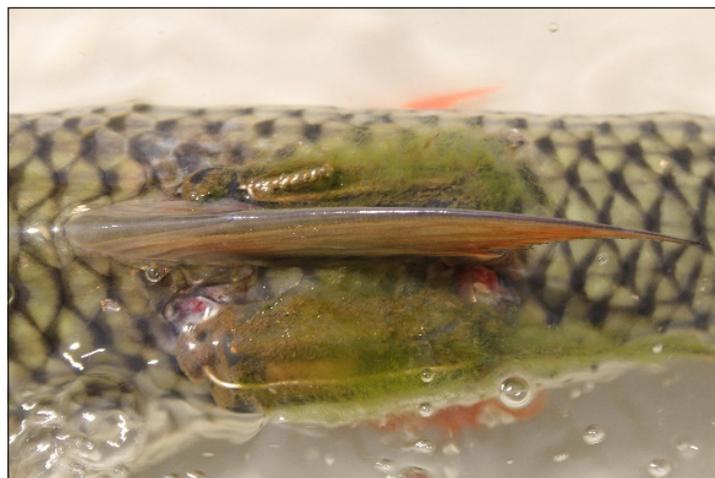


Figure 1. Fouling by green algae observed on the externally attached radio transmitter, antenna, attachment wire and plastic back-plate on tigerfish recaptured 49 days after tagging in the Kavango River, Namibia



Figure 2. Visible dermal irritation approximately one scale row below the position of the externally attached radio transmitters which was probably caused by movement of the transmitter on a tigerfish recaptured 49 days after tagging in the Kavango River, Namibia. The green algae had to be removed from the transmitter to reveal the tag number

ETHICS APPROVAL

This research was authorized by the Namibian Government under the Ministry of Fisheries and Marine Resources (Inland Fisheries Resources Act 1 of 2003 ref/INTERNAL/21MAY2017) to provide for the conservation and protection of aquatic ecosystems and the sustainable development of inland fisheries resources, to provide for the control and regulation of inland fishing; and to provide for related matters.

CONFLICT OF INTEREST

The authors declare no competing financial interests.

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AUTHOR CONTRIBUTIONS

FJJ conceived the paper with, OLW, EMU, CH, and TFN. FJJ collected and analysed data, and wrote the paper. OLW, EMU, CH, and TFN contributed valuable comments to the manuscript.

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