CSIRO PUBLISHING

www.publish.csiro.au/journals/mfr *Marine and Freshwater Research*, 2009, **60**, 281–283

Preface. Tagging for telemetry of freshwater fauna

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Introduction

Many fresh waters support diverse and often endemic fauna, yet they are probably the most threatened type of ecosystem on the planet (Abell *et al*. 2008). Effective conservation of this fauna relies on a full understanding of its behaviour, including habitat preferences, home ranges and migration requirements. Telemetry is based on tagging an animal with a transmitter that emits a signal, which in turn is detected from a manual or remote receiver (Cooke 2008). This evolving technology is enhancing our understanding of the distribution and behaviour of freshwater fauna (e.g. Peterman *et al*. 2008) and its interactions across interfaces with terrestrial, estuarine and marine systems (e.g. Grotheus *et al*. 2005; Roshier *et al*. 2006).

Telemetry studies use a range of methods, including passive integrated transponder (PIT), radio, acoustic and satellite telemetry, depending on study aims and the performance of equipment in different habitats (Cooke and Wagner 2004). Similarly, various tagging techniques are required for telemetry studies of the diverse fauna occupying freshwater ecosystems. For instance, tagging a fish is a very different proposition to tagging a crayfish, waterbird or platypus. Although tagging is an important stage in any telemetry study, the expertise required to tag a particular species is often underestimated (Kenward 2001; Cooke 2008).

This Special Issue was prompted by the need to collate the burgeoning literature on tagging methods for telemetry, to discuss attachment methods and their limitations and to explore future advances in telemetry of freshwater fauna. Further development and testing of tagging methods is likely to be required, especially for rare and/or small species. It is also likely that the capacity to tag multiple species across diverse animal groups will become necessary in the shift towards large collaborative research programs with an ecosystem focus.

Main themes of this Special Issue

This Special Issue consolidates information on tagging a wide cross-section of taxa including aquatic reptiles, waterbirds, elasmobranchs and teleosts. As ecologists often specialise in studying a single taxonomic group (e.g. teleosts, birds, reptiles) and frequently become familiar with telemetry through applications at a taxon-specific population level, it was intended that this Special Issue would highlight possibilities for collaborative telemetry studies at the community level in freshwater ecosystems. Therefore, the issue opens with a review by Franklin *et al*. (2009) on radio, acoustic, archival and satellite tagging applications to different crocodilian species. This is complemented by Doody *et al*. (2009), with case studies illustrating effective methods for attachment and implantation of radio-tags to freshwater reptiles of diverse sizes, shapes and attachment surfaces. The significance of telemetry-tag attachment and the skill involved in developing and applying a tagging technique to waterfowl is presented by Roshier and Asmus (2009) with a focus on grey teal. Whitty *et al*. (2009) describe tagging of sawfishes, including 0+ year olds, since they are of sufficient size to tag at birth, unlike most fauna in fresh waters. These authors, along with Koehn (2009) and Franklin *et al*. (2009), explore depth use in rivers, contrasting with most telemetry research in rivers where use of horizontal space is the primary focus (e.g. Ebner *et al*. 2009*a*).

Knowledge of telemetry tagging freshwater fishes comes principally from research in the northern hemisphere particularly involving salmonids (Jepsen *et al*. 2002). In this Special Issue, most papers explore the tagging of teleosts in Australia or New Zealand. Jellyman (2009) provides a comprehensive review of telemetry applications to fishes including several introduced species in New Zealand, a country largely devoid of other large-bodied aquatic fauna. Daniel *et al*. (2009) and O'Connor *et al*. (2009) report on difficulty with tagging the ubiquitous carp (*Cyprinus carpio*), emphasising the point that tagging of even some common vertebrate species remains to be resolved and is not necessarily straightforward. Tagging studies of species from the families Gadopsidae, Mugilidae, Percichthyidae, Plotosidae and Terapontidae, including several case studies involving threatened species, are described (Broadhurst *et al*. 2009*a*, 2009*b*; Butler *et al*. 2009; Ebner *et al*. 2009*a*, 2009*b*; O'Connor *et al*. 2009). Collectively, these studies demonstrate species-specific suitability of different tagging methods, and Ebner *et al*. (2009*b*) outline a framework for developing a suitable tagging method for a threatened species based on an experience using a surrogate species.

Future research

This Special Issue indicates that further methodological research into tagging of most freshwater fauna is required. This is most apparent for teleosts owing to the super diversity of this group, which includes many families from which no single

 10.1071/MF09006 1323-1650/09/040281

representative species has ever been tagged. Suitable tagging methods are required for applications to several newly tagged species (e.g. Butler *et al*. 2009; O'Connor *et al*. 2009). Species-specific testing of methods is one way forward. It would also be valuable if more systematic solutions were pursued. In this regard, the use of surrogate species or representative species of a family may be useful, although ecologists should be wary of species-specific responses to tagging (e.g. Ebner *et al*. 2009*b*). Centralised and coordinated experimentation aimed at developing a general understanding of important factors affecting tagging of teleosts will counter the current inefficiency of many small research groups conducting trials on single species.

One important question is whether to use captive or field tagging trials. Captive trials appear to be more commonly used in cases involving fish relative to other taxa such as reptiles, elasmobranchs and waterbirds. This may have a logistical basis. For instance, holding elasmobranchs in captivity generally requires substantially greater resources than keeping smaller-bodied teleosts in aquaria (cf. Skomal 2007). The paradox is that there is generally much greater scope for controlled experiments and detailed observation of tagging effects in captivity but field-based trials afford a greater level of reality. Future tagging trials should include improved observation of tagged animals under captive field or non-captive field conditions and use of mixed strategies involving captive and field trials (e.g. Zeller 1999; Jepsen *et al*. 2008; O'Connor *et al*. 2009).

The use of anaesthesia and alternatives to anaesthesia during internal tagging requires further investigation and will continue to be scrutinised from an animal ethics perspective. Clearly, anaesthesia serves to minimise pain in the short term and can serve to subdue an animal that is otherwise difficult to tag (without danger to itself or the researcher) (Hall *et al*. 2000). However, the type of anaesthetic can affect the outcome of tagging (Zeller 1999; Jepsen *et al*. 2002), and administering and recovering individuals from anaesthesia can be time-consuming (Merrick 1990). Therefore, anaesthesia may be undesirable in cases where excessive handling or holding periods are detrimental to the health of a species (e.g. Skomal 2007). Rapid tag and release methods may suit some species (e.g. Skomal 2007) but not others (e.g. Zeller 1999). Comparative studies of tagging with and without anaesthesia and investigating the effects of different types of anaesthetic will inform best practice tagging of different species for telemetry-based study.

Further meta-analysis of tagging information from telemetry studies (e.g. Boarman *et al*. 1998; Jepsen *et al*. 2002; Jellyman 2009) is needed. Limitation on journal space restricts most research papers from detailing all aspects of the tagging method but subtle and seemingly minor aspects of a method can influence tagging success (e.g. Jepsen *et al*. 2002; Roshier and Asmus 2009). Reporting basic information such as anaesthestic concentration, temperature, time to achieve and recover from anaesthesia, and surgery and tag attachment time is recommended, particularly from studies of rare and threatened species or taxa that have not been tagged previously.

Successful conservation and understanding of our freshwater fauna relies on effective telemetry methods that minimise stress to animals, are cost- and time-efficient and that provide reliable data. Telemetry is particularly useful for researching rare and threatened species where critical data on habitat use and migration are needed but relies on effective tag attachment. Therefore, conservation ecologists must be aware of emerging telemetry technology and advances in tagging methods. This Special Issue addresses some of these needs and highlights gaps in our knowledge, issuing some key challenges for future research in this cutting-edge field.

Acknowledgements

Craig Franklin influenced my drafting of this preface and comments from Jayson Semmens substantially improved the manuscript. I am grateful to John Koehn and colleagues from the Arthur Rylah Institute for pioneering radio-tracking of freshwater fishes in Australia and sharing with me their knowledge of radio-tagging. Thank you to Andrew Boulton and Leanne Hamilton for support and guidance in editing this preface and the special issue.

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