Animal Behaviour 78 (2009) 1477–1483

Contents lists available at ScienceDirect

Animal Behaviour

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

Commentaries

Guidelines for the instrumentation of wild birds and mammals

Ruth M. Casper*

Wildlife Advisory Panel, University of Tasmania Animal Ethics Committee

ARTICLE INFO

Article history:
Received 29 July 2009
Initial acceptance 28 August 2009
Final acceptance 14 September 2009
Available online 16 October 2009
MS. number 09-00507R

Keywords:
animal behaviour
animal welfare
biologging
ethics
telemetry

Attaching electronic devices to wild animals to acquire behavioural data is becoming increasingly more widespread. Birds and mammals are the most common taxa instrumented, with devices usually designed to store or transmit information relating to movement patterns. The electronic devices most often used are radiotransmitters, platform transmitter terminals, geolocation positioning system loggers and depth loggers. These are generally attached to animals externally using glues, collars or harnesses, or are implanted internally. It is recognized that negative effects associated with instrumentation cannot be completely avoided. This is because handling alone is likely to cause some stress to wild animals and also because some energetic cost is associated with carrying an extra load (Murray & Fuller 2000; Kenward 2001; Wilson & McMahon 2006). However, only a small proportion of publications include information on the impact of instrumentation on animals and the range of species used in these studies is limited, as are the parameters used to evaluate effects (Calvo & Furness 1992; Murray & Fuller 2000; Kenward 2001; Withey et al. 2001; Hawkins 2004). In particular, there is a lack of evidence with which to justify the broad application of hard and fast rules for instrumentation across avian or mammalian species which span widely different sizes and lifestyles. Furthermore, the reasons underlying adverse impacts of instrumentation are multifactorial and are related not only to the mass, size and shape of the device, but also, for example, to the sensitivity of the animal to disturbance, the capture method, the handling time, the attachment method, food availability and the length of deployment. Consequently, attaching devices to animals may result in combinations of immediate, delayed, short-term, long-term, direct and indirect effects. As such, the magnitude of the effects of instrumentation of animals is case-, species- and physiological status-specific (Gaunt et al. 1997; Murray & Fuller 2000; Kenward 2001; Withey et al. 2001; Hawkins 2004).

Researchers and animal ethics committees alike aim to minimize the negative effects of instrumentation. This not only considers the welfare of the animals, but also provides confidence that the data collected from instrumented animals are representative of the behaviour of the sampled population. However, a practical framework with which to achieve this is currently lacking and guidelines for instrumentation are often based on limited rules which do not account for the complexity and specificity of each situation. In particular, there appears in the literature a '5% (or 3%) rule' which refers to a commonly accepted standard that the mass of an instrument should not exceed 5% (or 3%) of the body mass of an animal, and that any ratio less than 5% (or 3%) is acceptable (Gaunt et al. 1997; Wilson et al. 2002; Phillips et al. 2003; Gannon & Sikes 2007). The '5% rule' is essentially arbitrary (Caccamise & Hedin 1985; Aldridge & Brigham 1988; Gessaman & Nagy 1988), while the '3% rule' appears to have been extrapolated from a review of albatross and petrel studies correlating device loads with foraging trip durations and nest desertions (Phillips et al. 2003).

It is clear that this approach is too simplistic. Differences in energy budgets between, and within, species preclude a single rule

* Correspondence: R. Casper, Wildlife Advisory Panel, University of Tasmania Animal Ethics Committee, Private Bag 1, Hobart, Tasmania 7001, Australia.
E-mail address: ruth.casper@utas.edu.au

doi:10.1016/j.anbehav.2009.09.023

for device loading (Murray & Fuller 2000; Kenward 2001). For example, transmitter weights based on a fixed percentage of body weight affect flight characteristics of large birds more than those of small birds because they have proportionally less surplus power (Caccamise & Hedin 1985). Alternatively, small birds may work with much narrower safety margins (the difference between the working mass and mass at nest desertion) than larger species (Chaurand & Weimerskirch 1994; Weimerskirch et al. 2000), and may therefore be less able to tolerate device loads. Furthermore, it is likely that an animal can carry a particular load with more ease when attached close to its centre of gravity than when placed towards an extremity (Kreighbaum & Barthels 1996). This may not always be possible, for example in mammalian species where a collar is the best method of attaching a device. In these cases, application of the '5% (or 3%) rule' may be misleading.

In this paper, I suggest a more comprehensive framework of guidelines for minimizing the effects of instrumentation. This method broadly categorizes the main components of experimental design that should be considered as potential sources of adverse outcomes. These are researchers, study animals, equipment (instruments plus attachments), expected effects of equipment, procedures (capture, handling and attachment methods), and expected effects of procedures. The need for pilot studies and control and/or monitoring components to experimental designs should also be considered. Below, guidelines for instrumentation are presented under each of these categories, with an emphasis on avian and mammalian examples.

Examining aspects of instrumentation in this way will allow more complete assessments and consequently more informed decisions to be made. While there is some overlap between categories, this framework provides a systematic method with which to highlight aspects of concern that are relevant in any particular case. These features can then be scrutinized to determine whether the identified potential risks can or need to be reduced, while still achieving the scientific aims of the study. Researchers and animal ethics committees can then decide if this resulting design is acceptable in terms of animal welfare. That issue, however, is beyond the scope of this paper (Plous & Herzog 2001).

Researchers

Competent instrumentation of animals requires the appropriate selection, capture, restraint and release of animals, as well as attachment of devices. Each of these techniques may vary depending on the species being instrumented. The research team must possess the necessary skills to carry out each of the proposed procedures in a manner that will minimize negative effects on the nominated species. In many cases, each procedure should be carried out by a person who is skilled at that procedure on the nominated species, or is under the direct supervision of someone who is (Murray & Fuller 2000; Rismiller & McKelvey 2000; Kenward 2001; Gannon & Sikes 2007). If this is not possible, or not deemed necessary, then the reasons for this should be justified. Similarly, to optimize experimental design and reduce the risk of adverse outcomes, it is important that researchers are familiar with the relevant literature already available, for example pertaining to the study species, methods, parameters and behaviours that they are studying (CCAC 2003b; Beausoleil et al. 2004).

Study Animals

The effects of devices on animals may vary depending on their lifestyle. For example, attention to aerodynamics is important for flying and gliding animals, such as albatrosses and bats (Aldridge & Brigham 1988; Obrecht et al. 1988), while attention to hydrodynamics is important for swimming and diving animals, such as penguins and pinnipeds (Bannasch et al. 1994; Culik et al. 1994; Beausoleil et al. 2004). In some species, external equipment may increase drag in both air and water. This may occur, for instance, in alcids with very high wing loadings (high body mass to wing area ratio) which fly long distances and also forage underwater (Ackerman et al. 2004; Paredes et al. 2005). The effect of externally mounted devices on animals that inhabit or move through confined spaces should also be considered. For example, enlarging the profile of an animal that burrows or moves through dense vegetation or narrow openings, such as winter sea-ice holes, may impede its normal movement, cause it to expend extra energy or become entrapped.

The use of instruments such as radiotransmitters on juvenile mammals may require particular attention because juveniles of many mammalian species grow rapidly and tend to disperse. Rapid growth increases the risk of attachments such as collars and harnesses becoming too tight, while dispersal reduces the chances of recapturing these individuals to check on or remove equipment (Soderquist & Serena 2000; Kenward 2001; Vashon et al. 2003).

The species and classes of species used should be appropriate to the study questions being investigated. For example, broad ecological questions may be best addressed using a species and class for which basic life history traits are already known and the proposed procedures are already well established. Alternatively, questions may specifically address important knowledge gaps in a particular species or species class. It may be valid to study a particular species primarily because it is threatened or endangered. However, if the population is sensitive to disturbance, it may be more appropriate to use a similar but more common species, particularly where the proposed procedures are not well established (Sykes et al. 1990).

Equipment: Instruments Plus Attachments

While it is recommended that the smallest possible devices and attachments are used (Withey et al. 2001), attention to other aspects of equipment will also reduce potential adverse impacts. Equipment should be balanced and positioned so as to minimize effects on the animal's lifestyle. Equipment should not wound the animal, impair insulation, place pressure on internal organs, restrict normal movement or interfere with postures such as curling up to sleep, behaviours such as grooming and preening, or physiological processes such as moulting (Smith et al. 1998; Murray & Fuller 2000; CCAC 2003b; Godfrey et al. 2003; Hawkins 2004; Beausoleil et al. 2004).

Streamlining equipment is especially important for aquatic and flying animals and those that inhabit or move through confined spaces. This can be achieved by considering the effects of equipment shape, orientation and placement on the profile and energetics of the animal (Obrecht et al. 1988; Bannasch et al. 1994; Culik et al. 1994; Watson & Granger 1998; Bethge et al. 2003; Beausoleil et al. 2004; Hawkins 2004; Estes-Zumpf & Rachlow 2007). Ideally, equipment attached to aquatic animals should be neutrally buoyant because positively or negatively buoyant equipment may modify normal diving behaviour (Webb et al. 1998; Elliott et al. 2007). The colour of equipment may also influence the behaviour of animals, their social status and their vulnerability to predation (Kessler 1964; Wilson et al. 1990; Diefenbach et al. 2003; Hawkins 2004). Electronic devices may emit acoustic frequencies or light spectra to which animals are potentially sensitive. For example, some mammalian species use acoustic signals for communication and foraging and may modify their behaviour in response to anthropogenic emissions (Kalcounis-Reuppell et al. 2006; Schaub et al. 2008; Willis et al. 2009). Similarly, instruments producing a light