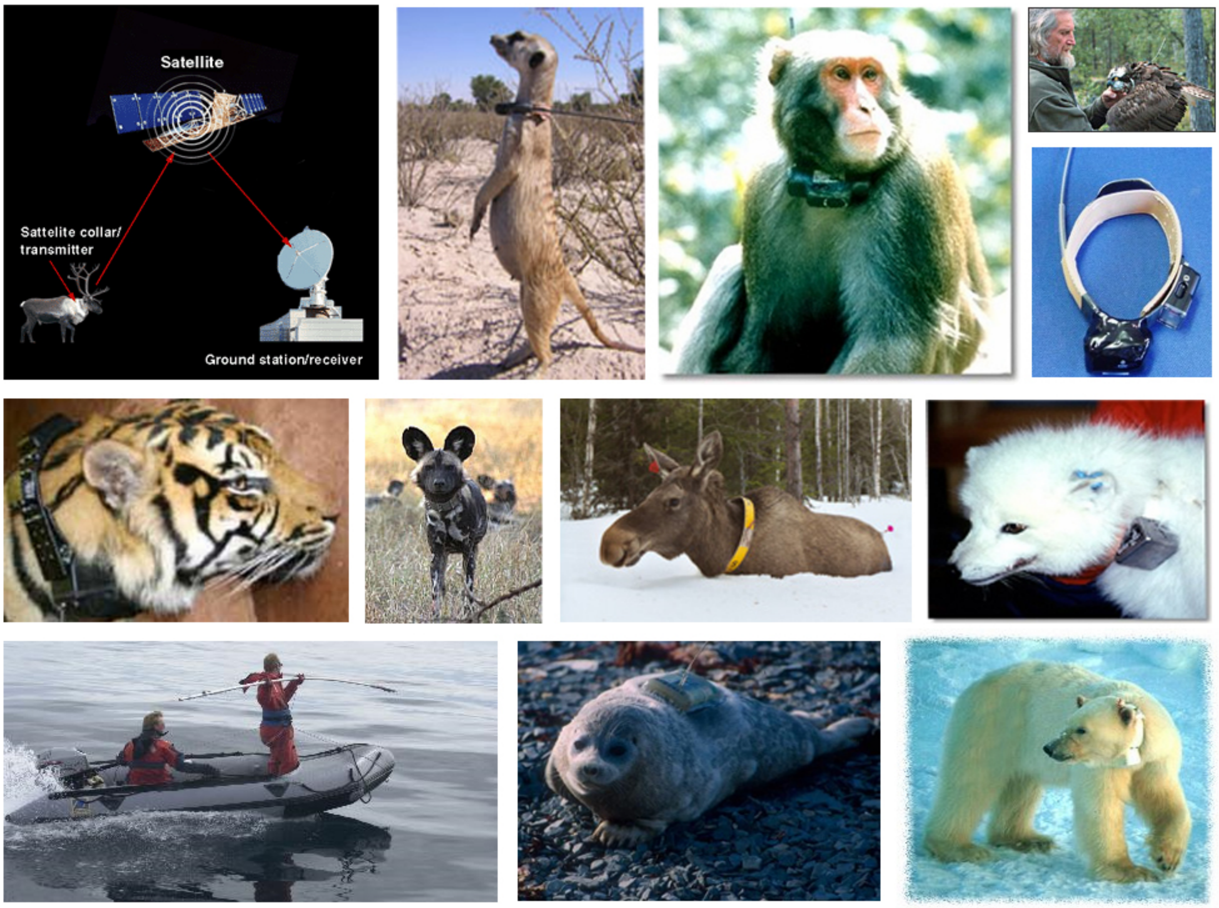
Gruppeoppgave i Dyreforsøkslære

The use of transmitters in biological research



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1. Introduction

Tagging of mammals and birds has been used as a tool in biological sciences for many years, e.g. migration of birds has been studied by the use of simple rings. In this report we discuss the use of tagging with transmitters, often referred to as telemetry. The use of telemetry enables scientists to monitor the movements of animals and, with specialized types of transmitters, monitoring of basic physiological parameters and environmental conditions is possible. We will give a description on how telemetry works, and examples from the use of telemetry on mammals and birds are presented to give an overview of the possibilities these techniques provide.

Along with the growing use of transmitters, an increased awareness of the ethics regarding this scientific field has emerged. The curiosity of the scientist has to be put up against animal welfare and ethics, and laws and legislations have been passed to ensure that animal pain and suffering is minimized. We will present the current legislations in Norway and further discuss ethics on a more general basis.

The use of telemetry in animal research is probably just in start-phase, and future technological advances will provide us with tools to get information we have never dreamt possible. In the last section we will present our view of the future use of transmitters in animal research.

2. What are transmitters?

A transmitter generally consists of a transmition unit and a data logger measuring different types of data. The data can be physical measuring environmental conditions such as surrounding temperature, pressure and/or biological data such as body temperature, heart rate, movement, speed, vocalization, sonar, behaviour and diving depth. The transmition unit can be used to pinpoint the position of the animal, which can be used to investigate migration, habitat range and more.

Some loggers have to be collected manually by the scientist to be able to retrieve the data, but most transmitters can send the logged data including position by satellite (GPS), radio (UHF/VHF), mobile phone (GSM) or a combination of these. We usually differentiate between receivers according to the transmition unit. Transmitters can be attached to the surface of the animal or surgically implanted inside the animal.

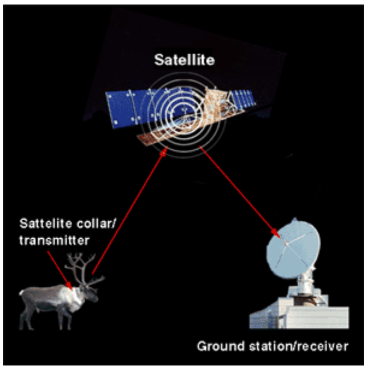
2.1. Satellite telemetry – the Argos system

So far, wildlife telemetry by satellite is only possible through the Argos System, run by a French-American company established in the early eighties.

- The system relies on five, polar-orbiting satellites which are at around 850 km above the Earth's surface.

- They receive signals coming from special radio-transmitters, called Platform Transmitters Terminals (PTT), that are attached to the animal to be tracked.

PTTs can also be equipped with extra sensors collecting environmental or biological data to be transmitted to the satellites. The signals have to be at a fixed frequency of 401.650 MHz and are usually emitted every 50-90 sec. The information received by the satellites is then relayed in real time to one of the system's ground stations in Virginia, Alaska and France.

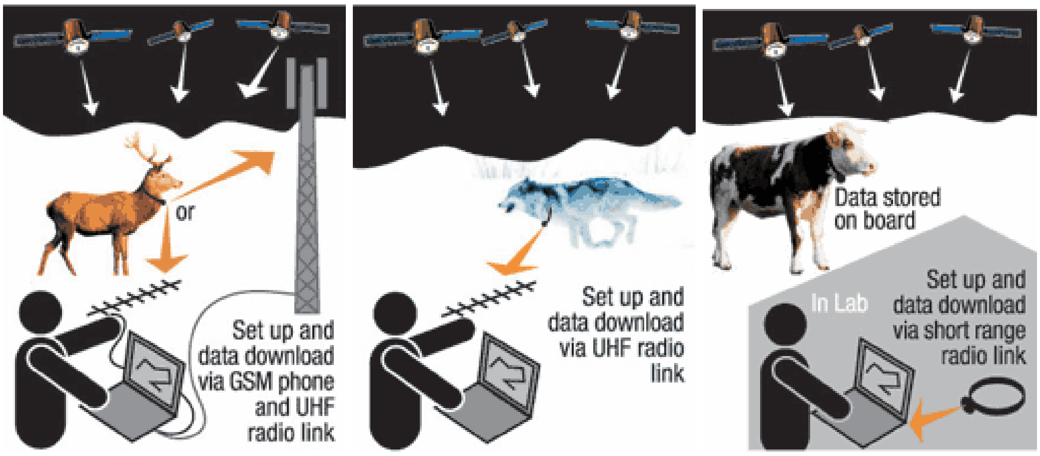


The main feature of the Argos system is the ability to localise the PTT anywhere on the Earth, by measuring the Doppler Effect on the received signals. In practice, every time one of the orbiting satellites receives a message from a given PTT, it measures the frequency of the incoming signal; by comparing it with the nominal frequency of 401.650 MHz, the system is then able to measure the Doppler shift in frequency of that transmission, deriving from the relative motion of the satellite and transmitter.

Satellite telemetry allows researchers to pinpoint the location of an animal tagged with a transmitter. Transmitters send signals to a receiver aboard one of a number of satellites orbiting the Earth. Several satellites are necessary because at least one must be in the right position to receive a signal. The satellite sends information about the animal's whereabouts to an Argos ground station. Each day, Argos relays this information to the wildlife researcher (1).

2.2. GSM, GPS, UHF and VHF Telemetry

Combined with UHF radio modem technologies, GSM mobile phone technologies and remote drop off units, data stored on the GPS collars can be recovered either physically or remotely from virtually anywhere in the world. All species of mammal greater than ca 15kg can be fitted with these transmitters (2).



The basics of telemetry

2.3. How Different Transmitters Work

Transmitters today are lightweight, compact, and weatherproof, with built-in batteries and external antennae. Miniaturized models are as small as a matchbox and weigh as little as 15 grams. Transmitters are mounted on some birds like backpacks with straps criss-crossing the breast or as rings on the leg. They are worn as collars on mammals such as polar bears, caribou, and moose, and mounted on teeth, with glue on fur or by skin piercing on marine mammals. They can also be operated into birds and mammals to measure heart rate, temperature and other parameters, leaving the antenna outside to locate satellites.

Life of transmitters lasts as long as the battery. Units are set to generate signals just often enough to transmit vital data. The transmitter on e.g. a falcon can send signals for six hours every three days in autumn and every 10 days in winter. The transmitter on seals only switches on when it is at the ocean surface, since orbiting satellites cannot detect signals sent through water. Most units will work for about six months. External transmitters are carefully designed to detach themselves from their animal carriers soon after their batteries have run out.

Transmitters attached to different animals and birds

Data can be transmitted in different ways. Before the researcher tags the animal, the tag device can be programmed to send in different ways, either by the researcher or pre-programmed from the manufacturer. It can be programmed to send at short intervals for a short time, say every 4.hour every day for 2 months. Or at long intervals, once a day or once a week, for a longer time - maybe more than a year (3).

2.4. Who produce transmitters?

Different companies who specialise in wildlife telemetry have their own labs and develop new technologies every year. The weight, size and methods in telemetry have been through an intensive 10 year period, with smaller and longer lasting tags every year. The following examples of transmitters are from Televilt, Sirtrack and National Geographic.

Televilt produce mostly collars. The weights of the transmitters are highly dependent on the capacity of the battery (-ies) chosen. One type is a processor controlled transmitter especially made to give as long lifetime as possible. The minimum weight is 5 grams (size: 26x12x11 mm). Another one is a processor controlled transmitter especially made for long range tracking. The minimum weight is 5 grams (size: 26x12x11 mm). The third one is a long-range, digitally controlled and temperature compensated transmitter (4).

TELLUS GPS System


TELLUS GPS collar

A store-on-board GPS collar with optional remote data download via VHF radio link or GSM. It is suitable for a great number of species and provides more than three times the positioning capacity compared to older generation of GPS collars. It allows data to be stored in the collar and downloaded by cable. This model can be upgraded for remote data download by radio (VHF) or GSM (SMS). The built-in VHF transmitter, used for tracking (and optional for data download), switches to a recovery pulse mode when the battery power is low to alert and guide the user to recover the collar. Temperature, mortality and activity data are stored with the position data and can be downloaded. A PC software package is used by the researcher to set collar functions.

TELLUS mini


TELLUS mini attached to a passerine bird

The smallest "Collar 2" weighs about 50 grams and is a "store-on-board" GPS collar suitable for hares and other small mammals and birds. A UHF transmitter is used for tracking and also for recovery after an automatic drop-off mechanism (patent pending) has released the collar. The GPS function and the transmitter of the collar are pre-programmed according to a file provided by the researcher. It is possible to include a delayed start of the GPS positioning. Depending on temperature and GPS positioning rate a typical number of 1.000 positions can be expected before the drop-off is released. The recovery beacon has a calculated life of one month. Data download to a PC is performed by the user. If the used GPS collar is sent back to the distributor, a discount is given when purchasing a new Tellus Mini. The small GPS unit, "Tellus Mini, backpack 1", weighs about 40 grams and is suitable for birds from a weight of 2 kg. It has all the features of collar 2, including the drop-off mechanism. The maximum expected number of GPS positions, however, is about 500. The backpack has a nylon thread for harness attachment. Optionally a smooth plastic tube can be used to put on the thread.

Sirtrack (3) produce almost all transmitters mounted by collar, ear tag, glued on, backpack, implanted, leg mounted or tail mounted.

<u>Implants</u> can either be subcutaneous (under the skin), within the peritoneal cavity (under the muscle layer), vaginal, horn (rhino´s) or stomach. Very often implants are used in conjunction with temperature studies, or where it may be the only feasible option, for example in snakes and fish.


Collars

Implants


Ear tags

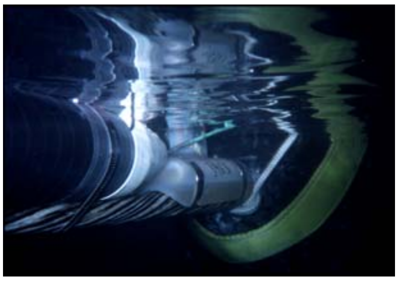
Leg mount

<u>Glue on.</u> In many situations the only feasible option for attachment is to glue the transmitter to the animal. This is often the case for smaller species were weight is the limiting factor. In species such as birds it ensures that the transmitter will always come off within a season, as soon as the bird moults. With marine mammals you have little choice but to glue a transmitter to the animals' fur.

Crittercam from National Geographic (5)


Marine crittercam

A camera adapted by the Remote Imaging laboratory at National Geographic headquarters that is like a transmitter and requires recollection after a few hours or days. It features a camera and environmental data sensors attached to an animal—from a shark or turtle to a lion or seal—that capture behaviour unaffected by humans. Crittercam is technically a data logger, correlating visual and audio information with standard measurements such as depth, pressure, temperature, and time


Crittercam on a narwhal's tusk

<u>Attachment</u>: For whales, dolphins, and leatherback turtles are developed special suction cups. With seals and hard-shelled turtles a small adhesive patch is used. Custom-tailored, backpack-like harnesses are attached to penguins, and a passive fin clamp on sharks. For land animals such as bears, lions, and hyenas, a collar is used. For marine animals, release systems happen remotely by programming a computer inside the system to trigger the release mechanism at a certain time. The Crittercam then floats to the surface, where researchers can track and recover it using its onboard radio VHF beacon. For land animals, a remote signal is sent anytime that causes the Crittercam collar to detach from the animal.

Terrestrial Crittercam uses live transmissions to send data back in "real time." Visual and audio information is relayed back to a research team's base camp via radio transmitter for observation and recording. By sending out a radio "ping," researchers can request when and for how long they want to receive transmissions. When the study period is over or battery power has been consumed, the Crittercam unit can be released and located by radio transmission as well. This mechanism also ensures that the unit can be released at a moment's notice should the subject animal be troubled by it.

Attachment for crittercam

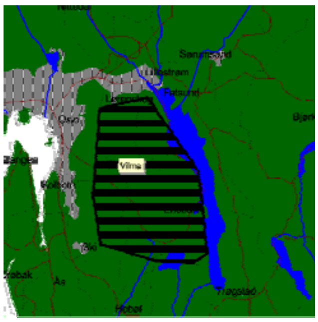
Live transmission gives researchers using Terrestrial Crittercam instant feedback on how the system is functioning and up-to-the-minute information on the subject itself. This technology avoids the often-harrowing data recovery measures necessary with marine Crittercams, which record within the unit and must be relocated and recovered before any data is received.

3. Examples of transmitter used in research

3.1. Terrestrial mammals

Lynx and row deer, Norway: Ecological study of predator and prey

The project ROSA (6) deals with ecological dynamics regarding lynx and row deer populations. The main goals were to study variations in space use, survival and reproduction of lynx with different access to prey, which is mainly row deer. The project gave valuable information for management of lynx populations and hunting



Left: The lynx is chased in a tree by dogs. Middle: Lynx Wilma’s home range. Right: Lynx with collar.

Since 1995, 68 lynx and 324 row deer have been trapped and collared in South-East Norway. Lynx are caught by snares, box traps, and helicopter or by the use of dogs. The snares were fitted with an alarm, and 2-3 people were never more than 5-15 min away. The box traps were controlled two times a day by radio signal, and manually checked 1-2 pr week. Some of them were also equipped with SMS-alarm. When dogs were used, lynx were chased up into trees; a net was put under it in which the lynx fell into when they were anesthetized by arrow shooting. Row deer were also caught by box traps, and also by the use of drop nets. On young animals expandable collars were used.

Brown hyena, Namibia: Impact of human infrastructure on an endangered species

Brown hyena with collar

The Brown Hyena research project in the southern Namibia Desert coast was founded in 1997. The area was a restricted diamond area with very little infrastructure, but a new land plan was drafted. The main focus for the scientists was to investigate the impact new roads had on the apex predator of the area, the brown hyena, which foraged on Cape fur seals on the Atlantic coast of the Namibia Desert. They mounted GPS collars on a few hyenas and monitored their whereabouts for a few months. The collar had a mechanism which made it drop off at a certain time point, and the data was downloaded (2500 data points) for subsequent analysis on home range estimates and also for foraging patterns on the local seal population (7).

The Sumatran Tiger: A critically endangered species

In the wild there are probably less than 400 Sumatran tigers, making the species critically endangered and in desperate need for assistance in order to survive in the future. The “Sumatran Tiger Trust” administrates a project to track and monitor tigers in the wild in order to prevent tigers from being killed by poaching. A pilot project was conducted in 2004 where a 2 year old male was sedated and equipped with a GPS collar. This animal was followed and they found that the 1.5 kg collar did not affect its hunting capacity. The only problem was that its mate chewed off the cables connecting the GPS to the battery (8).

Left: Sumatran Tiger with collar. Middle: Map of the tigers activity. Right: Wild dog with collar.

Wild fox, Botswana: Territorial behavior and conflicts with humans

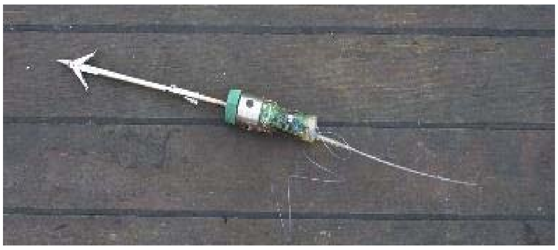
The Botswana Wild Dog Research Project (BWDRP) is involved in conservation of the endangered carnivore wild dog in the Okavango Delta in Botswana. The population of this species has declined by 20% the last three generations, and less than 5000 dogs are left in free-living populations. The population in this part of Botswana is about 800 dogs. GPS collars are being used to study territorial behavior, how packs of dogs interact and how they maintain border areas. Dogs are regularly killed by poaching, livestock conflicts, disease from domestic dogs and road kills, and tagging was also a way to monitor population size and the affect of human interactions (9).

3.2. Marine Mammals

Large marine mammals such as seals, whales, dolphins, porpoises, narwhals and belugas spend time in the ocean and some surface rarely, presenting challenges for data collection. Data from loggers and tags can collect information on temperature, depth, salinity, speed, acoustics, time, genetics, health, behaviour (video) and migration routes globally. Transmitters are glued on to the skin or fur, or pierced through the dorsal fin or dorsal skin. For this technique the animal has to be caught and handled on the beach or in the water for ca 30 min. If possible transmitters are mounted on to tusks or teeth for longer duration, like on walrus or narwhal. Tagging of large baleen whales can be performed with darts or suction cups, but the duration of these tags are limited. (10)

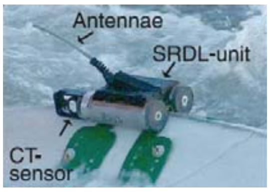






Top left: Narwhal. Middle: Harbour porpoise. Top right: Narwhal. Below: Humpback whale darting.

Implanting transmitters in marine mammals is difficult due to easy infections and is not implemented in wildlife telemetry by researchers today.



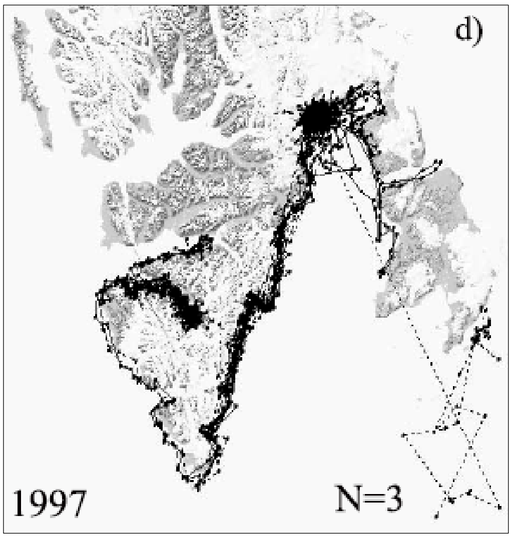
Beluga transmitter

Walrus transmitter

Harbour seal

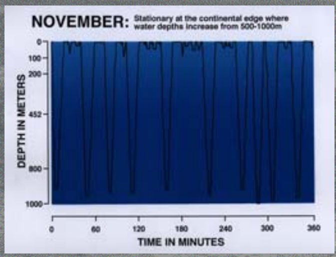
Examples of mounting transmitters on narwhals and belugas

Narwhals and belugas are tagged to trace population whereabouts to regulate native license hunting, to estimate population abundance and general biological parameters like placement of nursing and mating areas. Data obtained has a profound importance on management of populations and protection of these species of whales. Narwhals and belugas are not very well known to science and feeding habits, home ranges and migration routes are essential for generating political focus on management of this threatened species. Tagging by dorsal skin piercing is commonly used and the tag stays on for some months. A saltwater switch turns on the transmitter for transmission when it is out of the water. No anaesthesia or sedatives are used in connection with tagging these whales and so far non have died or shown unhealthy behaviour during or after the procedure.

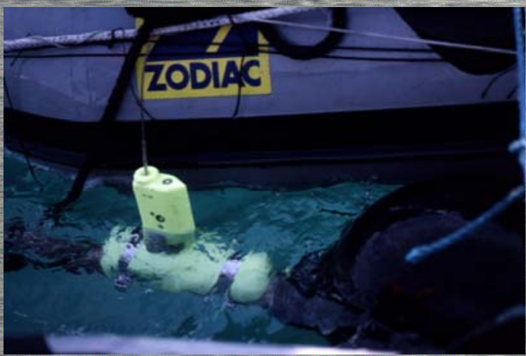


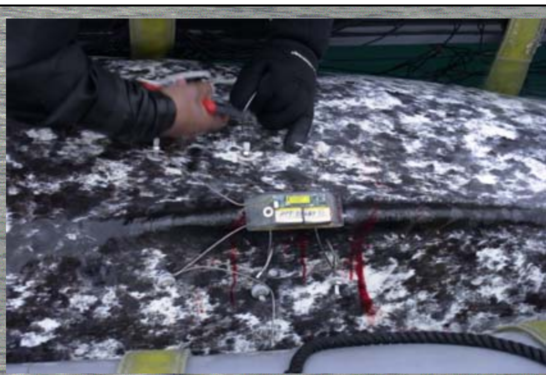
Top: Beluga migrations in Svalbard 1997 (3 months of data) (11). Below: tagging with suction cup (beluga)

The whales are captured using a net set from the beach. The whales are herded into the net-opening using speedboats and restrained in shallow water with a hoop net held around the head and a cushioned rope tied around the tail, and anchored to shore. Standard length and sex is determined and whales are classified into age groups. Only individuals classified as adults are equipped with satellite tags. The satellite data loggers are all pressure-resistant to 1500 m water depth. Previous studies involving satellite telemetry on white whales show that the tags normally fall off within 3 months. The battery capacity in the tags allow data output continuously without any duty cycling over this period. (11).



Mounting of a tusk and a backpack transmitter on narwhal
The whales are caught in nets and the process takes app. 30 mins before release of the animal. Migration routes show an overlap between Canadian and Greenlandic stocks and the management regulations on Inuit hunting can be altered according to the new information. The depth recordings show feeding trips and dive duration in minutes.





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3.3. Birds

Tagging of goose

Attachment of small radio transmitters to free-living birds has become a routine means of enabling investigators to monitor the location and movements of tagged individuals. Transmitters are applied most frequently to large (> 100 g) species, but the development of units weighing 2 g or less has made their application feasible even for small (< 50 g) birds. Birds can be indicators of the health of the global ecosystem and telemetry studies can tell us about food webs, ecology and migration of threatened species. We may learn that the ecology of California bald eagles is tied to the health of the northern salmon runs, and thus to the abundance of plankton in the Pacific Ocean (13, 14).

A wide variety of attachment methods is currently in use, including body harnesses, attachment to the skin of the back with adhesives and/or sutures, neck collars, attachment to rectrices, attachment to the leg, and abdominal or subcutaneous implants. Assuming that transmitters of appropriate size are used, most negative effects of radio transmitters on birds result from the attachment method. Birds are usually caught in nets and tagged approximately within an hour or less. The harness which attaches the radio to the bird can be secured using bio-degradable cotton.

After two or three years, when the unit has ceased to function, the radio will fall off the bird's back. The main part of the radio is often covered by the bird's feathers but the antenna protrudes through. Transmitters are usually specially designed and do not impede normal flight or lifestyle in larger birds (> 100g). In smaller birds, transmitters can weigh more than 5 % of their body mass and this is thought to have an influence on the birds behaviour or health, so new designs and methods need to be developed (15).

Examples of mounting of transmitters on birds

Tracking the threatened New Zealand kiwi by a leg mount to monitor the rare birds' whereabouts. Thanks to the combined results associated with the extensive trapping of predators, a predator fence, a predator-free Kiwi chick enclosure and the ongoing tracking and monitoring of resident Kiwis, the researchers have found that the numbers have finally stabilised and they are now marginally on the increase again. (3)

Mounting of transmitters on birds

Solar powered transmitters for birds

In 2000, four young Ospreys were fitted with solar-powered transmitters. It is claimed that four hours of exposure to a bright sky is enough to power the transmitter for 24 hours. This type of transmitter should have given up to three or four years operating lifetime, but feathers covered too much of its solar surface (16).

4. Norwegian regulations

There are several national regulations in Norway that scientist have to comply with in order to do wildlife telemetry research on free-ranging birds and mammals. The process can be divided into:

- Hunt/trapping and capturing of wildlife
- Handling and tagging with radio/satellite transmitter
- The use of radio frequencies in the airspace of Norway of the transmitter tags in question.

4.1. Hunt/trapping and capturing of live wildlife

According to Act No 38 of 29 May 1981 relating to wildlife and wildlife habitants (17), section 3: "All wildlife, including eggs, is protected unless otherwise prescribed by statutory law or by administrative decision issued in pursuance thereof." Furthermore, section 3 states that "It is prohibited to catch, hunt, kill or injure protected wildlife."…."In all activities, considerations shall be shown for wildlife, and to eggs, nests and habitants, so that they are caused no unnecessary suffering injury.” Hence, there is a general prohibition to catch/trap wildlife birds or mammals.

The capture and collecting of wildlife for the scientific and other purposes is controlled in regulation number 349 of 14 March 2003 (18). Section 3 of this regulation states that the Directorate for Nature Management can give permission to capture wildlife for research, teaching, information, breeding or other purposes.

Hence, scientists who want catch and tag wildlife must apply for permission at the Directorate for Nature Management in compliance with the above mentioned regulation. The regulation also states what information has to be included in the written application as well as conditions in a possible permit. It is also a requirement in the regulation that the applicant shall notify the involved landowners, local government and police about time and place for the hunting/trapping before it takes place. In addition it is common practice to notify other local officials, such as the district office of the Norwegian Food Safety Authority and the County Governor. In addition, if the trapping of wildlife to be tagged requires permanent installations (such as cages) the applicant must get a permit from the landowner(s) for this. However, the use of more temporarily trapping devices, such as snares, does not require such permit, and here the scientist only have to *notify* the landowner.

For catching of wildlife at Svalbard, the scientist must seek permission from the Governor of Svalbard.

If the hunt requires the use of helicopter, the scientist must seek permission from the local municipality government, and permission from landowners to land in the area in question.

4.2. Handling and tagging with transmitters

The whole process of handling and tagging wildlife birds and mammals with transmitters has to be in compliancy with the Act No.73 of 20 December 1974 of animal welfare (19).

The handling and tagging with transmitters requires permission from the National Animal Research Authority according to section 10 in Regulation No. 23 of 15 January 1996 of Animal Experimentation (20). A permission to do such field experiments can be given to an institution, a firm or a private person with up to two years validity. The application for a field experiment have to contain information on the objective of the study, type of experiment, which species and how many individuals of each species, duration of the field experiment and where it will take place (see Regulation on Animal Experimentation, sections 7, 8 and 10).

The use of anesthetics to immobilize the animal be able to handle it and to prevent that it is too stressed or scared during the handling, and/or the use of analgesic to prevent possible pain during attachment of the transmitter, also require permission according to the Regulation on Animal Experimentation and should be described in the same application form.

An institution or company may have a competent person with authority delegated from the National Animal Research Authority to approve animal experiments within the framework of the institution’s or company’s general approval document. Hence, the scientists may apply directly to their own competent person and receive permission to do field experiments, such as tagging with transmitters, without applying to the National Animal Research Authority. However, the competent person has to send a copy of the approved application to the National Animal Research Authority within one week after the approval. If the experiment is controversial or if the competent person is in doubt if it falls within the framework of the institutions approval, the applications shall be sent to the National Animal Research Authority for approval.

The persons that are involved in handling the animals in field experiments have to receive a form of training approved by the National Food Safety Authority. Also, the use of anesthetics and analgesics, as well as surgical insertion has to be performed by a veterinarian according to section 18 of the Act of 15 June 2001 No. 75 relating to Veterinarians and Other Animal Health Personnel (21). According to section 15 in this Act, a veterinarian also may train and delegate this work to other personnel (here the scientist without a veterinary authorization). But the veterinarian will always be the responsible part.

It is mandatory to report back to the National animal research authority about how the research was preformed, how many animals were tagged and so on, according to section 24 in the Regulation on Animal Experimentation (20).

4.3. The use of radio frequencies

Since the radio/satellite transmitters used in tagging projects use specific radio frequencies, the use of these particular frequencies has to be approved by the Norwegian post and telecommunication authority.

5. Ethical consideration by the use of transmitters on wildlife birds and mammals

The main goal of doing biological research with the use of telemetry and tagging of animals is to be able to study animals in their natural habitat and hence get a better understanding about its physiology, ethology, social behavior, and ecology without disturbing its natural life cycle. This is a great advantage for biological science, especially studying animals that move over large areas not readily accessible or logistically feasible for scientist to do field observations.

The gain for research and nature management using tagging devises is large because the amount of date and different types of data that can be measured is not achievable by other means. It is perhaps also considered in the research community and general population to be less invasive and better form of animal experimentation than doing experiments on laboratory animals kept in cages, experimented on and then killed. The tagged animals will get to live on in the natural habitats.

However, the tagging of wildlife bird and mammals is not without ethical considerations. Animal welfare organization and the media have become more critical this branch of animals experiments. One can ask many questions: How much are the animals used in tagging experiments disturbed or stressed? Are they subjected to pain and suffering during tagging or after the transmitter is attached/inserted? How natural will it be for animals to carry a foreign object? Can the scientist ever get good and natural data from research objects that have been subjected to *unnatural* treatment? Can the scientific results justify if the wild animals suffer and die as a cause of the scientists' treatment. How well are these types of animal experiments regulated?

5.1. Stress, suffering and pain?

One must remember that the wild animals have a natural instinct to be afraid of humans, and will at any cost try to avoid being captured or be in the vicinity of humans. There are many steps in the process of catching, handling and tagging of wild animals which can lead to detrimental stress and cause suffering for the animal. In some cases the stress can even be fatal. Also, carrying a transmitter mounted to its body surface or internally can be of great stress for the animal.

During the last 10 years in Norway 25 moose, 16 lynx, 13 wolverines, 3 bears and 3 wolves have died as a result of procedures related to tagging according to "Dyrevernalliansen" (22).

The first obstacle a scientist has to face using loggers is that the animal has to be physically immobilized. Entrapment of the animal may be accomplished by traps or by shooting with anesthesia darts and the methods are in most cases very stressful. The animal can die waiting in the trap, and this has often been seen for row deer and for otters (23). Helicopters are often in use to track down bigger animals for tagging, and this is very disturbing for the environment of the survey area.

The use of collars is less harmful than surgically inserted transmitters, but it has some obvious negative consequences. Firstly, the collar must fit in a way that it does not injure the animal or fall off. The collar may cause wounds and subsequent infections. Often an expandable collar is used on young and growing animals, but these collars have sometimes been shown not to work properly and the animals will suffocate. Secondly and much less considered, the collars may affect normal behavior. If the collar affects social behavior, it might affect the animals' social status, and the data received from such an animal will not be biologically correct. At the island Vega in Nordland, they have observed that moose with collars keeps in packs separated from un-collard moose. Thirdly, a colorful or heavy collar might also make the animal more exposed to predation. A heavy collar might disable a predator from catching prey. The latter two may also be the case for transmitters attached to animal's body surface with glue or by piercing through the skin.

On some animals, like otters and badgers, it is impossible to get a collar to stay on the neck. In such cases receivers surgically implanted inside its body cavity is used. And these are even more harmful for animals than the collars. The normal procedure is to implant the receiver inside the abdomen cavity in such a way that is "floats freely". Use of such intraperitoneal radio-transmitters has been successfully used in lynx according to Arnemo (24). Medical doctor Hans J. Engan (25) questions the sterility in field research along with the fact that a surgically implanted transmitter will be rejected from the body since it is not supposed to be there in the first place. The latter might lead to complications over time and chronic pains. He also questioned the assessment of the electromagnetic waves from these transmitters, and proposed that this energy might lead to genetic alterations since transmitters often is located close to ovaries and testes of the animal.

The use of transmitters may also enable poachers equipped with the correct receiver easier accessibility to the tagged animals. This has been a problem in the ROSA-project mentioned earlier, where at least 16 of the 101 tagged lynx have been victims of illegal hunting.

An ongoing debate in Norwegian mass media started 18 October 2005 when the program “Ut i naturen” on NRK showed clips of scientists from Norwegian Institute for Nature Research (NINA) chasing wolverines and wolves from helicopters. The journalist claimed that the surgically implanted transmitters caused the death of a wolverine cub soon after operation. NINA thereafter changed their routines for implants.

The use of surgically implanted transmitters has also been under some controversy earlier in Norway. As mentioned above, Dr. Med. Hans J. Engan (25) gave several insights into negative side effects of surgical implants. An additional three wolverine casualties was mentioned in his article as a result of this activity in Engan’s comment, since they were found dead within three days of the operation. One of the wolverines had five cubs, so these also had to be killed. Another wolverine female was found dead 18 days after the surgical procedure, and her wound from the operation was torn and caused infections leading to her death.

The National Animal Research Authority have in 2002 stated that they will be very restrictive with permitting use of intraperitoneal transmitters in the abdomen of the animals because this will risk that the animals are subjected to unnecessary suffering according to the Animal welfare Act section 2 (26).

5.2. How good is the regulation of tagging?

As mentioned in chapter 4.2, the scientist has to apply to the National Animal Research Authority (or to the institution’s competent person) describing the purpose and how the tagging will be done. The application will be thoroughly evaluated with the goal of minimizing the suffering of animals involved in the experiment and that the experiment is justified by giving knowledge, taking scientific or social considerations.

But, as the Norwegian Council for Animal Ethics (23), which is appointed by the Ministry of Agriculture, have described in an official evaluation on tagging of wildelife (September 1994), there is a loophole in the Regulation on Animal experiments. According to section 3 simple tagging which is not believed to influence the animal’s normal way of life, or cause other than minimal and transient pain or discomfort, is exempted from this Regulation. This can by some scientist be interpreted in a way that they do not need a permit from National Animal Research Authority to their tagging with transmitters. Norwegian Council for Animal Ethics points out that this is a wrong interpretation of the Regulation and recommends that the Regulation is changed appropriately so that it is clearer that all tagging projects are evaluated by the National Animal Research Authority.

Although the large research institutions in Norway, including the Universities, seek the appropriate permissions to do tagging on wildlife birds and mammals, there seem to be a need to clarify the regulations on this point and also perhaps have national guidelines on how to best conduct this kind of research.

6. The future of transmitters

Technological advances will expand the use of telemetry tools in the future. The main problems with the transmitters today are the size and the battery capacity. With a down-scaling in size in addition to increased battery capacity the surgical procedures may not even be as harmful as they are today. The battery capacity may be drastically increased if the battery had a possibility for self-charging e.g. generating power by the animals' movements. Solar powered transmitters have been tested more or less successfully on birds. In addition, if the technology allows it, nano-technological analyzers connected to the transmitter might be implanted in animals in the future. Today there are loggers that can measure heart rate and depth during diving. Maybe in the near future we can have loggers that log basic blood values like hematocrit and blood gases? Later we might be able to use antibody-coated loggers which can be used to detect diseases or specific proteins?

With the increasing use of transmitters, there is an apparent need for international collaboration. Scientists working on projects in developing countries may find themselves only being restricted by their own moral standards, and this calls for laws and legislations covering all countries in order to maintain animal welfare as the top priority. This is not only a problem concerning the use of transmitters, but also generally when animals are being used for scientific purposes. There is a need for a new international infrastructure; with a regulation which makes it mandatory to coordination wildlife telemetry research on an international level. As advanced technology opens the door for improved tools for biomonitoring, the curiosity of the scientist must be supervised by an international board making sure that animal welfare is being not only considered, but have the highest priority.

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