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Semi-permanent methods

Semi-permanent methods of identification are designed to last from days to months or years; however, most marks are lost within the lifetime of the animal. Therefore, researchers should select materials and attachment methods appropriate to the desired study duration. Semi-permanent methods such as tags, collars, harnesses and bands can be used exclusively to differentiate marked and unmarked animals, but they are generally coupled with additional identifying information, and are also commonly used to attach telemetric and other equipment (Table 3). Such devices often need to be removed, or are designed to fall off, to facilitate recovery of data and/or to avoid hindrance to the growth and development of the animals.

TABLE 3. SEMI-PERMANENT IDENTIFICATION METHODS[1].

METHOD	SPEED OF APPLICATION	COMPLEXITY	COST
Tags	Intermediate–Fast, depending on location	Low–Intermediate, depending on location and species	Low–Intermediate, depending on tag material
Neck collars, harnesses, bands	Slow–Fast, depending on method	Intermediate–High, depending on method	Low–High, depending on equipment
Nocturnal lights	Slow–Fast, depending on method of attachment	Low–High, depending on method of attachment	Low–High, depending on method of attachment
Telemetry (radio, satellite, bio), archival data recorders	Slow–Intermediate, depending on method of attachment	Intermediate–High, depending on method of attachment and equipment	Intermediate–High, depending on method of attachment and equipment

1 Ranks in columns (e.g. slow, intermediate and fast) are qualitative, comparative scores for the parameter listed for the methods in the table.

Seal with transponder (an external device, glued to the fur, which drops off when glue fails or when fur is shed as part of the normal growth cycle). PHOTO: BRUCE DIX.

SHORT-TERM STRESS	INFLUENCE OF OPERATOR	VISIBILITY	APPROPRIATE SPECIES
Intermediate: handling, some pain, infection risk	Intermediate–High, depending on location	Low–High, depending on location and tag size	Terrestrial and marine mammals, some reptiles and amphibians, fish
Intermediate–High, depending on species and method: handling, possible anaesthetic use	Intermediate–High, depending on method	Moderate–High, depending on device, material, location	Terrestrial mammals, birds, some small cetaceans, pinnipeds, some reptiles and amphibians
Low–High, depending on method of attachment: handling, possible anaesthetic use	Intermediate–High, depending on method of attachment	Moderate–High, depending on distance, light intensity, viewing method	Nocturnal terrestrial mammals, reptiles, amphibians, some invertebrates
Intermediate–High, depending on method of attachment: handling, possible anaesthetic use	High	Low–Moderate, depending on attachment method	Any animal large enough to carry equipment without detrimental effect

TAGS

Tags are made from a variety of materials, most commonly metal or plastic, and are usually augmented by alphanumeric codes for individual or group recognition (Table 3). In general, there is a trade-off between tag size and visibility, and the negative effects on the wearer; larger tags are more visible, but affect the wearer more. The endurance of a tag depends on factors such as tag material, size, shape and placement (e.g. in ears, webs, flippers, fins, toes or jaws), as well as wearer characteristics that include anatomy, behaviour, habitat and infection rate. Tags may also be used as attachment vehicles for radioactive marks or telemetric equipment used for tracking animals.

Advantages

- Highly versatile, cost-effective, easy to apply and result in unambiguous identification
- Often visible to the observer at a distance, making recapture unnecessary (depending on tag size, colour, location, etc.)
- Can be returned to the research team after loss or death of the wearer, thereby making public reporting possible

Disadvantages

- High rates of mark loss
- Tag endurance is influenced greatly by operator proficiency
- May cause pain-inducing tissue damage or lead to the development of infection
- The physical presence of the mark may affect the animal's behaviour: for example, the animal may vigorously and/or persistently attempt to rid itself of the device, which could result in stress or injury
- May increase visibility of study animals both to human observers, and to predators or prey
- May cause marked animals to be treated differently by conspecifics
- Recapture may be necessary for re-identification of tagged animals

Safeguards

- Adhere to the General Safeguards listed on page 13
- Select a tag and body location appropriate to the anatomy and behaviour of the wearer, duration of the study and distance at which identification is required
- Ascertain whether measures are required to reduce pain or the risk of infection (e.g. antiseptics)
- Quantify and account for rates of tag loss specific to the population being tagged, especially in population studies. This can be achieved by double tagging or by applying a less visible, permanent mark such as a tattoo, in conjunction with tagging

Acceptability

- *Practicality*: High, because of their versatility, low cost and ease of application.
- *Biological and welfare acceptability*: High, provided all safeguards are followed. In general, tags are small relative to the size of the wearer, and have minimal impact on behaviour and survivorship. Exceptions include animals that experience long-lasting pain or infection as a result of tagging, or those that lose their marks very soon after tagging. The welfare of such animals would be harmed (e.g. pain of application) with no redeeming benefit.
- *Public perceptions*: Generally neutral or positive, as the public is likely to identify tags as associated with research efforts. In addition, the fact that farm animals are commonly seen wearing tags may reduce public disquiet about the method. Tagging that results in long-lasting pain or infection or tags that are disproportionately large relative to the size of the animal would likely be viewed negatively by the public.

NECK COLLARS, HARNESSES OR BANDS

Neck collars and harnesses are primarily used as vehicles for the attachment of telemetric transmitters, nocturnal lights or radioactive marks. Collars and harnesses are most often used on terrestrial mammals, and occasionally on birds, pinnipeds and

dolphins (Table 3). Legbands, armbands and waistbands are usually inscribed with identifying symbols or codes, or are augmented with identifying tags. Such bands are often used on reptiles, amphibians and birds. The longevity of collars, harnesses and bands depends on the device's material and design, and the habitat and characteristics of the wearer such as behaviour, age and sex.

Advantages

- Allow the attachment of telemetric equipment, lights and other marking devices
- Wide range of designs, allowing application to species ranging from quite small to very large
- May allow identification or tracking of marked animals from a distance (e.g. by radio-telemetry), making disturbance or recapture unnecessary

Disadvantages

- Devices that are too loose can chafe (damaging underlying skin), snag on elements in the environment or lead to premature loss of the mark
- Devices that are too tight can lead to impaired circulation, skin damage, infection and even loss of the marked appendage, and can also interfere with feeding or breathing, especially in animals growing or developing while wearing the mark (amphibians, reptiles, juveniles)
- The physical presence of the mark may affect the animal's behaviour: for example, the animal may vigorously and/or persistently attempt to rid itself of the device, which could result in stress or injury
- Operator proficiency has major impact on the success of the method
- Marked animals must be monitored regularly to ensure their welfare is not harmed
- Marked animals may have to be recaptured to remove collars, harnesses or bands, or for re-identification
- May increase the visibility of study animals to human observers and to predators or prey

- May cause animals to be treated differently by conspecifics
- Use of such devices on marine mammals is problematic, owing to the increases in hydrodynamic drag they cause and subsequent changes in behaviour and energy use

Safeguards

- Adhere to the General Safeguards listed on page 13
- Devices must be designed and fitted carefully, ensuring that they are neither too tight nor too loose, and must allow for growth or development, and weight loss or gain
- Corrodible or hard parts must not come into contact with the surface of the animal as they may damage underlying skin by rubbing or electrolysis
- Devices must be appropriate for the animal's stage of life (e.g. growing, pregnant, lactating, mature) and specific attributes (e.g. amphibians and reptiles usually grow throughout their lives)
- Animals must be monitored regularly in order to prevent or rectify problems associated with the wearing of a collar, harness or band
- Any equipment attached to such devices must be kept to a size, weight and configuration appropriate to the animal's size, behaviour and habitat
- The eventual removal or release of such devices must be considered

Acceptability

- *Practicality*: Moderate, because they are versatile and relatively cheap, but significant expertise and effort are required to minimise harmful effects on the animals. In addition, monitoring and removal of devices may be required.
- *Biological and welfare acceptability*: Moderate, provided all safeguards are followed. The potential for negative effects on health, behaviour and survivorship is significant, especially in growing or developing animals. For pinnipeds and dolphins wearing collars or harnesses, the effects on behaviour and energy use can be marked.

- *Public perceptions*: Generally neutral or positive, as the public would probably identify such devices as being associated with research efforts, e.g. with international bird banding programmes. However, devices that obviously impact on health, or alter behaviour or survivorship, would be perceived negatively. This would be especially true of those devices that cause gross injuries owing to a poor fit, or lead to entanglement or strangulation.

NOCTURNAL LIGHTS

Chemical, electrical or radioactive light sources can be attached to animals in order to track them visually at night. Such devices can be attached directly to the animal using non-toxic adhesives, or via neck collars, harnesses or tags. Nocturnal lights are primarily used on terrestrial mammals, but they have also been used successfully on amphibious invertebrates (Table 3), and could conceivably be used to track amphibians and reptiles. Depending on the light source, such devices can be used to identify and track nocturnal animals for hours to months or years. The detection distance depends on the device and viewing method and may vary from a few metres to about one kilometre. Note: Betalights consist of radioactive material that decays inside a capsule, causing the phosphor coating to emit light. All the harmful beta radiation is absorbed by the phosphor, and none escapes to affect the bearer of the light.

Advantages

- Allow tracking and identification at night
- Relatively cheap and versatile; applicable to a wide range of species (different light sources and sizes are available)
- Allow identification of individuals (using different intensities, colours, blinking sequences)
- Can provide data for hours to years
- Light characteristics can be linked to physiological parameters: e.g. changes in blinking rate to reflect body surface temperature
- Disturbance of the animal appears to be minimal (depending on attachment method and wavelength of emitted light)

- Allow tracking of marked animals for long periods without direct interference by the researcher

Disadvantages

- Useful for tracking only where there is a clear line of sight between observer and subject; the amount of vegetation cover and habits of the animal will affect tracking
- The physical presence of the device may affect the animal's behaviour: for example, the animal may vigorously and/or persistently attempt to rid itself of the device, which could result in stress or injury
- May increase the visibility of study animals to prey and predators
- May cause marked animals to be treated differently by conspecifics
- Other disadvantages may be associated with the method of attachment (neck collar, harness, band or tag—see above)

Safeguards

- Adhere to the General Safeguards listed on page 13
- Use non-toxic adhesives to attach lights
- Choose a device with size and light emission characteristics (e.g. infrared) appropriate to the animal
- Adhere to safeguards outlined for other methods of attachment
- Follow safeguards appropriate for use of radioactive material if necessary

Acceptability

- *Practicality*: Moderate to high, depending on the light source and method of attachment. Nocturnal lights are relatively cheap, versatile and can last from hours to years, but if neck collars, harnesses, bands or tags are used for attachment, significant expertise is required to minimise harm to the animals.
- *Biological and welfare acceptability*: Moderate to high, depending on the method of attachment. If neck collars,

harnesses, bands or tags are used, the potential for negative effects on health, behaviour and survivorship is significant, especially in growing or developing animals, and animals likely to experience weight changes.

- *Public perceptions*: Generally neutral or positive to the lights themselves. The public may be concerned that lights could increase the visibility of the wearer to predators or prey, but current scientific evidence does not support such concern. Careful explanation could dispel public disquiet about radioactive light sources, e.g. Betalights. The method of attachment is likely to cause more public concern than the lights themselves. Attachment devices that obviously impact on health, or alter behaviour or survivorship would be perceived negatively. This would be especially true of those devices that cause gross injuries due to poor fit, or lead to entanglement or strangulation.

RADIO-, SATELLITE- AND BIO-TELEMETRY AND ARCHIVAL DATA RECORDERS

Telemetry refers to the interception of energy radiated from an animal, with the objective of remotely collecting data on an animal's location, behaviour and physiology and characteristics of the environment. Energy forms that can be used to transmit such data include acoustic, electric, magnetic and electro-magnetic (e.g. visible light, radio- and micro-waves). In wildlife biology, information is most commonly transmitted using high frequency radio-waves (radio-telemetry) (Table 3). Radio-telemetric equipment consists of a transmitter, a power source and a transmitting antenna, all of which must be attached to the animal. Transmitter packages can be externally attached (using adhesives, collars, harnesses, bands or tags), or implanted internally. Radio signals are detected by receiving antennae, which can be hand held or carried on land vehicles, ships, planes or satellites. Satellite-telemetry, including GPS (global positioning systems), enables information to be relayed from the transmitter to a receiver via satellites, thereby reducing the labour and costs associated with conventional telemetric fieldwork. Bio-telemetry refers to the transmission of biological information from sensors on the animal, without direct contact between the transmitter

and receiver. Internal physiological data (e.g. information about heart rates, body temperature, blood and heat flow; or electrocardiograms) can be relayed, along with behavioural data (e.g. diving time and depth) and environmental information (e.g. ambient temperature, light, salinity). Archival data recorders are self-contained bio-telemetric units that collect and archive data for later recovery.

Advantages

- Allows information to be gathered on wide ranging or remote species, which would otherwise be difficult/impossible to study, especially marine species
- A wide range of designs and methods of application make them useful for studying a variety of species
- Continuing miniaturisation of components will allow tracking of smaller animals, tracking for longer periods and more efficient and extensive data collection
- Allows remote, and often continuous, monitoring of location, behaviour and physiology of free-ranging animals, without direct interference by the researcher

Disadvantages

- Telemetric equipment is expensive and complex to use, and successful use of it is highly dependent on operator proficiency
- Suitable only for animals large enough to carry a transmitter package
- Battery capacity/size limits transmission longevity and strength
- The physical presence of the device may affect the animal's behaviour: for example, the animal may vigorously and/or persistently attempt to rid itself of the device, which could result in stress or injury
- Other disadvantages may be associated with external methods of attachment (neck collar, harness, band or tag – see above)
- Internal implantation of transmitter packages can make an animal vulnerable to the effects of anaesthetic, surgery (risks of infection, adhesion to internal organs) and pain

- Attachment and retention of the transmitter package may be difficult, especially for marine mammals, where increased hydrodynamic drag may alter behaviour and energy expenditure
- Transmitting devices must eventually detach from the animal or be removed, often necessitating recapture
- Recovery of archival recorders is required in order to retrieve data, which may also necessitate recapture
- The amount of information that can be collected by satellite receivers is presently limited by the number of satellites available and their orbits

Safeguards

- Adhere to the General Safeguards listed on page 13
- Select a transmitter package and attachment method appropriate to the animal. In general, packages should not exceed 10% of an animal's body weight
- Use non-toxic adhesives
- Follow the safeguards outlined for external attachment methods (neck collars, harnesses, bands or tags)
- For transmitter packages inserted into the body, use minimally invasive techniques and appropriate anaesthetic, anti-septic and methods of pain control
- The force-feeding of transmitter packages disturbs behaviour (e.g. snakes) and is no longer recommended

Acceptability

- *Practicality*: Moderate, because it is versatile and provides unique information, but data collection requires time, expertise and costly equipment. In addition, both external and internal methods of attachment require significant expertise to minimise harm to the animals.
- *Biological and welfare acceptability*: Moderate, provided all safeguards are followed. Welfare problems relate primarily to the method of attaching the transmitter package, although its weight can also affect behaviour and energy expenditure. If external methods are used, the potential for negative effects

on health, behaviour and survivorship is significant, especially in growing or developing animals. If internal methods are used, risks associated with surgery (e.g. infection) and anaesthetic as well as pain and the adherence of the package to internal organs can adversely affect animal welfare.

- *Public perceptions*: Generally neutral or positive, as the public would probably associate transmitters with conservation or research efforts. However, attachment devices which obviously impact on health or alter behaviour or survivorship, or are disproportionately large or heavy, would be perceived negatively. Attachment of transmitters to endangered animals is likely to be perceived negatively if the associated risks are high.

Sea lion pups with permanent blue flipper tags. They also have temporary plastic disks glued to their fur (on head or back). Orange disks number individual pups for growth studies; white disks are attached for a mark-recapture annual census.

PHOTO: © PADRAIG DUIGNAN, MASSEY UNIVERSITY.

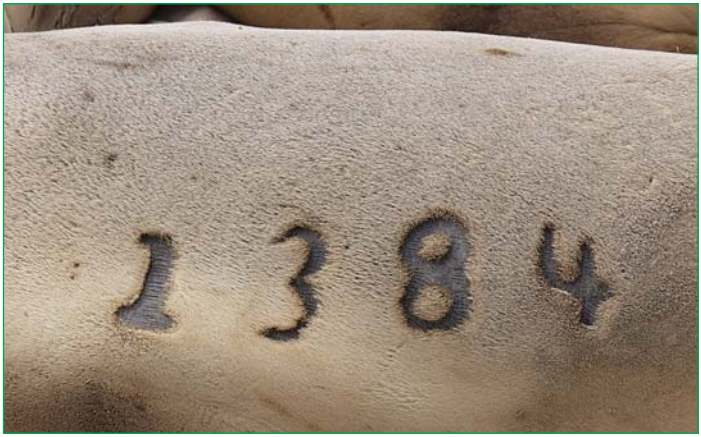
Permanent methods

Permanent methods tend to create marks that are less readily visible, and often involve tissue damage (permanent or temporary). Despite their designation, there is no guarantee that these marks are permanent, and variables including species, age, environment and operator experience can strongly influence the permanence of marks (Table 4). Permanent marks can be advantageous if they eliminate the need to recapture animals for re-marking and/or identification, and can be used in conjunction with more visible, temporary methods.

TABLE 4. PERMANENT IDENTIFICATION METHODS[1].

METHOD	SPEED OF APPLICATION	COMPLEXITY	COST
Hot brands	Fast	Low–Intermediate, depending on heat source and amount of hair	Low
Freeze brands	Slow–Intermediate, depending on species	Intermediate–High, depending on method	Intermediate
Chemical brands	Slow–Intermediate, depending on method	Intermediate–High, depending on method	Intermediate
Tattoos	Slow	Intermediate	Intermediate
Passive integrated transponders	Intermediate–Fast	High	High
Visible implant fluorescent elastomer tags	Intermediate	Intermediate	Low
Tissue removal	Fast	Low	Low
Vital stains	Intermediate	Intermediate	Intermediate–High, depending on stain and recovery method
Natural marking identification	Slow–Fast	High	Low–Intermediate, depending on equipment

1 Ranks in columns (e.g. slow, intermediate and fast) are qualitative, comparative scores for the parameter listed for the methods in the table.



Adult female sea lion with brand.
PHOTO: © PADRAIG DUIGNAN, MASSEY UNIVERSITY.

SHORT-TERM STRESS	INFLUENCE OF OPERATOR	VISIBILITY	APPROPRIATE SPECIES
Intermediate–High: handling, pain, infection risk	Very High: application duration, temperature of branding iron	Intermediate–High, depending on location, size, success of brand	Terrestrial mammals, pinnipeds, reptiles
Intermediate: handling, delayed pain, infection risk	Very High: application duration, temperature of branding iron	Intermediate–High, depending on location, size, success of brand	Terrestrial mammals, pinnipeds, small cetaceans, reptiles, amphibians
Intermediate: handling, skin irritation, infection risk	High: application duration, chemical	Intermediate–High, depending on location, size of brand	Terrestrial mammals, amphibians
Intermediate–High: handling, pain, infection risk	High: location and depth of ink application	Low	Terrestrial mammals, pinnipeds, reptiles, amphibians
Intermediate–High: handling, pain, infection risk	Intermediate–High: location and depth of transponder	Not visible	Terrestrial mammals, pinnipeds, birds, reptiles, amphibians, fish, invertebrates
Intermediate–High: handling, pain, infection risk	Very High: location and depth of elastomer implantation	Intermediate, depending on location and depth of implant	Larval and transparent-skinned amphibians, fish
High: handling, pain, infection risk	Low	Low–Intermediate, depending on method	Reptiles, amphibians, some terrestrial mammals and pinnipeds
Low–High, depending on method of administration and data recovery	Low	Low–Intermediate, depending on method, species, visibility of targeted structure	Terrestrial and marine mammals, larval amphibians
Low–Intermediate, depending on handling required	Very high	Low–High, depending on marks, size of animal	Any animal with stable, distinguishing natural markings

HOT, FREEZE AND CHEMICAL BRANDING

A permanent brand results from tissue damage caused by the application of excessive heat or cold, or chemicals to the skin (Table 4). Brands can have symbolic shapes to identify groups or individuals, and when successful can produce highly visible, long-lasting marks. The objective of hot branding is to promote the formation of scar tissue, which has few viable hair follicles or is visibly different from the surrounding skin. Freeze branding selectively destroys the pigment-producing cells in the hair follicles, resulting in the production of white hair or de-pigmented skin, which contrasts with the original coat/skin colour. Likewise, certain chemicals applied to the skin can cause changes in pigmentation.

Advantages

- Large numbers of animals can be marked with only a few symbols in combination
- Hot branding is quick and inexpensive and the mark may last throughout the animal's life
- Successful brands can result in highly visible marks, which may allow identification from a distance, thereby avoiding the need for recapture
- After healing, there is no energetic cost to the animal because it is not hindered by equipment or extra weight
- Healed brands exert minimal effects on behaviour and physiology
- Handling and brand application are shorter with hot compared with freeze brands
- Marking success can be determined quickly after hot brand application
- Pain and stress during freeze brand application may be less than with hot brands because of the anaesthetic effects of refrigerants

Disadvantages

- Branding success is heavily dependent on operator proficiency
- There is high variability between animals in healing and legibility of brands, especially with freeze branding
- All forms of branding cause tissue damage and subsequently pain and stress, and increase the risk of infection
- Successful branding requires the animal to be securely restrained, immobilised or anaesthetised and this causes handling stress
- Pain-induced vocalisation, struggling, escape behaviours and, with hot branding, smoke from burning hair and/or skin, are aesthetically unpleasant to operators and the public
- Success of freeze and chemical brands cannot be determined until some time after branding
- Chemicals used for branding may cause severe tissue damage, pain and stress
- Hot and freeze brands are not permanent in amphibians
- Freeze brands may not be permanent in marine mammals (e.g. dolphins, manatees)
- Freeze branding may induce moulting in reptiles, thereby increasing their vulnerability to predators
- Freeze and chemical brands may be obscured by natural pigment loss in older animals

Safeguards

- Adhere to the General Safeguards listed on page 13
- Determine optimal brand application time and temperature for the particular species, in order to ensure successful branding, and to minimise pain, infection and premature loss of marks
- Use appropriate restraint, anaesthetic, anti-septic and measures of pain control
- Carefully consider location and size of brands to minimise effects on conspicuousness and camouflage
- Hot branding of amphibians is not recommended owing to the risk of uncontrollable water loss through damaged integument

Acceptability

- *Practicality*: Moderate, because of the permanence and visibility of successful marks. However, inconsistency in healing and legibility make branding less useful. Freeze branding requires complex equipment which is difficult to transport and use in the field.
- *Biological and welfare acceptability*: Moderate, provided all safeguards are followed. All branding necessitates restraint during brand application and causes tissue damage, pain and stress. Wounds that heal quickly have minimal effects on behaviour and physiology, in contrast to those where healing is protracted. When brand marks are illegible after healing, the animal's welfare would be harmed (e.g. pain of application) with no redeeming benefit.
- *Public perceptions*: Variable. The application of hot brands is aesthetically unpleasant; however, well-healed marks would probably be considered to be acceptable by the public. Poorly healed or infected brands or animals suffering prolonged pain or discomfort owing to brand wounds would elicit negative responses. In addition, unreadable marks would be perceived negatively because the pain and stress caused by branding would have been purposeless. Freeze branding may be viewed more favourably than hot or chemical branding, owing to the anaesthetic properties of refrigerants, but freeze branding requires longer restraint during its application and the results are less consistent. Careful explanation of the benefits of branding may help reduce public disquiet.

TATTOOING

Tattooing refers to the introduction of pigment into the skin of an animal (Table 4). Forceps, needles or hammer instruments can be used to pierce the skin and ink, dye or paste can then be rubbed into the pinprick wounds. Alternatively electro-vibrator systems both pierce the skin and inject the dye, and can be used to 'write' an identifying code into the skin. Dye can also be injected subcutaneously or intra-dermally using a needle. Tattooing is considered to be the most permanent method for marking wildlife, but the durability of tattoos depends on the species and

age of the animal, as well as the quality of the application, and the depth and location of the mark. Tattoos are often used in conjunction with more visible, temporary marks.

Advantages

- Tattoos generally last for the animal's lifetime, and can be used to evaluate loss rates for other marking methods
- Unlimited numbers of animals may be identified individually
- Tattoos can be applied to a wide range of species (small to large)
- After healing, there is no energetic cost to the animal because there is no equipment or extra weight to carry
- Healed tattoos exert minimal effects on behaviour and physiology
- Marks do not usually make animals more conspicuous to predators or prey
- Different pigment colours are available for marking light and dark integuments

Disadvantages

- Durability of the mark is moderately influenced by operator proficiency
- Marks are not readily visible from a distance, so recapture is usually required for identification
- Application of tattoos causes pain and can lead to infection
- Application takes longer than other permanent methods (e.g. hot branding), increasing handling stress
- Furred animals can only be marked on naked parts (e.g. soles of feet, inguinal region, inner lips, ears)
- Tattoos may disrupt integument patterns, especially in small animals, affecting social signalling or camouflage

Safeguards

- Adhere to the General Safeguards listed on page 13
- Use appropriate restraint, anaesthetic, anti-septic and measures of pain control

- Carefully consider the location and size of tattoos to minimise the effects on an animal's conspicuousness and camouflage

Acceptability

- *Practicality*: Moderate. The benefits of mark permanence are offset by the low visibility of tattoos, which makes recapture necessary for identification.
- *Biological and welfare acceptability*: High, provided all safeguards are followed. Pain associated with tattoo application appears to be relatively minor and short lived. Well-healed tattoos have minimal effects on behaviour and physiology.
- *Public perceptions*: Generally neutral or positive. Most tattoos are not visible to the casual observer, and have minimal effects on the behaviour and physiology of the marked animal after healing. Tattoos that are disproportionately large, poorly healed, infected or adversely affect camouflage or social interactions would elicit negative perceptions.

PASSIVE INTEGRATED TRANSPONDERS (PITs)

PITs are small electronic units encased in biologically inert capsules that can be used to identify a wide variety of animals (Table 4). They do not require a continuous power source (e.g. battery); when the tag is held in an electromagnetic field, the microchip transmits its own unique identification code to an electronic reader. PITs are most commonly injected subcutaneously or intra-abdominally, but can also be swallowed (within boluses) or attached as part of an external tag.

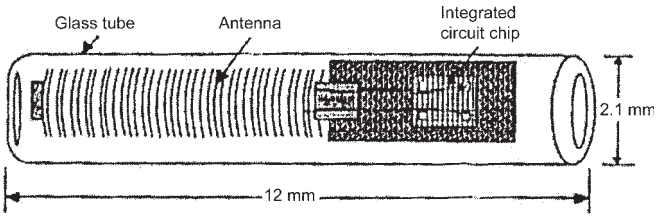


Diagram of a typical Passive Integrated Transponder Tag. From: Prentice et al. 1990.

Prentice, E.F.; Flagg, T.A.; McCutcheon, S. 1990: Feasibility of using implantable passive transponder (PIT) tags in Salmonids. *American Fisheries Society Symposium* 7: 317–322.

Advantages

- Can be used to permanently identify a wide range of animals (small to large)
- Unlimited numbers of animals can be identified individually
- The operational lifespan of each PIT is exceptionally long
- Internally injected PITs are well retained and highly reliable
- Portable and fixed tag monitoring systems are available; fixed readers allow automatic monitoring of free-living animals passing near antennae
- Their very small size and weight mean that PITs do not alter the appearance or behaviour of the animals
- Relatively quick to apply, minimising handling stress

Disadvantages

- PITs, electronic readers and other equipment are expensive
- PITs may migrate away from the site of insertion, making detection difficult and posing a threat to internal organs
- Retention and migration of internally injected PITs is heavily dependent on operator proficiency
- Short reading distances; currently most PIT-tagged animals must be recaptured for identification
- Implantation will cause handling stress and pain, and may lead to infection
- Lack of external signs means that marked animals cannot be distinguished visually; if portable readers fail in the field, marked animals cannot be identified
- The long-term effects of intra-abdominal implants in small animals are not well known

Safeguards

- Adhere to the General Safeguards listed on page 13
- Appropriate restraint, anaesthetic, anti-septic and measures of pain control must be used
- PITs should be placed in areas of low movement, e.g. around the ears or into the body cavity

- PITs should be manipulated away from the point of insertion to reduce transponder loss
- In very small animals, the transponder to body weight ratio should not exceed 10%
- Long-term effects of intra-abdominal implants should be assessed in the species being investigated

Acceptability

- *Practicality*: Moderate. The benefits of virtually permanent identification are offset by the present high cost of PITs, electronic readers and other equipment. In addition, PIT migration within the body and the inability to visually identify PIT-tagged animals may hinder identification.
- *Biological and welfare acceptability*: High, provided all safeguards are followed. PITs generally have minimal effects of behaviour and physiology owing to their small size and weight. Exceptions include PITs that migrate and threaten internal organs. The pain of application and risk of infection are relatively minor.
- *Public perceptions*: Generally neutral or positive, because PITs are not visible to researchers or the public, and do not apparently alter behaviour. PIT implantations that cause prolonged pain, infection or damage internal organs would elicit negative responses.

VISIBLE IMPLANT FLUORESCENT ELASTOMER (VIE) TAGS

VIE tags consist of two bio-compatible elastomer materials which solidify when mixed and can be injected under the skin. Animals can be identified individually by the combination of position and colour of the VIE tags. The material is visualised through transparent skin and is, therefore, suitable only for animals like fish, salamanders and tadpoles (Table 4).

Advantages

- Material is inexpensive and only a small amount is required to mark each animal

- Use of fluorescent material allows detection in dark pigmented skin (under UV light)
- Marked animals are not more conspicuous to predators, prey or conspecifics
- Useful for identifying animals which are otherwise difficult to mark (e.g. salamanders)

Disadvantages

- Only useful for animals with transparent skin
- Misidentification may occur through loss of some inserted material, and recognition of such loss is prevented by an absence of scarring or injection holes
- Success of marking is heavily dependent on operator proficiency
- Implantation can cause handling stress and pain, and may cause infection
- Limited availability of materials

Safeguards

- Adhere to the General Safeguards listed on page 13
- The same number of marks should be applied to each animal at a given study site, to allow recognition of lost marks

Acceptability

- *Practicality*: High, in a limited context, because of the low cost and opportunity to mark animals which are otherwise difficult to identify.
- *Biological and welfare acceptability*: High, provided all safeguards are followed. The appearance of the marked animal is unchanged (except to those conspecifics, predators or prey capable of detecting fluorescence). The pain and infection risks associated with implantation are relatively minor.
- *Public perceptions*: Generally neutral or positive. VIE tags are not visible to the casual observer and appear to have minimal effects on behaviour and survivorship. Negative perceptions would be elicited by those implantations which resulted in prolonged pain or infection, or altered behaviour or survivorship.

TISSUE REMOVALS: EAR NOTCHING; TOE, DISC AND WEB CLIPPING

This method is used for marking a wide variety of animals (Table 4), and is based on the removal of tissue in coded sequences. Each ear, toe, disc or web location is assigned a code and the combination of removals provides a single identification number. The tools for removing tissue include nail clippers, scissors, ear punches and notchers. Toe clipping is the most common method for marking amphibians and reptiles.

Advantages

- Extremely easy, fast and cheap to perform
- Operator proficiency has minimal influence on marking success
- Large numbers of animals can be identified individually
- Tissues collected can provide valuable data on age and genetics
- Tissue removals are permanent in most species (except salamanders and some other amphibians)
- After healing, there is no equipment or extra weight to hinder the wearer

Disadvantages

- Pain of tissue removal is likely to be significant
- Risk of infection is higher than with other permanent methods
- Tissue removals may have significant effects on behaviour, risk of predation and survivorship
- Identification almost always requires re-capture and handling
- More tissue removals (e.g. toes) per animal are required to achieve individual identification as population size increases
- Natural tissue loss can confound identification
- Identification is time consuming and the potential for misidentification is great
- There is potential to spread the chytridiomycosis fungal infection in frogs through toe clipping

Safeguards

- Adhere to the General Safeguards listed on page 13
- Equipment should be kept extremely sharp to minimise bruising and tearing
- Equipment should be kept very clean to prevent transmission of diseases and to minimise the risk of infection
- Researchers should choose a coding system which minimises the number of tissue removals per animal, and coding systems should be well documented for future researchers
- Appropriate restraint, anaesthetic, anti-septic and measures of pain control must be used
- When the effects of tissue removal on behaviour and survivorship are not known, they should be evaluated
- Toe and disc removals should be performed only on animals where associated blood loss is known to be minimal
- Only non-adjacent toes should be clipped and specialised structures should not be altered
- Ear notching should not be performed on species with specialised ears (e.g. otariid seals)

Acceptability

- *Practicality*: High, because of the low cost, ease and permanence of tissue removal (except with some amphibians).
- *Biological and welfare acceptability*: Low to moderate, provided all safeguards are followed, given that such tissue removals probably cause considerable pain and stress, and the risk of infection is greater than with other invasive marking methods. In addition, animals must be recaptured and handled for identification, and the effects on behaviour are generally unknown.
- *Public perceptions*: Negative to neutral. The public may feel that tissue removals without anaesthetic or pain control are barbaric. In addition, those tissue removals that result in infection, or alter behaviour or survivorship are likely to be perceived very negatively. Careful explanation of the benefits and safeguards associated with tissue removal may reduce public disquiet.

VITAL STAINS

Certain chemicals can be used to mark internal anatomical structures in living animals (Table 4). Vital stains can be injected intravenously or administered orally. They allow measurement of the growth of stained tissues (e.g. teeth, bones, hair, claws, gut wall) between the time of stain administration and subsequent inspection. Vital stains are also used for age determination and to study metabolic processes.

Advantages

- Provide information which may be impossible to collect otherwise; e.g. age of cetaceans
- Stains usually do not interfere with biological functioning of animals
- Some stains can be visualised within the live animal
- Oral administration may allow staining without capture or handling

Disadvantages

- Significant stress may be associated with initial capture and handling, and with recapture if it is required for data recovery
- Data recovery usually necessitates tissue removal or euthanasia of the marked animal
- Significant pain and/or risk of infection is associated with tissue removals for data recovery from live animals (e.g. tooth extractions)
- Not useful on a large scale, or for individual identification
- Limited value in field studies, as the equipment and procedures required to perform readings are sophisticated

Safeguards

- Adhere to the General Safeguards listed on page 13
- Select chemicals which are non-toxic and do not interfere with biological function
- Appropriate restraint, anaesthetic, anti-septic and measures of pain control must be used during stain administration and data recovery

- Use appropriate euthanasia techniques when required for data recovery
- Necropsy or tissue removal should be part of well-planned and co-ordinated research, to maximise the information gained from each study animal

Acceptability

- *Practicality*: Poor to moderate. Animals often have to be captured for staining, and recaptured for data recovery. In addition, data collection usually requires anaesthesia and tissue removal or euthanasia, and sophisticated procedures are often needed for interpreting results.
- *Biological and welfare acceptability*: Poor to moderate, even when all safeguards are followed. Data collection usually involves invasive tissue removal. Pain and the risk of infection associated with data recovery could be significant, and may have subsequent effects of behaviour and survivorship. Euthanasia, if required, removes the animal from the population.
- *Public perceptions*: Generally neutral or positive for vital staining itself. However, the public may view tissue removals from live animals and euthanasia of healthy animals for data recovery as unacceptable, even if it means gaining valuable information. This would be especially true for threatened species. If retrieval of stained tissues were incidental to euthanasia conducted for some other reason, it might then be perceived to be more acceptable.

NATURAL MARKING IDENTIFICATION

Although not technically a marking method, identification of animals by their natural markings is commonly used in wildlife biology, especially for those species that are difficult to mark artificially, or for populations that are threatened (e.g. some cetaceans) (Table 4). Characteristics which can be used to identify individuals include: sex and size of the animal; the colour, presence or absence, size, shape, location or configuration of particular marks or structures; idiosyncrasies such scars, deformities or behavioural oddities. Photographic records, sketches and coded descriptors are used to keep track of individual features.

Advances in digital and computer technologies are expected to improve both the objectivity and speed of natural marking identification.

Advantages

- Especially useful for small or contained populations under intensive study
- Non-invasive and does not cause pain
- Does not alter the appearance, behaviour or survivorship of the animal (except for effects of repeated capture and handling when necessary)
- Larger animals can often be identified at a distance, allowing researchers to follow individuals for long periods of time without disturbance
- Sub-groups identified by natural markings can be used as control groups to test the effects of artificial marking on animals

Disadvantages

- Identification is laborious, time-consuming and relies heavily on operator proficiency
- May require recapture and long handling times to identify individuals positively
- Many species lack distinguishing markings, or populations are large or widespread
- Natural marks may not be stable over the lifetime of the animal and may not be unique within the population
- The possibility of misidentification is high, as character assessment is open to observer bias and may be inconsistent over time

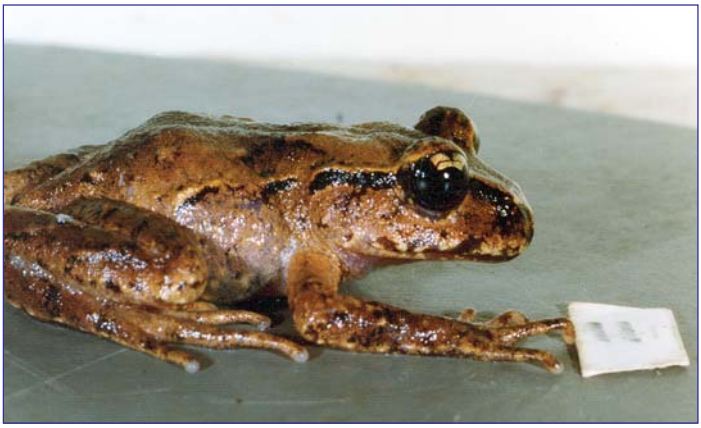
Safeguards

- Adhere to the General Safeguards listed on page 13
- Determine the amount of information and number of characters required to get reliable identification of individuals by running a sample trial

- Photographs can reduce handling times required for identification
- Minimise handling stress during any capture
- Oddities (e.g. scars) should be used only to supplement identification, as they may not be unique or stable
- Avoid using graded characters (e.g. shade of colour) as subjective judgement is likely to differ between observers
- For greater reliability, artificial marks may need to be used

Acceptability

- *Practicality*: Poor to moderate. Natural marking identification is usually laborious, time consuming and heavily influenced by observer bias, but may be the only suitable method for some species. Technological advances have made, and will continue to make, this method more practicable.
- *Biological and welfare acceptability*: Moderate to high, depending on whether animals can be identified at a distance, or if repeated recapture and handling are required. The method is non-invasive, does not change the appearance of the animal and does not alter behaviour or survivorship (except possibly with repeated capture and handling).
- *Public perceptions*: Generally positive, as the method is non-invasive, does not cause pain or alter the appearance, behaviour or survivorship of the animal. Repeated capture and long handling times may be perceived as mildly negative, but compared with more invasive marking methods, the public is likely to find this approach more acceptable.



Two Hamilton's frogs (*Leiopelma hamiltoni*) from the Frog Bank. Note difference in skin colour and pattern, particularly along upper lips.

PHOTOS: DON NEWMAN.

Concluding comments

Scientists have a responsibility to select the most appropriate marking method for the population under study, and weigh the benefits of the research against the method's associated harms to the individual animal, the population and the ecosystem. Each marking method has its own advantages and disadvantages. These relate to mark application, wearing of the mark and the procedures required for observing the mark. Wildlife managers or researchers who consider using a new marking method, or the application of an existing method to a new population, must first conduct an evaluation of the effects of the method. Application of the General Safeguards, together with those specific to each method, as outlined above, should help to maximise the benefits of marking programmes. Moreover, by following the advice given here, scientists and managers can demonstrate that they have adopted a responsible approach to wildlife marking, which will help to engender and retain public confidence in their activities.

Marking wildlife will always be subject to controversy as there are people who object to interfering with wildlife *per se* and others who object to inflicting pain or stress on any wild animal. In general, however, it is marking strategies that impact negatively on health, welfare, survival, reproductive success or behaviour of the individual, or disrupt population dynamics or ecological balance, that the public would find unacceptable. An informed public will be less likely to respond negatively to encounters with marked wildlife. Information about specific marking programmes should be prominently displayed or otherwise readily available where members of the public are likely to encounter marked animals.