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A practical guide to methods for attaching research devices to vultures and condors

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Cover image: Adult Bearded Vulture with satellite GPS transmitter (Shane Elliott).

A practical guide to methods for attaching research devices to vultures and condors

by

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AIMS AND SCOPE

Vulture News publishes original articles, reports, literature reviews and other material relevant to the field of vulture and condor biology, research and conservation from across the world.

BACKGROUND

The IUCN Vulture Specialist Group (VSG), part of the Species Survival Commission, is an international organisation devoted to Accipitrid and Cathartid vulture conservation, research and education.

The VSG was founded in 2011 and is made up of biologists, conservationists and people from other areas of expertise that work with or have an interest in vultures. The conservation philosophy is based on the concept that groups of concerned people can take a group of threatened species under their protection and assume responsibility for their survival.

Vulture News is the journal of the IUCN Vulture Specialist Group. It was originally the journal of the Vulture Study Group, which started in 1973 in southern Africa and became part of the Endangered Wildlife Trust's Birds of Prey Programme.

Vulture News has been in print since 1979 and is published biannually, open access. It is a venue for publishing research, news, information and reports on vultures in all parts of the word where they occur. Contributions from ornithologists, research biologists, bird watchers, conservationists and any other interested people are encouraged.

This guide is the first technical publication from the IUCN VSG and *Vulture News*

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Several representatives of companies that make or supply research devices and tags attended the technical workshop. They exhibited their devices and also contributed usefully to discussions on technical matters.

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We are very grateful for the funding that made this workshop possible. Two main grants were made early on, which allowed us to proceed: one from the IUCN Species Survival Commission, thanks to the generous support of the Environment Agency - Abu Dhabi, and hosted by Global Wildlife Conservation, and a second from the RSPB's Asian Vulture Programme. Commitment to host the workshop and invaluable in-kind and logistical support came from the Director and staff of ICBP. The following equipment suppliers, who attended the workshop, provided valuable additional funding: *Microwave Telemetry, Lotek UK, Pathtrack, Ornitela, Ecotone, Cellular Tracking Technologies.*

Contents

Introduction

Jemima Parry-Jones, Chris Bowden & Rhys Green

Most species of Old and New World Vultures are globally threatened and accurate scientific studies related to their conservation are therefore essential. The range of available tracking and telemetry devices is becoming wider and they are performing more tasks better, as well as becoming more affordable. These changes open up opportunities to a wider community of researchers, but some of these will initially be inexperienced. Research groups on five continents have attached tracking and telemetry devices to vultures and condors using several methods, including thoracic and pelvic harnesses of various designs and patagial tags. The development of attachment techniques has mostly been conducted independently by a dispersed network of experts and rather little information has been documented and published about the relative advantages and safety of different techniques. The international conservation consortium SAVE (Saving Asia's Vultures from Extinction) has identified a growing need to monitor the success of population recovery efforts by safely tagging more Gyps vultures in Asia (SAVE 2020). In addition, the IUCN Vulture Specialist Group (VSG), the Raptors MoU Raptor TAG and others had independently recognised an urgent need to identify and disseminate expertise (CMS Raptors MoU 2018). To address these needs, and under the auspices of the VSG, we invited globally-recognised experts to participate in a three-day practical workshop at the International Centre for Birds of Prey, in Newent, United Kingdom, in August 2019. The key aims were to compare and document the various current attachment methods and to discuss ways to make the information available for wider use. At present, there is remarkably little published information of this kind with adequate practical detail, so accessible documentation of practical aspects would be an important step forward.

Tracking, using Platform Transmitter Terminal (PTTs), GPS-PTTs and GPS-GSM tags, contributes both to basic and applied research and conservation, such as the identification and monitoring of threats, exposure to spent lead ammunition and veterinary non-steroidal anti-inflammatory drugs (NSAIDs), deliberate poisoning, retaliatory poisoning directed at other species, electrocution on power infrastructure and collisions with wind turbines and power transmission lines. Tracking also allows nesting, roosting and foraging areas to be mapped and more appropriately managed. In addition, data from accelerometers and other sensors can be used to assess energetics, the speed and height of flight and the risk of collisions with man-made structures.

Deploying these devices is therefore of great potential value for conservation, and science. Researchers hope and intend that attaching them does not affect the birds' welfare or the aspects of survival, breeding success and behaviour they are trying to measure. However, it must always be remembered that placing any device on a living bird must run some risk of negative effects on its welfare, survival and breeding (Bodey et al. 2018). Hence, there should always be a good scientific or conservation reason for tagging birds. The new technology available allows many more detailed questions to be addressed as each year goes by, but everyone tagging birds should ask themselves whether it is justified if there is a risk to the individual birds or their conservation status and a danger that the data collected are biased and misleading because of undetected adverse effects.

So far, few robust comparative studies have attempted to quantify such effects for any bird

species, and we know of none for vultures and condors. For raptors, the comparative study by Sergio et al. (2015) of Black Kites *Milvus migrans* with and without harness-mounted satellite tags weighing 4% of body weight is the most thorough research of this kind that we know of. Although this study detected no adverse effects of the tags on the demographic rates of kites, it would be unwise to assume that this is the case for all species, devices and attachment methods.

We wish to encourage future comparative studies of vultures and condors, as well as large eagles, with and without devices to quantify any adverse effects, but we recognise that rigorous statistical comparisons between matched samples of birds with and without devices, like that of Sergio et al. (2015) on kites, are technically difficult and need to be long-term. It is therefore not possible at present to use studies of this type to establish whether any of the wide array of device attachment methods in use on vultures and condors offer significant advantages over others in minimising the risk of adverse effects. However, a more easily-achieved, short-term objective is to bring researchers together to make detailed descriptions of the methods they use for device attachment, to share expertise and to identify, document and disseminate good practice. That is the aim of this ***Practical guide to methods for attaching research devices to vultures and condors***. The guide is the result of the workshop held at the International Centre for Birds of Prey in August 2019.

Our experience of the effects of research interventions on wild birds is that much depends upon the details of the methods and equipment used and especially upon the skill and experience of the researchers. However, different groups of researchers rarely get the opportunity to study the details of alternative methods to their own, used by others, and to question them about the reasons behind differences in the selection of materials and methods. The brief Methods sections of published scientific papers are no substitute for such detailed discussions. The three-day ***Global Workshop on Methods for Attaching Tracking Devices to Vultures and Condors*** attracted tag attachment experts from around the world who demonstrated their materials and methods to each other by deploying real and dummy tags on live captive vultures and on stored bodies of dead birds. The demonstrations were recorded through images, videos and notes and later turned into illustrated step-by-step guides showing how to build and prepare harnesses and how to attach them to the bird. Demonstrations were monitored by experienced veterinarians, who made observations and measurements to assess the level of stress during handling. In addition, Neil Forbes, a veterinarian with long experience of birds of prey, gave a presentation on steps that can be taken to minimise adverse effects during the fitting of harness-mounted tags. Professor Rory Wilson (Swansea University, UK) gave a detailed presentation to the workshop participants about the evidence that all devices, large and small, and their attachment methods have effects on the energetic costs of locomotion of flying birds and therefore potentially on their fitness. An article based upon his presentation is not included in this guide because it is relevant to studies of all species of flying birds, not just vultures and condors. We hope that this work will soon be published in a widely-read scientific journal.

The guide includes a proposed classification of the principal methods used to attach devices to vultures and condors, including some that we do not yet have detailed descriptions for. There is a set of recommendations on how to handle and monitor birds during the deployment of devices in such a way as to minimise the risk of adverse effects. Then there are seven step-by-step guides to the preparation and fitting of devices, each of which was contributed by a different group of researchers.

This is the first workshop held under the auspices of the IUCN Vulture Specialist Group, and we hope more will follow. We hope that researchers studying vultures and condors will make good use of this guide and study its recommendations carefully. There is no substitute for practical demonstration and training by experts in this field, and we should emphasise that studying this document in itself will not be a substitute, but rather a reference point for further development. Equipment and know-how will continue to develop, so we feel sure that this guide and others should receive feedback and develop over time through revision and the addition of new methods.

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Health, stress and welfare aspects of fitting research devices to vultures and condors

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The following principles should guide the fitting of research devices to vultures and condors. First, do no harm and second – trap, catch, restrain and fit tags / transponders in a 'welfare sound manner' in order to gain accurate research data in an ethical way

Operators may feel reassured that they have not observed any obvious signs of distress during the deployment of research devices, but even slight stress can result in suppression of the immune system, which will then render the bird more susceptible to infections, in particular viral or fungal (e.g. *Aspergillus* spp.) infections, which are at best debilitating and frequently fatal, with the effects often not being seen until 4-6 weeks later. Avoiding or minimising stress is therefore vitally important.

Birds do not sweat and heat loss by panting is limited, especially if the head is restrained, covered or hooded. The normal core body temperature of birds is 40-41^{o}C (104–111.2^{o}F). An increase of 4^{o}C (7^{o}F) to a bird's core body temperature is inevitably fatal.

The duration of the procedure, macro- and micro-environmental ambient temperature, restraint and management, time of day and use of restraint boxes to hold birds in, all have a bearing and must be correctly managed and monitored.

Operators should not deploy devices on birds, unless they can be confident of completing the task (catch to release) within 15 minutes. Preparing everything in advance is essential. Practice on soft toys followed by cadavers is essential prior to harnessing live birds.

Planning should include ensuring that the procedure is carried out at a cool time of year or day. Harnessing at temperatures over 26^{o}C carries significant risk and should not be conducted if over 30^{o}C. When trapping, netting or catching a number of birds to harness, any birds awaiting harnessing must be kept in a cool environment pending harnessing. Being enclosed in carrier boxes with no internal ventilation results in the bird heating up rapidly, even when in the shade. During device fitting application, the bird must never be laid on a hot or warm surface, (e.g. on your lap, against your chest or on a warm table or rock), cool bag frozen blocks, or self cooling gel filled pads for dog beds[a], can be very useful, but you must be careful to avoid perforating the gel pads.

Monitoring during device deployment

One member of the team must be delegated the task of observing throughout the procedure for any signs of distress; collapse (abnormal respiratory sounds, reactions, nervous signs (e.g. tremors, shaking etc.)), gasping, breathing more deeply, change in vocalisation, becoming limp, feet feeling or measuring hot. That person must have the power to abort the procedure at any point.

It is useful and important to keep monitoring the bird's temperature. The most accurate method is to use a cloacal probe, but this must be soft (such that internal trauma is impossible) and the readout must be remote from the body. Some inexpensive types of digital indoor thermometer/hygrometer with a probe sensor can be used[b]. Alternatively, one can use a remote infrared laser thermometer[c] to record the skin temperature of the feet. Do not measure facial temperature for fear of laser damage to the retina. Temperature should be checked every 10 minutes, increasing to every 5 minutes if it has already increased by 2^{o}C or 3.5^{o}F). **If core body**

temperature increases by 3.5ºC or 6ºF, or skin temperature increases by 4ºC or 7ºF, the procedure must be aborted immediately and restraint of the bird released as soon as possible. The body skin, feet, face and neck can be cooled by wetting with water. As the water evaporates, the body will cool.

Impaired breathing

Overheating apart, birds do not have a diaphragm, as such, greater care must be taken not to compromise their breathing. A bird should never be kept on its back as this will result in a 10-60% reduction in tidal volume. Care must be taken not to squash or constrict the trachea when restraining the head. No jacket or cloth should be wrapped tight around the body and no operator or assistant should restrict respiration by holding around the chest.

To hood or not to hood?

Keeping a bird in the dark by hooding or using a lightweight dark cloth around the head, will generally keep a diurnal bird calmer, however great care must be taken to ensure that if a bird regurgitates, there is no risk of aspiration into the air sacs or lungs. Therefore any hood applied should be loose-fitting, facilitating good beak opening and unhindered regurgitation. Whilst hooding does reduce heart and respiratory rate, it does not reduce increases in body temperature. It is also important to appreciate that hooding does impair visual monitoring for signs of distress by the operator.

Safety considerations when mounting research devices on the wing

Most of the methods used to attach research devices to vultures and condors do not involve any piercing of the birds' tissues. However, the attachment of coloured plastic or fabric tags bearing alphanumeric characters, without a device, to the wing with a pin or peg through the propatagium is a widely-used method for marking vultures and condors as individuals. The propatagium is an elastic membrane extending between the shoulder and carpus. It forms the leading edge of the wing and is vital for aerodynamics required for flight. This region is not simply skin, but contains vital tendons and ligaments, with feather follicles and blood vessels distributed throughout. It is possible to visualise and feel the locations of feather follicles and blood vessels if surgical alcohol is applied to the ventral aspect of the propatagium. Misplacement of the tag can and does cause damage to the vital structures resulting in crippling injuries, grounding and loss of life if the bird is not rescued.

This problem has been documented in a recent review of eight grounded and failed long-term released rehabilitated *Gyps* vultures marked with identification tags which had been positioned incorrectly (Hirschauer *et al.* 2019). Dissection of vulture cadavers revealed the vital structures which must be avoided during propatagial wing tag placement. Figure A.1 shows the location and dimensions of the safe area of the propatagium of the Cape Vulture *Gyps coprotheres* within which the pin or peg of the tag and any washer should be placed. The structures to be avoided are the same in other vulture species, but the dimensions of the safe area and its margins would need to be adjusted to allow for differences in body size. Hirschauer *et al.* (2019) found that placement of the pin or peg of the tag outside the safe area in any direction would cause injury. These recommendations have been determined for identification tags without research devices, but tracking devices weighing up to 73g have also been attached to the propatagium of *Gyps* vultures and condors (see Gilbert *et al.* (2007) and Method 6 of this guide). The same safety

considerations for the placement of the pin or peg also apply to such deployments (Figure A.1).

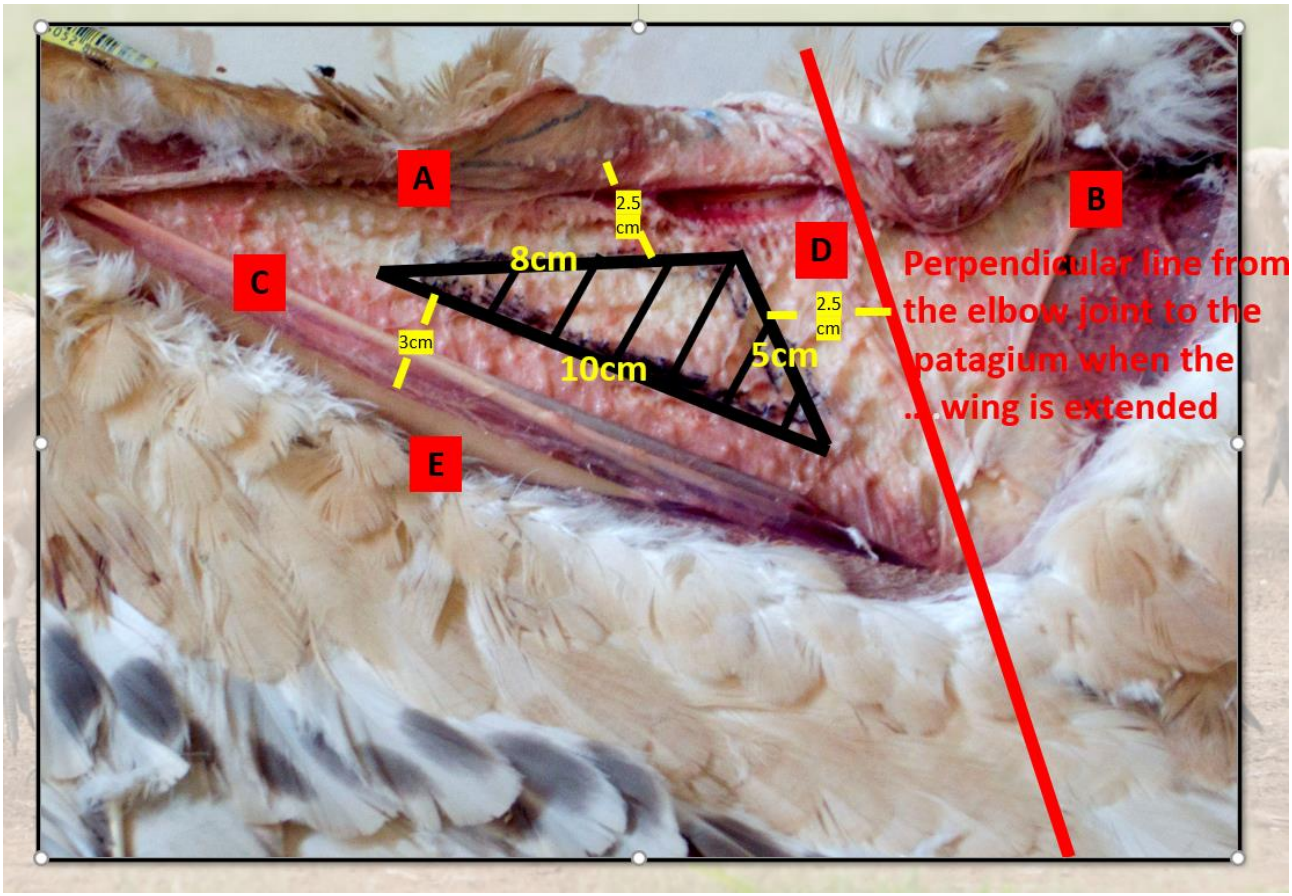

Figure A1: Ventral view of the safe area for wing tag placement in the Cape vulture. The underside of the extended right wing is shown with the proximal (closest to body) part of the wing on the right. The red line is perpendicular to the extended wing and extends from the elbow joint (bottom of photo) to the bend in the leading edge of the propatagium (top of photo). The triangular safe area for insertion of the pin or peg of a propatagial tag is shown by the black outline and hatching. The safe area commences 2.5 cm distal (towards the carpus) from the red line. The cranial limitation of the safe area is 2.5 cm caudal to (behind) the leading edge of the wing, and the caudal extremity of the safe area is 3 cm cranial to (in front of) the radius. Important structures to be avoided are marked by the letters in red boxes: (A) *Ligamentum propatagialis pars longus*, (B) *Ligamentum propatagialis pars brevis*, (C) *M. extensor carpi radialis* (running in parallel to the radius and ulna bones) (D) *Ligamentum limitans cubiti*, and (E) radius (bone).

On completion of device fitting

If it is possible to observe the bird in a confined area (e.g. travel box) on completion of harnessing to ensure the bird can stand, walk freely and appears clinically normal, this is advisable. Any bird whose procedure has extended beyond 20 minutes, whose core body temperature has increased above 44°C (111°F), who looks distressed, is not behaving normally, who is breathing faster than normal, whose eyes are lemon shaped and sleepy rather than round and bright, should have oral fluid therapy

administered, so long as the operator is suitably experienced and equipped to administer such. Fluids should be administered at a rate of 20ml/kg body weight, taking great care to administer into the oesophagus and not the trachea, using one of several suitable syringes, a metal 12-6g metal feeding tube, or a 6-10mm diameter plastic tube (so long as a wooden or plastic gag is used to prevent this from being chewed off. Glucose saline or Lactated Ringers solution should be administered which are available as concentrated solutions to dilute, as powders to dissolve or as ready to use fluid bags.

Take-home points:

(1) Placing the bird's head in the dark may assist.
(2) Minimising abnormal sounds/noise whilst birds are close to us.
(3) Prepare everything well in advance.
(4) Minimise duration of boxing, restraint and handling.
(5) Be confident and quick when catching a bird.
(6) Minimise the risk of overheating, if it is unavoidable consider the involvement of a vet and sedation for the bird (which does reduce overheating) – always reverse sedation prior to release.
(7) Be aware of and monitor for effects of stress or collapse (abnormal sounds, reactions, nervous signs, gasping, breathing more deeply, change in vocalisation, becoming limp, feet feeling or measuring hot).
(8) Avoid harnessing in hot conditions (>30^{o}C, >86^{o}F).
(9) Practice (e.g. on a dead bird) several times beforehand so your technique is as quick and skilled as possible.
(10) Restrain the bird correctly to avoid causing respiratory distress or overheating.
(11) Monitor the bird's temperature. Record the temperature each time. If the temperature goes up more than the specified amount, spray feet, face and crop with water or abort the procedure.
(12) When the harness is on, you should put the bird in a box and watch it through a hole to check that it stands and walks normally.
(13) All operators should carry with them a suitable first aid kit and be equipped and be experienced in administering oral fluid therapy if relevant, prior to release of the bird.

Products mentioned

[a]XIAPIA Cooling Mat for Dogs Large Gel Pet Cool Mat Self Cool Pad Waterproof and Scratch Resistant for Dogs and Cats:
https://tinyurl.com/y43qogep

[b] Digital Indoor Thermometer/Hygrometer:
https://tinyurl.com/y42waw5r

[c]Etekcity Lasergrip 774 Non-contact Digital Laser IR Infrared Thermometer: https://www.amazon.co.uk/dp/B01AT9TM3M?tag=celheal-21

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A classification of methods used to attach devices to vultures and condors

Mary Davies & Rhys Green

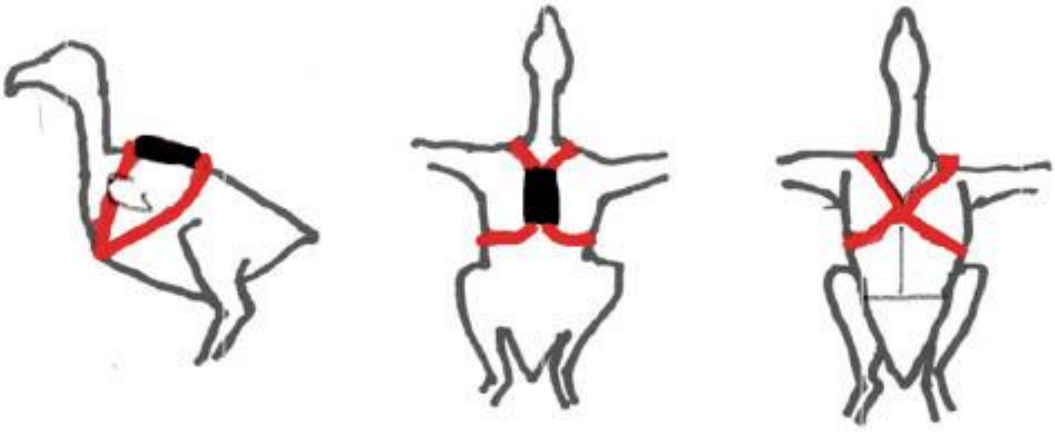
There are many publications about the results obtained from deploying tracking and telemetry devices on vultures and condors, but only a few provide precise details of the design of the attachment apparatus used. Frequently, reference is made to a generic publication about the type of attachment method used, such as the much-cited publications by Kenward (2001) and Rappole & Tipton (1991) about particular designs, but enquiries we have made to authors often reveal that they made several modifications, or even used a completely different design from that described in the cited publication. Hence, we suggest that there are actually more types of attachment than one might think from reading the scientific literature. For this reason, we asked all expert participants in the technical workshop held at the International Centre for Birds of Prey at Newent, UK, on 20-22 August 2019, to contribute information on attachment methods they had used or knew about. These were summarised in the series of diagrams, showing 12 different attachment types, presented below. We do not know of any widely accepted classification or terminology for attachment designs. Terms such as "backpack" and "wing-loop harness" are often used in Methods texts, but authors frequently mean quite different things by them. We suggest some names for different attachment designs below and propose them as a first step towards a standardised terminology. We would welcome corrections, revisions and additions to this prototype. We do not intend, by suggesting this classification, to endorse or approve any of these designs; only to define what they are and what to call them.

Although our classification identified 12 types of attachment method, the experts present at the ***Global Workshop on Methods for Attaching Tracking Devices to Vultures and Condors*** demonstrated just three of these broad classes; the thoracic X-strap harness, the leg loop harness and the patagial mount. However, we were struck by the differences between groups of researchers in the details of the construction and fitting of harnesses of the same broad type. Hence, the following practical step-by-step guides describe three variants of the thoracic X-strap harness and three variants of the leg loop harness and one version of the patagial mount.

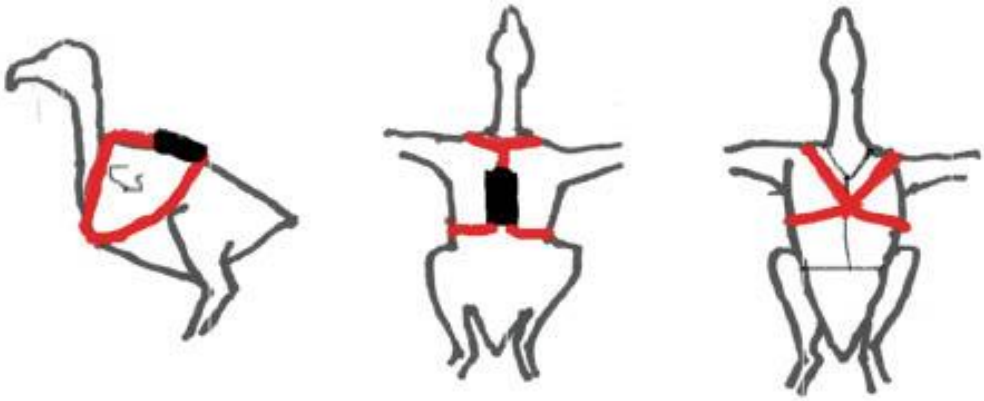
Figure B.1 shows diagrams of 12 attachment designs used for research devices deployed on Vultures and Condors.

Lateral ***Dorsal*** ***Ventral***

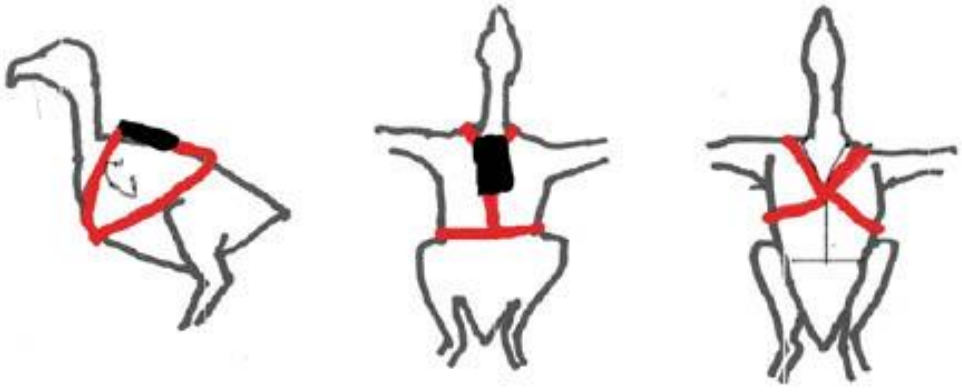
1. **Thoracic (X-strap)**



2. **Thoracic (X-strap with forward strap)**

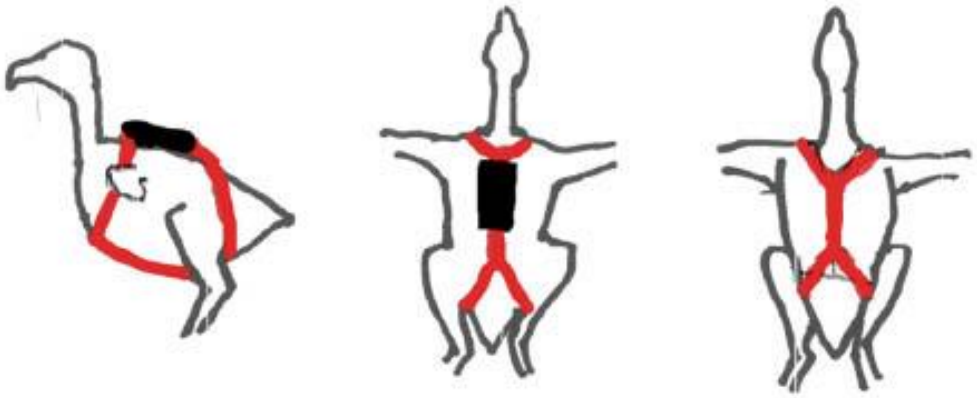


3. **Thoracic (X-strap with back strap)**

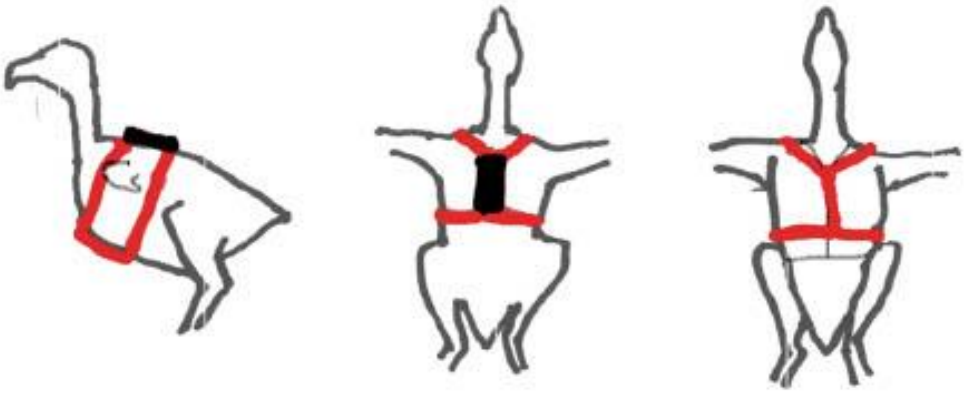


Lateral ***Dorsal*** ***Ventral***

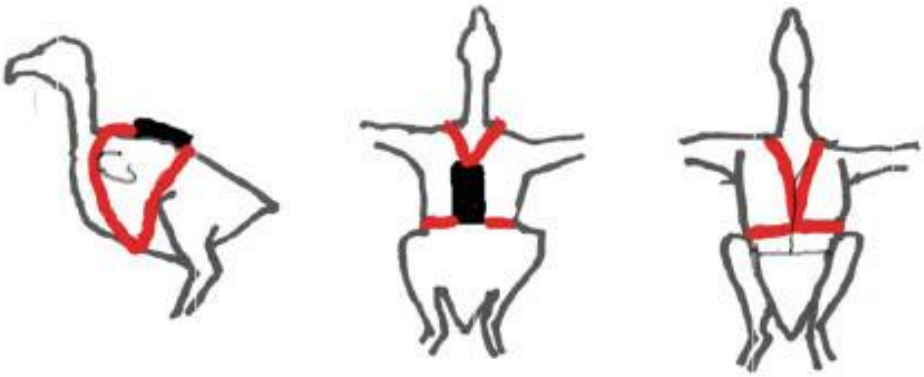
4. **Thoracic (parachute)**



5. **Thoracic (breast strap)**

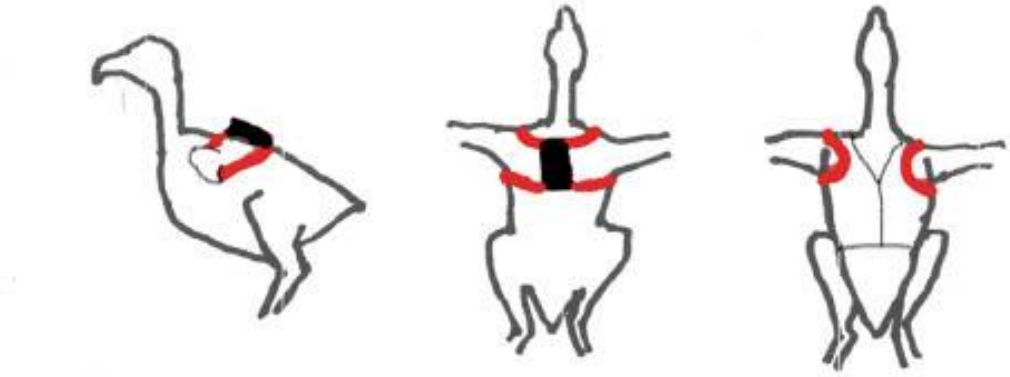


6. **Thoracic (belt-style strap)**

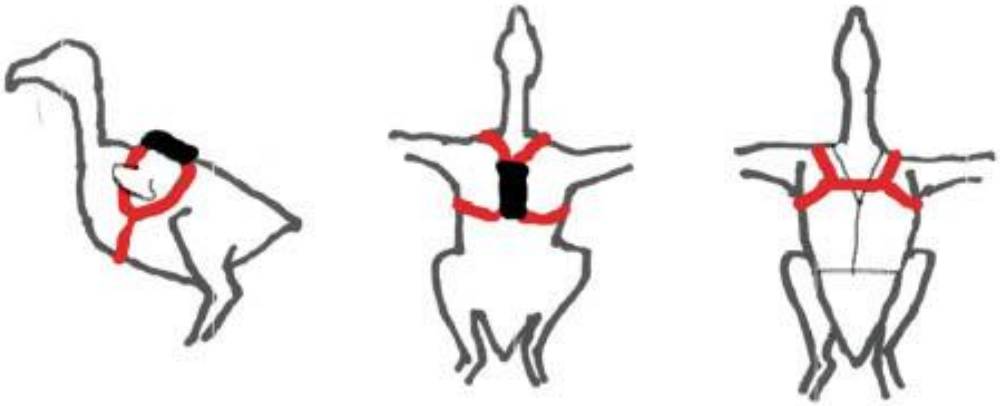


Lateral ***Dorsal*** ***Ventral***

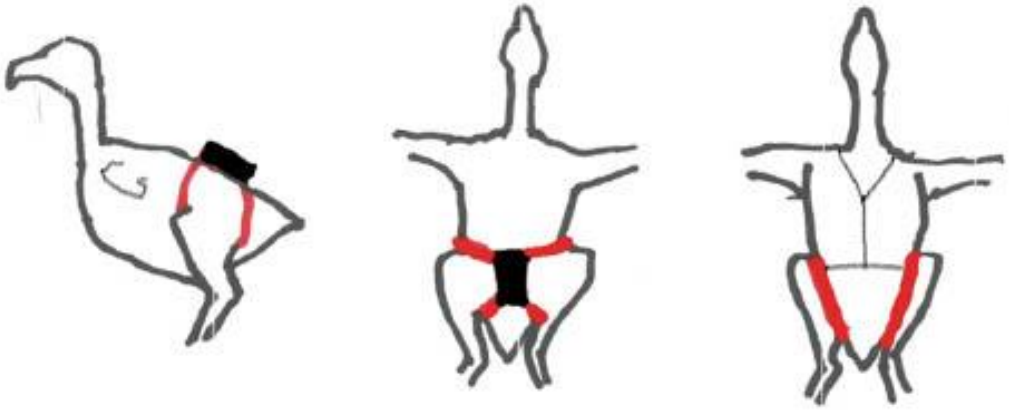
7. **Wing loop**



8. **Wing loop (breast strap)**



9. **Leg loop**



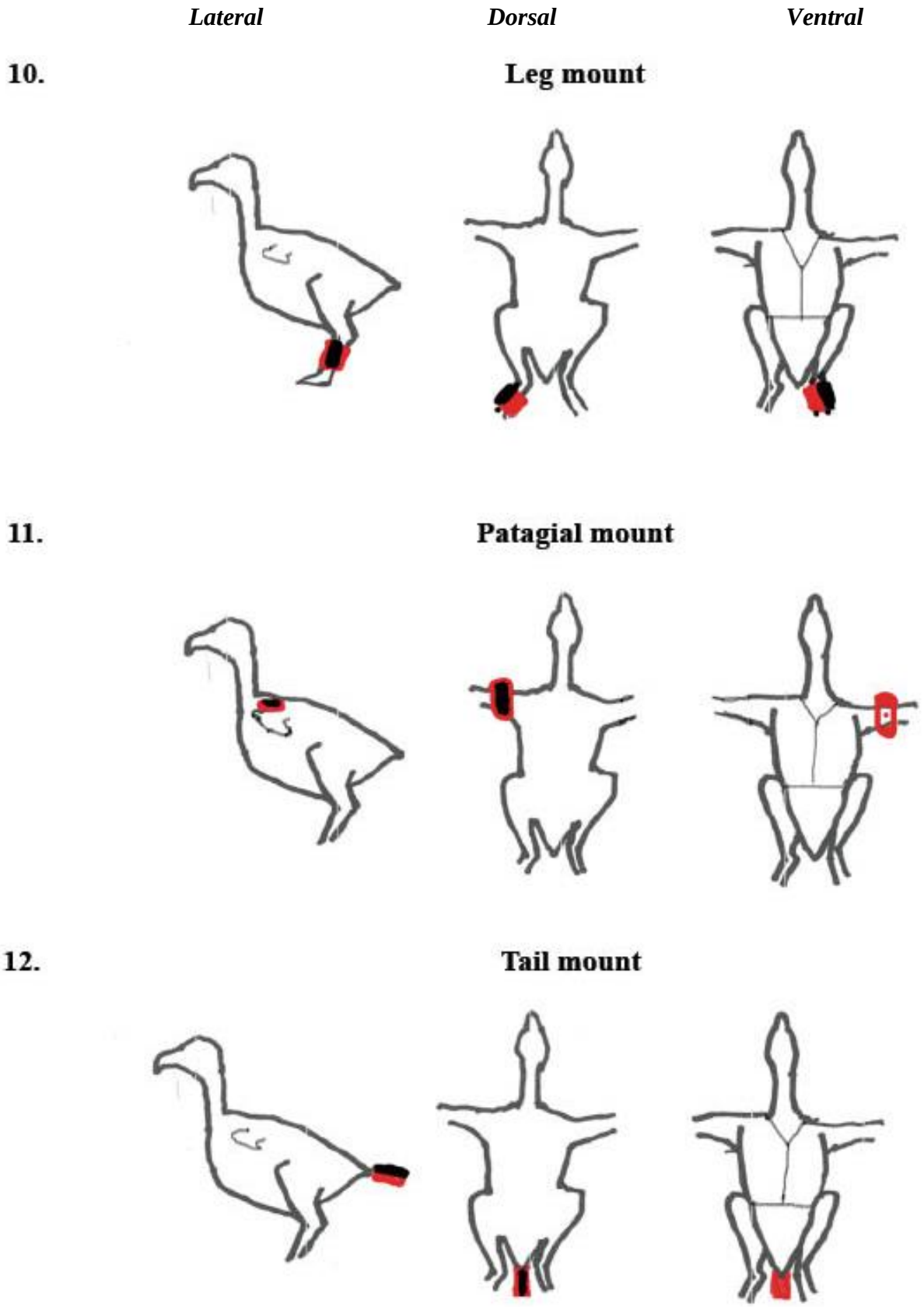


Figure B.1. Diagrams showing 12 designs of attachments used for research devices deployed on Vultures and Condors.

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Thoracic X-Strap Harness. Design and Method 1

Keith Bildstein, André Botha & Sergio A. Lambertucci

Tracking devices made by the following manufacturers have been fitted using this harnessing method: Ornitela, Ecotone, Microwave Telemetry, Wildlife Computers, North Star, MadebyTheo, Gpscollars (UK), Wildfind, Cellular Tracking Technology (CTT) and Vektortek LLC. Devices have been fitted using this harness design and method to the following species: African White-backed Vulture *Gyps africanus*, Lappet-faced Vulture *Torgos tracheliotos,* White-headed Vulture *Trigonoceps occipitalis,* Egyptian Vulture *Neophron percnopterus*, Hooded Vulture *Necrosyrtes monachus,* Cape Vulture *Gyps coprotheres,* Rüppell's Vulture *Gyps rueppelli,* White-rumped Vulture *Gyps bengalensis,* Turkey Vulture *Cathartes aura,* Black Vulture *Coragyps atratus,* Andean Condor *Vultur gryphus,* Striated Caracara *Phalcoboenus australis,* Martial Eagle *Polemaetus bellicosus,* Wahlberg's Eagle *Hieraeetus wahlbergi,* Lesser Spotted Eagle *Clanga pomarina,* Secretarybird *Sagittarius serpentarius,* African Grass Owl *Tyto capensis,* Lesser Flamingo *Phoencopterus minor,* Marabou Stork *Leptoptilos crumeniferus,* Saddle-billed Stork *Ephippiorhynchus senegalensis,* Southern Ground Hornbill *Bucorvus leadbeateri.*

Equipment needed

- Teflon ribbon: 11.2 mm/0.44" wide (*Gyps*, Lappet-faced- and White-headed Vultures, Andean Condor); 8.4mm/0.33" wide (Egyptian, Hooded and Turkey Vulture).
- Leather hub cross-pad perforated to size. Alternatively, it can be replaced by a flat knot tied in the Teflon.
- Scissors
- Clamp scissors
- Ringing or normal fencing pliers
- Stainless steel clamps
- Superglue
- Ruler/Measuring tape
- Neoprene pad
- Neoprene glue

The attachment harness must be prepared in advance.

Measurements and preparations: Key stages/steps

The length of Teflon ribbon will depend on the target species:

- Hooded Vulture and similar-sized species – 120 cm
- *Gyps* Vultures – varies from 150-180 cm
- Lappet-faced Vulture – 170-190 cm
- Andean Condors 150-180 cm
- Turkey and Black Vultures 110-130 cm

We recommend that measurements are taken before the harness is assembled if you are not familiar with the species. The Teflon ribbon is then cut accordingly.

1) There are two possible initial preparation methods, depending on the type of device used.
   a) If the device has two attachment lugs at the front and two at the back;
      i. the Teflon ribbon can be cut into two equal lengths and attached to the two front lugs by tying them to each lug with a sturdy knot and then securing the knot with a stainless steel clamp which is pressed flat
      ii. alternatively, the ribbon can be threaded through the two front lugs and then be knotted at the front of the device with the knot being secured with a stainless steel clamp as described above.
   b) If the device has one attachment lug at the front and two at the back, follow the same procedure as in point ii above. Ensure that the ribbon is at equal lengths before tying and securing the knot in the front.

2) Knots can be further secured by stitching through each knot using a needle and Kevlar thread or dental floss. Tie a knot in the thread. Start sewing from the top downwards (towards the bird's body) so that the Kevlar knot sits on top. Sew five stitches into each knot. Then wrap the end thread around the needle three times to pull into a knot. Cut off the ends of thread.
3) Apply superglue to the outward facing Kevlar/ribbon knots. This will help to keep the knot secure and to smooth down the edges.
4) If not already fitted to the underside of the device, neoprene padding should be glued to the device using neoprene glue to provide a soft base which will rest on the bird's back. Draw around the tag and cut the padding to fit (making sure you include a wider area to pad the undersides of the lugs and knots). Other than these wider parts of the neoprene under the lugs, the pad should fit the outline of the tag closely so that it does not fray or have excess areas of neoprene that the bird can pull at.

Fitting the leather-hub

A leather-hub pre-cut to size through which the Teflon ribbon is threaded will enable easier fitting and adjustment of the harness before it is secured to the bird. The leather-hub can be cut from suitable soft leather in advance using a sharp chisel or crafts knife. Slit lengths should match the width of ribbon used and cut as can be seen in Figs. 1.1 & 1.2. Each length of the ribbon is threaded through opposing slits on the hub. Ensure that the ribbon is flat and the there are no kinks/folds along its entire length after threading both ends through the hub.

Figure 1.1: Teflon ribbon threaded through the slits cut in the soft leather-hub. The end facing the camera should rest on the bird's sternum when fitted.

Figure 1.2: Teflon ribbon threaded through the slits cut in the soft leather-hub.

If material for the manufacture of the leather-hub is not available, a flat knot can also be tied at the appropriate length of the Teflon ribbon so that it lies on the prescribed area on the sternum of the bird. Care must be taken that both lengths of ribbon extending from the front lug/s are of equal length once the knot is tied to ensure that the harness fits properly.

Restraint and hooding

A minimum of two people (or three for larger species as Lappet-faced Vulture and Condors) should be used to restrain and hold the bird during the fitting of the harness, especially when working with larger species. One person should hold the head of the bird with one hand and use the other to manage the wings during fitting (Fig. 1.3). With larger species one person holds the head, another the wings and the third the legs, so that the person that will tag the bird is safe and can work well (Fig. 1.4). The head should be held firmly from behind with the thumb and forefinger placed under the jawbone where it meets the skull on either side to prevent the bird from moving/turning its head and biting the handlers, but allowing the bird to breathe freely and regurgitate if it wants to. The bird's head should be kept near the edge of the platform on which the bird is processed so that any regurgitation can fall on the ground or in a container placed on the ground for this purpose. Regurgitation should be safely disposed of after fitting and release of the bird.

A second person can hold the legs and feet of the bird which should lie on a table on its sternum (or if there is an extra person, they can hold them separately). The bird will need to be lifted about 20 cm from the table when the harness and leather cross-pad is fitted. This will be easier with two-three individuals holding and handling the bird. A third/fourth person will be responsible for fitting

the harness and completing any other procedures required by the relevant protocol/study.

Figure. 1.3: Two handlers holding the bird as prescribed after the head-covering has been removed just prior to the release of the bird. Note the blanket covering the surface that the bird is resting on.

Figure 1.4: Three handlers holding the bird as prescribed for a large species such as Condors (particularly juvenile males which struggle most of the time). The fourth person tags the bird. Note the knot is located in the chest, just over the beginning of the keel. (Photo: Jorgelina Guido).

In order to keep the bird calm while restrained, a loose material tube (or a sock with the toes cut off) can be used to cover the head. A hole in the end is needed so that the bird will not choke if it regurgitates food whilst hooded. Alternatively, a small towel can be placed over the bird's head to cover it while still allowing for regurgitation. The temperature should be controlled since the head covered may increase the body temperature, in that case avoid covering it.

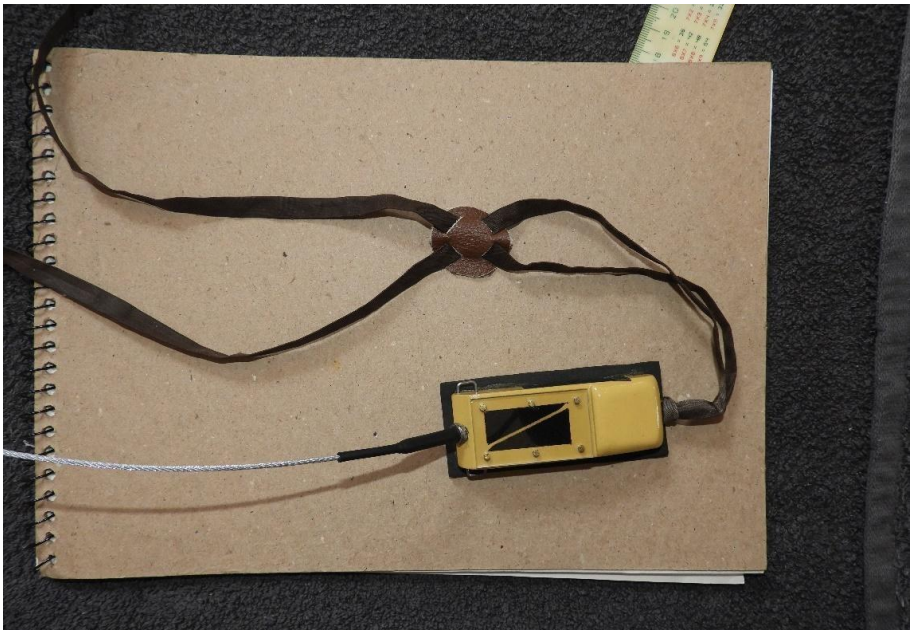

Figure 1.5: Harness fitted to a Microwave PTT without stainless steel clamps fitted.

Figure 1.6: Tracking device positioned on the bird's back with Teflon strap in the foreground being held on the back lug with clamp scissors while the second strap is threaded through the lug on the opposite side of the device.

Fitting to the bird

1) Pull the harness over the bird's head with the straps attached to the front lug or lugs passing either side of the head and with the leather-hub hanging below the neck. In the case you do use a flat knot instead of the leather-hub, pass the tied Teflon around the neck (see Fig. 1.4).
2) The device should be positioned on the back in the position where it will lie. One of the handlers can place a finger on the device to keep it in position while the straps and leather-hub or the flat knot are placed in position.
3) Front straps should be run along the two clavicular depressions on either side of the bird's neck and fed over the shoulders.
4) The bird should then be lifted at least 20 cm and the leather-hub positioned on the apex of the sternum at least 4-5 cm from the top thereof. The straps that extend beyond the leather-hub can then be spread out on either side of the bird and the bird can be placed back on the table.
5) The straps can then be pulled along either side of the bird and up onto the back while making sure that the straps run along the sides above the thighs onto the back, ensuring that no secondary or tertial feathers are trapped behind the strap.

6) Before the straps are thread through the rear lugs on the device, thread each strap through a single stainless-steel clamp.
7) Then thread the two straps through each of the lugs at the back of the device and pull them tight to allow for a comfortable fit. Clamp scissors can be used to hold the straps together on either side until all adjustments have been made and the device is positioned properly.
8) Before fastening the straps at the rear, check the position of the unit on the back to ensure that it is positioned in the middle of the back, that the straps fitting over the bird's shoulders are tight enough to prevent the harness slipping out of the clavicular-channel on either side, the position of the leather-hub on the sternum and that no flight feathers are trapped behind the straps. Also ensure that the are no folds in the Teflon ribbon and that it lies flat against the bird's body with no distortion of the body coverts.
9) The harness should not be too tight-fitting. A good rule of thumb before fastening the harness is to check that it allows enough room for the bird to breathe freely and to compensate for possible increase in weight by making sure that you can fit two fingers under the unit.
10) Leaving the clamp scissors in place on either side at the back, a sturdy knot can be tied securing the straps to each of the lugs at the back of the harness. Once this has been done, the clamp scissors can be removed.
11) Check the fit of the harness again after the knots have been tied to the rear lugs to ensure that it still is fitting properly. If not, loosen the knots, re-position the harness and fasten again.
12) Knots can then be further secured by stitching through each knot using a needle and Kevlar thread or dental floss. Tie a knot in the thread. Start sewing from the top downwards (towards the bird's body) so that the Kevlar knot sits on top. Sew five stitches into each knot. Then wrap the end thread around the needle three times to pull into a knot. Cut off the ends of thread.
13) The tip of the straps can then be thread through the stainless-steel clamp on either side and the clamp can be pulled over the knot before being clamped shut using the pliers. Ensure that the clamps are flattened properly and sit properly over the knots to prevent them from being tampered with or loosed by the bird.
14) Cut any remaining length of the Teflon ribbon off against either knot at the back and use Superglue to ensure that any exposed end of the ribbon is prevented from fraying.
15) Check the harness and device again. Once satisfied, you can proceed with other procedures such as ringing, collection of biometric and moult data and collection of relevant samples before the bird is released.

Figure 1.7: Microwave PTT fitted to an African White-backed Vulture. In this instance, the Teflon straps were attached separately to the lugs at the front of the device.

Figure 1.8: Cellular Tracking GPS fitted to an immature Andean Condor. In this instance, the Teflon was attached to the front of the device with a knot in the middle hole.

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Thoracic X-Strap Harness. Design and Method 2

Duncan Orr-Ewing, David Anderson & Ewan Weston.

This method has been used on Golden Eagles *Aquila chrysaetos* and White-tailed Eagles *Haliaeetus albicilla* in Scotland and on *Gyps* vultures in Asia.

Equipment needed:

- Ornitela or Microwave Telemetry 30g satellite tag
- Teflon ribbon: 11.2 mm wide (0.44")
- Silicone tubing four pieces, 3 mm width, 110 mm length
- Prepared circular breast template made from a PVC milk bottle or similar material
- Linen thread (Hemline or similar, available from Amazon)
- Surgical clamps (UK NHS or similar), bulldog clips
- Small sharp scissors
- Curved needles (available from Amazon)
- Superglue/leather glue (Bostik)
- Neoprene foam material (available on Amazon)
- Marker pen

The satellite tag and harness is largely prepared in advance.

Figure 2.1: Equipment and materials.

Measurements and preparations: Key stages/steps

1) Take two pieces of Teflon ribbon. Cut lengths (for White-rumped Vulture- 660 mm for the back ribbon and 620 mm for the front ribbon).

2) For Ornitela or Microwave Telemetry 30g tags, pass 620 mm ribbon through the front attachment lug at the front of the device using clamps to pull through as required. Tie a simple loop knot at the centre and over the lug making sure the loose strands are of equal length. Knot can be lightly superglued as required. Ornitela tag requires attachment of neoprene foam base using leather glue (Bostik). The surface area of the neoprene base should be wide enough to cover whole tag including lugs.

3) Take 660 mm ribbon and pass through the two attachment lugs at the back of the device tying a loop knot in each and passing ribbon either under or around the back of the tag, checking that the two strands are of equal length. No sewing needed for these knots, however knot can also be lightly superglued as required.

4) Cut four pieces of hollow silicone tubing to 110 mm lengths and cover in talcum powder to help push them into tubular Teflon ribbon. Tubing stays in place in tag although does not pass through lug and is short enough to leave room at end with no tubing in ribbon to push through breast template and for sewing later at sternum.

5) Using a thin plastic sheet or other durable material (e.g. UK plastic milk bottles) to make round circular discs 50 mm in diameter. Cut out eight slits with sharp scissors around the disc (see images below), big enough through which tubular Teflon ribbon can be passed.

6) Fit front two straps through the top two slits of the template and diagonally across to bottom two slits so ribbons cross in the middle of the template.

Figure 2.2: Circular disc.

Figure 2.3: Prepared harness.

Restraint and hooding

Using this method, the tag is best fitted by one person holding the vulture upright whilst the person holding the bird is leaning against a table or similar. The holder of the bird will have one hand around the legs of the bird with finger between legs and another holding the neck below the head of the bird. The breast of the of the bird should face forward. A falconry hood should be fitted to keep the bird calm. The other person then fits the tag. An experienced holder will be able to help move the bird to allow ribbons to be easily passed under wings and manoeuvre the bird into the right positions for fitting the tag. This work is therefore best done by two experienced practitioners.

Fitting to the bird

1) Pass the front two straps attached to the harness over the head of the bird. Ensure tag is placed on upper back of the bird where it should sit, and adjust template to align with the sternum avoiding the crop. Then bring back two straps over and under wing, carefully ensuring that no wing feathers are caught up in the harness lug , and thread diagonally through remaining slits on template. All harness ribbons should now cross at the centre of the template at sternum. Ensure that all ribbons are not twisted. Clamp in place using surgical clamps or bulldog clips. Then preen ribbons into place to ensure that ribbons are next to the skin of the bird. Using clamps to hold ribbons in place adjust ribbons to ensure good fit on bird allowing two index fingers to fit under tag on back of bird. Ensure that front and back ribbons are each the same length.

2) When the tag is correctly adjusted take a length of linen twine and a curved needle and sew through the middle of the four ribbons where they cross at the sternum, starting from the top of the ribbons to ensure no knots are on the underside of the harness and adjacent to the skin of the bird. The presence of the template ensures that you cannot sew the skin or feathers of the bird. Sew through the middle of the four ribbons 5-6 times; then seal the knot by sewing through it and binding it on the top side; and then remove the clamps. Check all four ribbons are correctly sewn together. Then carefully cut off the template using sharp scissors, avoiding cutting the harness.

Fig. 2.4: Clamping the harness in place.

Figure 2.5: Securing the harness.

3) Check the harness and fit of the tag on the bird again, by running your fingers around the Teflon loops and putting index fingers under the tag. Use a small amount of Superglue to seal the knot on the sternum. Cut the four ends of Teflon ribbon at the breast template to make them shorter and then seal each Teflon ribbon at the end with a strip of 5 mm of Superglue to prevent unravelling.

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Thoracic X-Strap Harness. Design and Method 3

Volen Arkumarev

This design and method has been used to attach tags to Egyptian Vultures, Eurasian Griffon Vultures *Gyps fulvus*, Imperial Eagles *Aquila heliaca* and White-tailed Eagles in Bulgaria and Greece.

Equipment needed:

- Teflon ribbon: 11.2 mm/0.44” wide (Griffon, Cinereous); 8.4 mm/0.33” wide (Egyptian)
- Ornitela device, Microwave Telemetry, E-obs and Ecotone
- Scissors
- Clamp scissors
- Needles (1 mm/1.2 mm)
- Needle threader (according to the size of the needle)
- Curved needle (1 mm/1.2 mm)
- Kevlar fishing thread (0.35 mm or 0.30 mm)
- Superglue (Loctite glue)
- Paint marker pen – silver
- Ruler
- Neoprene pad
- Neoprene glue

Attachment must be prepared in advance.

Figure 3.1: Equipment.

Measurements and preparations: Key stages/steps

Need 120 cm length of Teflon ribbon.

1) There are two initial preparation methods, depending on the type of device used:

a) If the device has two attachment lugs at the front and two at the back, cut the ribbon into four 30 cm lengths. Take one piece of 30 cm Teflon ribbon and feed the ribbon through one of the attachment lugs just enough to tie both ends into a knot. Tie a simple knot to secure the ribbon, leaving one end long. Repeat this, tying each piece of ribbon to an attachment lug.

b) If the device has one attachment lug at the front and two at the back, cut the 120 cm ribbon into one 60 cm length and two 30 cm lengths. Tie each one of the 30 cm pieces of ribbon to one of the back-attachment lugs as above. With the longer 60cm Teflon ribbon, feed this through the single attachment lug at the front of the device and pull this half the way through. Check that the lengths are equal and tie in a simple knot.

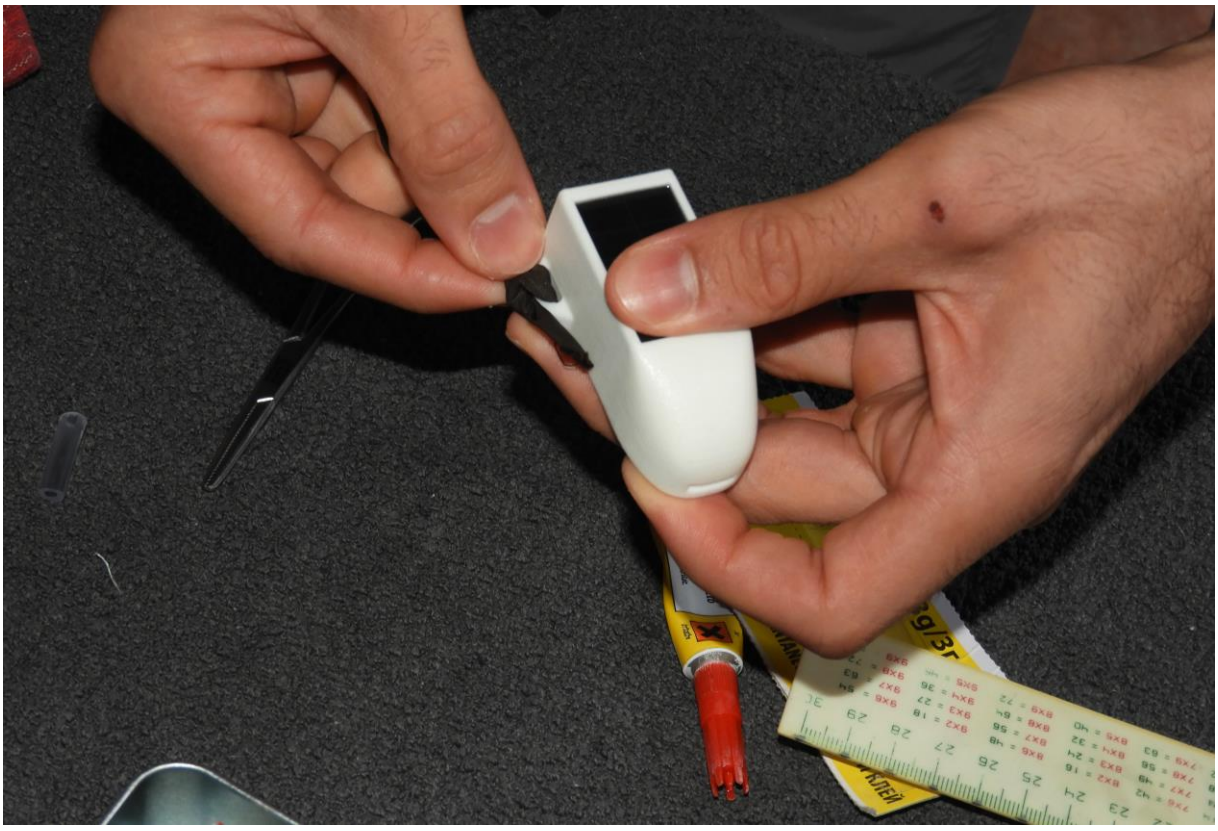

Figure 3.2: Feeding ribbon into the device.

Figure 3.3: Tying the ribbon.

Figure 3.4: Knots on ribbon.

2) Stitch through each knot using a needle and the Kevlar thread (a needle threader can be useful here). Tie a knot in the thread. Start sewing from the top downwards (towards the bird's body) so that the Kevlar knot sits on top. Sew three or four stitches into each knot. The end of the Teflon ribbon should be frayed and slightly unravelled. Incorporate the frayed ribbon into the last stitch

3) Apply superglue to the outward facing Kevlar/ribbon knots. This will help to keep the knot secure and to smooth down the edges.

4) Along each length of ribbon add scale marks using a ruler and a silver paint marker pen. From 15 cm from the device, make marks 10 mm apart. Number the lines on the ribbon. This will allow you to calculate how much ribbon makes up each strap of the harness and to ensure that the straps are of equal length. Write on same sides so that when attaching the device to the bird you can check that you have an even fit by matching up of the Kevlar knot. Then wrap the end thread around the needle three times to pull into a knot. Cut off the ends of thread.

If a three lugged device is being used, only two stitches are needed in the knot tied in the front lug with the 60 cm length of ribbon. This is because when fully attached there will be no loose ends of ribbon at this lug.

the numbers.

5) On the underside of the device, use neoprene padding. Draw around the tag and cut the padding to fit (making sure you include a wider area to pad the undersides of the lugs and knots). Other than these wider parts of the neoprene under the lugs, the pad should fit the outline of the tag closely so that it does not fray or have excess areas of neoprene that the bird can pull at. Use neoprene glue to attach the pad to the bottom of the device.

Figure 3.5: Marking the ribbon.

Figure 3.6: The prepared harness.

Restraint and hooding

In order to keep the bird calm while restrained, a loose material tube (or a sock with the toes cut off) can be used to cover the head. A hole in the end is needed so that the bird will not choke if it regurgitates food whilst hooded.

At this stage an additional person is needed to hold the bird whilst the tag is being attached. It is recommended that the bird is held breast downwards as much as possible, though angling the bird upwards will be necessary when making the final attachment at the sternum.

Fitting to the bird

1) The device should be positioned on the back in the approximate position where it will lie. Front straps can be fed around shoulders and back straps fed under the wings like a backpack.

2) The four straps then meet on the sternum and can be held in place using the clamp scissors. Numbers from the top two straps and the bottom two straps should match up (e.g. two 4s at the top, two 6s at bottom). It is helpful to stand the bird on its feet (though still restrained) whilst assessing the fit.

3) Make sure the ribbons meet on the sternum and not over the crop. Adjust the feathering so that the straps are not forcing it from its natural position.

4) Assess the fit of the harness by putting two fingers between the tag and the bird's back. It should be possible to move the fingers but without there being a gap. It is better to leave the fit a little bit loose, in case the bird gains weight/grows, rather than having it too tight.

5) When satisfied, put a piece of card or cloth under the point where the ribbons join at the sternum to protect the bird. Then stitch the four ribbons together with Kevlar thread using the curved needle. Sew towards the bird's body so that all knots will be on the side of the harness away from the body. Stitch in each corner of the square where the ribbons meet, then remove the clamp. Cut

off the loose ends of ribbon, then stitch two or three times in the centre of the square. The end of the Teflon ribbon should be frayed and slightly unravelled. Then incorporate the frayed ribbon into the last stitch of the Kevlar knot. Superglue the outward facing knots and the ribbon ends to achieve a smooth finish.

Figure 3.7: Assessing the fit.

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Leg loop Harness. Design and Method 4

Olivier Duriez

This design is a development of a method first used to attached VHF radio tags to small passerines (Rappole & Tipton 1991). It has been deployed successfully on the following species: large vultures and condors (*Gyps*, *Aegypius*, *Gypaetus*, *Vultur*), small vultures (*Neophron, Necrosyrtes*), eagles (*Aquila*, *Haliaeetus*), kites and hawks (*Milvus, Parabuteo*), kestrels and falcons (*Falco naumanni, F. peregrinus*), species from other families (Kittiwake *Rissa tridactyla*, Eurasian Woodcock *Scolopax rusticola*, rollers *Coracias garrulus*, choughs *Pyrrhocorax graculus*, Raven *Corvus corax*, grouse and ptarmigan *Lagopus* spp.). The design was found to be unsuitable for Osprey *Pandion haliaetus* and pelicans *Pelicanus* spp.

Equipment needed:

- Teflon ribbon: 11.2 mm/0.44" wide or 8.4 mm/0.33" wide. Length 1.2 m for large vultures, 0.8 m for Egyptian Vultures or Golden Eagles.
- Scissors
- Clamp scissors or crocodile pliers

There are two alternative attachment methods:

1) Light non-elastic harness
   - Superglue (Loctite glue)
2) Elastic harness
   - Silicone tube (Versilic THT 3 mm diameter): https://tinyurl.com/y4l6sfas
   - Cable threader or soft needle
   - 2-4 earclips, double 5-7 mm: https://tinyurl.com/y2kypxn9
   - A set of pliers: ringing pliers, flat pliers, pincer

Fig. 4.2: Equipment.

Measurements and preparations: Key stages/steps

1) Non-elastic harness

Use this option when the Teflon ribbon is narrow (<0.8 mm), when weight must be reduced, and when tag's lugs are narrow (<3 mm).

Tip: cut the Teflon ribbon diagonally instead of square at the ends (see below): this helps to insert the Teflon into the tag's lugs.

2) Elastic harness

The goal is to increase elasticity of the Teflon ribbon by inserting a silicone tube inside. Note that this increases the weight of the harness slightly and requires a large lug on the tag.

There are two options to insert the tube:

a) Use a cable threader (used for electrical wires). This only works for the large 11.2 mm ribbon.

b) Use a soft needle attached to the silicone tube by a thread which allows you to slowly pull the silicone inside the ribbon.

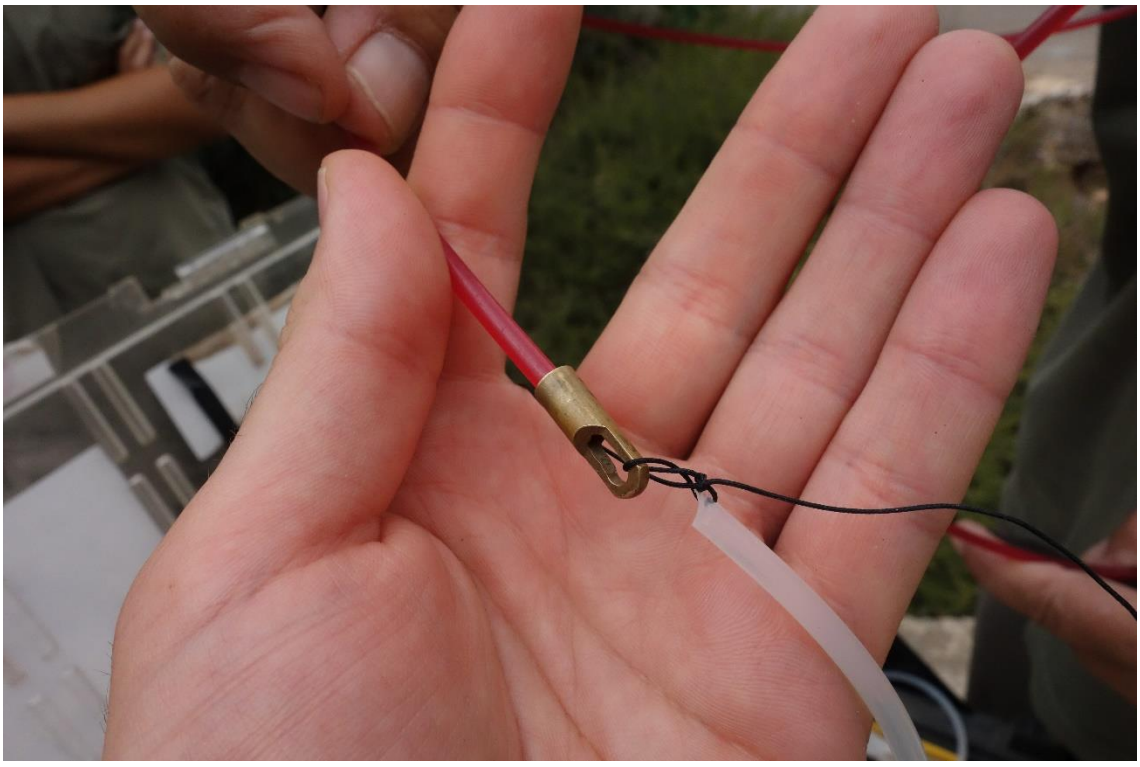

Figure 4.3: Needle and silicone tubing.

Figure 4.4: Pulling the tube through the ribbon.

Tip: cut the Teflon ribbon diagonally, instead of square at the ends: this helps to hold the Teflon while inserting the silicone tube, and also helps to insert the Teflon into the tag's lugs.

Once inserted, cut the silicone but leave 5 cm to stick out of the Teflon. Then pull on each side of the Teflon to create elasticity.

Before fitting the tag to the bird, it is necessary to attach the Teflon thread to part of the tag. Important: the two ribbons must have exactly the same length on each side of the tag. To do that, you can make one or two knots or attach an earclip in the middle of the thread and pass it into the tag's lugs to fix it.

If the tag has external antennas, it is easier to attach the ribbon at the rear-end of the tag (below the antennas). If the tag has no external antennas, you can attach the tag at rear or front of the tag. If your tag has one central lug, then it may be simpler to attach the ribbon at this end.

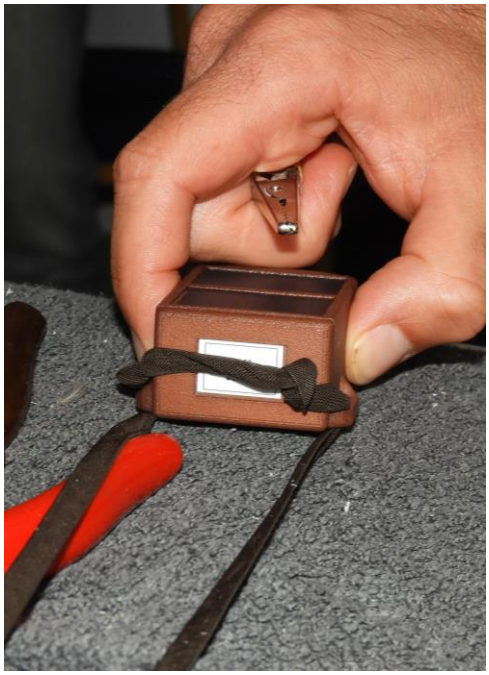

Figure 4.5: Knots on the device.

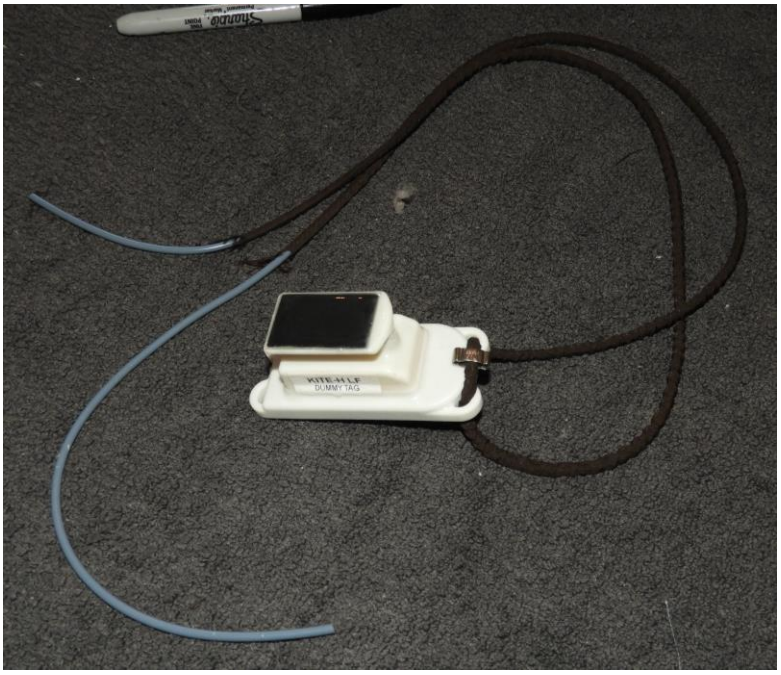

Figure 4.6: Prepared harness.

Restraint and hooding

For a large vulture, at least two people are needed, three being preferable. One person holds the head-neck and the body around the wings, one person holds the legs in an extended position and spread apart and one person fits the tag

Fitting to the bird

1) Put the tag on bird's back.
2) Pass one end around the knee of one leg, and back again towards the bird's back; insert in the
3) tag lug and secure it with clamp scissors. Repeat with the second thread around the other leg.
4) Adjust the fit by pulling on both ribbons, making sure that both threads have the same length thereby ensuring that the tag will be at the centre of the back.

Important: check that each thread remains in the space between the knee and the body. Leave space for fingers to pass below the tag.

Securing the harness: non-elastic

5) After thread length adjustment (step 3), make a double knot with both threads;
   a) put glue on the knot and make a third knot on top, to glue all knots together or
   b) sew the knot with linen (flax) thread.
6) Cut the remaining parts.
7) Final check of harness fitting around the legs. This is very important.

Figure 4.7: Adjusting the fit.

Figure 4.8

Note that for small species, e.g. falcons, the leg-loops can be pre-fixed into the lugs and maintained by knots (not glued). Then after fitting around the legs (steps 2-3), the adjustment can be quicker.

Securing the harness: elastic

Before inserting the threads into the lugs (step 2), insert one or two earclips into each thread.

4) After thread length adjustment (step 3), re-thread the free end of the thread into the earclips.
5) Secure the earclips with pincers. It is preferable to make the earclip rounded to prevent injuries. To do that, use two pincers to bend the earclip, then make it round with ringing pliers with holes.
6) Cut the remaining parts.
7) Final check of harness fitting around the legs. This is very important.

Figure 4.9: Rounded earclip.

A quick harness method for doing experiments with falconry birds

A similar leg-loop harness can be used to attach an aluminium plate, covered with Velcro, where the tag's underside is covered with the opposite Velcro. This allows multiple attach-detachments of the tags (to charge batteries and download data), without changing the harness. The harness can be adjusted to fit several birds by leaving the rear-end with an electric wire twisted around the threads. Then the harness can be quickly removed by un-twisting the electric wire.

Figure 4.10: Harness with Velcro.

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Leg loop Harness. Design and Method 5

Sonja Krüger

This method has been used successfully on Bearded Vultures *Gypaetus barbatus* in South Africa and Europe and on Cape Vultures in South Africa. Daniel Hegglin is acknowledged his role in the leg loop harness design and method.

Figure 5.0: Adult Bearded Vulture with satellite GPS transmitter

Materials and Equipment needed:

- Tubular Teflon ribbon: 6.4 mm wide (0.25") and 8.4 mm wide (0.33") (use one or both)
- Silicone cord – 2 mm thick, or clothing elastic – 5 mm wide
- Heat shrink tubing
- Two-ear clamps #5 / #7 (can also use cable ties)
- Elastic thread (white)
- Medical tape & cellotape
- Powder
- Superglue
- Transmitter (have used Microwave, NorthStar)
- Neoprene pad and glue (if not supplied by manufacturer of transmitter)
- Thin sewing needle and cotton thread
- Surgical clamps
- Long thin piece of metal/copper wire
- Scissors
- Pliers

Attachment must be prepared in advance.

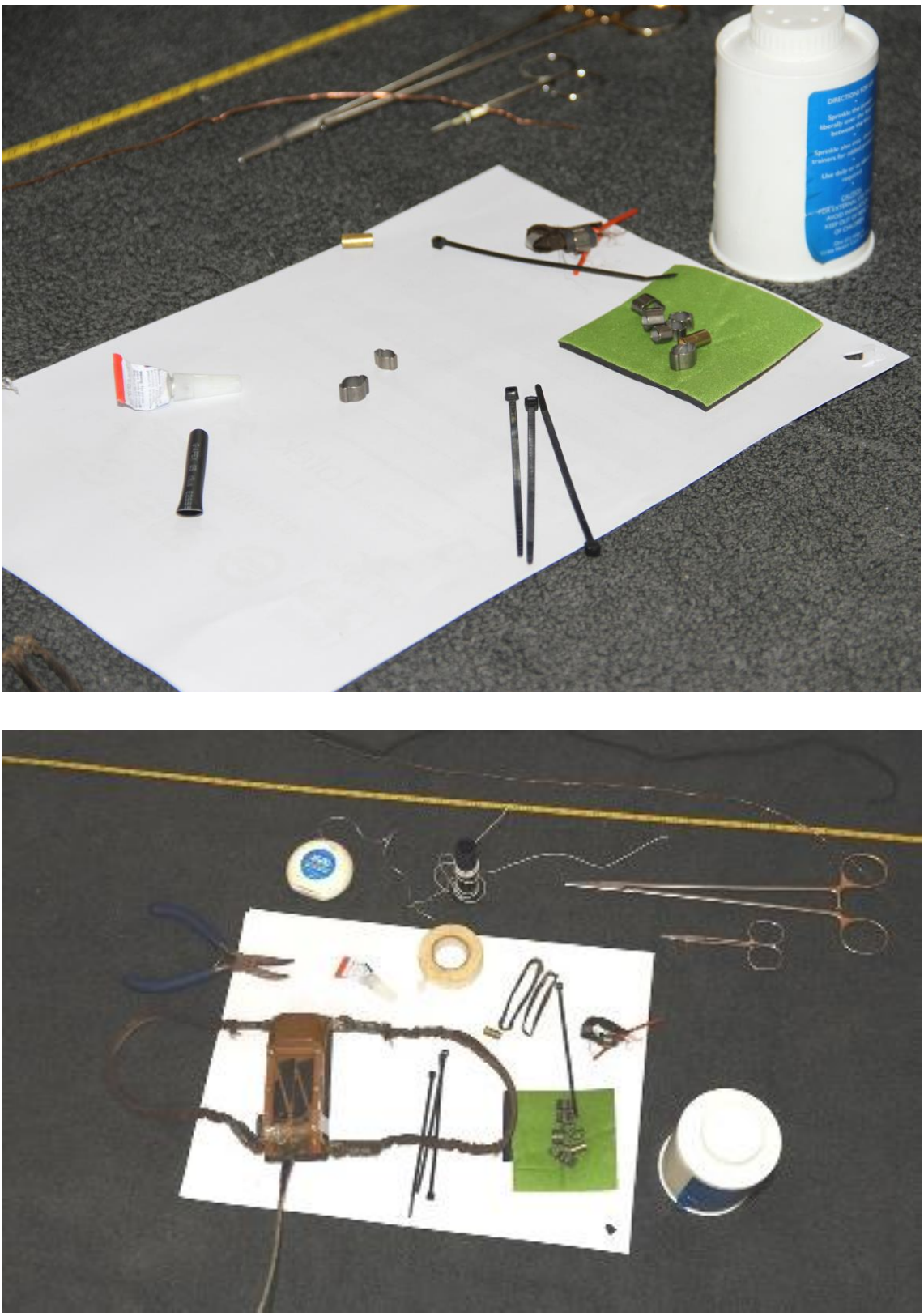


Figure 5.1: Equipment.

Measurements and preparations: Key stages/steps

The leg loop harnesses can be made "expandable". These harnesses have been used successfully on numerous Bearded Vultures, some even lasting more than 10 years on the bird. The expandable version provides additional elasticity (the Teflon provides some elasticity) for comfort and to date no evidence of chaffing, as a result of the additional bunched up material, has been found.

For the expandable version; use silicone cord (2 mm diameter) which is highly durable, or clothing elastic (5 mm wide) that is easily obtainable and easy to work with. For the non-expandable version (used successfully on Cape Vultures), leave out the step that involves the cord or elastic.

The measurements below are for Bearded Vultures (4–6 kg)- for a larger bird use approximately 10 cm more and for a smaller bird use 10 cm less.

1) Cut a 120 cm piece of the narrow (0.25") Teflon, 115 cm piece of the wider (0.33") Teflon and 120 cm of the silicone cord/elastic (Fig 5.2). kg. You can either use both Teflon ribbon sizes for extra strength (see below) or just one. Use the wider one (even 0.44") for larger birds.
2) Thread the elastic or cord through the narrow Teflon using a piece of wire (Fig 5.3).

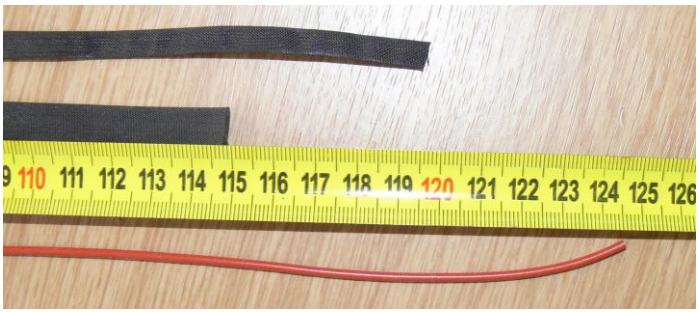


Figure 5.2

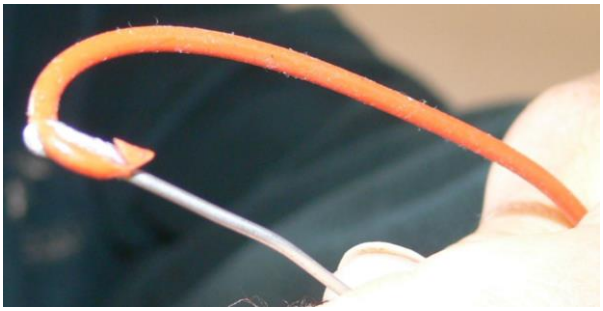


Figure 5.3

3) Place Cellotape around the ends of the Teflon ribbon to prevent fraying whilst you are working (Fig 5.4).
4) Thread the narrow Teflon ribbon through the wider Teflon ribbon, using the wire if necessary (Fig 5.4).

5) Tape the wider Teflon ribbon to the narrower one with medical tape to prevent the narrow piece from disappearing into the wider one (Fig 5.5).

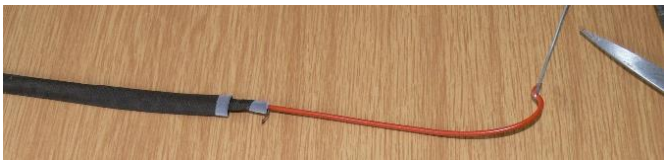


Figure 5.4

Figure 5.5

6) Using the elastic thread (white is easier to see than black), tie off a 1 cm section to secure the elastic and Teflon ribbon and ensure that none of the individual pieces move when you thread them into the lugs of the transmitter. Knots can be made on alternating sides of the ribbon for 1 cm (Fig 5.6). Cut off the ends (Fig 5.7). From now on the elastic cord in the narrower Teflon both of which are in the wider Teflon will be referred to as harness material.

Figure 5.6

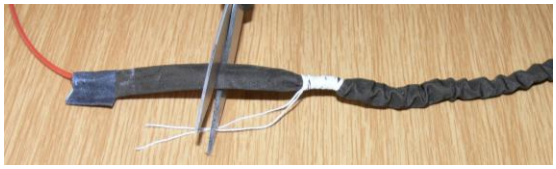


Figure 5.7

7) Your harness material should now be approximately 80 cm long (Fig 5.8) and 100 cm long at full stretch (Fig 5.9).

Figure 5.8

Figure 5.9.

8) Thread the harness through the lugs at the back of the transmitter (Fig 5.10). Use the ends of the elastic thread for this or the surgical clamps (Fig 5.11).

Figure 5.10

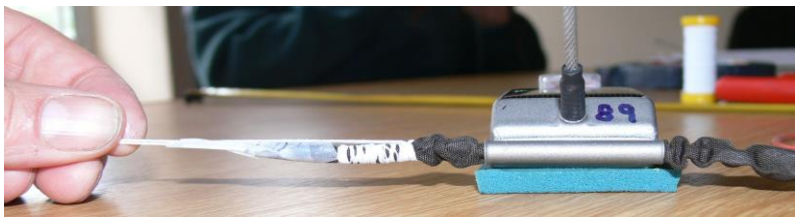


Figure 5.11

9) Create a weak link to thread through the front attachment points of the transmitter. The weak link is to ensure that the harness will drop off after some time. Create a weak link by cutting a piece of narrow Teflon ribbon, that when sewn together as a loop (Fig 5.12), will fit through the front lug and extend on either side by about 5–8 mm (Fig 5.13; enough to thread the harness material through). The "strength" of the weak link will depend on the number and position of stiches. Use cotton for sewing the weak link- dental floss is too durable and will last >10 years. Even cotton will last >8 years. Adding Superglue to the stiches will increase durability of the thread.

Figure 5.12

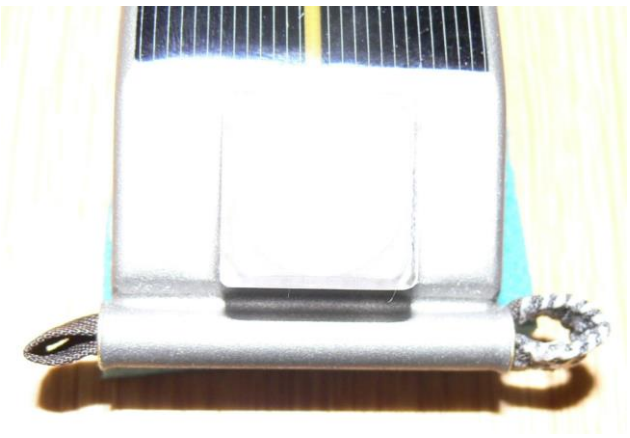


Figure 5.13

10) To secure the harness on the back end of the transmitter, cut a piece of heat shrink tubing (black plastic) just longer then the length of a two-ear clamp (or two clamps to make it more secure). Thread the heat shrink tubing on the harness material and thread the clamp over this. Use pliers to flatten/tighten the clamp (Fig 5.14). Ringing pliers will allow you to crimp the ears of the two-ear clamp. Note, plastic cable ties (easily obtainable and as durable?) may be used instead of clamps, but be sure to have no sharp edges that can injure the bird- hence flat metal clamps are preferable (Fig 5.15).

Figure 5.14

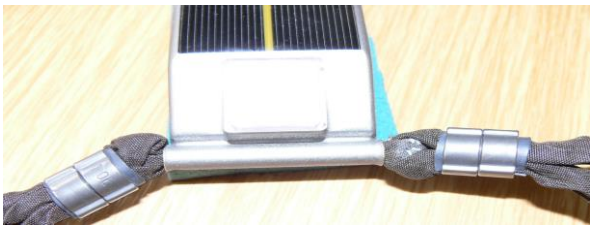


Figure 5.15

11) Place another piece of heat shrink tubing on each end of the harness material and insert one or two clamps on this. The heat shrink tubing protects the Teflon from being cut by the clamp. Thread the ends of the harness material through the weak link loops prepared in 9) and then back onto itself and insert the end into the heat shrink tubing and clamp (Fig 5.16). Do not close these clamps- this is the end that will be adjusted once on the bird, and the clamps will be tightened after final adjustments have been made (see below).

Once the harness has been adjusted on the bird and the clamps tightened, the end that has been threaded through can be cut off. Superglue can be placed on the cut end to stop fraying; care must be taken not to get glue on the feathers of the bird. Place a piece of paper underneath when gluing. Powder can be placed on the glue to dry it quicker.

Depending on the type of attachment the transmitter has, it may not be possible to thread the harness material through the lugs on the

transmitter. In this instance, you may need two weak links (front and back) and two pieces of the harness material to thread through the lugs of the transmitter, one at the front of the transmitter and one at the back. Ideally and if the attachments are wide enough, you should be able to thread the entire length through both ends (see 12).

12) The harness is now ready for fitting. Ensure that it has been tested before fitting to a bird. Make sure solar panels are fully charged before fitting. Keep the magnet on (if the transmitter is activated by removing a magnet) until the bird is ready to be released.

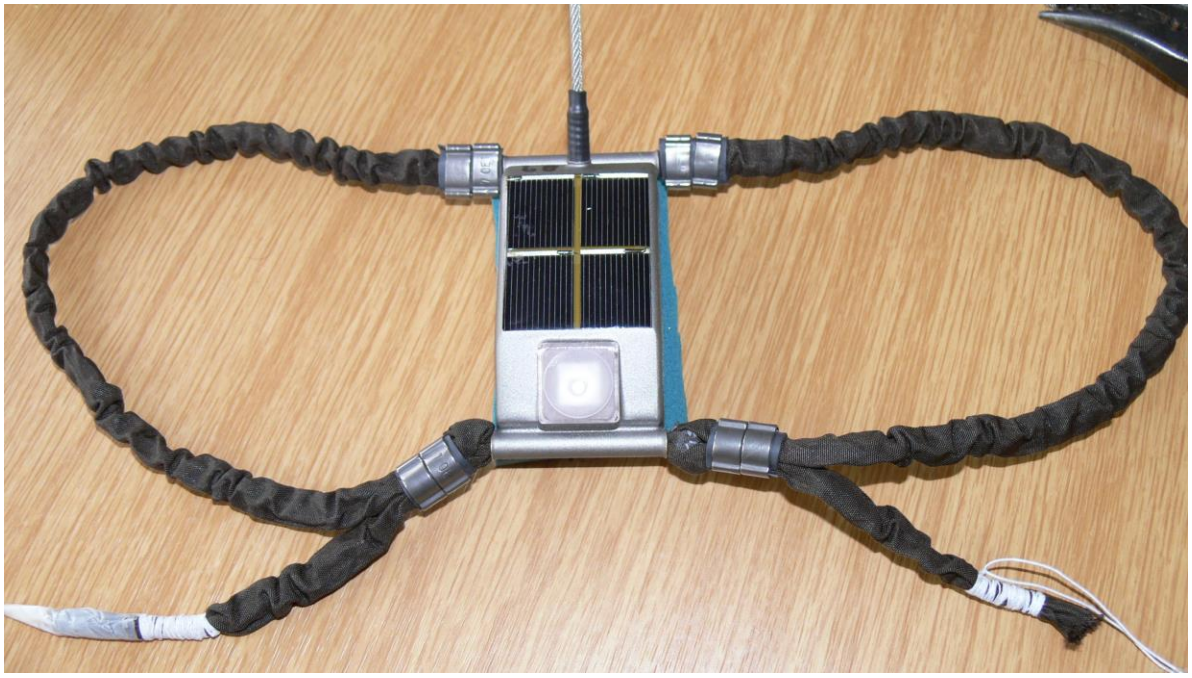
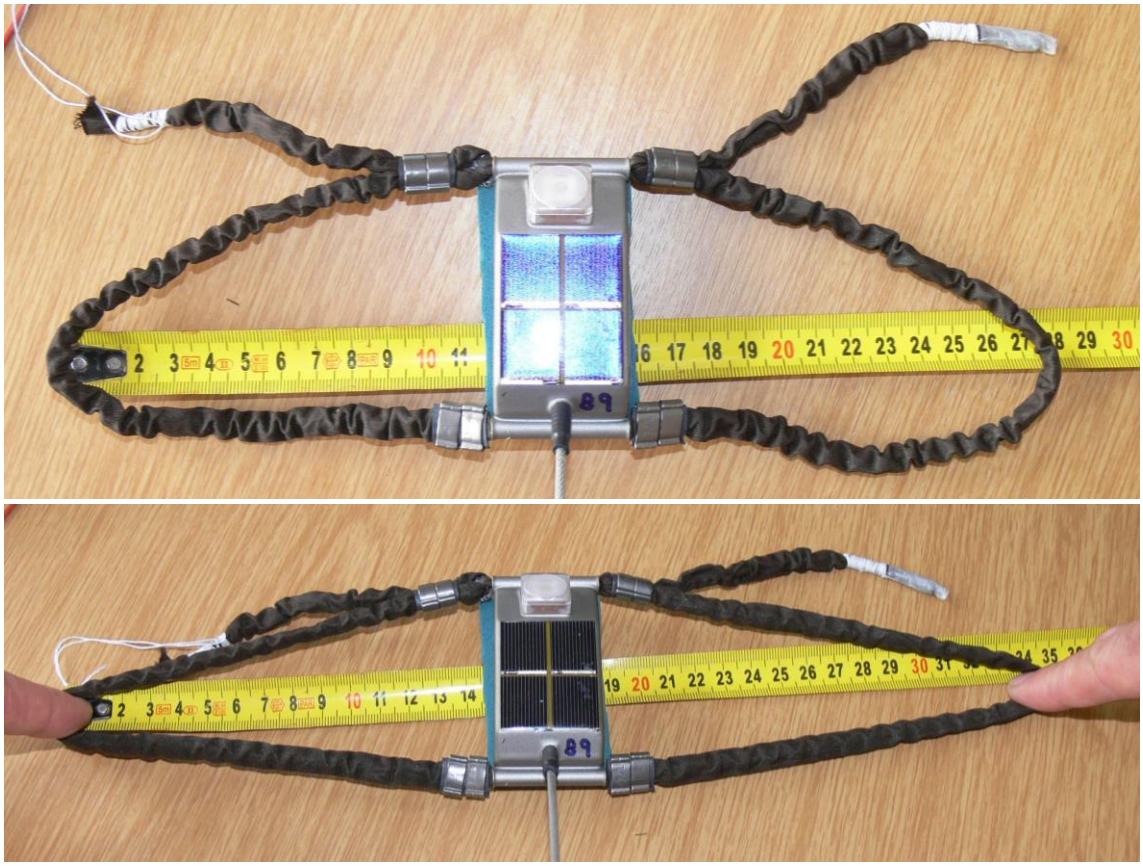
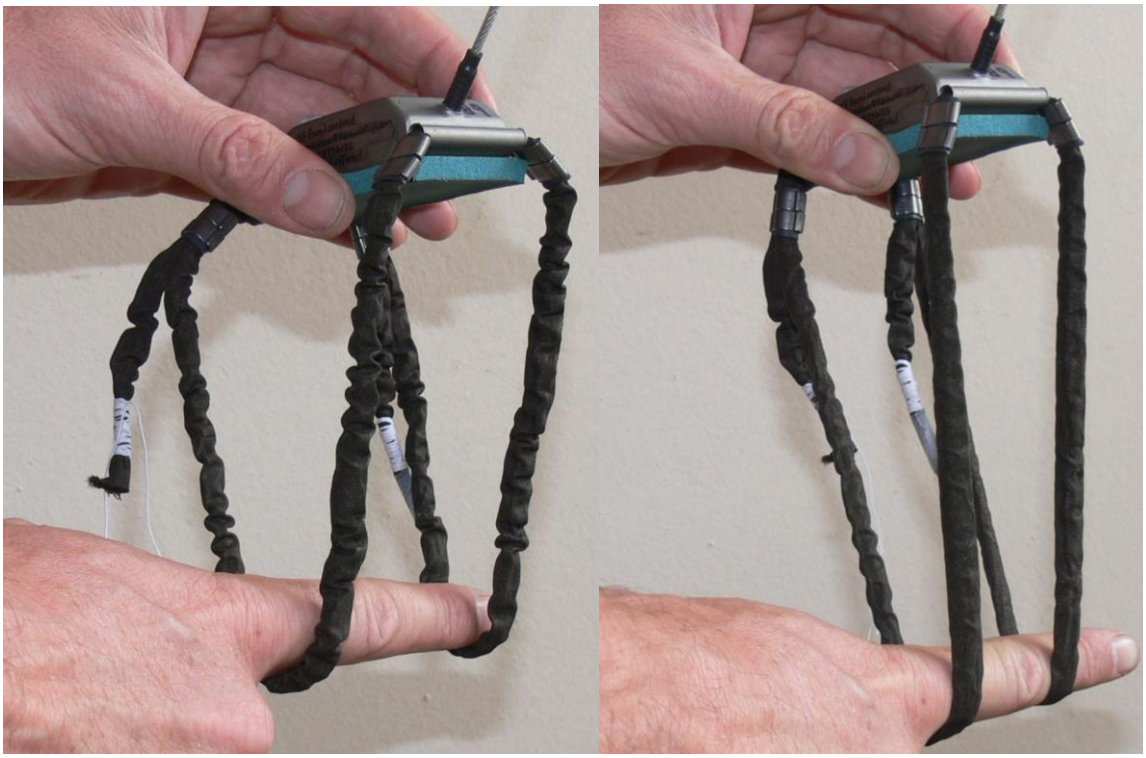


Figure 5.16

13) If elastic was used, then the elasticity of the harness is as depicted in Figs 5.17-20.





Figures 5.17-20

14) Make sure your contact details are on the transmitter (Fig 5.21).

15) Make sure a neoprene pad has been glued to the bottom of the transmitter (with a bit of overlap) if the transmitter did not come complete with a pad.

Figure 5.21

Restraint and hooding

At this stage an additional person is needed to hold the bird whilst the tag is being attached. It is recommended that the bird is held breast downwards with legs retracted (Fig 5.22). When fitment is completed and the clamps have not yet been tightened, both legs should be stretched backward (or the bird made to stand) before final adjustments are made. The bird can be held on the ground or on someone's lap to make it easier to manoeuvre the harness on.

In order to keep the bird calm while restrained, a loose material tube (or a sock with the toes cut off - Fig 5.22) can be used to cover the head. A hole in the end is needed so that the bird will not choke if it regurgitates food whilst hooded.

Figure 5.22

Fitting to the bird

1) The two leg loops can be stretched over the leg one at a time (Fig 5.24) until the material settles nicely in the leg joint on either side (Fig 5.25). The device should be positioned on the lower back in the approximate position where it will lie. Run a finger along the harness material to ensure that it lies smoothly in the leg joint and that no feathers are obstructed.

Figure 5.24

Figure 5.25

2) The two loose ends of harness material should then be pulled evenly to tighten the harness. Assess the fit of the harness by putting two fingers (side by side) between the tag and the bird's back (Fig 5.26). It should be possible to move the fingers but without there being a gap. It is helpful to stand the bird on its feet (though still restrained) whilst assessing the fitting. As a guide you can compare the lengths of the two ends of the harness material (Fig 5.27).

Figure 5.26

Figure 5.27

3) Once the harness has been adjusted on the bird, close/tighten the two-ear clamps using pliers (Fig 5.28). The end that has been threaded through can be cut off (Fig 5.29). Superglue can be placed on the cut end to stop fraying, but care must be take not to get glue on the feathers of the bird (Fig 5.30). Place a piece of paper or your finger underneath when gluing. Powder can be placed on the glue to dry it quicker.

Figure 5.28

Figure 5.29

Figure 5.30

4) Remove the magnet (if the transmitter has one) to activate the transmitter before releasing the bird.

Figure 5.31

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Leg loop Harness. Design and Method 6

Alfonso Godino

This method has been used on Bearded Vultures *Gypaetus barbatus*, Cinerous Vulture *Aegypius monachus*, Eurasian Griffon Vulture *Gyps fulvus*, Rüppell`s Vulture *Gyps ruepelli*, Short-toed eagle *Circus gallicus*, Red Kite *Milvus milvus*, Montagus´ Harrier *Circus pygargus*, Bonelli´s Eagle *Aquila fasciata* and Golden Eagle *Aquila chrysaetos* in Spain, Portugal, Italy and Morocco.

With the Bearded Vulture, Cinereous Vulture and Red Kite, individuals tagged included full-grown birds and nestlings, where a potential size increase could still occur after the tagging in this last group. For other species, only full-grown individuals were tagged with this method.

Devices used include: Aquila 33g, Anitra 50g, BTO 25g, Microwave 45g, Ornitela 50, 25 and 10g, Vectronic 90g.

Materials and Equipment needed

- Tubular Teflon ribbon: 4.1mm (0.16”) and 6.4 mm wide (0.25”) for small-medium species (*Milvus, Circus*) and 8.4 mm wide (0.33”) for bigger (vultures, eagles, etc.)
- For expandable or elastic harness, a clothing elastic to insert in the Teflon (0.08”/2mm narrower than Teflon used).
- Cyanocrylate (superglue)
- Cyanocrylate activator spray
- 10 x 6 cm rough/porous pad (scouring or neoprene pad are useful)
- Neoprene pad to glue to the lower part of the device (if not supplied by the transmitter´s manufacturer)
- Plastic needle
- Scissors
- Clamp scissors - straight and curved

Figure 6.1: Equipment

Measurements and preparations: Key stages/steps

Here I present the harness used to fit two types of devices, one model with a tube/hole in front and back of the device (A) and the second one mounted on a device with one lug in front and two lugs on the back-lateral side (B) (Fig 6.2)

Figure 6.2:

It should be easy to adapt these two methods for different transmitters with other attachment lugs.

Both methods allow the use of expandable and non-expandable harness.

The attachment of the harness to the device is made before fitting it to the bird, with the goal of reducing the time spending handling the bird.

If you have no experience with the species, it is highly recommended to test any harness in captivity (rehabilitation and breeding in captive centres, zoos, falconry shows/exhibitions, private collections, etc), before using on a wild bird, or to be trained by more experienced practitioners on the given method and species.

A. Device with hole/tubes in front and back

The Teflon tape will be in one piece (length will depend with the species) and, to facilitate the insertion through the holes/tubes, tips of the Teflon are cut sharply.

Figure 6.3

Additionally, and to avoid the fraying of the tip, a little superglue can be added to the tip. With the glue, the tip will be stiff and this will make it easier to pass the Teflon through the holes/tubes.
Pass the Teflon through the front hole/tube and be sure the length is equal on both sides.

Figure 6.4

Then make a knot as close to the device as you can.

Figure 6.5

Before tying the knot, add glue inside the knot, and again add glue around the knot once tied. To make the glue dry faster use cyanoacrylate activator spray.
Pass both Teflon tips through the back hole/lug. When both tips are passed though the holes/tubes, knot them on the back side of the device.

Figure 6.6

This knot should not be very tight, since we will need to tie off later when attached it to the bird.
If you prefer the knot in front of the device and not in the back, the process is the opposite, inserting the Teflon through the back hole/tube and keep the knot in the front.

B. Device with one lug in front and two lugs on the back-lateral side

As previously, Teflon tape will be in one piece (length will depend with the species) and to facilitate the insertion through the lugs, tips of the Teflon must be cut sharply (Fig 6.3) and glue can be added to the tip.

Pass the Teflon through the front lug and be sure the length is equal on both sides (Fig 6.4). Then make a knot as close to the device as you can.

Figure 6.7

Before tying the knot, add glue inside the knot, and again add glue around the knot once tied. To make the glue dry faster use cyanoacrylate activator spray.

Pass both Teflon tips through each one of the lugs and knot them on the back side of the device.

Figure 6.8

This knot should not be very tight, since we will need to tie off later when attached it to the bird.

With the harness attached to the device, on both models, you can glue the neoprene pad on the base of the transmitter. Care must be taken to not spread glue too close to the corners where hole/tubes or lugs are.because it could make difficult when we adjust the harness on the bird (neoprene pad could be glued to the Teflon ribbon).

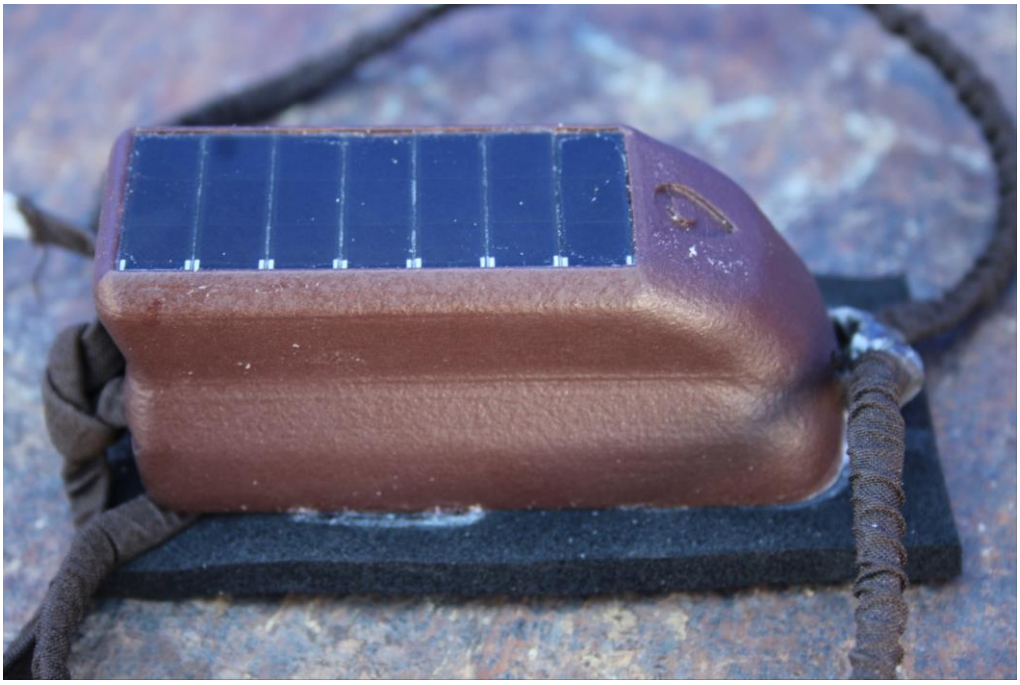

Figure 6.9

C. Expandable harness

To make expandable on both methods previously described, a clothing elastic or silicone cord can be inserted into the Teflon ribbon. Recently we have been using clothing elastic as an alternative to the silicone cord for several reasons: it is cheaper, it is easier to get and it is much easier to insert into the Teflon ribbon. To insert the clothing elastic inside the Teflon, a plastic needle is used to avoid damaging the Teflon.

Figure 6.10

It is advisable to use longer elastic than Teflon ribbon. Normally 6-10 cm will be enough. With this measurement, the harness will have 3-5 cm of extra elastic in each part.

Figure 6.11

With the elastic inside the Teflon, follow the steps shown previously in A and B.

Restraint and hooding

Normally two persons are needed, one person to hold the bird and the second to fit the harness. Only in bigger and more active species, such as *Gyps*, a third person is recommended to help hold the bird. To keep the bird calm, the use of a hood designed for raptors is recommended. There are hood designs for all vulture species and many other raptors, even for those species where due to the morphology of the head and neck, as *Gyps* species, it may be difficult for the bird to wear a hood.

Figure 6.12

The advantage of the hood is that it is easy to put it on and remove it, it does not touch the eyes as socks would do. If the same hood is used with several birds (several individuals trapped at the same time and one or few hoods), it must be disinfected when used on a new bird, especially the inner part (e.g. disinfectants with quaternary ammonium and biguanidine are very effective, non-toxic, non-irritating, non-corrosive and biodegradable).

The collaboration of a wildlife veterinarian during trapping, handling and tagging is also an advisable precaution against potential problems, especially when you plan to trap/tag several birds at the same time.

Birds must be kept with the breast on the ground, if possible on a soft or padded carpet and in shade. For small and medium size species, e.g. *Circus*, *Falco*, it is easier to keep them in the hand during the handling and tagging (Fig 6.13).

Figure 6.13

Fitting to the bird

Non-elastic harness

1) With the breast on the ground, the bird will stay in the same position and you can place the device on the back. Tie off the knot on the back side of the transmitter and pass each ribbon in front of the knee and under the leg to recover the tip by the back of the leg. Insert the ribbon through the hole/tub or lug. After passing the ribbon, hold both tips together using clamp scissors.

Figure 6.14

In this situation you can adjust the harness until you get the correct fit (paying attention to keep the same ribbon length). Check the correct adjustment by passing the fingers in between the ribbon and the body all along the ribbon. Check the presence of feathers: tertials, axillaries and thigh, in between the ribbon and the body. No feathers must be trapped in this position.If you prefer the knot in the front side of the transmitter, in the devices with a hole/tube, the process is the opposite as described. You must keep the knot with glue in the back part of the device and tie off the knot in the front part.

2) When you have the harness well adjusted, it is advisable to hold the bird and allow it to stretch the legs.

Sometimes there is a small adjustment of the harness and you must correct it.

Figure 6.15

3) Check again the harness passing the fingers around the Teflon as described previously. Before you tie the knot, insert a rough/porous pad under the transmitter to prevent glue getting onto the feathers. This pad must be bigger than the device to absorb the glue that may drop by mistake. Add glue to the inner part of the ribbon before tying and remove the clamp scissors. After this, tie the knot and add again glue over it.

One knot is enough but two gives extra security. Cut the rest of the ribbon off and glue the tips to avoid fraying of the Teflon. Spray the knot and ribbon tips with cyanoacrylate activator to reduce the waiting time.

4) If you want to create a drop-off or breaking point, you can sew with floss or surgical thread both ribbons when you have them fixed with the clamp scissor. Sew 5-6 times the ribbons (or more if you want longer life of the harness on the bird) and add glue on the knot to seal it. Cut the extra ribbon and glue both tips to avoid fraying. Spray the knot and ribbon tips with cyanoacrylate activator to reduce the waiting time.

5) Remove the hood and the pad under the device and release.

Figure 6.16

Elastic harness

1) With the elastic harness it should already be about the right size. Place the device on the back of the bird, which will be with the breast on the ground. Then, stretch one of the loops and pass the leg into the loop and repeat this operation with the other loop and leg.

2) Now the process is similar to the non-elastic harness, checking the right situation of the ribbon under the legs (no feathers in between the ribbon and the body), checking the tension of the harness and adjusting it if needed. To adjust, only tie off the knot and pull or release the elastic/ribbon until you get the proper adjustment.

3) For the final step, insert the rough pad under the device and glue inside the knot and over it after tie, cutting the extra elastic/ribbon and glue the tips.

4) Add a second knot for more security or create a drop-off or breaking point following step 4 of the non-elastic harness.

5) A stronger needle will be necessary to sew the ribbon with the elastic inside if you create a drop-off or breaking point. The use of cyanoacrylate activator will reduce the time waiting.

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Patagial Mount. Design and Method 7

Chris N. Parish

Figure 7.1: California Condors.

Patagial-mounted tags and transmitters are less favorable than other identification/tracking aids, but in some cases, such as the case with California Condors, they are widely preferred and used with success. These techniques stem from decades of use and application in the Condor Recovery Programme in the southwestern United States and were described well by Wallace et al. (1994). They have also been used in Andean condors in different South American countries.

It should be noted that researchers have modified techniques through time and preferences for tools vary greatly. Conserving patagial integrity/health by alternating or removing transmitters and wing tags can help prolong trackability for long-lived, long-tracked species like condors, especially when opportunities to re-trap individuals exist.

Materials and Equipment needed:

- Patagial identification tags - e.g. vinyl coated fabric, usually polyester
- Vinyl paint (Nazdar is one such product) for painting numbers or alpha numerics
- Cattle ear tags (various sizes depending on application), male buttons made by Allflex among others, and a plastic lock strap cut from ear tag material with locking bolt, washers and nylock nut (bottom left of Item 3. below)
- Tag applicator tool (Allflex Universal total tagger applicator)
- Scissors and/or razor-edge cutters
- High quality (new) leather hole punch or piercing needle(s)
- Stainless steel bolts, washers and nylock nuts and heat shrink to cover threads
- Nut drivers and/or screwdrivers or allen wrenches for bolts, depending on type/size used, and transmitter posts (not pictured)
- Heat shrink tubing (to cover threads of bolts from both transmitter posts and tag applications without transmitters (pictured in item #7)
- Patagial Transmitters (VHF, GSM, or GPS).
- Alcohol or other cleaning disinfectant

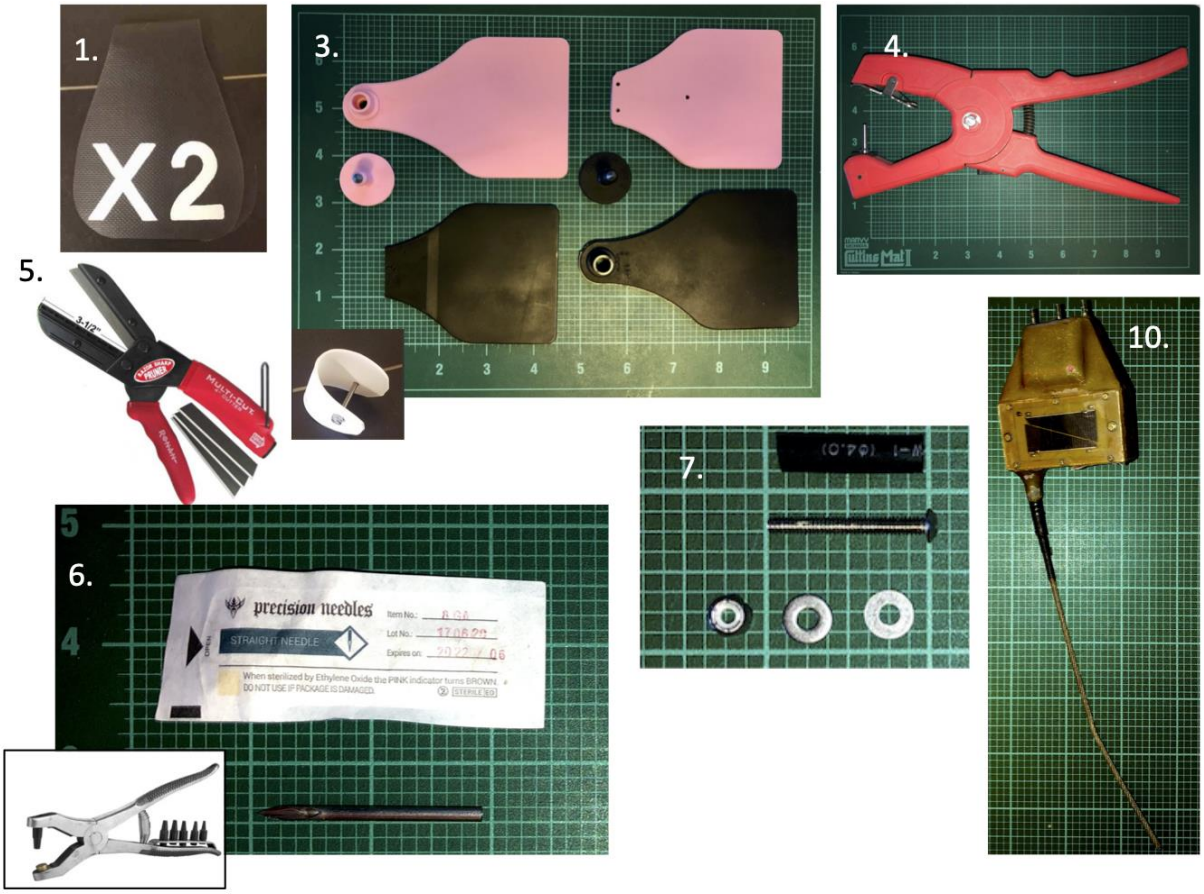

Figure 7.1

Identification (I.D.) Tag Attachment:

The patagium, a web of skin that stretches between the shoulder and carpus to form the leading edge of a wing when fully extended, creates somewhat of a triangle of skin bordered on the leading edge by a tendon while the radius and humerus bones create the other two arms of the triangle (Fig. 7.3). When split into two right triangles, the triangle containing the radius (green), or the section farthest from the body, is the section where holes (as small and precise as possible) can be pierced/punched allowing for outer- and under-wing visibility of the identification tag without impingement of the humeral-side of the triangle while wing is folded, extended or in flapping flight.

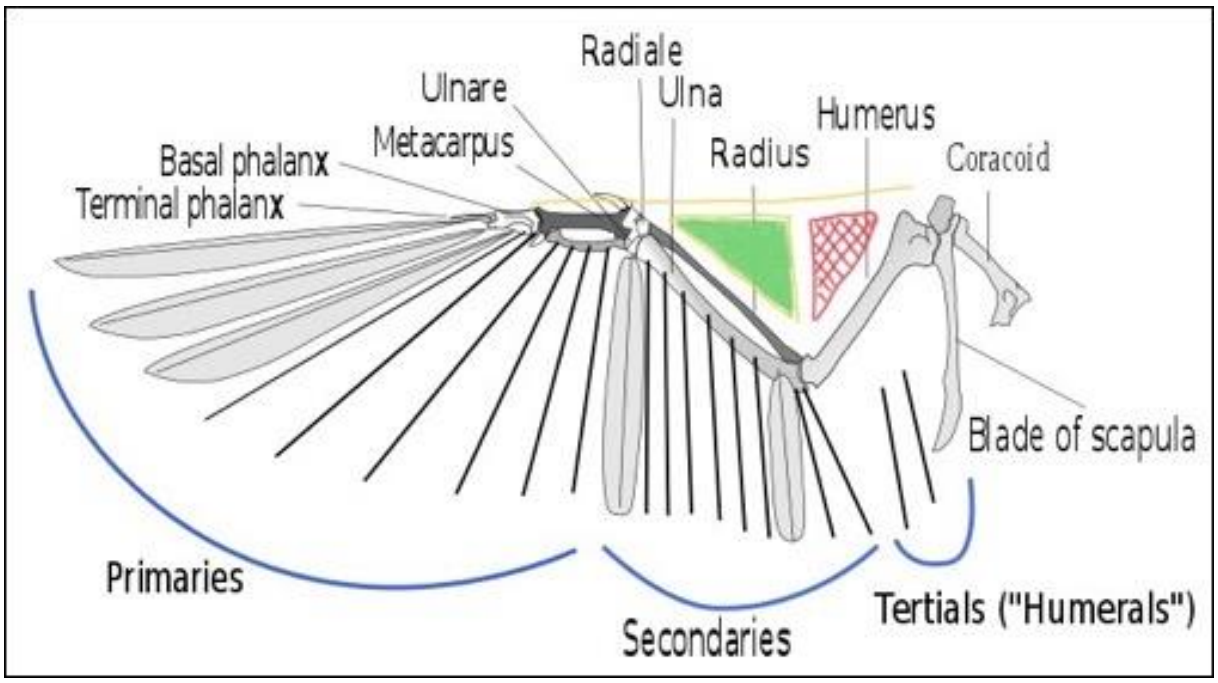

Figure 7.3: Wing anatomy. Original image from wikiwand.com and modified.

Fitting to the bird

1) After carefully cleaning the selected area, pierce or punch a hole within the radius-side right triangle (green) while maintaining the correlation of upper and lower layers of skin by pinching firmly with the hand opposite of the one running the needle or leather punch (sometimes the two layers of skin will slip thus ending up with the holes out of alignment).

2) If using the tubular-style piercing needle, one can slide the heat-shrink-tubing-encased stainless steel bolt inside of the needle's back end so that the needle passes through and the bolt is thereby left in place of the needle's shaft and ready for attachment on the inside of the wing by the plastic lock strap. This, however, would require one lobe of the tag, washer, and bolt be pre-loaded and applied to the outside of the wing so that once the post is placed through the patagium, the remaining side of the tag and plastic lock strap fold over the leading edge of the wing, locked down with washer and nylock nut (Fig. 6.4).

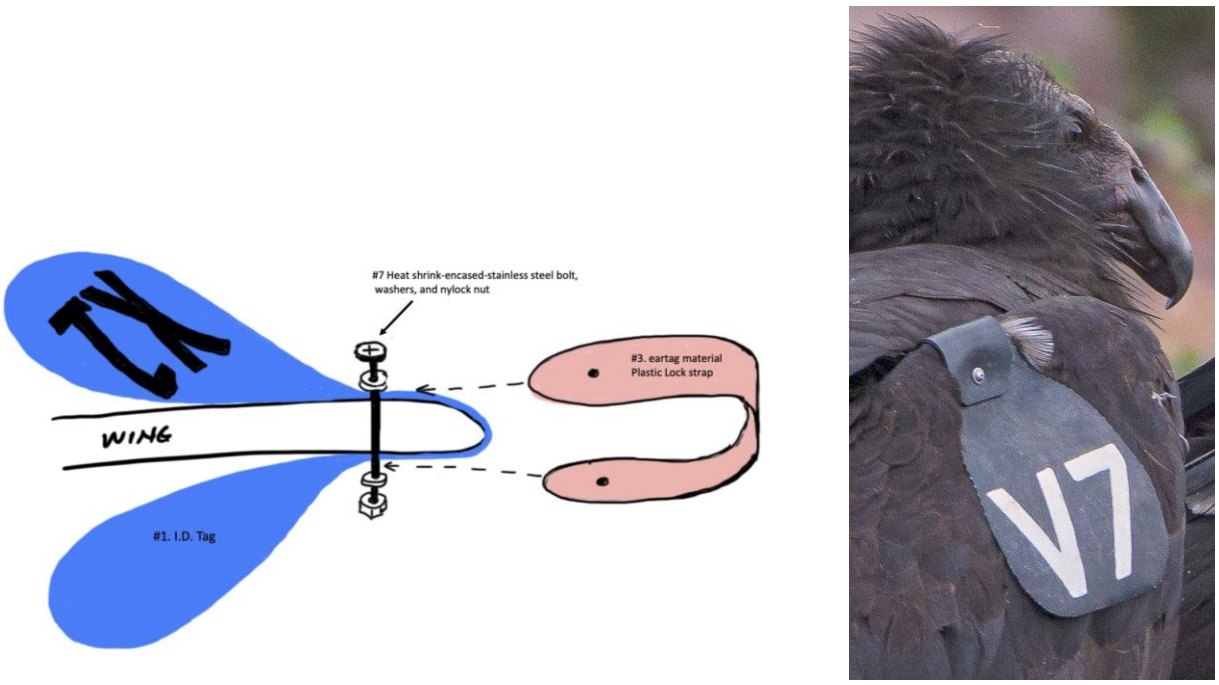

Figure 7.4: Patagial-mount number tag using plastic lock strip.

3) Make sure that the apparatus is not pinching the patagium. It should be firmly attached as to not allow severe movement independent of the wing, but not pinch or in any way restrict movement of blood flow. Additionally, feathers should be dressed as to not impinge, although sometimes (as pictured below) feathers do twist or move after placement. Alternatively, if the patagial hole is punched or pierced slightly larger in diameter, cattle ear-tag buttons, (equipment #3) can be attached with the Tag Applicator Tool (equipment item #4) (Fig. 7.5).

Figure 7.5: Cattle ear-tag button tag method.

Transmitter/I.D. Tag attachment:

Transmitter placement follows the same steps as affixing an I.D. tag with the bolt and plastic lock technique but the post from the transmitter replaces the stainless steel bolt and the plastic lock strip is replaced by a full-size ear tag, trimmed of the button portion of equipment item #3, and attached to the top, or leading edge of the transmitter (Fig. 7.6).

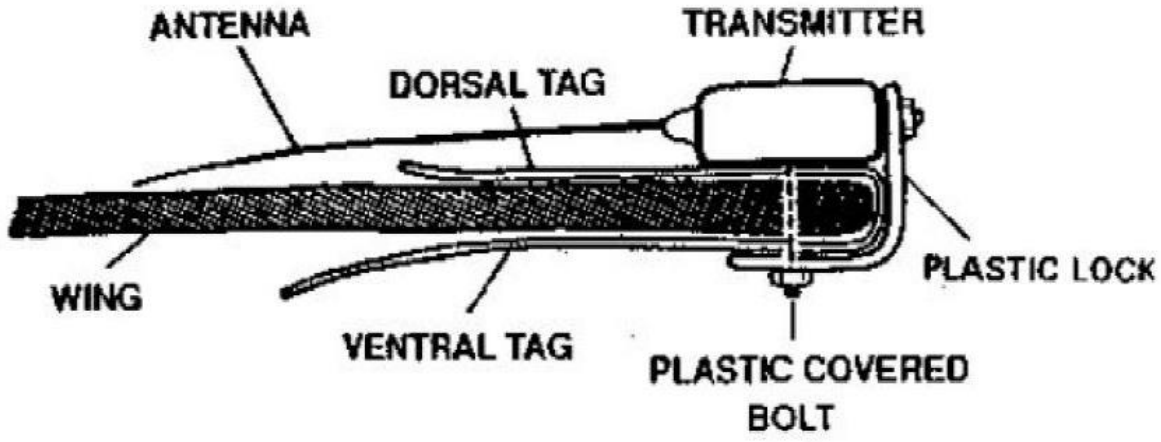

Figure7.6: Original illustration from Wallace et al. 1994.

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