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Tracing pugmarks - wildlife and technology

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INTRODUCTION

Radio collars are pivotal tools for tracking the movement, behaviour, and ecology of free-ranging wildlife. They can help understand patterns of home range, migration, habitat use, social interactions, mortality causes, and responses to environmental change. (Cagnacci *et al.,* 2010).

RADIO COLLARS: COMPONENTS AND TECHNOLOGY

Fernando *et al.* (2015) observed that earlier very high- frequency (VHF) type collars were used that used a VHF transmitter and could be traced using a directional antenna to trace any animal but it was time-taking. So, nowadays, GPS- collars are used that transmit data remotely without the need to be present on field for receipt of signals. It is more accurate than VHF collars in locating the animal.

Toe clipping or scute-clipping are some conventional techniques for identification used in lizards and snakes and heated wire branding and shell notching is reportedly used in turtles. Thirty sand lizards (*Lacerta agilis*) were radio tagged in for study of habitat utilisation and behaviour study. The lizards were caught and fitted with radio transmitter using Rappole- harness method (Simbula *et al.,* 2025).

Efforts are made to ensure the weight of collar does not exceed 3% of the animal's weight (Foley and Zubiri, 2020). While, as per variable belt and battery, some sources quote that collar weight should not exceed 5% body weight (Sikes *et al.,* 2016).

RFID stands for radio-frequency identification technology is also implemented in the form of microchips or passive integrated transponder (PIT) tags and can be used for monitoring of wild animals (Harrison and Kelly, 2022). The tag eventually gets encapsulated by fibrous tissue that stabilizes its location. Such PIT tag can placed subcutaneously with the caution to minimise injury or complication in the triceps muscular area reptiles such as the Kemp's Ridley turtle. Physiological stress driven reduced immunity poses the risk of infection in the site of tagging (Wyneken *et al.,* 2010).

MODERN VARIANTS

GPS Collars: They can automatically record geographic locations at set intervals. The tracking is based on radio receiver and thus, the collar does not carry any transmitter. Satellite helps in tracking the animal location through the radio receiver. They have helped reduce field work required to trace animals and helps in accurate tracking of animals.

Satellite Collars: They transmit GPS data via satellites, enabling real-time tracking across remote regions (Tomkiewicz *et al.,* 2010). They are of higher cost and durability is less than VHF collars.

Iridium uplink GPS collar: These collars have been used in fourteen elephants in Kinabatangan floodplains in Indonesia and weight of collar was reported to be 14 kg *i.e.* less than 1% of the body weight (Abram *et al.,* 2022). It helped identify the habitat usage by the elephants.

Argos uplink GPS collar: They were fitted on adult migratory Caribou (*Rangifer tarandus*) to study effect of weight of collar on survivability and migration of animals (Rasiulis *et al.,* 2014).

APPLICATIONS IN WILDLIFE RESEARCH AND MANAGEMENT

Habitat Use and Home Ranges

Radio collars reveal crucial data about space use. For example, jaguar home ranges in tropical forests vary with prey availability, impacted by habitat fragmentation (Silver *et al*., 2004).

Movement Ecology and Migration

Species like caribou undertake long migrations. Satellite collars trace these patterns across vast landscapes, informing corridor protection. Five snow leopards (*Panthera uncia*) were tracked for information of Iridium linked GPS radio collar data in Kanchenjunga conservation area, Nepal. The data was used to study the home range of animals in the difficult mountainous terrain, not accessible physically for observation (Shrestha *et al.,* 2025).

Long-term Effects

Improperly fitted collars can cause skin abrasions, impede movement, or impact foraging. Research shows refined designs reduce these impacts significantly (Lennox and Good, 2015).

CASE STUDIES

A female sloth bear infamous for several conflict scenarios was immobilized and and a GPS/ VHF collar was fitted. The collected location data was used to study the animal's location and behaviour over a duration of six months (Arun *et al.,* 2021). GPS collars installed on Gaur Bandhavgarh tiger reserve helped evaluate impact of reintroduction and ecology of gaur (Manjrekar *et al.,* 2017). Five snow leopards in the Altai mountains area, Mongolia were immobilized and GPS collars were fitted on them. Data collected was used to study their home range and ecology (Rosenbaum *et al.,*2023).

11 wild elephants- 6 females and 5 males were immobilized in the Kodagu coffee plantation area in Karnataka using drugs Etorphine and Xylazine using kumki elephants. Advanced satellite collars (Africa Wildlife Tracking cc, Pretoria, South Africa) imbibed with Iridium satellite transmitter were fitted on all the elephants. The transmitter on activation telecasted the animal's location at regular intervals to the stakeholders. The initiative helped control incidents of vandalizing of coffee plantations by elephants without displacing them. It was used to generate an early alert system to communicate about elephant movements to residents who could practise caution to avoid conflict. It facilitated the timely action by rapid response team to help move the elephants away from human settlements. It helped affirm the safety for forest personnels and staff from human- animal conflict scenarios. Further, it has helped in ecological studies (Muliya *et al.,* 2025).

Three tigers were immobilized by administering the Hellabrunn mixture (Xylazine and Ketamine). The animals were weighed and measured. Very high frequency (Telonics TM) type and satellite type (Vectronics TM) radio- collars were fitted on the animals. (Majumdar *et al.,* 2012). The Project tiger introduced the use of radio telemetry for sambar, nilgai, chital and wild boar but the results were unpublished. In 1983, the Wildlife Institute of India published the first study based on radio- tracking of gharials in Crocodile research centre, Hyderabad. Four leopards (*Panthera pardus fusca*) were immobilized and collared using Vectronics GPS plus collar in Maharashtra (Deka *et al.,* 2012).

Ten Indian eagle owls (*Bubo bengalensis*) were captured using noose carpet trap in Tiruchirappalli, Tamil Nadu. GPS type and VHF type radio tags were affixed on the birds. Data was interpreted over a period of six months. The transmitter in the tag relayed the location at two hours interval in a 24-hour cycle. The collected data was used to study the home range of Indian Eagle owl (Muthusamy *et al.,* 2024).

Nine Malay civets (*Viverra tangalunga*) were captured and collared in Sanah, Malasia using GPS collars imbibed with UHF radio transmitter and GPS microchip were placed on them. The data was used to ecological study of the animal (Evans *et al.,* 2016).

Nineteen Asiatic lions (*Panthera leo*) were captured and radio collared in Gir national park, Gujarat. Vectronic GPS satellite radio-collars were used and data was analysed using ArcMap software. The technique helped in risk monitoring and developing an ecological database for ethological and conflict management study (Ram *et al.,*2022).

CONCLUSION

Radio collars have transformed wildlife science by enabling in-depth, data-driven insights into animal ecology. From early VHF tracking to modern satellite telemetry, these tools inform conservation, management, and ethical stewardship of biodiversity.

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