



Animal Identification

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First Edition, 2012

ISBN 978-81-323-4076-8

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Published by:

White Word Publications

4735/22 Prakashdeep Bldg,

Ansari Road, Darya Ganj,

Delhi - 110002

Email: info@wtbooks.com

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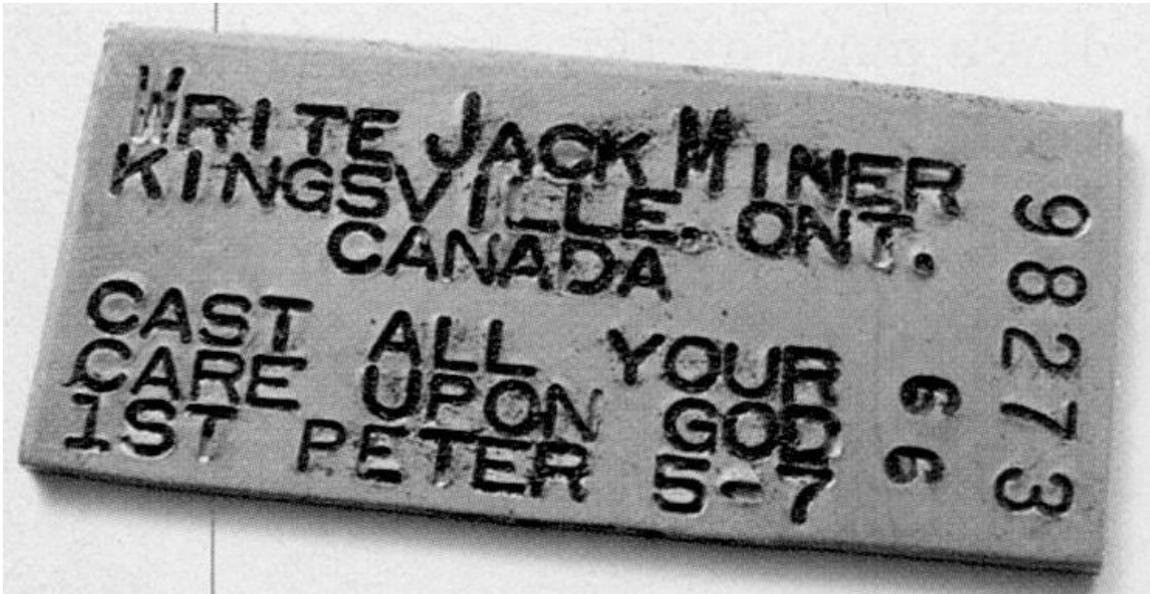
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Chapter 1

Bird Ringing



An early bird band used by Jack Miner for geese. The Bible quote on the band is from 1 Peter 5



A researcher uses a tool to attach the band to the leg of this European Serin.

Bird ringing or **bird banding** is a technique used in the study of wild birds, by attaching a small, individually numbered, metal or plastic tag to their legs or wings, so that various aspects of the bird's life can be studied by the ability to re-find the same individual later. This can include migration, longevity, mortality, population studies, territoriality, feeding behaviour, and other aspects that are studied by ornithologists.

Terminology and techniques



A ringed Ruby-crowned Kinglet recaptured in a mist net

Bird ringing is the term used in the UK and in some other parts of Europe; elsewhere it is known as *bird banding*, as the shape of the tag is more band-like than ring-like.

Organised ringing efforts are called ringing or banding schemes, and the organisations that run them are ringing or banding authorities. (Birds are *ringed* rather than *rung*.)

Those who ring or band birds are known as ringers or banders, and they are typically active at ringing or banding stations.

Birds are either ringed at the nest, or after being trapped in fine mist nets, Heligoland traps, drag nets, cannon nets, or by other methods. Raptors may be caught in bal-chatri traps.

When a bird is caught, a ring of suitable size (usually made of aluminium or other lightweight material) is attached to the bird's leg, and has on it a unique number, as well as a contact address. The bird is often weighed and measured, examined for data relevant to the ringer's project, and then released. The rings are very light, and are designed to have no adverse effect on the birds - indeed, the whole basis of using ringing to gain data about the birds is that ringed birds should behave in all respects in the same way as the unringed population. The birds so tagged can then be identified when they are re-trapped, or found dead, later.

When a ringed bird is found, and the ring number read and reported back to the ringer or ringing authority, this is termed a *ringing recovery* or *control*. The finder can contact the address on the ring, give the unique number, and be told the known history of the bird's movements. Some national ringing/banding authorities also accept reports by phone or on official web sites.

The organising body, by collating many such reports, can then determine patterns of bird movements for large populations. Non-ringing/banding scientists can also obtain data for use in bird-related research.

More commonly in North America, the bands (or rings) have just a unique number (no address) that is recorded along with other identifying information on the bird. If the bird is recaptured the number on the band is recorded (along with other identifying characteristics) as a *retrap*. All band numbers and information on the individual birds are then entered into a database and the information shared throughout North American banding operations. This way information on retrapped birds is more readily available and easy to access.

History

The earliest recorded attempt to mark a bird was made by Quintus Fabius Pictor. This Roman officer, during the Punic Wars around 218-201 BC, was sent a swallow by a besieged garrison, which suggests that this was an established practice. Pictor used a thread on the bird's leg to send a message back. A knight interested in chariot races during the time of Pliny (AD 1) would take swallows to Volterra, 135 miles (217 km) away and release them with information on the race winners.

Falconers in the Middle Ages would fit plates on their falcons with seals of their owners. From around 1560 or so, swans were marked with a *swan mark*, a nick on the bill.

Storks injured by arrows (termed as pfeilstorch in German) traceable to African tribes were found in Germany in 1822 and constituted some of the earliest evidence of long distance migration in European birds.

Ringling of birds for scientific purposes was started in 1899 by Hans Christian Cornelius Mortensen, a Danish schoolteacher. He used zinc rings on European Starlings. The first banding scheme was established in Germany by Johannes Thienemann in 1903 at the Rossitten Bird Observatory on the Baltic Coast of East Prussia. This was followed by Hungary in 1908, Great Britain in 1909 (by Arthur Landsborough Thomson in Aberdeen and Harry Witherby in England), Yugoslavia in 1910 and the Scandinavian countries between 1911 and 1914. In North America John James Audubon and Ernest Thompson Seton were pioneers although their method of marking birds was different from modern ringling. Audubon tied silver threads onto the legs of young Eastern Phoebes in 1803 while Seton marked Snow Buntings in Manitoba with ink in 1882.

Similar schemes

Wing tags



This female Great Frigatebird has been tagged with wing tags as part of a breeding study

In some surveys, involving larger birds such as eagles, brightly-coloured plastic tags are attached to birds' wing feathers. Each has a letter or letters, and the combination of colour and letters uniquely identifies the bird. These can then be read in the field, through binoculars, meaning that there is no need to re-trap the birds. Because the tags are attached to feathers, they drop off when the bird moults. **Imping** is the practice of replacing a bird's normal feather with a brightly-colored false feather. A **patagial tag** is a permanent tag held onto the wing by a rivet punched through the patagium.

Radio transmitters and satellite-tracking

Where detailed information is needed on individual movements, tiny radio transmitters can be fitted on to birds. For small species the transmitter is carried as a 'backpack' fitted over the wing bases, and for larger species it may be attached to a tail feather or looped to the legs. Both types usually have a tiny (10 cm) flexible aerial to improve signal reception. Two field receivers (reading distance and direction) are needed to establish the bird's position using triangulation from the ground. The technique is useful for tracing individuals during landscape-level movements particularly in dense vegetation (such as tropical forests) and for shy or difficult-to-spot species, because birds can be located from a distance without visual confirmation.

The use of satellite transmitters for bird movements is currently restricted by transmitter size - to species larger than about 400g. They may be attached to migratory birds (geese, swans, cranes, penguins etc.) or other species such as penguins that undertake long-distance movements. Individuals may be tracked by satellites for immense distances, for the lifetime of the transmitter battery. As with wing tags, the transmitters may be designed to drop off when the bird moults; or they may be recovered by recapturing the bird.

Field-readable rings

A field-readable is a ring or rings, usually made from plastic and brightly coloured, which may also have conspicuous markings in the form of letters and/or numbers. They are used by biologists working in the field to identify individual birds without recapture and with a minimum of disturbance to their behaviour. Rings large enough to carry numbers are usually restricted to larger birds, although if necessary small extensions to the rings (leg flags) bearing the identification code allow their use on slightly smaller species. For small species (e.g. most passerines), individuals can be identified by using a combination of small rings of different colours, which are read in a specific order. Most colour-marks of this type are considered temporary (the rings degrade, fade and may be lost or removed by the birds) and individuals are usually also fitted with a permanent metal ring.



A Brandt's Cormorant fledgling with a green field-readable J75



Colour-ringed Passerini's Tanager wearing 4 rings in the combination LightGreen/Blue, White/Yellow



Colour-ringed White-collared Manakin (juvenile male) in Costa Rica.



A colour-ringed Herring Gull

Leg-flags

Similar to coloured rings or bands are leg-flags, usually made of Darvic and used in addition to numbered metal bands. Although leg-flags may sometimes have individual codes on them, their more usual use is to code for the sites where the birds were banded in order to elucidate their migration routes and staging areas. The use of colour-coded leg-flags is part of an international program, originated in Australia in 1990, by the countries of the East Asian - Australasian Flyway to identify important areas and routes used by migratory waders.

Other markers

Head and neck markers are very visible, and may be used in species where the legs are not normally visible (such as ducks and geese). **Nasal discs** and **nasal saddles** can be attached to the culmen with a pin looped through the nostrils in birds with perforate nostrils. They should not be used if they obstruct breathing. They should not be used on birds that live in icy climates, as accumulation of ice on a nasal saddle can plug the

nostrils. **Neck collars** made of expandable, non-heat-conducting plastic are very useful for larger birds such as geese.

Some results



Ringed Larus ridibundus in flight

An Arctic Tern ringed as a chick not yet able to fly, on the Farne Islands off the Northumberland coast in eastern Britain in summer 1982, reached Melbourne, Australia in October 1982, a sea journey of **over 22,000 km** (14,000 miles) in just three months from fledging.

A Manx Shearwater ringed as an adult (at least 5 years old), breeding on Copeland Island, Northern Ireland, is currently (2003/2004) the oldest known wild bird in the world: ringed in July 1953, it was retrapped in July 2003, at least **55 years** old. Other ringing recoveries have shown that Manx Shearwaters migrate over 10,000 km to waters off southern Brazil and Argentina in winter, so this bird has covered a *minimum* of 1,000,000 km on migration alone (not counting day-to-day fishing trips). Another bird nearly as old, breeding on Bardsey Island off Wales was calculated by ornithologist Chris Mead to have flown over 8 million kilometres (5 million miles) during its life (and this bird was still alive in 2003, having outlived Chris Mead).

Ringling activities are often regulated by national agencies but because ringed birds may be found across countries, there are consortiums that ensure that recoveries and reports are collated. In the UK, bird ringling is organized by the British Trust for Ornithology. In

North America the US Bird Banding Laboratory collaborates with Canadian programs and since 1996, partners with the North American Banding Council (NABC). The European Union for Bird Ringing (EURING) consolidates ringing data from the various national programs in Europe. In Australia, the Australian Bird and Bat Banding Scheme manages all bird and bat ringing information, while SAFRING manages bird ringing activities in South Africa. Bird ringing in India is managed by the Bombay Natural History Society. The National Center for Bird Conservation CEMAVE coordinates a national scheme for bird ringing in Brazil.

Chapter 2

Dog Collar

A **dog collar** is a piece of material put around the neck of a dog. A collar might be used for control, identification, fashion, or other purposes. Identification tags and medical information is often placed on dog collars. Collars are also useful for controlling a dog manually, as they provide a handle for grabbing. Collars are often used in conjunction with a leash, and a common alternative to a dog collar is a dog harness. Dog collars are the most common form of directing and teaching dogs.

Dog collar is also an informal term for the clerical collar used by Anglican vicars and other clergy.

Basic collars



Leather buckle collar with traditional buckle.

- **Buckle collars**, also called **flat collars**, are usually made of nylon webbing or leather (less common materials can include polyester, hemp, or metal) with a buckle similar to a belt buckle, or a quick-release buckle, either of which holds the collar loosely around the dog's neck. Identification is commonly attached to such a collar; it also comes with a loop to which a leash can be fastened.



Nylon quick-release buckle collar with identification and medical tags.

- Flea collars are impregnated with chemicals that repel fleas. They are usually a supplementary collar, worn in addition to the conventional buckle collar.
- Elizabethan collars, shaped like a truncated cone, can be fitted on a dog to prevent it from scratching a wound on its head or neck or licking a wound or infection on its body.
- **Break-away collars** look similar to buckle collars, but have a safety mechanism installed that allows the dog to break free of the collar if excessive force is

applied. These collars are useful in situations where a non-quick release collar could get snagged and strangle the dog.

- **Safety Stretch Collars** an elastic panel in the sturdy nylon collar allows escape from potential strangulation dangers such as branches, fences, gates and other dogs. Unlike breakaways a stretch collar acts like a traditional static collar when clipped with a leash.
- **Stud collars** are leather collars fitted with dulled points and/or metal studs that traditionally prevented another animal from biting the dog's neck. In modern societies, stud collars are more commonly considered a fashion accessory.

Training collars

Several types of collars are used for the purposes of training dogs, though sometimes a collar is not used at all (such as in the case of dog agility training, where a collar could get caught on equipment and strangle the dog). Each training collar has its own set of advantages and disadvantages (briefly outlined below) which trainers might consider before using a select one. Training collars are typically used for training only and not left on the dog's neck all the time, as some collars can be harmful or dangerous if left on a dog unsupervised.

Flat collars

Some dogs are trained on leash using a buckle or quick-release collar.

Slip collars



Slip collar, showing how the chain pulls through the loop at one end.

Slip collars (also called **choke chains**, **slip chains**, or **choke collars**) are a length of chain or nylon rope with rings at either end such that the collar can be formed into a loop around the top of the dog's neck, just behind the ears. The ring which connects to the leash goes over the back of the dog's neck, not under. When the leash is attached to the *dead ring* the collar does not constrict on the dog's neck. When the leash is attached to the *live ring* the chain slips (adjusts) tighter when pulled and slips looser when tension is released. A quick jerk with an immediate release, euphemistically called a *leash pop*, *snap*, or *correction*, is used to coerce the dog into a 'heel' position.

Prong collar



Prong collar; the looped chain limits how tightly the collar can pull in the same way that a Martingale functions.

Prong collars (sometimes incorrectly termed 'pinch collars') are a series of chain links with blunted open ends turned towards the dog's neck. The design of the prong collar is such that it has a limited circumference unlike slip collars which do not have a limit on how far they can constrict on a dog's neck. The limited traction of the martingale chain combined with the angle of the prongs prevents the prongs moving close enough to pinch. The collar is designed to prevent the dog from pulling by applying pressure at each point against the dog's neck.

Prong collars must never be turned inside out (with the prongs facing away from the dog's skin), as this may cause injury against the body and head. Plastic tips are occasionally placed on the ends of the prongs to protect against tufts forming in the fur or, in the case of low quality manufactured collars with rough chisel cut ends, puncturing

the skin. Like the slip collar, the prong collar is placed high on the dog's neck, just behind the ears, at the most sensitive point.

Some dogs can free themselves from prong collars with large wire looped sides by shaking their head so that the links pop out, so some trainers have come to use a second collar (usually an oversize slip collar) in addition to the prong collar so when this happens the dog does not run loose.

Martingale collar



Martingale Collar with Chain Loop; martingale collars also come with a fabric loop instead of chain as well as optional buckles on both styles.

Martingale collars are recommended for Sighthounds because their heads are smaller than their necks and they can often slip out of standard collars. They can, however, be used for any breed of dog. Their no-slip feature has made them a safety standard at many kennels and animal shelters. A martingale collar has 2 loops; the smaller loop is the "control loop" that tightens the larger loop when pulled to prevent dogs from slipping out

of the collar. Similar to a prong collar, the martingale has limited constriction on the dog's neck and applies even pressure.

Head halters



The halter-style collar controls the dog's head but does not restrict its ability to pant, drink, or grasp objects.

Head halters, sold under the brand names *Halti* or *Gentle Leader* or *Snoot Loop*, are similar in design to a halter for a horse. This device fastens around the back of the neck and over the top of the muzzle, giving more control over a dog's direction and the intensity of pulling on a leash than collars that fit strictly around the neck. Pressure on this type of collar pulls the dog's head towards the handler.

Controversy

Supporters of the head halter say that it enables the handler to control the dog's head, and makes the dog unable to pull using its full strength. It is especially useful with reactive dogs, when control of the dog's head can be a safety issue.

Those who do not recommend use of the head halter say that some dogs find it unnatural and uncomfortable. If the collar is too tight, it may dig too deeply into the skin or the strap around the muzzle may push into the dog's eyes. Cervical injury is a possible result from improper use of the head halter; if a dog is jerked suddenly by the leash attached to the head halter, the dog's neck is pulled sharply to the side, which might result in neck injury. If the nose strap is fitted too tightly, the hair on the muzzle can also be rubbed off, or the dog might paw and scratch at its face, causing injuries ranging from mere bare skin to severe abrasions.

Shock collars

Shock collars (or *training collars*, *remote training collars*, *e-collars*, *electronic collars* and *hunting collars*) are electronic training aids developed to deliver an electrical signal, vibration, tone, through contact points attached to a dog collar.

Wolf collars

Wolf collars or **protection collars** are metal collars fitted with large spikes radiating away from the dog, usually worn by dogs protecting livestock in case they are attacked by wolves or other predators. Such collars protect the neck of a dog from direct attack. It is rare to see these collars being used in modern societies.

JASA Force Collar

A **force collar** is a leather collar with metal prongs staggered along the inside; similar to a prong collar.

Lighted Collar

A **lighted collar** (or *collar light*, *dog light*) is a collar that emits light in order to make a dog more visible in the dark to their owners and more importantly, nearby motorists. It should be noted that it is not designed to help a dog see at night, as it is well documented that dogs have very good vision in low light conditions.

Most lighted collars utilize one or more light emitting diodes for the light source and can be of virtually any color, although red and blue are most common. Power is provided by one or more batteries, most common types being AAA and lithium coin cells to minimize the added weight to the collar.

Flotation collar

A **flotation collar** (or *buoyant collar*) is a buoyancy aid designed for dogs. Although it is not designed to be used as a life preserver or life jacket, it can provide additional buoyant support for the head of a dog when in the water. It is often used in canine hydrotherapy services to assist in the rehabilitation of injured dogs. The collar may be constructed of closed cell foam material that is inherently buoyant or be of a type that is inflated with air.

Chapter 3

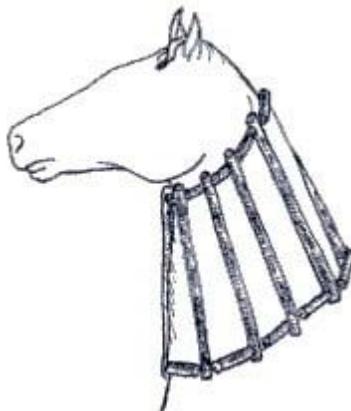
Collar (Animal)



Tie up collar correctly used with a headcollar on a stallion



Nylon quick-release buckle collar on a dog with identification and medical tags.



Wooden neck cradle

An animal **collar** is a device that attached to the neck of an animal to allow it to be harnessed, tied up or for various other reasons.

- **Pet collar.** A piece of material put around the neck of certain pet animals, such as dogs or cats, for control, identification, or other purposes. Identification tags and medical information is often placed on collars. Collars are also useful for controlling the animal, as they provide a handle for grabbing or means of leading. Similar collars are used with non-pet animals such as zoo animals and domestic animals including calves, goats and sheep etc. Pet collars can be made of leather, nylon or metal. Metal collars are normally used for larger and dangerous dogs. They can come with traditional or quick-release buckles. Collars are sometimes used for fashion purposes. Pet collars also include collars especially designed for raccoons, ferrets and other such pets.
- **Cat collar.** Similar to dog collars, but often include a bell to warn fauna of the cat's presence. Collars used on cats are smaller and thinner. They can be made of leather, nylon or other types of materials. Some of the cat collars have a solution impregnated which is helpful in fighting against flea, tick and mosquitoes.
- **Anti-bark dog collar, or bark control collar.** Produces a citronella spray or a high pitched sound in response to loud noise, to distract and deter a dog from barking. Bark control collars come in different designs and with various modalities to keep a dog quite. Other than citronella bark collars, there are the sonic or ultrasonic collars which also use vibration to stop a dog barking. These collars produce a very high resonance tone which cannot be heard by humans and which comes as a response to barking. Once a dog has worn the collar for a while, the sound or the vibration will cause it distress which will eventually lead to deterring it barking. Other bark control collars include devices that produce a mild electrical sensation whenever the dog barks. These types of collars must have a failsafe mechanism incorporated to make sure that the device is automatically turned off after a certain period of time. Many designs come with a combination of the bark collars mentioned above. Another type of bark control collar is the escalation one, a device that produces quiet sounds which keep increasing in intensity if the dog does not cease barking. They have proven to be more effective than the other types of bark control collars because the dog may get used to stop barking before the device produces sounds of high levels of output. However, the use of such collars is controversial. Many do not see these options as safe and viable, especially considering the electrical ones. Pet lovers criticize these devices, seeing in them a method of torture. As a result, it is recommended that all the other options such as training, trying to understand the communication or seeking professional advice are considered before choosing these bark control collars.
- **Training collar or shock collar.** These (usually for dogs) use an electric shock to improve animal training, reinforce commands and eliminate any bad habits. It

may be combined with an "invisible fence", a signal wire surrounding the dog's permitted area, the dog receiving a shock if it strays too near it.

- **Choke collars** are also a type of training collars. They are made of different materials with high resistance such as metal or various composites. This type of collar is suitable for obedience training as it tightens around the neck of the dog if it goes further than the owner allows it to. It is mainly used on dogs.
- **Insect collar** or **flea collar**. Impregnated with chemicals that repel or kill external parasites. They are usually a supplementary collar, worn in addition to the conventional buckle collar on a dog. They are also used on horses, too. Flea collars' effectiveness is arguable. Although they are convenient because of their cost and of their accessibility as well as the comfort they provide for the pet, they only protect them from fleas that could be found around the neck. They are considered to be more effective in preventing infestation with external parasites rather than fighting against them. Flea collars are best used when a proper disinfestation has been performed, both indoor and outdoor. These collars are primarily worn by cats and dogs.
- **Pig hunting dog collar**, This collar integrates a wide collar and a breastplate for pig dogs. They are made from multiple layers of extra tough fabric or leather to protect the vital carotid artery and jugular vein of pig hunting dogs should they be attacked. Some of the pig hunting dog collars come in the form of a full-body protection collar. These collars provide good protection for the dog's chest, neck and rib cage.
- **Elizabethan collar**. Shaped like a lamp shade to prevent an animal from licking something on their body, such as a wound.
- **Tie-up collar**. Used for bulls and other cattle, these may be a chain (sometimes covered in plastic hose), or a collar of heavy leather or synthetic material fastened with a heavy duty buckle.
- **Animal tracking collar**. Used for tracking animal migration, or to locate lost pets. In its simplest form contains a radio beacon to allow the location of the animal. More sophisticated devices may contain a GPS tracking unit to record the animal's track, other sensors to record water depth or other environmental information, and a mobile phone or other radio transmitter to report location and other data. May have a timed or remotely-controlled release device.
- **Horse collars**.
 - **Full collar** or **Horse Collar**. Used for horses or other draught animals, this consists of a robustly constructed leather device stuffed with straw or other material, that sits comfortably on the animal's shoulders around its lower neck, supporting a set of hames that transfer the draught forces from the animal to the traces.
 - **Breast collar** or **Breastplate**. Two forms: One is a simpler type of draught collar for lighter loads, consisting of a padded strap around the chest of the animal. The other is similar, but is attached to a saddle and used when riding a horse to prevent the saddle from sliding back.
 - **Horse tie-up collar**. A collar designed to teach horses to tie up and to tie stallions at public events. It is constructed from double-stitched wide

leather (sometimes fleece lined), with heavy duty dees sewn into each end. The collar is placed on a horse just behind the poll strap of a headcollar (headstall) which is used in conjunction, and a strong rope passes through the headcollar to secure the two dees so that the horse's wind is not impaired in any way. This manner of application will reduce the likelihood of the collar slipping and injuring or choking the horse. Sometimes used for tethering horses, they are expensive and are potentially dangerous if the horse should become entangled in the tether or frightened etc.

- **Mare collar.** A simple buckled neck strap that has a plastic ID tag attached.
- **Headcollar or halter.** Not strictly a collar, this consists of straps around the head for tethering, tying or leading horses or other livestock.
- **Cribbing or wind-sucking collar.** The "Nutcracker" collar is an adjustable strap with a lightweight aluminium 'nutcracker'. It is placed around a horse's neck to help prevent windsucking by stopping the flexing of the neck muscles whenever it tries to suck in air. Other varieties are also available, too.
- **Cornell Collar** A device developed for use on racehorses to prevent dorsal displacement of the soft palate during racing.
- **Neck cradle.** Used on horses to prevent them chewing at injuries and dressings.

Collars can be dangerous for pets that live in crates or which might get stuck in tree branches and that is why safety collars have been developed. There is a particular type of safety collar which is intended for both dogs and cats. Breakaway collars are especially designed to prevent the pet from choking or getting stuck because of their collar. They feature a clever design that releases quickly when a small amount of pressure is applied, such as the cat, hanging from a tree branch. The clasp will release, which quickly gets the pet out of a possibly desperate situation. However, pets are recommended to be taken their collar off when sleeping in a wired crate.

Chapter 4

Ear Tag and Earmark (Agriculture)

Ear tag



A sheep with an ear tag.

An **ear tag** is a plastic or metal object used for identification of domestic livestock and other animals. If the ear tag contains an RFID module conforming to ISO 11784 & 11785, then it is called an **electronic ear tag**.

Overview

An ear tag usually carries an individual identification number or code for the animal, or for its herd or flock. This identification number (ID) may be assigned by some national organisations (usually in the form of Property Identification Code, or PIC), or they may be handwritten for the convenience of the farmer ("management tags"). The National Livestock Identification System (NLIS) of Australia regulations require that all cattle be fitted with a RFID device in the form of an ear tag or rumen bolus before movement from the property and that the movement be reported to the NLIS. However, if animals are tagged for internal purposes in a herd or farm, IDs need not be unique in larger scales. The NLIS now also requires sheep and goats to use an ear tag that has the Property Identification Code inscribed on it. These ear tags and boluses are complemented by transport documents supplied by vendors that are used for identification and tracking. A similar system is used for cattle in the European Union, each bovine animal having a passport document and tag in each ear carrying the same number. Sheep and goats in the EU have a tag in each ear carrying the official number of their flock and also an individual number for each animal; one of these tags (usually the left) must have a RFID chip (or the chip may instead be carried in a rumen bolus).

An ear tag can be applied with an ear tag applicator (also called pliers), however there are also specially-designed tags that can be applied by hand. Depending on the purpose of the tagging, an animal may be tagged on one ear or both. If there exists a national animal identification programme in a country, animals may be tagged on both ears for the sake of increased security and effectiveness, or as a legal requirement. If animals are tagged for private purposes, usually one ear is tagged. Australian sheep and goats are required to have visually readable ear tags printed with a Property Identification Code (PIC). They are complemented by movement documents supplied by consignors that are used for identification and tracking.

Very small ear tags are available for laboratory animals such as mice and rats. They are usually sold with a device that pierces the animal's ear and installs the tag at the same time. Lab animals can also be identified by other methods such as ear punching or notching, implanted RFID tags (mice are too small to wear an ear tag containing an RFID chip), and dye.

History



A sow polar bear with ear tag

Although ear tags were developed as early as 1913 as a means to identify cattle when testing for tuberculosis, the significant increase of use of ear tags appeared with the outbreak of BSE in UK. Today, ear tags in a variety of designs are used throughout the world on many species of animal to ensure traceability, to help prevent theft and to control disease outbreaks.

The first ear tags were primarily steel with nickel plating. After World War II, larger, flag-like, plastic tags were developed in the United States. Designed to be visible from a distance, these were applied by cutting a slit in the ear and slipping the arrow-shaped head of the tag through it so that the flag would hang from the ear.

In 1953, the first two-piece, self-piercing plastic ear tag was developed and patented. This tag, which combined the easy application of metal tags with the visibility and colour options of plastic tags, also limited the transfer of blood-borne diseases between animals during the application process.

Some cattle ear tags contain chemicals to control insects such as buffalo fly etc. Metal ear tags are used to identify the date of regulation shearing of stud and show sheep. Today, a

large number of manufacturers are in competition for the identification of world livestock population.

The United States Department of Agriculture maintains a list of manufacturers approved to sell ear tags in the USA for the National Animal Identification System.

The International Committee for Animal Recording (ICAR) controls the issue electronic tag numbers.

The National Livestock Identification System (NLIS) is Australia's system for tracing cattle, sheep and goats from birth to slaughter.

Other forms of animal identification

Pigs, cattle and sheep are frequently earmarked with pliers that notch registered owner and/or age marks into the ear. Mares on large studs have a plastic tag attached to a neck strap for identification. Valuable animals, such as stallions, usually have a brass name plate on their headcollar during transportation. Dairy cows are sometimes identified with ratchet fastened plastic anklets fitted on the pastern for ready inspection during milking.

The National Livestock Identification System (NLIS) Australia, formerly used cattle tail tags for property identification and hormone usage declaration.

Earmark (agriculture)



L-R: swallowtail, half halfpenny and slit; and double L earmarks with the earmarkers designed for sheep.

An **earmark** is a cut or mark in the ear of livestock animals such as cattle, deer, pigs, goats, camels or sheep, made to show ownership, year of birth or gender.

The term dates to the 16th century in England, but the practice may date before that, especially in areas where people grazed livestock among the village herd on common fields.

Earmarks are typically registered when a stock owner registers a livestock brand for their use. There are many rules and regulations concerning the use of earmarks between states and countries. Tasmanian sheep and cattle must be earmarked before they become six months old.

Generally the owner's earmark is placed in a designated ear of a camel or sheep to indicate its gender. Typically if a registered earmark is used, it must be applied to the right ear for ewes and the left ear for female camels. The other ear of a sheep then may be used to show the year of its birth. Cattle earmarks are often a variety of knife cuts in the ear as an aid to identification, but it does not necessarily constitute proof of ownership.

Since the 1950s it has been more common to use ear tags to identify livestock because coloured tags are capable of conveying more information than earmarks. Such ear tags were popularised by New Zealand dairy farmers in the earliest successful use of them.

Because of the ubiquity of earmarking, in the nineteenth and twentieth centuries, it became common parlance to call any identifying mark an earmark. In early times many politicians were country or farming folk and were adept at using such words in different ways and in creating new concepts.

Today it is common to refer to an institution's ability to designate funds for a specific use or owner as an earmark. Also, earmark has different meanings in the fields of public finance and politics.

Chapter 5

Horse Markings



These young horses, though all the same color, exhibit uniquely different markings, which can be used to identify individual horses



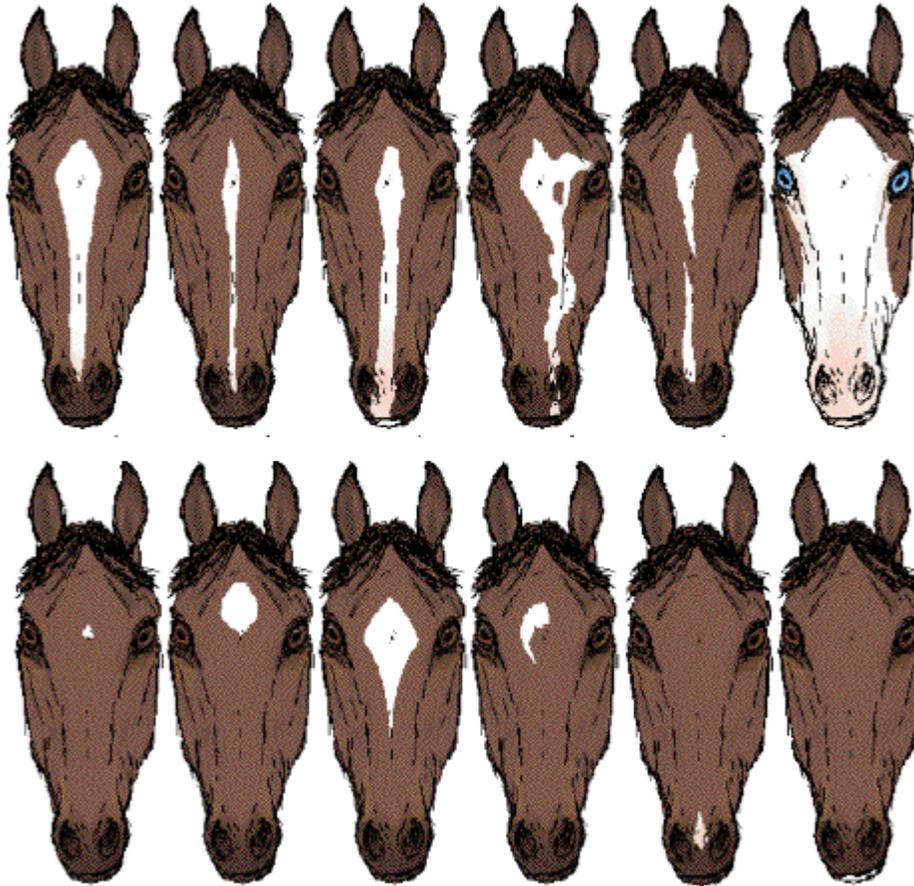
A marking on a horse's muzzle showing pink skin under most of the white hairs, dark skin at the edges of the marking.

Markings on horses usually are distinctive white areas on an otherwise dark base coat color. Most horses have some markings, and they help to identify the horse as a unique individual. Markings are present at birth and do not change over the course of the horse's life. Most markings have pink skin underneath most of the white hairs, though a few faint markings may occasionally have white hair with no underlying pink skin. Markings may appear to change slightly when a horse grows or sheds its winter coat, however the difference is simply a factor of hair coat length, the underlying design does not change.

On a gray horse, markings visible at birth may become hidden as the horse turns white with age, but markings can still be determined by trimming the horse's hair closely, then wetting down the coat to see where there is pink skin and black skin under the hair.

Types of white markings

Facial markings



Facial markings. Top row, L-R: Blaze, Stripe, Stripe (or thin blaze) and snip, Irregular blaze, Interrupted stripe, bald face. Bottom row, L-R: Faint star, Star, Star and strip, irregular star, snip, lip marking

Facial markings are usually described by shape and location. There may be more than one distinct facial marking and if so, will be named separately. Occasionally, when a white marking extends over an eye, that eye may be blue instead of brown, though this is not consistently seen in all cases.

Common facial markings are:

- Blaze: a wide white stripe down the middle of the face.
- Strip, stripe, or race: a narrow white stripe down the middle of the face.
- Bald Face: a very wide blaze, extending to or past the eyes. Some, but not all, bald faced horses also have blue eyes.

- Star: a white marking between or above the eyes. If a stripe or blaze is present, a star must be significantly wider than the vertical marking to be designated separately.
- Snip: a white marking on the muzzle, between the nostrils.

Additional terms used to describe facial markings include the following:

- Faint: A small, yet permanent marking that usually consists of white hairs without any underlying pink skin.
- Interrupted: A marking, usually a strip or blaze, that is broken and not solid for the entire length of the face.
- Connected: Occasionally used to describe distinctively different markings that happen to be joined to one another
- Irregular or crooked: A marking, usually a strip or blaze, that does not have a more or less straight path.
- Lip markings: have no specialized names, usually are described by location, such as "lower lip," "chin", etc. Lip markings may indicate presence of the sabino color pattern.



Leg markings. Top row, L-R: Stocking, Sock or Boot, Fetlock or Sock. Bottom row, L-R: Pastern, Coronet, Partial Pastern

Leg markings

Leg markings are usually described by the highest point of the horse's leg that is covered by white. As a general rule, the horse's hoof beneath a white marking at the coronary line will also be light-colored ("white"). If a horse has a partial marking or ermine spots at the coronary band, the hoof may be both dark and light, corresponding with the hair coat immediately above. Where the Leopard gene is present, the hoof may be striped even if markings are not visible at the coronary band.

From tallest to shortest, common leg markings are:

- Stocking: white marking that extends at least to the bottom of the knee or hock, sometimes higher.

- Sock: white marking that extends higher than the fetlock but not as high as the knee or hock. This marking is sometimes called a "boot."
- Fetlock or Sock: white marking that extends over the fetlock, occasionally called a "boot."
- Pastern: white marking that extends above the top of the hoof, but stops below the fetlock.
- Coronet: white just above the hoof, around coronary band, usually no more than 1 inch (2.5cm) above the hoof.

Additional terms used to describe white leg markings include:

- Irregular: A marking within the broad confines of a given height, but with significantly uneven edges. Indicated by the highest point of the white. Most often used to describe certain types of stockings.
- Partial: An irregular marking that only extends up part of the leg to the height indicated, sometimes with the other side of the leg dark. Usually used to describe socks and other short markings.
- "High White:" White stockings that extend above the knee or hock, sometimes extending past the stifle onto the flank or belly, considered characteristic of the sabino color pattern.

Examples

Facial markings



A "baldfaced" horse



A horse with a blaze



A horse with a star, interrupted stripe, and snip



A horse with a star

Leg markings



Shorter marking is sometimes called a "fetlock" or a "sock," taller marking is clearly a sock



A stocking



A horse with "high white," including stockings on all four legs



A coronet marking

Non-white markings



Ermine marks, seen here on the coronary band, just above the hoof.



A Bend-Or Spot

- Bend-Or spots: Dark faint spotting, usually seen on horses with a Chestnut or Palomino coat color.
- Ermine marks: The occurrence of black marks on a white marking, most often seen on leg markings just above the hoof.
- "Medicine hat": An unusual type of Pinto or Paint coloring where the horse has dark ears and poll (like a hat on the head), but surrounded on all sides of the head and neck by white.
- Shield: A dark Pinto marking where the horse has a dark colored chest, surrounded completely by white on the shoulders, legs, belly and neck. Occasionally used to describe the rarer example of a horse with a totally dark head surrounded completely by white.

Other markings



This horse has a belly spot. It also has a blaze and three stockings

Horses may have isolated body spots that are not large or numerous enough to qualify them as an Appaloosa, Pinto or Paint. Such markings are usually simply called "body spots," sometimes identified by location, i.e. "belly spot," "flank spot," etc. When this type of isolated spotting occurs, it is usually the action of the sabino gene.

Horses may develop white markings over areas where there was an injury to the animal, either to cover scar tissue from a cut or abrasion, or to reflect harm to the underlying skin or nerves. One common type of scarring that produces patches of white hairs are "saddle marks," which are round or oval marks on either side of the withers, produced by a pinching saddle that had been worn over a long period of time.



A white marking on the crest of a horse's neck artificially created by freeze branding, a form of marking for identification claimed to be nearly painless to the horse.

Natural markings

Birdcatcher spots are small white spots, usually between 1 mm and 1 inch (25.4 mm) in diameter. It is not yet known what controls their expression, although it is believed that they are not genetic. Birdcatcher spots occur in many breeds. These spots may occur late in a horse's life, or may occur and then disappear.

Ticking or *Birdcatcher ticks* are markings that involves white flecks of hair at the flank, and white hairs at the base of the tail, called a "skunk tail". These patterns are permanent and probably genetic. It is thought that this roaning effect might be linked to the rabicano gene. The name comes from a Thoroughbred horse named Birdcatcher, who had white hairs throughout his flank and tail

Scarring, skin disease and injury

- Rainscald or *Dermatophilus congolensis* can leave a horse with small white spots, especially along his top line.
- Roan horses often develop patches of solid (dark) hair on the roan sections of their bodies wherever there has been any scratch or damage to underlying skin, even if only slight. These are sometimes called "corn marks" or "corn spots."

Scarring on a horse usually results in white hairs growing in over the injured area, though occasionally there may be no hair growth over the scar at all.

- *Saddle marks* may be seen on the back or withers as a patch of white hairs, usually a result of wearing an improperly-fitted saddle for long periods, but also could be related to straightforward long-term saddle wear, unclean saddle blankets and other causes. White marks just forward of the withers may be the result of an ill-fitting horse blanket worn for a long period of time.



A hot brand on a horse.

- A type of deliberate human-created scarring that results in white hair is freeze branding, a method of permanently marking a horse for identification purposes.

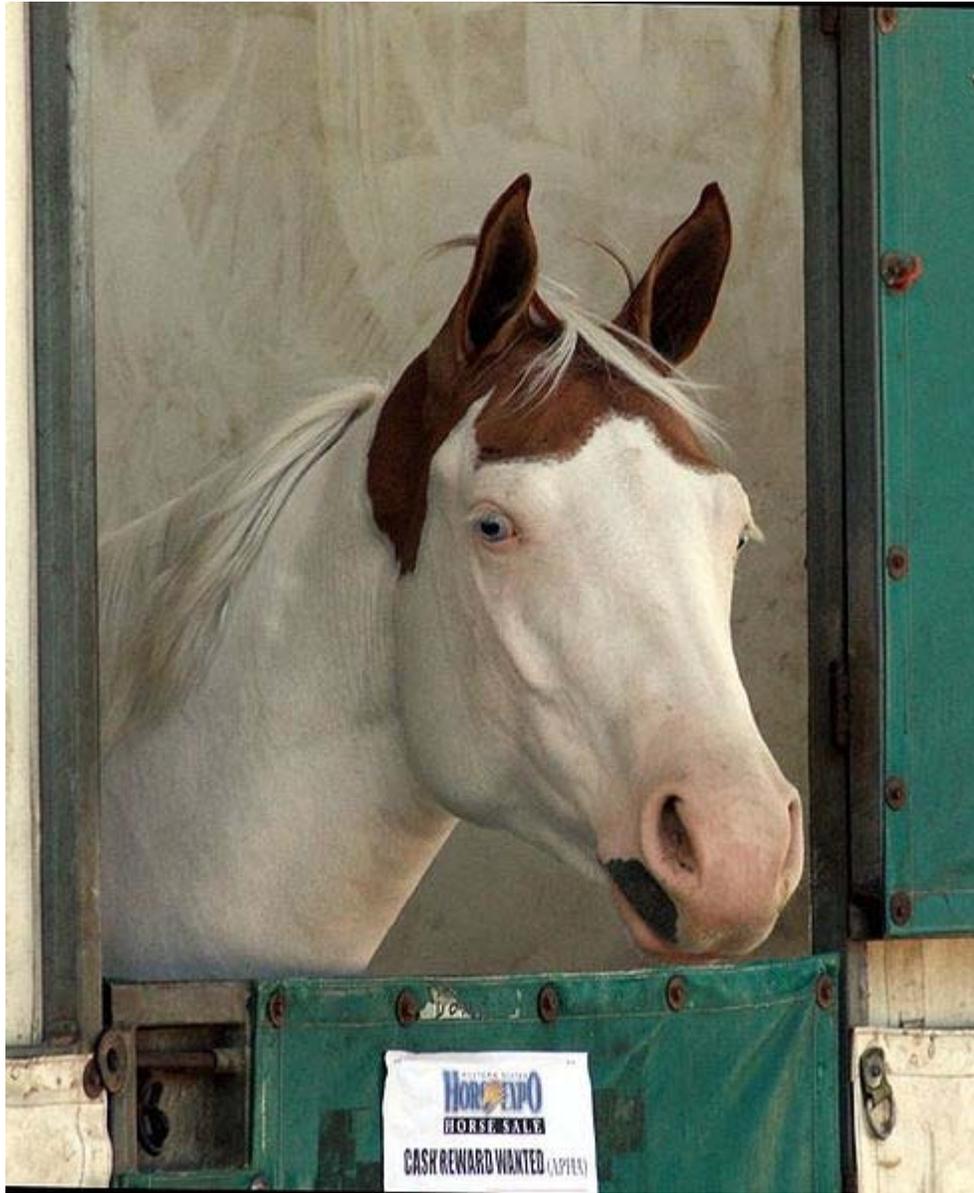
Some forms of hot branding may also scar lightly enough to leave white hairs rather than bare skin.



A freeze brand on a horse's shoulder, a common spot for branding.

- Leg scars left from pin firing or bar firing, in which an injury is blistered with hot iron, can leave dots or lines of white hair in a very distinct pattern. This is usually seen on Thoroughbreds that have raced. This treatment is not commonly practiced, but such markings are still occasionally seen.
- Scars from accidents, as well as old injury sites (such as bowed tendons), can also be used to identify a horse.

Other identifying features



A tovero horse with blue eyes and "Medicine hat" markings.

Horses can be uniquely identified by more than just markings or brands. A few other physical characteristics sometimes used to distinguish a horse from another are:

- Whorls, colloquially known as "cowlicks": divergent or convergent patches of hair found anywhere on the body but mostly on the head, neck, chest, belly, or just in front of the stifles.
- "Glass" eye, "Moon" eye, "China" eye, "Wall" eye or "Night" eye: A blue eye. Horses with blue eyes are less common than horses with brown eyes, but can see equally well.

- Chestnuts: A callous-like area on the inside of the horse's leg that has a subtle pattern, but one unique to each horse. It has been proposed that chestnuts could be used as a type of "fingerprint" to identify a horse, but the idea has failed to become widespread in practice, probably in part because the chestnut continually grows and sheds, making precise measurement a challenge.
- "Prophet's thumbs," or muscle dimples, are small indentations in the muscle, usually found on the horse's neck.

Coat Colors with distinctive patterns

Some horse coat colors are distinguished by unique patterns. However, even for horses with coat colors that are arranged in a manner unique to each individual horse, these patterns are not called "markings." Some coat colors partially distinguished by unique patterning include:

- Appaloosa or "Leopard": A breed and a horse coat color pattern of small leopard-type spotting.
- Bay: A horse coat color that features "black points" on a red base coat. All bay horses have a black mane, tail and legs (except where overlain by white markings), caused by the presence of the Agouti gene. Most have black hairs along the edges of their ears and on their muzzles, and occasionally will have a slight darkening of the hairs along their backbone.
- Brindle: An extremely rare horse coat color, it features faint vertical striping in a shade slightly diluted from the base coat color. (Not to be confused with the zebra, which is an entirely different species.) Brindling may be associated with chimerism.
- Dun: A horse coat color that features primitive markings: a slightly darker hair shade from the base coat located in a dorsal stripe along the horse's backbone, horizontal striping on the upper legs and sometimes transverse striping across the shoulders. These markings identify a horse as a dun as opposed to a buckskin or a bay.
- Pinto: A horse coat color that is distinguished by one of several possible broad spotting patterns, as opposed to the smaller spots typical of the Appaloosa. Variations include Piebald, Skewbald, Overo, Tobiano, Tovero and Sabino.
- Roan: A horse coat color that features white and dark hairs intermingled together, but the horse has head and legs of the base color with very little white. Roans sometimes have dark areas on their coats similar to Bend-Or spots, called "corn marks".

Chapter 6

Livestock Branding



A young steer being branded with an electric branding iron and cut to make an earmark.



A hot brand on a horse.



Cowboys branding a calf. South Dakota, 1888

Livestock branding is a technique for marking livestock so as to identify the owner. Originally, livestock branding only referred to a hot brand for large stock, though the term is now also used to refer to other alternative techniques such as freeze branding. Other forms of livestock identification include inner lip or ear tattoos, earmarking, ear tagging, and RFID tagging with a type of microchip. The semi-permanent paint markings used to identify sheep are called a paint or colour brand. In the American west, branding evolved into a complex marking system still in use today.

History



Branding calves in Colorado, c. 1900. Photochrom print.

The act of marking livestock with fire-heated marks to identify ownership has origins in ancient times, with use dating back to the ancient Egyptians. Among the ancient Romans, the symbols used for brands were sometimes chosen as part of a magic spell aimed at protecting the animal from harm.

In English lexicon, the word **brand** originally meant anything hot or burning, such as a *firebrand*, a burning stick. By the European Middle Ages, it commonly identified the process of burning a mark into stock animals with thick hides, such as cattle, so as to identify ownership under *animus revertendi*. The practice became particularly widespread in nations with large cattle grazing regions, such as Spain.

These European customs were imported to the Americas and were further refined by the *vaquero* tradition in what today is the southwestern United States and northern Mexico. In the American West, a *branding iron* consisted of an iron rod with a simple symbol or mark, which cowboys heated in a fire. After the branding iron turned red-hot, the cowboy pressed the branding iron against the hide of the cow. The unique brand meant that cattle owned by multiple ranches could then graze freely together on the open range. Cowboys could then separate the cattle at *round-up* time for driving to market. Cattle rustlers using "running irons" were ingenious in changing brands. The most famous brand change involved the making of the X I T brand into a star with a cross inside. Brands became so numerous that it became necessary to record them in books that the ranchers could carry in their pockets. Laws were passed requiring the registration of brands and the inspection of cattle driven through various territories. Penalties were imposed on those who failed to obtain a bill of sale with a list of brands on the animals purchased.

From the Americas, many cattle branding traditions and techniques spread to Australia, where a distinct set of traditions and techniques developed. Livestock branding has been practiced in Australia since 1866, but it was not until 1897 that each owner had to register his brand. These fire and paint brands could not then be duplicated legally.

Modern usage



Cattle brands used in Mitchell County in West Texas are displayed on a public mural in Colorado City, Texas.

Free-range or open range grazing is less common today than in the past. However, branding still has its uses. The main purpose is in proving ownership of lost or stolen animals. Many western US states have strict laws regarding brands, including brand registration and required brand inspections. In many cases, a brand on an animal is considered *prima facie* proof of ownership.

In the hides and leather industry, brands are treated as a defect, and can diminish the value of the hide. This industry has a number of traditional terms relating to the type of brand on a hide. *Colorado Branded* (slang *Collie*) refers to placement of a brand on the side of an animal, although this does not necessarily indicate the animal is from Colorado. *Butt branded* refers to a hide which has had a brand placed on the portion of the skin covering the rump area of the animal. *Cleanskin* is the term used to describe an animal without a brand. *Native* refers to a skin without a brand.

Methods of branding



Hot iron horse branding, Spain



Modern portable table calf branding cradle, NSW, Australia

The traditional cowboy or stockman captured and secured an animal for branding by roping it, laying it over on the ground, tying its legs together, and applying a branding iron that had been heated in a fire. Modern ranch practice has moved toward use of chutes where animals can be run into a confined area and safely secured while the brand is applied. Two types of restraint are the cattle crush or squeeze chute (for larger cattle), which may close on either side of a standing animal, or a branding cradle, where calves are caught in a cradle which is rotated so that the animal is lying on its side.



Bronco branding in the Top End.



A stud Merino ram that has been branded on his horn

Bronco branding is an old method of catching cattle on Top End cattle stations for branding in Australia. A heavy horse, usually with some draught horse bloodlines and typically fitted with a horse collar, is used to rope the selected calf. The calf is then pulled up to several sloping topped panels and a post constructed for the purpose in the centre of the yard, to be branded there. With the advent of portable cradles, this method of branding has been mostly phased out on stations. However, there are now quite a few bronco branding competitions at rodeos and campdrafting days, etc.

Some ranches still heat branding irons in a wood or coal fire, others use an electric branding iron or electric sources to heat a traditional iron. Gas fired branding iron heaters are very popular in Australia, as iron temperatures can be regulated and there is not the

heat of a nearby fire. Regardless of heating method, the iron is only applied for the amount of time needed to remove all hair and create a permanent mark. Branding irons are applied for a longer period of time to cattle than to horses, due to the differing thickness of the skin. If a brand is applied too long, it can damage the skin too deeply, thus requiring treatment for potential infection and longer-term healing. Stock that are wet when branded may result in the smudging of the brand. Brand identification may be difficult on long haired animals and may necessitate clipping of the area to view the brand.

Horses may also be branded on their hooves, but this is not a permanent mark and needs to be re-done about every six months. Merino rams and bulls are sometimes firebranded on their horns for permanent individual identification.

Temporary branding

Temporary branding is achieved by heat branding lightly, so that the hair is burned but the skin is not damaged. Because this persists only until the animal sheds its hair, it is not considered a properly applied brand.

Freeze branding



A white marking on the crest of a horse's neck created by freeze branding, a form of marking for identification that is nearly painless.

In contrast to traditional hot-iron branding, freeze branding uses a branding iron that has been chilled with a coolant such as dry ice or liquid nitrogen. Rather than burning a scar into the animal, a freeze brand damages the pigment-producing hair cells, causing the animal's hair to grow white where the brand has been applied. To apply a freeze brand, the hair coat of the animal is shaved so that the bare skin is exposed, then the frozen iron is applied to the bare area for a period of time that varies with both the species of animal and the color of its hair coat: Shorter times are used on dark-colored animals, simply causing the hair follicles to lose all color and regrow as white hairs. Longer times are needed on animals with white hair coats, as the brand is applied long enough to permanently stop the hair from growing in the branded area and only skin remains.



Freeze brand detail on shoulder of horse.

Freeze brands cause less damage to the animals' hides than hot iron brands, and can be more visible. Horses are frequently freeze-branded. At this time, hogs cannot be successfully freeze branded, as their hair pigment cells are better protected. Also, freeze branding is slower, more expensive, less predictable (more care is required in application to assure desired results), and in some places does not constitute a legal brand on cattle. When an animal grows a long hair coat, the freeze brand is still visible, but its details are not always clear. Thus, is it sometimes necessary to shave or closely trim the hair so that a sharper image of a freeze brand can be viewed.

An animal that is going to have a freeze brand applied will need to have the hair shaved off of the branding site. Hair is an excellent insulator and needs to be removed so that the extreme cold of the freeze branding iron can be applied directly to the skin. Then the freeze branding iron, made of metal such as brass or copper that removes heat rapidly from the skin, is submerged into the coolant. Immediately before the freeze branding iron is ready to be applied, the animal's skin is rubbed, squirted, or sprayed with a generous amount of 99% alcohol, then the freeze branding iron is removed from the coolant and held onto the skin with firm pressure for several seconds. The exact amount of time will vary according to the kind of animal, the thickness of its skin, the type of metal the branding iron is made of, the type of coolant being used, and other factors.

Immediately after the freeze branding iron is removed from the skin, an indented outline of the brand will be visible. Within seconds, however, the outline will disappear and within several minutes after that, the brand outline will reappear as swollen, puffy skin. Once the swelling subsides, for a short time, the brand will be difficult or impossible to see, but in a few days, the branded skin will begin to flake, and within three to four weeks, the brand will begin to take on its permanent appearance.

Horse branding regulations

In Australia all Arabian, Part Bred Arabians, Australian Stock Horses, Quarter Horses, Thoroughbreds, and the nine pony breeds registered in the Australian Pony Stud Book must be branded with an owner brand on the near (left) shoulder and an individual foaling drop number (in relation to the other foals) over the foaling year number on the off shoulder. In Queensland, these three brands may be placed on the near shoulder in the above order. Stock Horse and Quarter Horse classification brands are placed on the hind quarters by the classifiers.

Thoroughbreds and Standardbreds in Australia and New Zealand are freeze branded. Standardbred brands are in the form of the Alpha Angle Branding System, which the US also uses.

In the United States, branding of horses is not generally mandated by the government; however, there are a few exceptions: captured Mustangs made available for adoption by the BLM are freeze-branded on the neck, usually with the Alpha Angle Branding System or with numbers, for identification. Horses that test positive for Equine Infectious Anemia, that are quarantined for life rather than euthasized, will be freeze-branded for permanent identification. Race horses of any breed are usually required by state racing commissions to have a lip tattoo, to be identified at the track. Some breed associations have, at times, offered freeze branding as either a requirement for registration or simply as an optional benefit to members, and individual horse owners may choose branding as a means by which to permanently identify their animals. Currently, the issue of whether to mandate horses be implanted with RFID microchips under the National Animal Identification System is generating considerable controversy in the United States.

Symbols and terminology in branding



Branding irons

Most brands in the United States include capital letters, numerals, often combined with other symbols such as a *slash*, *circle*, *half circle*, *cross*, and *bar*. Brands of this type have a specialized language for "calling" the brand. Some owners prefer to use simple pictures; these brands are called using a short description of the picture (e.g., "rising sun"). Reading a brand aloud is referred to as "calling the brand". Brands are called from left to right, top to bottom, and when one character encloses another, from outside to inside. Reading of complex brands and picture brands depends at times upon the owner's interpretation, and it may require an expert to identify some of the more complex marks.

Terms used are:

- Upright symbols are called normally by the letters, numbers or other symbols involved.
- "Crazy" or "Reverse": reversed symbols. **K** would be read as "Crazy K".
- "Lazy": , symbols turned 90 degrees. Also, a symbol turned 90 degrees, lying on its face (or right hand side) can be read as "Lazy Down" or "Lazy Right" . Similarly, a symbol turned 90 degrees, lying on its back (or left had side) can be read as "Lazy Up" or "Lazy Left". **5** would be read as "Lazy 5" or "Lazy Up 5" or Lazy Left 5".
- "Tumbling": a symbol tipped about 45 degrees.
- "Flying": a symbol that starts and ends with a long serif or horizontal line.
- "Walking": a symbol with legs on it.
- "Running": a letter with a curving flare at the top, sometimes also leaning to the right like an italic letter.

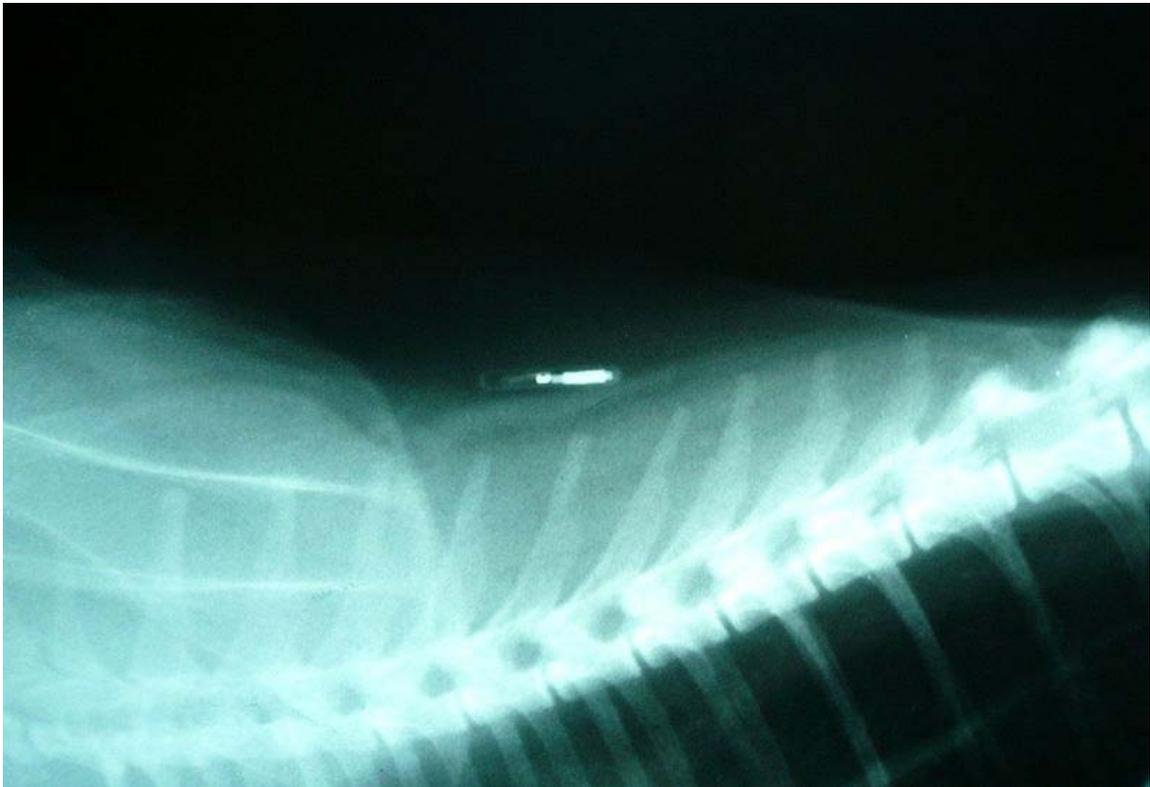
- "Over": a symbol over above another symbol, but not touching the other symbol. An H above a P would be read as "H Over P".
- "Bar": a short horizontal line. For example, a short horizontal line over a M or before an M would be read as "Bar M". Similarly, a short horizontal line under a M or after a M would be read as "M Bar."
- "Rail": alternative terminology to "bar" in some areas referencing a long horizontal line. For example, a long horizontal line over a M or before an M would be read as "Rail M". Similarly, a long horizontal line under a M or after a M would be read as "M Rail." .
- "Stripe": three or more rails, one above the others.
- "Box": a symbol within a square or rectangle or a square or rectangle by itself.
- "Diamond": a symbol within a four sided box, the box tilted 45 degrees or a four sided box tilted 45 degrees by itself.
- "Rafter": a half diamond over another symbol, but not touching the other symbol.
- "Circle": a symbol within a circle, or a circle by itself.
- "Half Circle or Quarter Circle": a half or quarter circle above or below a symbol, but not touching the symbol.

Combinations of symbols can be made with each symbol distinct, or:

- "Connected", with symbols touching. **TS** would be read as "T S Connected".
- "Combined or conjoined": symbols are partially overlaid. **JK** would be read as "J K Combined".
- "Hanging": a symbol beneath another symbol and touching the other symbol. The hanging nomenclature may be omitted when reading the brand, such as a H with a P below it, with the top of the P touching the bottom of the H would be read as "Hanging P", or just "H P".
- "Swinging": a symbol beneath a quarter circle and touching the quarter circle. The swinging nomenclature may be omitted when reading the brand, such as a H with a P below it, with the top of the P touching the quarter circle would be read as "H Swinging P" or just "H P".
- "Rocking": a symbol above a quarter circle, the bottom of the symbol touching the quarter circle. For example, a H above a quarter circle, with the bottom of the H touching the quarter circle, is read as "Rocking H".

Chapter 7

Microchip Implant (Animal)



Microchip implant in a cat.

A **microchip implant** is an identifying integrated circuit placed under the skin of a dog, cat, horse, or other animal. The chips are about the size of a large grain of rice and are based on a passive RFID (Radio Frequency Identification) technology.

The use of externally attached microchip devices such as RFID ear tags (piercings rather than implants) is another, related method commonly used for identifying farm and ranch

animals other than horses. In some cases the external microchips may be readable on the same scanner as the implanted style.

Uses and benefits

Microchips have been particularly useful in the return of lost pets. They can also assist where the ownership of an animal is in dispute.

Animal shelters and animal control centers benefit using microchip identification products by more quickly and efficiently returning pets to their owners. When a pet can be quickly matched to its owner, the shelter avoids the expense of housing, feeding, providing medical care, and outplacing or euthanizing the pet. Microchipping is becoming standard at shelters: many require all outplaced animals to receive a microchip, and provide the service as part of the adoption package. Animal-control officers are trained and equipped to scan animals.

In addition to shelters and veterinarians, microchips are used by kennels, breeders, brokers, trainers, registries, rescue groups, humane societies, clinics, farms, stables, animal clubs and associations, researchers, and pet stores.

Several countries require a microchip when importing an animal to prove that the animal and the vaccination record match. Microchip tagging may also be required for CITES-regulated international trade in certain rare animals: for example, Asian Arowana are so tagged, in order to ensure that only captive-bred fish are imported.

System of recovery

Effective pet identification and recovery depend on the following:

- A pet owner either adopts a pet at a shelter that microchips some or all adoptee animals, or the owner with an existing pet brings it to a veterinarian (or a shelter) that provides the service.
- The shelter or veterinarian does a pre-scan to verify that the animal initially does not have a chip, selects a microchip from their stock, makes a note of that chip's unique ID, and then inserts the chip into the animal with a syringe. The injection requires no anesthetic.
- Before sending the animal home, the vet or shelter performs a test scan on the animal. This helps ensure that the chip will be picked up by a scanner, and that its unique identifying number will be read correctly.
- An enrollment form is completed with the chip number, the pet owner's contact information, the name and description of the pet, the shelter's and/or veterinarian's contact information, and an alternate emergency contact designated by the pet owner. (Some shelters or vets, however, choose to designate themselves as the primary contact, and take the responsibility of contacting the owner directly. This allows them to be kept informed about possible problems with the animals they place.) The form is then sent to a registry keeper to be entered into its database.

- Depending on regional custom, selected chip brand, and the pet owner's preference, this registry keeper might be the chip's manufacturer or distributor, or an independent provider. In some countries a single official national database may be used. After receiving a registration fee, the registry keeper typically provides a 24-hour, toll-free telephone service for pet recovery, good for the life of the pet.
- The pet owner is also provided the chip ID and the contact information of the recovery service. This is often in the form of a collar tag imprinted with the chip ID and the recovery service's toll-free number, to be worn by the animal along with a certified registration certificate that can be sold/transferred with the pet. This ensures proper identification when an animal is sold or traded. A microchipped animal being sold or traded without a matching certificate could be a stolen animal.
 - If the pet is lost or stolen, and is found by local authorities or taken to a shelter, it is scanned during intake to see if a chip exists. If one is detected, authorities need to figure out which recovery service has the owner record, because there may be several different ones, each competing for the patronage of the pet owner. They then call the recovery service and provide them the ID number, the pet's description, and the location of the animal. If the pet is wearing the collar tag, anyone who finds the pet can call the toll-free number, making it unnecessary to involve the authorities. (The owner can also preemptively notify the recovery service directly if a pet disappears. This is useful if the pet is stolen, and is taken to a vet who scans it and checks with the recovery service.)
 - The recovery service notifies the owner that the pet has been found, and where to go to recover the animal.

Many veterinarians perform test scans on microchipped animals every time the animal is brought in for care. This ensures the chip still performs properly. Vets sometimes use the chip ID as the pet's ID in their databases, and print this number on all outgoing paperwork associated with its services, such as receipts, test results, vaccination certifications, and descriptions of medical or surgical procedures.

Components of a microchip

Microchips are passive, or inert, RFID devices and contain no internal power source. They are designed so that they do not act until acted upon.

Most microchips comprise three basic elements: A silicon chip (integrated circuit); a coil inductor, or a core of ferrite wrapped in copper wire; and a capacitor. The silicon chip contains the identification number, plus electronic circuits to relay that information to the scanner. The inductor acts as a radio antenna, ready to receive electrical power from the scanner. The capacitor and inductor act as a tuner, forming an LC circuit. The scanner presents an inductive field that excites the coil and charges the capacitor, which in turn energizes and powers the IC. The IC then transmits the data via the coil to the scanner.



Example of an RFID scanner used with animal microchip implants.

These components are encased in a special biocompatible glass made from soda lime, and hermetically sealed to prevent any moisture or fluid entering the unit. Barring rare complications, dogs and cats are not affected physically or behaviorally by the presence of a chip in their bodies.

Implant location

In dogs and cats, chips are usually inserted below the skin at the back of the neck, between the shoulder blades on the dorsal midline. Continental European pets may be an exception; they get the implant in the left side of the neck, according to one reference. The chip can often be manually detected by the owner by gently feeling the skin in that

area. It stays in place as thin layers of connective tissue form around the biocompatible glass which encases it.

Horses are microchipped on the left side of the neck, half the distance between the poll and withers, and approximately one inch below the midline of the mane, into the nuchal ligament.

Birds' microchips are injected into their breast muscles. Because proper restraint is necessary, the operation either requires two people (an avian veterinarian and a veterinary technician), or general anesthesia is administered.

Animal species



Horse microchipping

Many species of animals have been microchipped, including cockatiels and other parrots, horses, llamas, alpacas, goats, sheep, miniature pigs, rabbits, deer, ferrets, penguins, snakes, lizards, alligators, turtles, toads, frogs, rare fish, mice, and prairie dogs -- even whales and elephants. The U.S. Fish and Wildlife Service uses microchipping in its research of wild bison, black-footed ferrets, grizzly bears, elk, white-tailed deer, giant land tortoises and armadillos.

Worldwide use

Microchips are not in universal use, but there are legal requirements in some jurisdictions, such as the state of New South Wales, Australia. Some countries, such as Japan, require ISO-compliant microchips on dogs and cats being brought into the country, or for the person bringing the pet into the country to also bring a microchip reader that can read the non-ISO-compliant microchip.

In New Zealand, all dogs first registered after 1 July 2006 are to be microchipped. Farmers protested that farm dogs should be exempt, drawing a parallel to the Dog Tax War of 1898.. Farm dogs were exempted from microchipping in an amendment to the legislation passed in June 2006. A National Animal Identification and Tracing scheme in New Zealand is currently being developed for tracking livestock.

Australia has a National Livestock Identification System.

The National Animal Identification System is used in the United States. (It is applicable to farm and ranch animals rather than dogs and cats, and in most species other than horses, an external eartag device is typically used rather than an implant microchip. Eartags with microchips or those having only a visible stamped number can be used; either way, the 15 digit numbering scheme of the ISO type microchips is followed, using the U.S. country code of 840.)

Cross-compatibility and standards issues

In most countries, ID chips used in pets follow an international standard, enabling wide compatibility between the chips and scanners. But in the U.S., three proprietary types of chips compete for market share, along with the international type. Scanner models distributed to U.S. shelters and vets well into 2006 could each read at most three of the four types. (These "types" are also known as transmission protocols or standards) But now, several scanner models with quad-read capability are available, and increasingly, vets and shelters are considering these required equipment. Older scanner models continue to be distributed, and may be in use for some time, so U.S. pet owners still face a choice of getting a chip that gets best coverage on the older style scanners in use locally, or a chip with best acceptance in international travel. The four types include:

- The **ISO Conformant Full Duplex** type is the pet chip type with the most international acceptance, being common in many countries including those of Europe since the late 1990s, and now widely adopted in Canada. It is one of two chip protocol types (along with the "Half Duplex" type sometimes used in farm and ranch animals) which conform to International Organization for Standardization, or ISO, standards 11784 and 11785. To support international/multivendor application, each of these chips contains either a manufacturer code.(99 manufacturer codes from 900 to 998 are supported.) or a country code (Values below 900 are assigned as country codes.) along with its main identifying serial number. In the U.S., the distributing organizations that

introduced this type of pet chip have faced controversy. At least one of the Banfield-chipped pets was discovered to have been needlessly euthanized, and Americans debated the cause. Specifically, did this happen because "foreign" chips were sold to unsuspecting pet owners, or because scanners which were passed off as a Shelter-Grade product couldn't cope with "internationally standardized" chips? Or maybe both?

- The **Trovan Unique** type is another pet chip protocol type used in U.S. pets beginning in 1990. Then, due to patent problems, Trovan's implanter device was withdrawn from distribution in the United States and they became uncommon in U.S. pets, although Trovan's original registry database "infopet.biz" remained in operation. In early 2007, the American Kennel Club's chip registration database service, AKC Companion Animal Recovery Corp., "akccar.org", which had earlier been the authorized registry for HomeAgain brand chips made by Destron/Digital Angel corp., began distributing Trovan chips with a different implanter. These chips are read by the Trovan, HomeAgain (Destron Fearing), and Bayer (Black Label) readers. Despite multiple offers from Trovan to AVID to license the technology to read the Trovan chips, AVID continues to distribute readers that do not read Trovan or the ISO compliant chips.
- A third type sometimes known as **FECAVA** type or **Destron** type is available under various brand names. These include, in the U.S., "Avid Eurochip", the common current 24PetWatch chips, and the original (and still popular) style of HomeAgain chips. (although on request, U.S. HomeAgain and 24Petwatch now can supply the true ISO chip instead.) Chips of this type have 10 digit [hexadecimal] chip numbers. This "FECAVA" type is readable on a wide variety of scanners in the U.S., and has been less controversial, although its level of adherence to the ISO standards is sometimes exaggerated in some descriptions. The ISO standard has an annex (appendix) describing three older chip types considered worthy of legacy support by scanners, and a 35-bit "FECAVA"/"Destron" type is one of them. The common Eurochip/HomeAgain chips don't really agree with the annex description perfectly, although the differences might be considered overlookable by some. But the ISO standard also makes it clear that even chips (like the Trovan Unique chip) that do match one of the descriptions in the Annex are not "conformant"; only its 64-bit "full-duplex" and "half-duplex" types are "conformant". More visibly, the "FECAVA" type can't fit the ISO standard's required country codes or manufacturer codes. These chips, when implanted in traveling pets, may possibly be accepted by authorities in many countries where ISO chips are the norm, but not those that require literal ISO conformance. (France is an example mentioned by one reference.)
- Finally, there's the **AVID brand Friendchip** type, which is peculiar due to its encryption characteristics. The simple fact that a cryptographic feature is provided in a chip would not necessarily be unwelcome; few pet rescuers or humane societies would object to a chip design that outputs an ID number "in the clear" for anyone to read, and, in addition, has authentication features for use by

scanners that know how to use them, for detection of counterfeit chips. But the "Friendchips" have been found lacking in actual authentication features, and rather easy to counterfeit well enough to fool the AVID scanner. Although there's no authentication encryption involved, there is obfuscation encryption, meaning decryption secrets are needed, to convert what the chip transmits into its original label ID code. Well into 2006, scanners containing the secrets were provided to the U.S. market only by AVID and Destron/Digital Angel Corp.; Destron/Digital Angel put the decryption feature in some, but not all, of its scanners possibly as early as 1996. (For years, typically its scanners distributed to shelters through HomeAgain had full decryption, while many sold to vets would just flash a message that an AVID chip had been found.) And well into 2006, both of these were resisting calls from consumers and welfare group officials to bring scanners to the U.S. shelter community combining AVID decryption capability with full ability to read ISO pet chips. Some complained that AVID itself had long marketed combination pet scanners (compatible with all common pet chips except possibly Trovan) outside the U.S., and by keeping such technology out of the U.S., it could be considered partly culpable in the missed-ISO chips problem others blamed on Banfield. In 2006, the European manufacturer Datamars, a supplier of ISO chips used by Banfield and others, gained access to the decryption secrets, and began supplying scanners using them to U.S. customers. This "Black Label" scanner was the first four-standard full-multi pet scanner in the U.S. market. Then later in 2006 Digital Angel Corp. announced it would supply a full-multi scanner in the U.S. Finally in 2008 AVID itself announced a "breakthrough" scanner, although AVID's is still so uncommon in the field as of October 2010 that it's unclear whether it has support for the Trovan chip. Trovan itself also got the decryption technology somehow along the way, by 2006 or earlier, and now provides it in scanners distributed in the U.S. by AKC-CAR. (Some of these are quad-read, but others lack full support for the ISO chip.)

Numerous references in print state that the incompatibilities between different chip types are a matter of "frequency". One may find claims that early ISO adopters in the U.S. endangered their customers' pets by giving them ISO chips that work at a "different frequency" from the local shelter's scanner, or that the U.S. government considered forcing a change to a chip type that didn't operate at the same frequency as existing chips. The spread of these claims was little challenged by the manufacturers and distributors of the ISO chips, although later evidence suggests the claims were disinformation. In fact, all the pet chips operate slaved to the frequency of the scanner, and in practice, the ISO chips, although by design optimized to work best when given excitation energy at 134.2 kilohertz, have quite good readability working with 125 kilohertz excitation. Likewise, the "125 kilohertz" chip types are readable at 134.2 kilohertz. Confirmation of this comes from government filings which indicate that the supposed "multi-frequency" scanners now commonly available are really single-frequency scanners (each operating at 125 or 134.2 kHz, or an in-between frequency like 128 kHz.) In particular, the U.S. HomeAgain scanner didn't really change its excitation frequency when ISO-read capability was added; it's still a single frequency, 125 kHz scanner.

Banfield Pet Hospitals for a length of time advocated and practiced double chipping with both ISO and "FECAVA" type chips. (By December 2009 they had switched back to ISO-only.) A consequence of an animal having multiple chips for any reason, whether by design or by oversight, is that, since typical shelter scanners stop scanning after finding one chip, and "Which one" can't be predicted, all of an animal's chip numbers need to be kept on file and address-updated with an appropriate database keeper for life. Presumably Banfield's enrollment forms had a space for "second chip number." The on-line enrollment forms of most registries could use some improvement in this regard. For best protection, the owner of multi-chipped pet may want to have each chip separately enrolled in its most customary or manufacturer-provided registry.

| Scanner Compatibility table for chip types used in pets | | | | |
|--|---|-----------------------------------|---|--|
| | Expected results for chip type (OK=Good read NR=No read DO=Detect Only with no number given) | | | |
| Scanner to test | ISO Conformant Full Duplex chip | AVID Encrypted "FriendChip" | Original U.S. HomeAgain, AVID Eurochip, or FECAVA | "Trovan Unique" and current AKC CAR chips |
| Minimal ISO Conformant Scanner (also must read HALF Duplex chips common in livestock ear tags) | OK | NR | NR | NR |
| AVID Basic U.S. Scanner | NR | OK | NR | NR |
| AVID Deluxe U.S. Scanner | NR | OK | OK | NR |
| AVID Universal Scanner sold outside U.S. | OK | OK | OK | NR Assumed |
| AVID MiniTracker Pro Scanner announced August 2008 | OK | OK | OK | NR according to some (Few have seen one.) |
| Various vintages of U.S. HomeAgain | NR,DO, or OK | OK | OK | Possibly all OK |

| | | | | |
|--|----|---|----|---|
| "Universal" Shelter Scanners by Destron/Digital Angel Corp. | | | | |
| Typical Destron/Digital Angel Corp. U.S. Vet's scanner pre-2007 | NR | DO | OK | DO |
| Trovan LID-560-MULTI per mfr. specs on Web | OK | OK | OK | OK |
| U.S. Trovan Pocket Scanner per AKC-CAR Web Site | DO | OK | OK | OK |
| U.S. Trovan ProScan700 per AKC-CAR Web Site | OK | OK | OK | OK |
| Original 2006 Datamars Black Label Scanner | OK | OK | OK | OK but Reliability Questioned |
| Datamars Black Label Scanner "classypets" model | OK | NR or DO? | OK | OK but Reliability Questioned |
| Banfield-Distributed 2004-2005 Vintage Datamars Scanners | OK | Possibly all DO | OK | Possibly all OK but Reliability Questioned (Undocumented Feature) |
| Datamars Minimax and Micromax | OK | NR | NR | NR |
| Typical Homemade Scanner | OK | OK but extra step required (web-based decryption service) | OK | OK |

(For users requiring Shelter-Grade certainty, this table is not a substitute for testing the scanner with a set of specimen chips. One study cites problems with certain Trovan chips on the Datamars Black Label scanner. In general the study found none of the tested scanners to read all four standards without some deficiency. The study predates the most recent scanner models, however.)

Central microchip registration lookup

Because multiple independent registration databases exist, each of which could possibly be the one which contains an owner record for an individual found chipped pet, centralized lookup systems for use by the pet finder have been established. In the U.S., where a Free-for-All of multiple registries each soliciting registrations of all manufacturers' chips has been a particular problem, a good, complete centralized pet lookup system has been sought for some time.

September 2009, the American Animal Hospital Association (AAHA) launched the Web site petmicrochiplookup.org. This Web site allows a person, such as a veterinarian or shelter personnel, to enter a microchip number of a found pet, and searches several of the major U.S. microchip manufacturers/registries in real time to determine which registry(ies) the pet is enrolled with. Exactly how many true registries are members of the system is unclear; the web site lists AKC CAR, Home Again, PetLink, and "resq" as "participants", but "resq" according to its own web site uses PetLink as its database; it doesn't claim to actually have its own registry. It would seem that, of the five major U.S. registries, three, rather than four, have enlisted as actual tributary registries. One major critique of the AAHA petmicrochiplookup.org function is the search results for non-contracted microchip numbers where the search results will read "No Owner Found" even if the pet has a registered owner, instead the microchip look-up tool does not have access to non-contracted databases, as noted above.

Reported adverse reactions

RFID chips are used in animal research, and tumors at the site of implantation have been reported in laboratory mice and rats. Noted veterinary associations responded with continued support for the procedure as reasonably safe for cats and dogs, pointing to rates of serious complications on the order of one in a million in the U.K., which has a system for tracking such adverse reactions and has chipped over 3.7 million pet dogs. A recent study found no safety concerns for microchipped animals with RFID chips undergoing MRI at one Tesla

Chapter 8

Pet Tag and Tracking (Hunting)

Pet tag



A dog might wear several different identifying dog tags.

A **pet ID tag**, or **pet tag** is a small flat tag worn on pets' collars or harnesses.

Humane societies and rescue organizations recommend that dogs and cats wear these tags, which contain information to enable someone encountering a stray animal to contact the owner.

Some people object to pet id tags because of the jingling noise they make as their animals move. A collar-mount tag, either slide-on or riveted-on, flat to a collar's surface, is silent and therefore avoids this problem. Other people use a tag silencer to enclose the loose tags in a small neoprene pouch or a soft rubbery plastic ring around the edge of a tag.

The resemblance of human identification tags to this method of display led to military identification tags being called dog tags.

Identifying information

Identifying information on dog tags might include:

- On a license tag, the dog license number and contact information for the licensing organization
- On a pet ID tag, the pet's name, owner's phone number(s), address, or both, a reward offer, and a list of the animal's critical medical problems
- On a microchip registry tag, an identifying number for the dog with a phone number for the registry.

Some organizations recommend not putting a pet's name on an ID tag because, in an ownership dispute over a stray dog, the original owner could use the pet's name to demonstrate that the pet recognizes the name and therefore has an association with that owner. Others believe that a lost pet might feel more comfortable if strangers call it by its own name, so the name should be on the tag. Also, if a stray dog slips out of his collar, or is skittish, there is a greater chance of controlling him if his name is used.

Materials

Tags are made of a variety of materials.

Metal tags usually have their information embossed or engraved onto, or stamped into, their surface(s). The characters created by embossing or engraving are made by removing some of the tag's surface and are not typically as deep as stamped characters, which are made by stamping the tag with a metal die. Stamped tags are therefore often more durable than engraved tags, though some drag-engraving and laser-engraving methods can be as deep, or deeper, than the stamped versions.

Plastic chips can be etched or printed, come in many colors, and are often highly reflective to make the dog more visible if it gets loose and runs into the street after dark. Some plastics are sensitive to ultraviolet light and the color and even composition can fade over time. ABS plastics are among the most durable for use as pet i.d. tags.

The newest technology is now using sublimation to print images and artwork to aluminum tags. The image is permanent and resists fading and wear.

The most common metals used for pet tags of are aluminum, stainless steel, and brass. Aluminum is by far the least durable of the three. Brass is a soft metal, and not as durable as stainless steel. There are varying grades of stainless steel used for tags, but all variants are by far harder and more durably retain their lettering after wear and tear on a pet.



Aluminum tag with sublimated art.

Effectiveness

In this age of mobile phones, pet ID tags showing a pet's owner's cell phone and/or landline numbers make it easy for someone finding a stray pet to contact the owner.

Microchip implants, tattooing, and registering the dog's license number, microchip information, and tattoo number with lost-pet registries are good backups to identify stolen pets or strays found without ID tags.

Tracking (hunting)



A walking deer track located in the Apalachicola National Forest in northern Florida

Tracking in hunting and ecology is the science and art of observing animal tracks and other signs, with the goal of gaining understanding of the landscape and the animal being tracked (quarry). A further goal of tracking is the deeper understanding of the systems and patterns that make up the environment surrounding and incorporating the tracker.

The practice of tracking may focus on, but is not limited to, the patterns and systems of the local animal life and ecology. Trackers must be able to recognize and follow animals through their tracks, signs, and trails, also known as spoor. Spoor may include tracks,

scat, feathers, kills, scratching posts, trails, drag marks, sounds, scents, marking posts, the behavior of other animals, habitat cues, and any other clues about the identity and whereabouts of the quarry.

The skilled tracker is able to discern these clues, recreate what transpired on the landscape, and make predictions about the quarry. The tracker may attempt to predict the current location of the quarry and follow the quarry's spoor to that location, in an activity known as trailing.

Prehistoric hunters used tracking principally to gather food. Even in historic times, tracking has been traditionally practiced by the majority of tribal people all across the world. The military also use tracking to find enemy soldiers in the bush, sea, and desert.

The Art of Tracking

It has been suggested that the art of tracking may have been the first implementation of science (Liebenberg, 1990; Liebenberg, 2006; Carruthers, 2002; Carruthers, 2006; Pickering and Bunn, 2007), practiced by hunter-gatherers since the evolution of modern humans.

Apart from knowledge based on direct observations of animals, trackers gain a detailed understanding of animal behavior through the interpretation of tracks and signs. In this way much information can be obtained that would otherwise remain unknown, especially on the behavior of rare or nocturnal animals that are not often seen.

Tracks and signs offer information on undisturbed, natural behavior, while direct observations often influence the animal by the mere presence of the observer. Tracking is therefore a non-invasive method of information gathering, in which potential stress caused to animals can be minimized.

Some of the most important applications of tracking are in hunting and trapping, as well as controlling poaching, ecotourism, environmental education, police investigation, search and rescue, and in scientific research.

Recognition of signs

In order to recognize a specific sign, a tracker often has a preconceived image of what a typical sign looks like. Without such preconceived images many signs may be overlooked. However, with a preconceived image of a specific animal's spoor in mind, trackers will tend to 'recognize' spoor in markings made by another animal, or even in random markings (Liebenberg, 1990). Their mind will be prejudiced to see what they want to see, and in order to avoid making such errors they must be careful not to reach decisions too soon. Decisions made at a glance can often be erroneous, so when encountering new signs, trackers take their time to study signs in detail. While preconceived images may help in recognizing signs, the tracker must, however, avoid the

preconditioned tendency to look for one set of things in the environment to the exclusion of all others.

Trackers will always try to identify the trail positively by some distinguishing mark or mannerism in order not to lose it in any similar spoor. They will look for such features in the footprints as well as for an individual manner of walking. Often hoofs of antelope are broken or have chipped edges, or when the animal is walking it may leave a characteristic scuffmark. Experienced trackers will memorise a spoor and be able to distinguish that individual animal's spoor from others. When following a spoor, trackers will walk next to it, not on it, taking care not to spoil the trail so that it can easily be found again if the spoor is lost.

The shadows cast by ridges in the spoor show up best if the spoor is kept between the tracker and the sun. With the sun shining from behind the spoor, the shadows cast by small ridges and indentations in the spoor will be clearly visible. With the sun behind the tracker, however, these shadows will be hidden by the ridges that cast them. Tracking is easiest in the morning and late afternoon, as the shadows cast by the ridges in the spoor are longer and stand out better than at or near midday. As the sun moves higher in the sky, the shadows grow shorter. At midday the spoor may cast no shadows at all, making them difficult to see in the glare of the sunlight.

Trackers will never look down at their feet if they can help it, since this will slow them down. By looking up, well ahead of themselves, approximately five to ten meters (15-30 feet) depending on the terrain, they are able to track much faster and with more ease. Unless they need to study the spoor more closely, it is not necessary to examine every sign. If they see a sign ten meters ahead, those in between can be ignored while they look for spoor further on. Over difficult terrain it may not be possible to see signs well ahead, so trackers will have to look at the ground in front of them and move more slowly.

Trackers must also avoid concentrating all their attention on the tracks, thereby ignoring everything around them. Tracking requires varying attention, a constant refocusing between minute details of the track and the whole pattern of the environment.

Anticipation and prediction

Although in principle it is possible to follow a trail by simply looking for one sign after the other, this may prove so time-consuming that the tracker will never catch up with the quarry. Instead, trackers place themselves in the position of their quarry in order to anticipate the route it may have taken (Liebenberg, 1990). They will thereby be able to decide in advance where they can expect to find signs and thus not waste time looking for them.

Trackers will often look for spoor in obvious places such as openings between bushes, where the animal would most likely have moved. In thick bushes they will look for the most accessible throughways. Where the spoor crosses an open clearing, they will look in the general direction for access ways on the other side of the clearing. If the animal was

moving from shade to shade, they will look for spoor in the shade ahead. If their quarry has consistently moved in a general direction, it may be possible to follow the most likely route by focusing on the terrain, and to look for signs of spoor only occasionally. They must, however, always be alert for an abrupt change in direction.

Animals usually make use of a network of paths to move from one locality to another. If it is clear that an animal was using a particular path, this can simply be followed up to the point where it forks, or to where the animal has left the path. Where one of several paths may have been used, trackers must of course determine which path that specific animal used. This may not always be easy, since many animals often use the same paths.

In areas of high animal densities that have much-used animal paths which interlink, it may seem impossible to follow tracks. However, once tracks have been located on an animal path, it is often possible for a tracker to follow the path even though no further tracks are seen. By looking to either side of the path, the tracker can establish if the animal has moved away from the path, and then follow the new trail.

In difficult terrain, where signs are sparse, trackers may have to rely extensively on anticipating the animal's movements. In order to move fast enough to overtake the animal, one may not be able to detect all the signs. Trackers sometimes identify themselves with the animal to such an extent that they follow an imaginary route which they think the animal would most likely have taken, only confirming their expectations with occasional signs (Liebenberg, 1990).

When trackers come to hard, stony ground, where tracks are virtually impossible to discern, apart from the odd small pebble that has been overturned, they may move around the patch of hard ground in order to find the spoor in softer ground.

When the trackers lose the spoor, they first search obvious places for signs, choosing several likely access ways through the bush in the general direction of movement. When several trackers work together, they can simply fan out and quarter the ground until one of them finds it. An experienced tracker may be able to predict more or less where the animal was going, and will not waste time in one spot looking for signs, but rather look for it further ahead (Liebenberg, 1990).

Knowledge of the terrain and animal behavior allows trackers to save valuable time by predicting the animal's movements. Once the general direction of movement is established and it is known that an animal path, river or any other natural boundary lies ahead, they can leave the spoor and move to these places, cutting across the trail by sweeping back and forth across the predicted direction in order to pick up tracks a considerable distance ahead (Liebenberg, 1990).

To be able to anticipate and predict the movements of an animal, trackers must know the animal and its environment so well that they can identify themselves with that animal. They must be able to visualize how the animal was moving around, and place themselves in its position. If the animal was moving in a straight line at a steady pace, and it is

known that there is a waterhole or a pan further ahead, trackers should leave the spoor to look for signs of it at the waterhole or pan. While feeding, an animal will usually move into the wind, going from one bush to another. If the trackers know the animal's favored food, and know moreover how they generally move, they need not follow its zigzag path, but leave the spoor at places, moving in a straight course to save time, and pick up the spoor further on (Liebenberg, 1990).

Since signs may be fractional or partly obliterated, it may not always be possible to make a complete reconstruction of the animal's movements and activities on the basis of spoor evidence alone. Trackers may therefore have to create a working hypothesis in which spoor evidence is supplemented with hypothetical assumptions based not only on their knowledge of animal behavior, but also on their creative ability to solve new problems and discover new information. The working hypothesis is often a reconstruction of what the animal was doing, how fast it was moving, when it was there, where it was going to and where it might be at that time. Such a working hypothesis enables the trackers to predict the animal's movements. As new information is gathered, they may have to revise their working hypothesis, creating a better reconstruction of the animal's activities. Anticipating and predicting an animal's movements, therefore, involves a continuous process of problem-solving, creating new hypotheses and discovering new information (Liebenberg, 1990).

Stealth

In order to come close to an animal, trackers must remain undetected not only by the animal, but also by other animals that may alert it. Moving as quietly as possible, trackers will avoid stepping on dry leaves and twigs, and take great care when moving through dry grass.

If the trackers are in close proximity to the animal, it is important that they remain downwind of it, that is, in a position where the wind is blowing away from the animal in the direction of the tracker. They must never be in a position where their scent could be carried in the wind towards the animal and thereby alert it. It is also important that the animal does not have the opportunity to cross their tracks, since the lingering human scent will alert it. Most animals prefer to keep the wind in their faces when traveling so that they can scent danger ahead of them. Trackers will therefore usually be downwind from them as they approach the animals from behind. The wind direction may, however, have changed. If the wind direction is unfavorable, the trackers may have to leave the spoor to search for their quarry from the downwind side (Liebenberg, 1990).

As the trackers get closer to the animal, they must make sure that they see it before it sees them. Some trackers maintain that an animal keeps looking back down its own trail, always on the alert for danger coming from behind. When the spoor is very fresh, trackers may have to leave the spoor so that the animal does not see them first. Animals usually rest facing downwind, so that they can see danger approaching from the downwind side, while they can smell danger coming from behind them. An animal may also double back on its spoor and circle downwind before settling down to rest

(Liebenberg, 1990). A predator following its trail will move past the resting animal on the upwind side before realizing that the animal had doubled back, and the resting animal will smell the predator in time to make its escape.

When stalking an animal, trackers use the cover of bushes, going down on their hands and knees where necessary. In long grass they go down on their stomachs pulling themselves forward with their elbows. The most important thing is not to attract attention by sudden movements. Trackers take their time, moving slowly when the animal is not looking, and keeping still when the animal is looking in their direction. When stalking an animal, trackers must also be careful not to disturb other animals. A disturbed animal will give its alarm signal, thereby alerting all animals in the vicinity, including the animal being tracked down.

Chapter 9

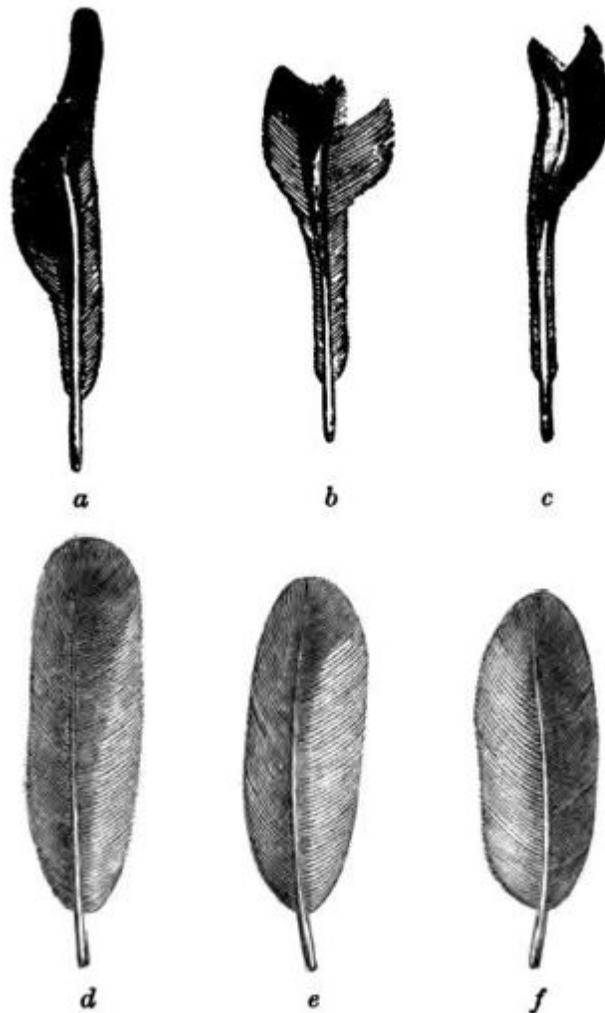
Bird Vocalization



A male Blackbird (*Turdus merula*) singing. Bogense havn, Funen, Denmark.

Bird vocalization includes both bird calls and bird songs. In non-technical use, bird songs are the bird sounds that are melodious to the human ear. In ornithology and birding, (relatively complex) songs are distinguished by function from (relatively simple) calls.

Definition



Secondary wing-feathers of *Pipra deliciosa* (from Mr. Sclater, in Proc. Zool. Soc. 1860). The three upper feathers, a, b, c, from the male; the three lower corresponding feathers, d, e, f, from the female.

a. and d. Fifth secondary wing-feather of male and female, upper surface. b and e. Sixth secondary, upper surface. c and f. Seventh secondary, lower surface.

Wing feathers of a male Club-winged Manakin, with the modifications noted by P L Sclater in 1860 and discussed by Charles Darwin in 1871

The distinction between songs and calls is based upon complexity, length, and context. Songs are longer and more complex and are associated with courtship and mating, while calls tend to serve such functions as alarms or keeping members of a flock in contact. Other authorities such as Howell and Webb (1995) make the distinction based on function, so that short vocalizations such as those of pigeons and even non-vocal sounds such as the drumming of woodpeckers and the "winnowing" of snipes' wings in display flight are considered songs. Still others require song to have syllabic diversity and temporal regularity akin to the repetitive and transformative patterns which define music.

It is generally agreed upon in birding and ornithology which sounds are songs and which are calls, and a good field guide will differentiate between the two.

Bird song is best developed in the order Passeriformes. Most song is emitted by male rather than female birds. Song is usually delivered from prominent perches although some species may sing when flying. Some groups are nearly voiceless, producing only percussive and rhythmic sounds, such as the storks, which clatter their bills. In some manakins (Pipridae), the males have evolved several mechanisms for mechanical sound production, including mechanisms for stridulation not unlike those found in some insects.

The production of sounds by mechanical means as opposed to the use of the syrinx has been termed variously *instrumental music* by Charles Darwin, *mechanical sounds* and more recently *sonation*. The term *sonate* has been defined as the act of producing non-vocal sounds that are intentionally modulated communicative signals, produced using non-syringeal structures such as the bill, wings, tail, feet and body feathers.

Anatomy

The avian vocal organ is called the syrinx; it is a bony structure at the bottom of the trachea (unlike the larynx at the top of the mammalian trachea). The syrinx and sometimes a surrounding air sac resonate to sound waves that are made by membranes past which the bird forces air. The bird controls the pitch by changing the tension on the membranes and controls both pitch and volume by changing the force of exhalation. It can control the two sides of the trachea independently, which is how some species can produce two notes at once.

Function

Scientists hypothesize that bird song has evolved through sexual selection, and experiments suggest that the quality of bird song may be a good indicator of fitness. Experiments also suggest that parasites and diseases may directly affect song characteristics such as song rate, which thereby act as reliable indicators of health. The song repertoire also appears to indicate fitness in some species. The ability of male birds to hold and advertise territories using song also demonstrates their fitness.

Communication through bird calls can be between individuals of the same species or even across species. Birds communicate alarm through vocalizations and movements that are specific to the threat, and bird alarms can be understood by other animal species, including other birds, in order to identify and protect against the specific threat. Mobbing calls are used to recruit individuals in an area where an owl or other predator may be present. These calls are characterized by wide frequency spectra, sharp onset and termination, and repetitiveness which are common across species and are believed to be helpful to other potential "mobbors" by being easy to locate. The alarm calls of most species, on the other hand, are characteristically high-pitched making the caller difficult to locate.

Individual birds may be sensitive enough to identify each other through their calls. Many birds that nest in colonies can locate their chicks using their calls. Calls are sometimes distinctive enough for individual identification even by human researchers in ecological studies.

Many birds engage in duet calls. In some cases the duets are so perfectly timed as to appear almost as one call. This kind of calling is termed antiphonal duetting. Such duetting is noted in a wide range of families including quails, bushshrikes, babblers such as the scimitar babblers, some owls and parrots. In territorial songbirds, birds are more likely to countersing when they have been aroused by simulated intrusion into their territory. This implies a role in intraspecies aggressive competition.

Some birds are excellent vocal mimics. In some tropical species, mimics such as the drongos may have a role in the formation of mixed-species foraging flocks. Vocal mimicry can include conspecifics, other species or even man-made sounds. Many hypotheses have been made on the functions of vocal mimicry including suggestions that they may be involved in sexual selection by acting as an indicator of fitness, help brood parasites, protect against predation but strong support is lacking for any function. Many birds, and especially those that nest in cavities, are known to produce a snake like hissing sound that may help deter predators at close range.

Some cave-dwelling species, including Oilbird and Swiftlets (*Collocalia* and *Aerodramus* spp.), use audible sound (with the majority of sonic location occurring between 2 and 5 kHz) to echolocate in the darkness of caves. The only bird known to make use of infrasound (at about 20 Hz) is the western capercaillie.

The hearing range of birds is from below 50 Hz (infrasound) to above 20 kHz (ultrasound) with maximum sensitivity between 1 and 5 kHz. The range of frequencies at which birds call in an environment varies with the quality of habitat and the ambient sounds. It has been suggested that narrow bandwidths, low frequencies, low-frequency modulations, and long elements and inter-element intervals should be found in habitats with complex vegetation structures (which would absorb and muffle sounds) while high frequencies, broad bandwidth, high-frequency modulations (trills), and short elements and inter-elements may be expected in habitats with herbaceous cover. It has been hypothesized that the available frequency range is partitioned and birds call so that overlap between different species in frequency and time is reduced. This idea has been termed the "acoustic niche". Birds sing louder and at a higher pitch in urban areas, where there is ambient low-frequency noise.

Bird Language

The language of the birds has long been a topic for anecdote and speculation. That calls have meanings that are interpreted by their listeners has been well demonstrated. Domestic chickens have distinctive alarm calls for aerial and ground predators, and they respond to these alarm calls appropriately. However a language has, in addition to words, structures and rules. Studies to demonstrate the existence of language have been difficult

due to the range of possible interpretations. Research on parrots by Irene Pepperberg is claimed to demonstrate the innate ability for grammatical structures, including the existence of concepts such as nouns, adjectives and verbs. Studies on starling vocalizations have also suggested that they may have recursive structures.

The term "bird language" may also more informally refer to patterns in bird vocalizations that communicate information to other birds or other animals in general. Wilderness Awareness School groups bird vocalizations into 5 different classes, sometimes called "voices," each of which communicates different information. Companion calling is a short vocalization made between mates, parent and young, or members of a flock to maintain contact when out of visual range. Juvenile begging is a strident, loud vocalization often made by young to a parent when begging for food. Intraspecific aggression can consist of loud, alarmed-sounding vocalizations or of energetic song, and may be heard when members of the same species behave aggressively toward each other. Alarm may be heard when birds are startled, frightened, or terrified for their lives, and can take many forms. Mobbing is one example of alarm, while a high-pitched alarm call is another.

Of the 5 voices of the birds, four of them communicate the message that the bird feels safe. Birds that engage in song, companion calling, juvenile begging, and intraspecific aggression all display what Jon Young calls "baseline" behavior, or a relaxed state free of the fear of predation. Alarm communicates the presence of a predator, or an influence that the bird may see as predatory such as a human hiker. Alarms have distinct sounds and shapes, each of which is specific to the source of the disturbance. For example, ravens mobbing a hawk or owl in a tree will clump around the predator in a loose ball, calling and diving. If the ravens rise off the tree and fly higher, the predator was a hawk and has flown up to escape, as is typical of hawks. If the ravens drop out of the tree and fly low and away, the predator was an owl and has dropped low off its perch to escape, as is typical of owls.

Neurophysiology

The main brain areas involved in bird song are:

- Anterior forebrain pathway (vocal learning): composed of the lateral part of the magnocellular nucleus of anterior neostriatum (LMAN), which is a homologue to mammalian basal ganglia); Area X, which is part of the basal ganglia; and the Dorso-Lateral division of the Medial thalamus (DLM).
- Song production pathway: composed of the HVC (sometimes, inaccurately, called the Hyperstriatum Ventralis pars Caudalis); robust nucleus of the arcopallium (RA); and the tracheosyringeal part of the hypoglossal nucleus (nXIIts).

Both pathways show sexual dimorphism, with the male producing song most of the time. It has been noted that injecting testosterone in non-singing female birds can induce growth of the HVC and thus production of song.

Birdsong production is generally thought to start at the nucleus uvaefornis of the thalamus with signals emanating along a pathway that terminates at the syrinx. The pathway from the thalamus leads to the interfacial nucleus of the nidopallium to the HVC, and then to RA, the dorso-lateral division of the medial thalamus and to the tracheosyringeal nerve.

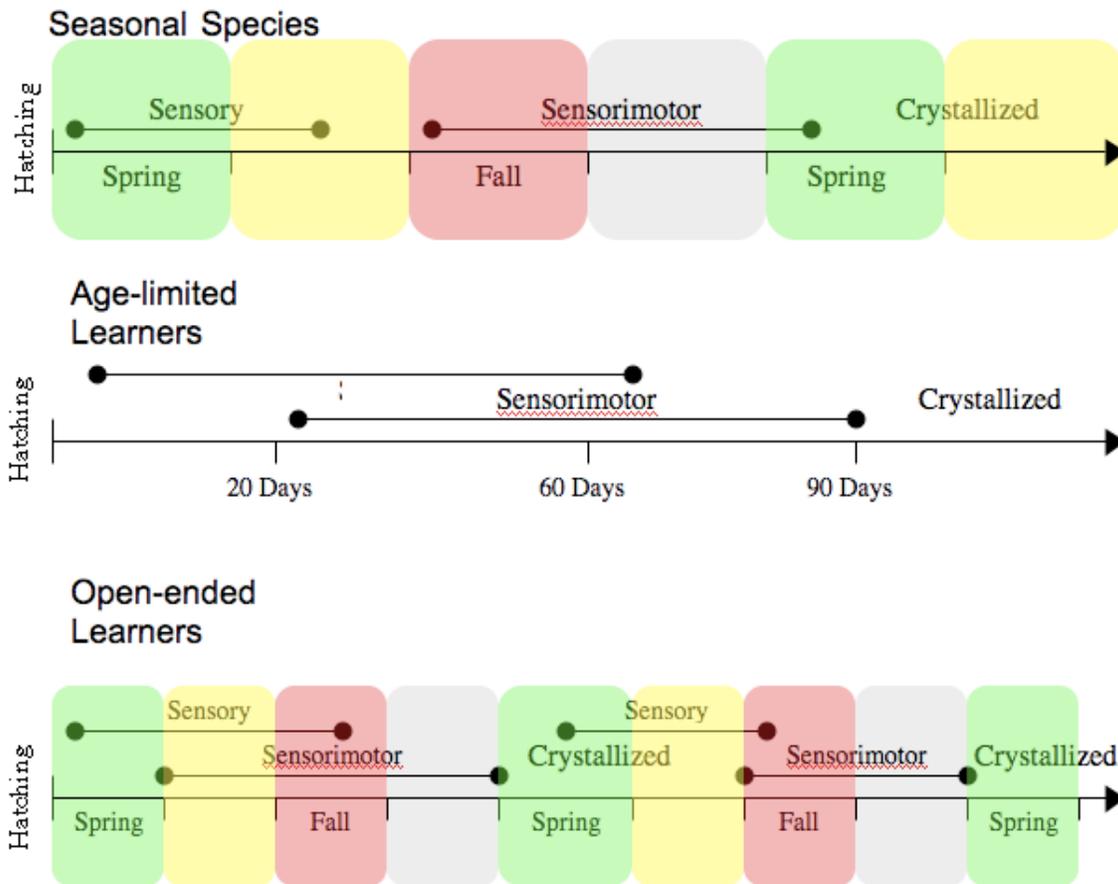
The gene FOXP2, defects of which affect both speech and comprehension of language in humans, becomes more active in the striatal region of songbirds during the time of song learning.

Recent research in birdsong learning has focused on the Ventral Tegmental Area (VTA), which sends a dopamine input to the para-olfactory lobe and Area X, LMAN and the ventrolateral medulla. Other researchers have explored the possibility that HVC is responsible for syllable production, while the robust nucleus of the arcopallium, the primary song output nucleus, may be responsible for syllable sequencing and production of notes within a syllable.

Learning

The songs of different species of birds vary, and are more or less characteristic of the species. In modern-day biology, bird song is typically analysed using acoustic spectroscopy. Species vary greatly in the complexity of their songs and in the number of distinct kinds of song they sing (up to 3000 in the Brown Thrasher); in some species, individuals vary in the same way. In a few species such as starlings and mockingbirds, songs imbed arbitrary elements learned in the individual's lifetime, a form of mimicry (though maybe better called "appropriation" [Ehrlich *et al.*], as the bird does not pass for another species). As early as 1773 it was established that birds learnt calls and cross-fostering experiments were able to force a Linnet *Acanthis cannabina* to learn the song of a skylark *Alauda arvensis*. In many species it appears that although the basic song is the same for all members of the species, young birds learn some details of their songs from their fathers, and these variations build up over generations to form dialects.

Birds learn songs early in life with sub-vocalizations that develop into renditions of adult songs. Zebra Finches, the most popular species for birdsong research, develop a version of a familiar adult's song after 20 or more days from hatch. By around 35 days, the chick will have learned the adult song. The early song is "plastic" or variable and it takes the young bird two or three months to perfect the "crystallized" song (which is less variable) of sexually mature birds.



Timeline for song learning in different species. Diagram adapted from Brainard & Doupe, 2002.

Research indicates birds' acquisition of song is a form of motor learning that involves regions of the basal ganglia. Models of bird-song motor learning are sometimes used as models for how humans learn speech. In some species such as zebra finches, learning of song is limited to the first year; they are termed 'age-limited' or 'close-ended' learners. Other species such as the canaries can develop new songs even as sexually mature adults; these are termed 'open-ended' learners.

Researchers have hypothesized that learned songs allow the development of more complex songs through cultural interaction, thus allowing intraspecies dialects that help birds stay with their own kind within a species, and it allows birds to adapt their songs to different acoustic environments.

Auditory feedback in bird song learning

Early experiments by Thorpe in 1954 showed the importance of a bird being able to hear a tutor's song. When birds are raised in isolation, away from the influence of conspecific males, they still sing. While the song they produce resembles the song of a wild bird, it

- Lesions parts of the anterior forebrain pathway, or vocal learning pathway, DLM and area X, result in deficits in learning in all birds.
- Lesioning LMAN, located in the anterior forebrain pathway in young birds disrupts song production.
- Lesioning LMAN on an adult bird shows no effect.
- Lesioning LMAN on an adult canary (an "open-ended learner" species, which can learn songs later in life) shows a progressive deterioration of song.

These results show that the area known as LMAN is the only brain area in the pathway that shows some plasticity and further studies have shown that this area of the brain responds best to the bird's own song. This neuroplasticity is vital for a bird being able to learn a song. The ability to make small adjustments based on auditory feedback is needed for the complexity of these beautiful songs. Just like any musician, birds need to practice and be able to evaluate what their song sounds like and what it's supposed to sound like in order to get it right.

To complete the picture on bird song learning, experimenters needed to discover the true plasticity of the brain. While deafening and creating auditory isolation were good techniques for discovering basic characteristics about the brain, a reversible procedure was needed to investigate further. The solution was found in disruption of the auditory feedback, or what a bird hears. A computer is able to capture the song of a singing bird and play back portions of its song, or selectively play back a certain syllable while the bird is singing. The computer is basically playing the age old trick of repeating whatever the bird sings, the "stop copying me" game. This creates such a disruption that an adult bird will start to decrystallize its song, which includes a loss of spectral and temporal rigidity characteristic of adult song. It reverts back to the song it started singing with, before any learning took place. Furthermore, when the feedback was stopped, the birds slowly recovered their original song, something that was unheard of. These results show that there is a fair amount of plasticity retained in the brain, even for close-ended learners. This new found plasticity in adult birds and the results on the plasticity of LMAN (shown above) combine into a model for bird song learning (diagram coming soon).

Mirror neurons and vocal learning

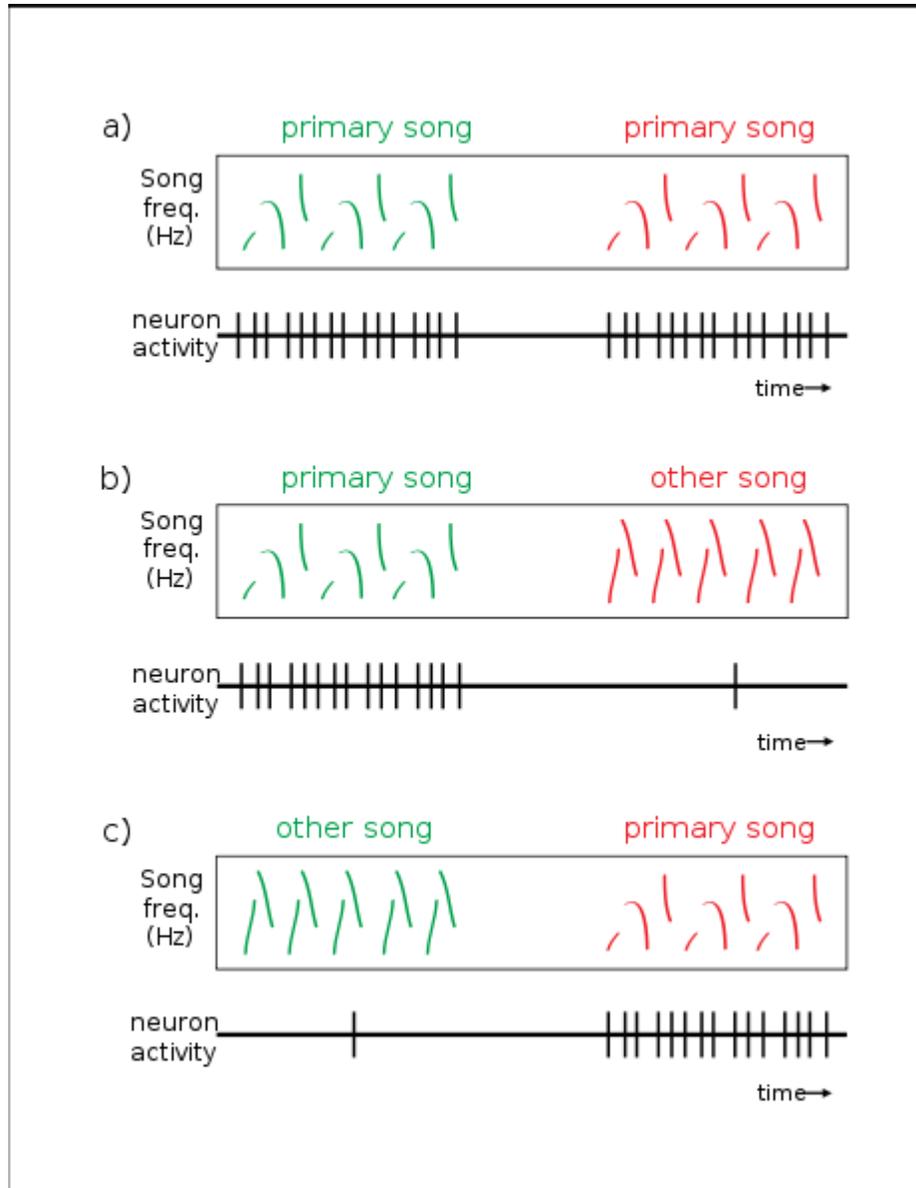
A mirror neuron is a neuron that discharges both when an individual performs an action, and when he perceives that same action being performed by another. These neurons were first discovered in macaque monkeys, but recent research suggests that mirror neuron systems may be present in other animals including humans.

Mirror neurons have the following characteristics:

- They are located the premotor cortex
- They exhibit both sensory and motor properties

- They are action-specific – mirror neurons are only active when an individual is performing or observing a certain type of action (e.g.: grasping an object).

Because mirror neurons exhibit both sensory and motor activity, some researchers have suggested that mirror neurons may serve to map sensory experience onto motor structures. This has implications for birdsong learning– many birds rely on auditory feedback to acquire and maintain their songs. Mirror neurons may be mediating this comparison of what the bird hears and what he produces.



Song selectivity in HVCx neurons: neuron activity in response to calls heard (green) and calls produced (red). **a.** Neurons fire when the primary song type is either heard or

sung. **b,c.** Neurons do not fire in response to the other song type, regardless of whether it is heard or sung. Sketch based on figure from Prather et al. (2008)

In search of these auditory-motor neurons, Jonathan Prather and other researchers at Duke University recorded the activity of single neurons in the HVCs of swamp sparrows. They discovered that the neurons that project from the HVC to Area X (HVC_X neurons) are highly responsive when the bird is hearing a playback of his own song. These neurons also fire in similar patterns when the bird is singing that same song. Swamp sparrows employ 3-5 different song types, and the neural activity differs depending on which song is heard or sung. The HVC_X neurons only fire in response to the presentation (or singing) of one of the songs, the primary song type. They are also temporally selective, firing at a precise phase in the song syllable.

Because the timing of the neural response is identical regardless of whether the bird was listening or singing, how can we be sure that the bird isn't just hearing himself? Prather et al. found that during the short period of time before and after the bird sings, his HVC_X neurons become insensitive to auditory input. In other words, the bird becomes "deaf" to his own song. This suggests that these neurons are producing a corollary discharge, which would allow for direct comparison of motor output and auditory input. This may be the mechanism underlying learning via auditory feedback.

Overall, the HVC_X auditory-motor neurons in swamp sparrows are very similar to the visual-motor mirror neurons discovered in primates. Like mirror neurons, the HVC_X neurons:

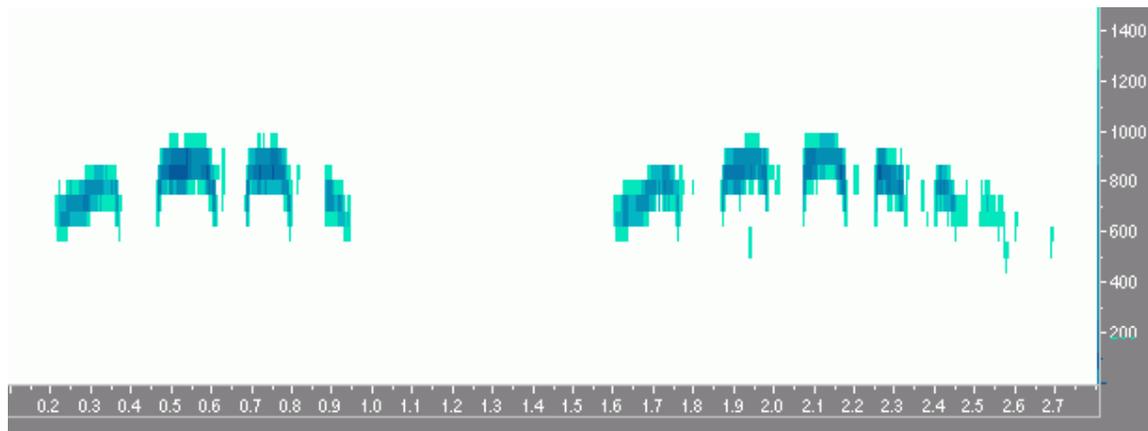
- Are located in a premotor brain area
- Exhibit both sensory and motor properties
- Are action-specific – a response is only triggered by the 'primary song type'

The function of the mirror neuron system is still unclear. Some scientists speculate that mirror neurons may play a role in understanding the actions of others, imitation, theory of mind and language acquisition, though there is currently insufficient neurophysiological evidence in support of these theories. Specifically regarding birds, it is possible that the mirror neuron system serves as a general mechanism underlying vocal learning, but further research is needed. In addition to the implications for song learning, the mirror neuron system could also play a role in territorial behaviors such as song-type matching and countersinging.

Identification and systematics

The specificity of bird calls has been used extensively for species identification. The calls of birds have been described using words or nonsense syllables, or line diagrams. Common terms in English include words such as *quack*, *chirp* and *chirrup*. These are

subject to imagination and vary greatly; a well-known example is the White-throated Sparrow's song, given in Canada as *O sweet Canada Canada Canada* and in New England as *Old Sam Peabody Peabody Peabody* (also *Where are you Frederick Frederick Frederick?*). In addition to nonsense words, grammatically correct phrases have been constructed as likenesses of the vocalizations of birds. For example, the Barred Owl produces a motif which some bird guides describe as *Who cooks for you? Who cooks for you all?* with the emphasis placed on *you*.



Sonogram of the call of a Laughing Dove.

The use of spectrograms to visualize bird song was first introduced by W. H. Thorpe. These visual representations are also called sonograms or sonagrams. Some recent field guides for birds use sonograms to document the calls and songs of birds. The sonogram is objective, unlike descriptive phrases, but proper interpretation requires experience. Sonograms can also be roughly converted back into sound.

Bird song is an integral part of bird courtship and is a pre-zygotic isolation mechanism involved in the process of speciation. Many allopatric sub-species show differences in calls. These differences are sometimes minute, often detectable only in the sonograms. Song differences in addition to other taxonomic attributes have been used in the identification of new species. The use of calls has led to proposals for splitting of species complexes such as those of the *Mirafra* Bushlarks.

Bird song and music

Some musicologists believe that birdsong has had a large influence on the development of music. Although the extent of this influence is impossible to gauge, it is sometimes easy to see some of the specific ways composers have integrated birdsong with music.

There seem to be three general ways musicians or composers can be affected by birdsong: they can be influenced or inspired (consciously or unconsciously) by birdsong, they can include intentional imitations of bird song in a composition, or they can incorporate recordings of birds into their works.

One early example of a composition that imitates birdsong is Janequin's "Le Chant Des Oiseaux", written in the 16th century. Other composers who have quoted birds or have used birdsong as a compositional springboard include Vivaldi (*Spring* from the *Four Seasons*), Biber (*Sonata Representativa*), Beethoven (*Sixth Symphony*), Wagner (*Siegfried*) and the jazz musicians Paul Winter (*Flyway*) and Jeff Silverbush (*Grandma Mickey*).

The twentieth-century French composer Olivier Messiaen composed with birdsong extensively. His *Catalogue d'Oiseaux* is a seven-book set of solo piano pieces based upon birdsong. His orchestral piece *Réveil des Oiseaux* is composed almost entirely of birdsong. Many of his other compositions, including *Quatuor pour la fin du temps*, similarly integrate birdsong.

The Italian composer Ottorino Respighi, with his *The Pines of Rome* (1923–1924), may have been the first to compose a piece of music that calls for pre-recorded birdsong. A few years later, Respighi wrote *Gli Uccelli* ("The birds"), based on Baroque pieces imitating birds.

The Finnish composer Einojuhani Rautavaara in 1972 wrote an orchestral piece of music called *Cantus Arcticus* (Opus 61, dubbed *Concerto for Birds and Orchestra*) making extensive use of pre-recorded birdsongs from Arctic regions, such as migrating swans.

The American jazz musician Eric Dolphy sometimes listened to birds while he practiced flute. He claimed to have incorporated bird song into some of his improvisational music.

In the psychedelic era of the 1960s and 1970s, many rock bands included sound effects in their recordings. Birds were a popular choice. The English band Pink Floyd included bird sound effects in many of the songs from their 1969 albums *Soundtrack from the Film More* and *Ummagumma* (for example, Grantchester Meadows). Similarly, the English singer Kate Bush incorporated bird sound effects into much of the music on her 2005 album, *Aerial*.

The Music hall artist Ronnie Ronalde has gained notoriety for his whistling imitations of birds and for integrating birdsong with human song. His songs 'In A Monastery Garden' and 'If I Were A Blackbird' include imitations of the blackbird, his "signature bird."

The French composer François-Bernard Mâche has been credited with the creation of zoomusicology, the study of the music of animals. His essay *Musique, mythe, nature, ou les Dauphins d'Arion* (1983) includes a study of "ornitho-musicology", in which he speaks of "animal musics" and a longing to connect with nature.

The German DJ, techno music producer and naturalist Dominik Eulberg is an avid bird watcher, and several tracks by him prominently feature sampled bird sounds and even are titled after his favourite specimens.

The productions of The Jewelled Antler Collective often use field recordings featuring birdsong.

In 2007, The CT Collective issued two free albums devoted to music made using bird songs (one with human interaction, one without). The project was co-ordinated by looping musician Nick Robinson

Bird song and poetry

Bird song is a popular subject in poetry. Famous poems inspired by bird song include Percy Bysshe Shelley's *To a Skylark* ("Hail to thee, blithe Spirit!/Bird thou never wert") and Gerard Manley Hopkins' *Sea and Skylark*. Birdsongs and their relations to Middle-earth inhabitants are a common motif in J. R. R. Tolkien's literary work. The Grateful Dead performed a song called "Bird Song" that Jerry Garcia wrote and dedicated to Janis Joplin.

Chapter 10

Snake Scales



Elaborately shaped scales on the head of a **Vine snake**, *Ahaetulla nasuta*.

Snakes, like other reptiles, have a skin covered in **scales**. Snakes are entirely covered with scales or scutes of various shapes and sizes. Scales protect the body of the snake, aid it in locomotion, allow moisture to be retained within, alter the surface characteristics such as roughness to aid in camouflage, and in some cases even aid in prey capture (such as *Acrochordus*). The simple or complex colouration patterns (which help in camouflage and anti-predator display) are a property of the underlying skin, but the folded nature of scaled skin allows bright skin to be concealed between scales then revealed in order to startle predators.

Scales have been modified over time to serve other functions such as 'eyelash' fringes, and protective covers for the eyes with the most distinctive modification being the *rattle* of the North American rattlesnakes.

Snakes periodically moult their scaly skins and acquire new ones. This permits replacement of old worn out skin, disposal of parasites and is thought to allow the snake to grow. The arrangement of scales is used to identify snake species.

Snakes have been part and parcel of culture and religion. Vivid scale patterns have been thought to have influenced early art. The use of snake-skin in manufacture of purses, apparel and other articles led to large-scale killing of snakes, giving rise to advocacy for use of artificial snake-skin. Snake scales are also to be found as motifs in fiction, video games and films.

Functions of scales

The scales of a snake primarily serve to reduce friction as it moves, since friction is the major source of energy loss in



Rainbow boas get their name from the coloration of their scales caused by iridescence.

snake locomotion. The ventral (or belly) scales, which are large and oblong, are especially low-friction, and some arboreal species can use the edges to grip branches. Snake skin and scales help retain moisture in the animal's body. Snakes pick up vibrations from both the air and the ground, and can differentiate the two, using a complex system of internal resonances (perhaps involving the scales).

Morphology of scales



Keeled scales of Buff-striped keelback *Amphiesma stolatum*, a Colubrid.

Snake scales are formed by the differentiation of the snake's underlying skin or epidermis. Each scale has an outer surface and an inner surface. The skin from the inner surface hinges back and forms a free area which overlaps the base of the next scale which emerges below this scale. A snake hatches with a fixed number of scales. The scales do not increase in number as the snake matures nor do they reduce in number over time. The scales however grow larger in size and may change shape with each moult.

Snakes have smaller scales around the mouth and sides of the body which allow expansion so that a snake can consume prey of much larger width than itself. Snake scales are made of keratin, the same material that hair and fingernails are made of. They are cool and dry to touch.

Surface and shape

Snake scales are of different shapes and sizes. Snake scales may be granular, have a smooth surface or have a longitudinal ridge or keel on it. Often, snake scales have pits, tubercles and other fine structures which may be visible to the naked eye or under a microscope. Snake scales may be modified to form fringes, as in the case of the Eyelash Bush Viper, *Atheris ceratophora*, or rattles as in the case of the rattlesnakes of North America.

Certain primitive snakes such as boas, pythons and certain advanced snakes such as vipers have small scales arranged irregularly on the head. Other more advanced snakes have special large symmetrical scales on the head called *shields* or *plates*.

Snake scales occur in variety of shapes. They may be cycloid as in family



Cycloid scales on *Leptotyphlops humilis* and other blind snake species are fluorescent, as a result when they are put under low frequency ultraviolet light (black light) they glow.

Typhlopidae, long and pointed with pointed tips, as in the case of the Green Vine Snake *Ahaetulla nasuta*, broad and leaf-like, as in the case of green pit vipers *Trimeresurus* spp or as broad as they are long, for example, as in Rat snake *Ptyas mucosus*.

In some cases, scales may be keeled weakly or strongly as in the case of the Buff-striped keelback *Amphiesma stolatum*. They may have bidentate tips as in some spp of *Natrix*. Some snakes, such as the Short Seasnake *Lapemis curtus*, may have spinelike and juxtaposed scales while others may have large and non-overlapping knobs as in the case of the Javan Mudsnae *Xenodermis javanicus*.

Another example of differentiation of snake scales is a transparent scale called the *brille* or *spectacle* which covers the eye of the snake. The brille is often referred to as a fused eyelid. It is shed as part of the old skin during moulting.

Rattles



Modified tail scales form a rattle on a **Western Diamondback Rattlesnake** *Crotalus atrox*.

The most distinctive modification of the snake scale is the *rattle* of rattlesnakes, such as those of the genera *Crotalus* and *Sistrurus*. The rattle is made up of a series of loosely linked, interlocking chambers that when shaken, vibrate against one another to create the warning signal of a rattlesnake. Only the bottom button is firmly attached to the tip of the tail.

At birth, a rattlesnake hatchling has only a small button or 'primordial rattle' which is firmly attached to the tip of the tail. The first segment is added when the hatchling sheds its skin for the first time. A new section is added each time the skin is shed until a rattle is

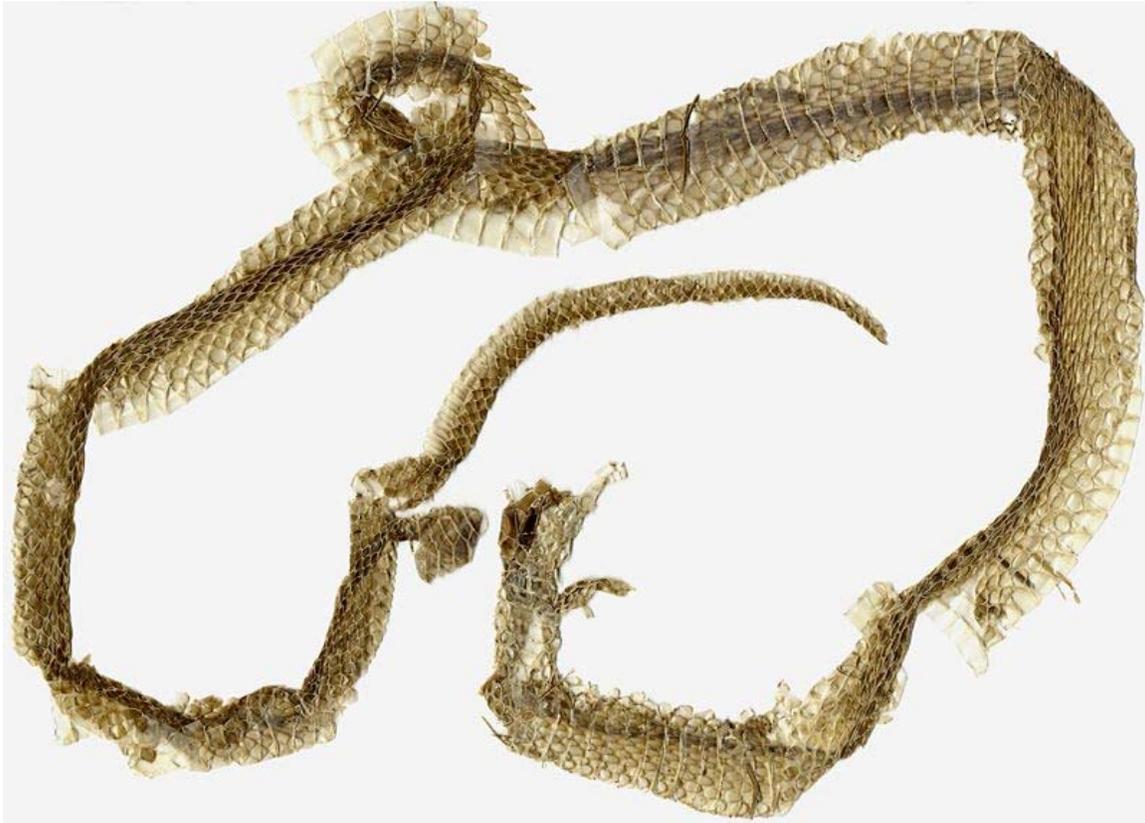
formed. The rattle grows as the snake ages but segments are also prone to breaking off and hence the length of a rattle is not a reliable indicator of the age of a snake.

Colour

Scales, more specifically, mostly consist of hard beta keratins which are basically transparent. The colours of the scale are due to pigments in the inner layers of the skin and not due to the scale material itself. Scales are hued for all colours in this manner except for blue and green. Blue is caused by the ultrastructure of the scales. By itself, such a scale surface diffracts light and gives a blue hue, while, in combination with yellow from the inner skin it gives a beautiful iridescent green.

Some snakes have the ability to change the hue of their scales slowly. This is typically seen in cases where the snake becomes lighter or darker with change in season. In some cases, this change may take place between day and night.

Ecdysis



Empty skin (exuvia) of a Grass Snake (*Natrix natrix*) whose length exceeds one metre.

The shedding of scales is called *ecdysis*, or, in normal usage *moulting* or *sloughing*. In the case of snakes, the complete outer layer of skin is shed in one layer. Snake scales are not discrete but extensions of the epidermis hence they are not shed separately, but are

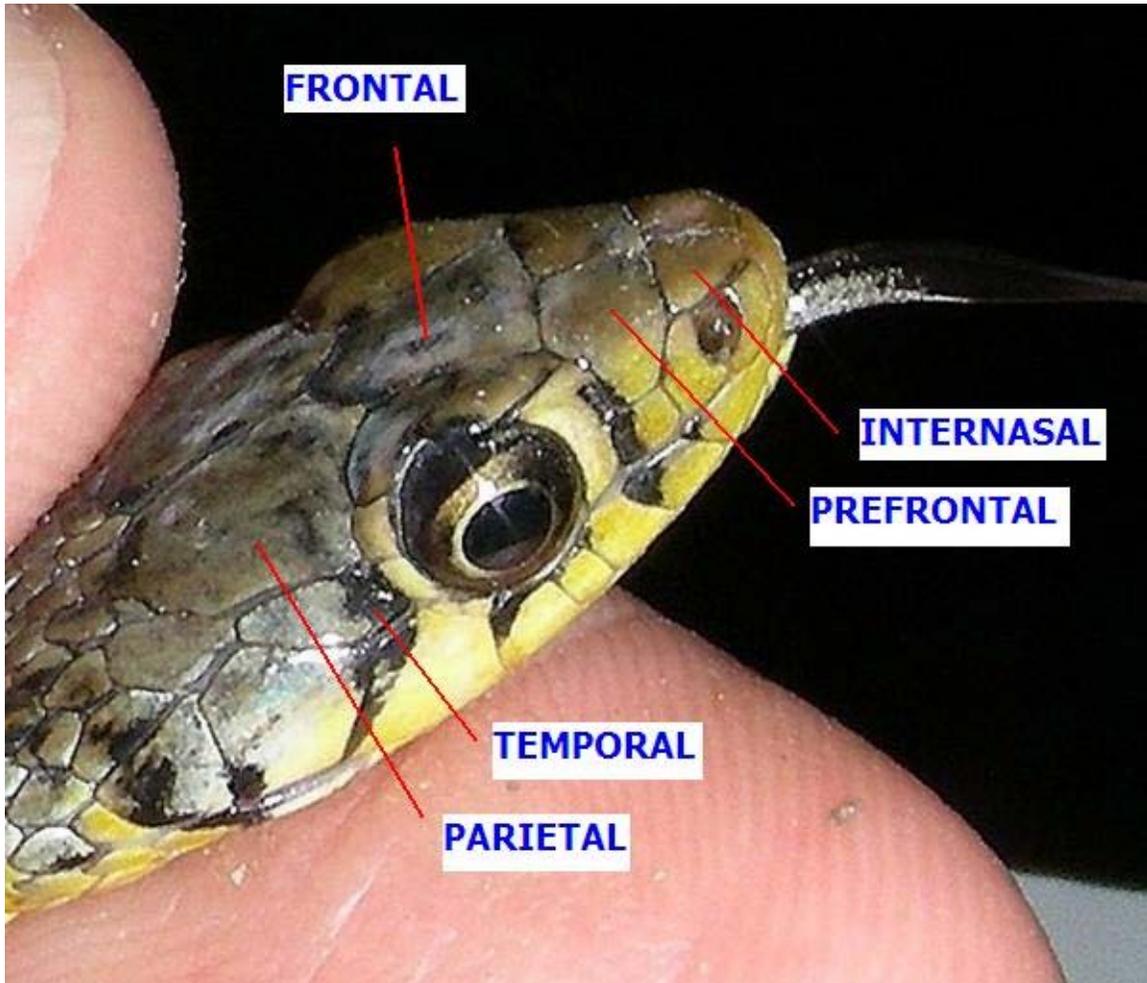
ejected as a complete contiguous outer layer of skin during each moult, akin to a sock being turned inside out.

Moulting serves a number of functions - firstly, the old and worn skin is replaced, secondly, it helps get rid of parasites such as mites and ticks. Renewal of the skin by moulting is supposed to allow growth in some animals such as insects, however this view has been disputed in the case of snakes.

Moulting is repeated periodically throughout a snake's life. Before a moult, the snake stops eating and often hides or moves to a safe place. Just before shedding, the skin becomes dull and dry looking and the eyes become cloudy or blue-colored. The inner surface of the old outer skin liquefies. This causes the old outer skin to separate from the new inner skin. After a few days, the eyes clear and the snake "crawls" out of its old skin. The old skin breaks near the mouth and the snake wriggles out aided by rubbing against rough surfaces. In many cases the cast skin peels backward over the body from head to tail, in one piece like an old sock. A new, larger, and brighter layer of skin has formed underneath.

An older snake may shed its skin only once or twice a year, but a younger, still-growing snake, may shed up to four times a year. The discarded skin gives a perfect imprint of the scale pattern and it is usually possible to identify the snake if this discard is reasonably complete and intact.

Arrangement of scales



Nomenclature of head scales (top view of head)

Scale arrangements are important, not only for taxonomic utility, but also for forensic reasons and conservation of snake species. Excepting for the head, snakes have imbricate scales, overlapping like the tiles on a roof. Snakes have rows of scales along the whole or part of their length and also many other specialised scales, either singly or in pairs, occurring on the head and other regions of the body.

The dorsal (or body) scales on the snake's body are arranged in rows along the length of their bodies. Adjacent rows are diagonally offset from each other. Most snakes have an odd number of rows across the body though certain species have an even number of rows e.g. *Zaocys* spp. In the case of some aquatic and marine snakes, the scales are granular and the rows cannot be counted.

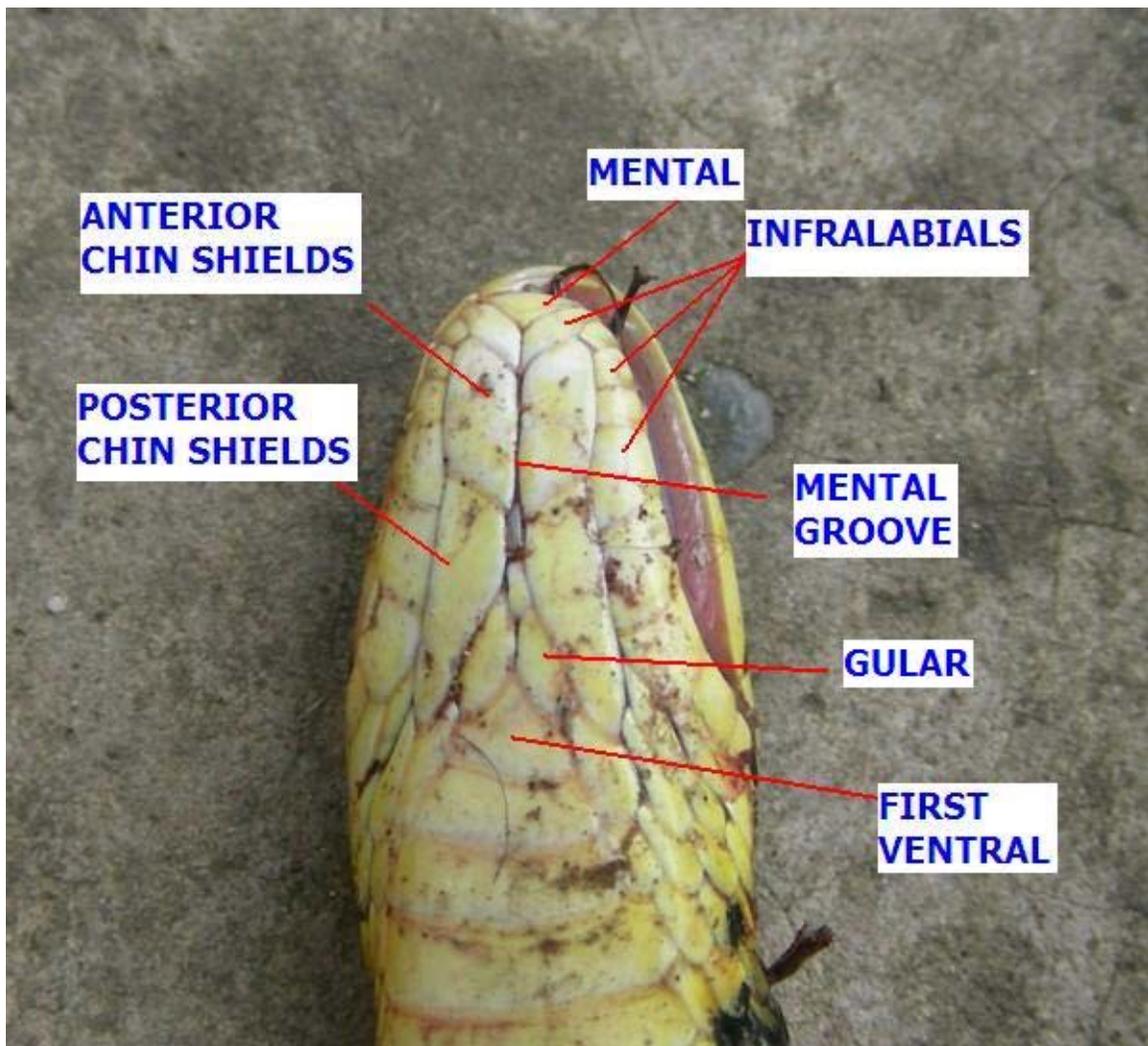
The number of rows range from ten in Tiger Ratsnake *Spilotes pullatus*; thirteen in *Dryocalamus*, *Liopeltis*, *Calamaria* and Asian coral snakes of genus *Calliophis*; 65 to 75 in pythons; 74 to 93 in *Kolpophis* and 130 to 150 in *Acrochordus*. The majority of the

largest family of snakes, the *Colubridae* have 15, 17 or 19 rows of scales. The maximum number of rows are in mid-body and they reduce in count towards the head and on the tail.

Nomenclature of scales

The various scales on a snake's head and body are indicated in the following paragraphs with annotated photographs of Buff-striped Keelback *Amphiesma stolata*, a common grass-snake of South Asia and a member of Colubridae, the largest snake family.

Head scales



Nomenclature of scales (underside view of head)

Identification of cephalic scales is most conveniently begun with reference to the nostril which is easily identified on the snake. There are two scales enclosing the nostril which are called the **nasals**. In colubrids, the nostril lies between the nasals while in vipers it

lies in the centre of a single nasal scale. The outer nasal (near the snout) is called the **prenasal** while the inner nasal (near the eye) is called the **postnasal**. Along the top of the snout connecting the nasals on both sides of the head are scales called **internasals**. Between the two prenasals is a scale at the tip of the snout called the **rostral** scale.

The scales around the eye are called **circumorbital** scales and are named as 'ocular' scales but with appropriate prefix. The **ocular scale** proper is a transparent scale covering the eye which is called the **spectacle, brille** or **eyecap**. The circumorbital scales towards the snout or the front are called **preocular** scales, those towards the rear are called **postocular** scales and those towards the upper or dorsal side are called as **supraocular** scales. Circumorbital scales towards the ventral or lower side, if any, are called as **subocular** scales. Between the preocular and the postnasal scales are one or two scales called as **loreal** scales. Loreal scales are absent in elapids.

The scales along the lips of the snake are called as **labials**. Those on the upper lip are called **supralabials** while those on the lower labial are called **infralabials**. Between the eyeballs on top of the head, adjacent to the supraoculars are the **frontal** scales. The **prefrontal** scales are the scales connected to the frontals towards the tip of the snout which are in contact with the internasals. They may have a scale in between them. The back of the top of the head has scales connected to the frontal scales called as the **parietal** scales. At the sides of the back of the head between the parietals above and the supralabials below are scales called **temporal** scales.



Part of the body of a snake having yellow and black rings. The body is triangular in section and has a prominent line of scales on the apical vertebral ridge.

On the underside of the head, a snake has an anterior scale called as the **mental** scale. Connected to the mental scales and all along the lower jaws are the **infralabials**. Along the lower jaw connected to infralabials are a pair of shields called the **anterior chin shields**. Next to the anterior chin shields, further back along the jaw are another pair of shields called the **posterior chin shields**. In some texts the chinshields are referred to as *submaxillary* scales.

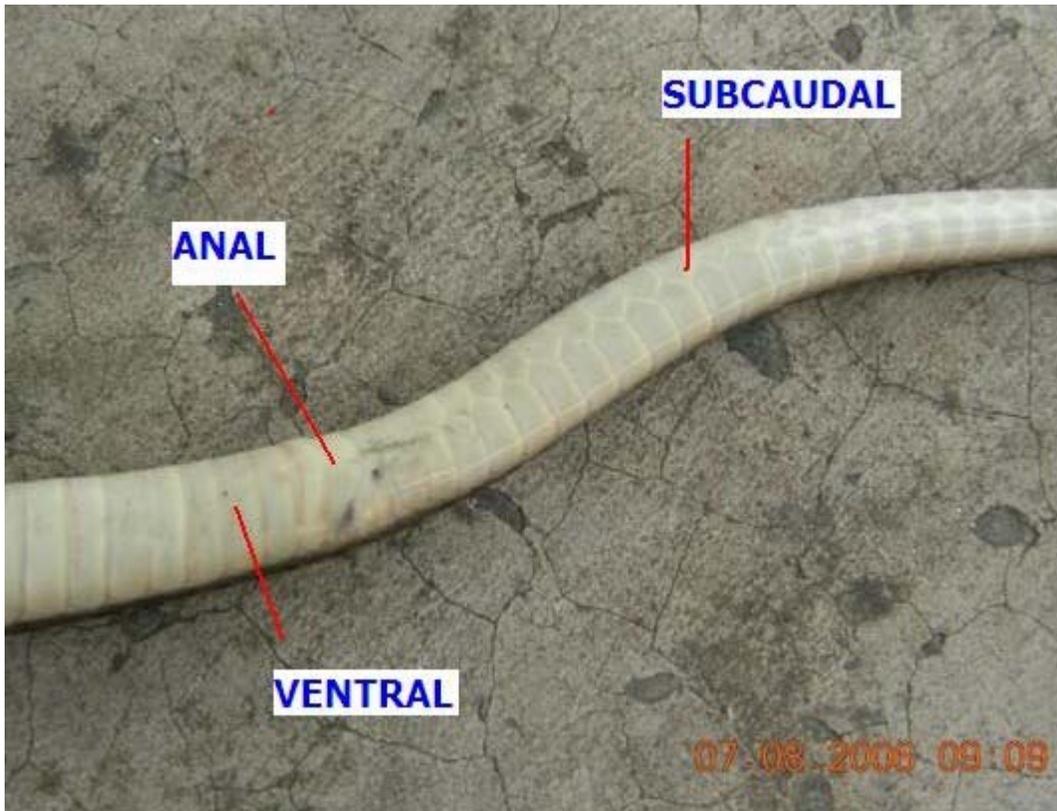
Scales in the central or *throat* region, which are in contact with the first ventral scales of a snake's body and are flanked by the chin shields, are called **gular scales**. The **mental groove** is a longitudinal groove on the underside of the head between large, paired chin shields and smaller gular scales.

Body scales

The scales on the body of the snake are called the **dorsal** or **costal** scales. Sometimes there is a special row of large scales along the top of the back of the snake, i.e., the uppermost row, called the **vertebral** scales. The enlarged scales on the belly of the snake

are called **ventral** scales or **gastrosteges**. The number of ventral scales can be a guide to the species. In "advanced" (Caenophidian) snakes, the broad belly scales and rows of dorsal scales correspond to the vertebrae, allowing scientists to count the vertebrae without dissection.

Tail scales

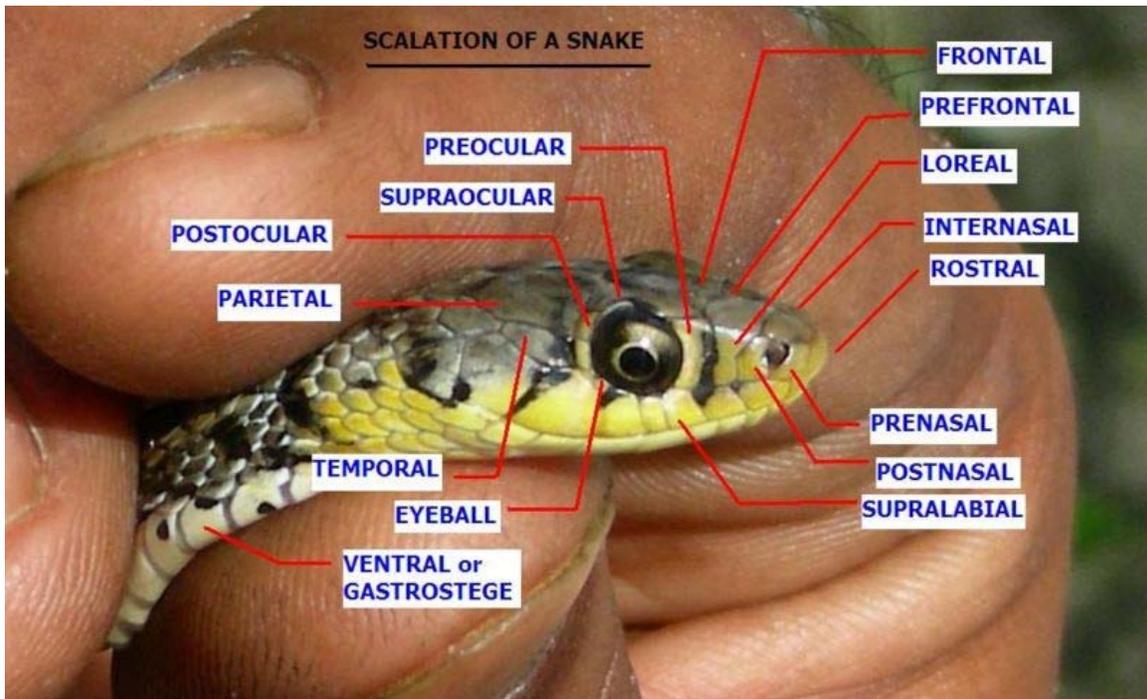


Nomenclature of scales (underside view of body),

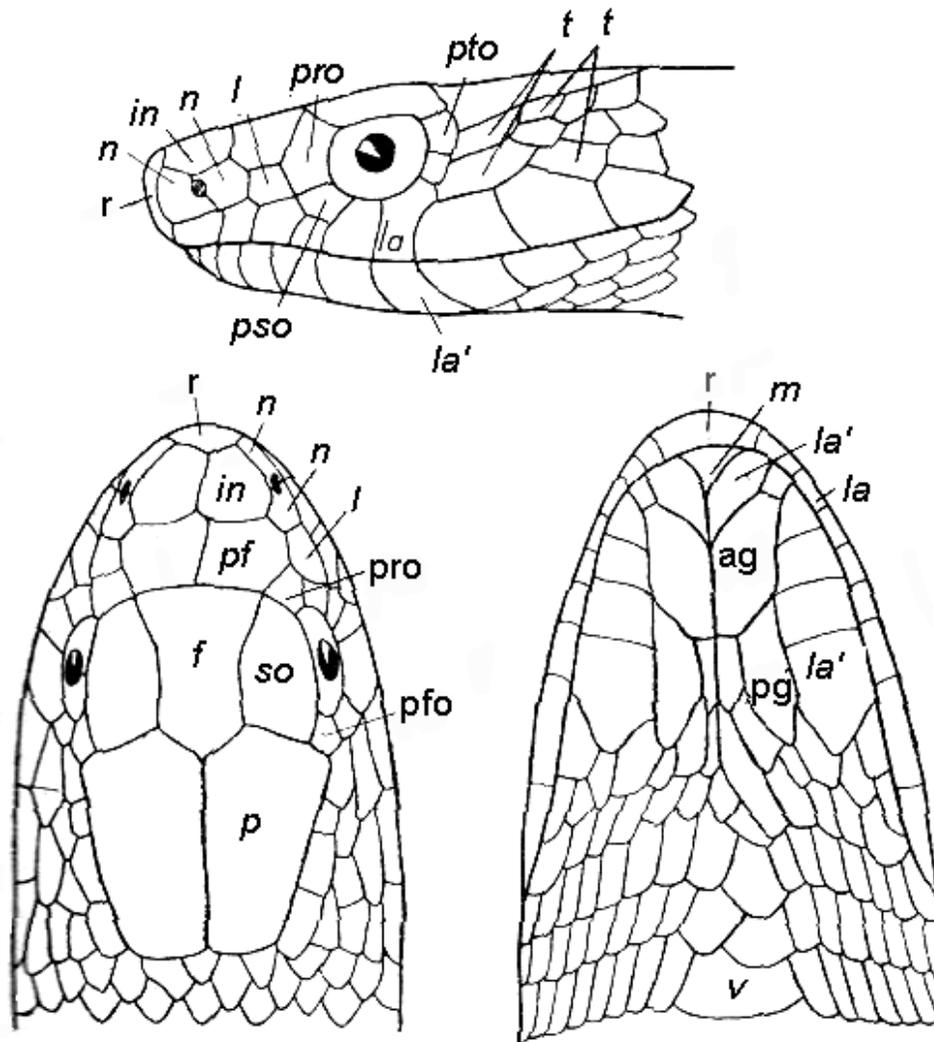
At the end of the ventral scales of the snake is an anal plate which protects the opening to the cloaca (a shared opening for waste and reproductive material to pass) on the underside near the tail. This **anal** scale may be single or divided into a pair. The part of the body beyond the anal scale is considered to be the tail.

Sometimes snakes have enlarged scales, either single or paired, under the tail; these are called **subcaudals** or **urosteges**. These subcaudals may be smooth or keeled as in *Bitis arietans somalica*. The end of the tail may simply taper into a tip (as in the case of most snakes), it may form a spine (as in *Acanthophis*), end in a bony spur (as in *Lachesis*), a rattle (as in *Crotalus*), or a rudder as seen in many sea snakes.

Glossary of scales



Nomenclature of scales (side view of head)



Terminology of snake head shields explained with help of line diagrams of the head of *Coluber ventromaculatus* from Malcolm A. Smith (1943).

Legend

- ag** - Anterior genials or Chin shields
- f** - Frontal
- in** - Internasal
- l** - Loreal
- la** - Supralabial
- la'** - Infralabial
- m** - Mental
- n** - Nasal
- p** - Parietal
- pf** - Prefrontal

pg - Posterior Genials or Chin shields
pro - Preocular
pso - Presubocular
pto - Postocular
r - Rostral
so - Supraocular
t - Anterior and Posterior Temporals
v - First Ventral

- **Scales on the head.**

- Rostral.
- Nasorostral.
- Nasal.
 - Prenasal.
 - Postnasal.
 - Supranasal.
 - Fronto-nasal.
- Internasal.
- Brille, spectacle, ocular scale, eyecap.
- Circumorbital.
 - Preocular.
 - Postocular.
 - Supraocular.
 - Subocular.
- Loreal.
- Interorbital, Intersupraocular.
- Frontal.
- Prefrontal.
- Parietal.
- Occipital.
- Interoccipital.
- Temporal.
- Labial.
 - Supralabial, Upper labial.
 - Sublabial, Infralabial, Lower labial.
- Mental or Symphysial.
- Chin shield.
 - Anterior chin shield, Anterior genials.
 - Posterior chin shield, Posterior genials.
 - Intergeneial.
- Gular.

- **Scales on the body.**

- Dorsal.
- Vertebral.
- Ventral, Gastrostege.

- **Scales on the tail.**
 - Anal.
 - Subcaudal, Urostege.

Other pertinent terms

- Canthus, or *Canthus rostralis*.
- Mental groove.

Taxonomic importance

Scales do not play an important role in distinguishing between the families but are important at generic and specific level. There is an elaborate scheme of nomenclature of scales. Scales patterns, by way of scale surface or texture, pattern and colouration and the division of the anal plate, in combination with other morphological characteristics, are the principal means of classifying snakes down to species level.

In certain areas in North America, where the diversity of snakes is not too large, easy keys based on simple identification of scales have been devised for the lay public to distinguish poisonous snakes from non-poisonous snakes. In other places with large biodiversity, such as Myanmar, publications caution that venomous and non-venomous snakes cannot be easily distinguished apart without careful examination.

The scales patterning may also be used for individual identification in field studies. Clipping of specific scales, such as the subcaudals, to mark individual snakes is a popular approach to population estimation by mark and recapture techniques.

Distinguishing between venomous and non-venomous snakes



Banded Krait (*Bungarus fasciatus*), an Elapid, with no loreal scale between nasal and pre-ocular scales.

There is no simple way of differentiating a venomous snake from a non-venomous one merely by using a scale character. Finding out whether a snake is venomous or not is correctly done by identification of the species of a snake with the help of experts,^{:190} or in their absence, close examination of the snake and using authoritative references on the snakes of the particular geographical region to identify it. Scale patterns help to indicate the species and from the references, it can be verified if the snake species is known to be venomous or not.

Species identification using scales requires a fair degree of knowledge about snakes, their taxonomy, snake-scale nomenclature as well as familiarity with and access to scientific literature. Distinguishing by using scale diagrams whether a snake is venomous or not in the field cannot be done in the case of uncaught specimens. It is not advisable to catch a snake to check whether it is venomous or not using scale diagrams.^{:190} Most books or websites provide an array of traits of the local herpetofauna, other than scale diagrams, which help to distinguish whether a snake in the field is venomous or not.

In certain regions, presence or absence of certain scales may be a quick way to distinguish non-venomous and venomous snakes, but used with care and knowledge of exceptions. For example, in Myanmar, the presence or absence of loreal scales can be used to distinguish between relatively harmless Colubrids and lethally venomous Elapids. The rule of thumb for this region is that the absence of a loreal scale between the nasal

scale and pre-ocular scale indicates that the snake is an Elapid and hence lethal. This rule-of-thumb cannot be used without care as it cannot be applied to vipers, which have a large number of small scales on the head. A careful check would also be needed to exclude known poisonous members of the Colubrid family such as *Rhabdophis*.

In South Asia, it is advisable to take the snake which has bitten a person, if it has been killed, and carry it along to the hospital for possible identification by medical staff using scale diagrams so that an informed decision can be taken them as to whether and which anti-venom is to be administered. However, attempts to catch it or kill the venomous snake are not advised as the snake may bite more people.

Cultural significance



Snakeskin boots, Arizona.

Snakes have been a motif in human culture and religion and an object of dread and fascination all over the world. The vivid patterns of snake scales, such as the Gaboon Viper, both repel and fascinate the human mind. Such patterns have inspired dread and awe in humans from pre-historic times and these can be seen in the art prevalent to those times. Studies of fear imagery and psychological arousal indicate that snake scales are a vital component of snake imagery. Snake scales also appear to have affected Islamic art in the form of tessellated mosaic patterns which show great similarity to snake-scale patterns.

Snakeskin, with its highly periodic cross-hatch or grid patterns, appeals to people's aesthetics and have been used to manufacture many leather articles including fashionable accessories. The use of snakeskin has however endangered snake populations and resulted in international restrictions in trade of certain snake species and populations in the form of CITES provisions. Animal lovers in many countries now propagate the use of artificial snakeskin instead, which are easily produced from embossed leather, patterned fabric, plastics and other materials.

Snake scales occur as a motif regularly in computer action games. A snake scale was portrayed as a clue in the 1982 film *Blade Runner*. Snake scales also figure in popular fiction, such as the Harry Potter series (desiccated Boomslang skin is used as a raw material for concocting the Polyjuice potion), and also in teen fiction.