an effective range of between 5 and 200 m for targets of 5–15 cm in length. The echoes are received back through the lower jaw and transmitted up to the inner ear, with the animal responding based on the information received.

Other animals known to use echolocation primarily for navigational purposes are some species of shrew, the nocturnal oilbird and swiftlets. The birds, however, use clicks that are audible to humans, and are not thus classed as ultrasound. The shrews' echolocation is carried out using ultrasonic squeaks.

Ultrasound in veterinary medicine

Ultrasonography is widely used in both human and veterinary medicine. It can be used both as a diagnostic tool and a therapeutic tool. In diagnostics, it can be used as a non-invasive method of visualizing soft tissue structures. As with echolocation, the methodology is based on the transmission of ultrasound and interpretation of the reflected sound back from the tissue. The sound wave is typically produced by a piezoelectric transducer encased in a probe. Electrical pulses make the transducer ring at the desired frequency, which is usually between 1 and 18 MHz. Superficial structures are scanned using higher frequencies, while deeper structures are scanned using lower frequencies. The transducer also receives the echo, which in turn creates vibration that is turned into electrical impulses for processing and digital imaging. As a technique, diagnostic ultrasonic imaging has multiple applications but, within the veterinary field, it is most commonly used to confirm pregnancy in domestic animals. It may also be used by veterinarians to diagnose disease, as in human medicine, and by animal scientists to determine production parameters such as back-fat depth and loin eye muscle area.

Pregnancy checking in domestic animals can help with the management of pregnancy – ensuring that care of the mother is tailored towards her gestational needs. The exact benefits will depend on whether the species is **companion animal** or **farmed animal**. With companion animals (such as pedigree dogs or competition horses), the mother and/or offspring may have high commercial value as well as emotional value. With farm animals, the commercial value of the individual animal is likely to be considerably less, but the collective financial well-being of the farm will be dependent on high proportions of successful conceptions. Many farms employ ultrasonic pregnancy checking as a management tool to ensure that 'open' females are not entered into the gestation herd or flock, but are either retained in the breeding system or culled due to reproductive difficulties. (JNM-F)

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Umwelt

Jakob von Uexküll (1936) termed an individual's entire subjectively perceived world its 'umwelt'. Umwelts differ between individuals, because sensory abilities differ and because stimuli have different relevance to each individual; Von Uexküll used the example of a flower stem being a path for ants, but a food morsel for cows. (CCB)

See also: Ethological relevance; Perception

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Ungulates

Ungulates are the mammals that have replaced claws with hooves during their **evolution**. The surviving primitive ungulates are **elephant**s, hyraxes and the aardvark. Fairly soon after they first arose, the ungulates diverged into even-toed (order Artiodactyla) and odd-toed (order Perissodactyla) ungulates. The asses, **horse**s and zebras, the tapirs, and the **rhinoceros**es are perissodactyls and the **pig**s, peccaries, hippos, **camelid**s, chevrotains and musk deer, **deer**, **giraffe**s and bovids are artiodactyls. Bovids comprise the pronghorn, wild **cattle** (bovines), duikers, gazelles and grazing antelopes, and goat antelopes.

All ungulates are terrestrial herbivores or omnivores. Specializations for a diet of plant material are evident in their teeth, jaws, digestive systems and behavioural ecology. A key feature is **rumination** (retention of food in a specialized stomach chamber system where it is fermented by symbiotic microorganisms), which most artiodactyls (but not the pigs, peccaries or hippos) employ to extract energy and nutrients from plant material. Perissodactyls have other adaptations – they house their symbionts in the hindgut, which is a less effective way of extracting energy and nutrients but is better able to cope with a coarser diet.

Many ungulates have social systems with strong social **bonding** and a clear **dominance hierarchy**. These, and other characteristics, suited them for **domestication** and they include the most important **farmed animals**. (SJGH)

Urban wildlife

Urban wildlife is defined as animals that make use of resources (breeding habitat, roosting substrates, food, etc.) in urbanized areas. Urban wildlife includes a broad range of animals (e.g. house sparrows, Canada geese, pigeons, bats, **deer**, opossums, raccoons, etc.) that can have different degrees of association with humans.

Species highly dependent upon humans, particularly in terms of food (e.g. pigeons, **feral cat**s, house **mouse**), are known as synanthropes. Synanthropes can be full synanthropes (also called exploiters or urbanophiles), which obtain most of their resources in urban areas, or casual synanthropes (also called adapters or moderately urbanophilic), which can adapt to exploit resources in urban habitats but also use other resources in more natural environments. Full synanthropes are generally found in areas with low vegetation within cities, but casual synanthropes do use urban vegetation for food or nesting/**roosting**. Finally, species that are highly sensitive to urbanization (e.g. rare in cities) are called avoiders or urbanophobes.

Urban wildlife can be composed of native and non-native species. Native species are local species that use certain resources in urban areas, but they are also dependent on other habitats (e.g. casual synanthropes). Non-native species have been introduced locally from other ecosystems (or have colonized a local area after a regional introduction). Non-native species fare well in cities because of their high competitive ability and the high availability of foraging resources in cities. Two well-known examples are house sparrows (*Passer domesticus*) and European starlings (*Sturnus vulgaris*). The house sparrow, a native from Eurasia, was initially introduced to North America (in New York) in 1851. The species had expanded its geographic distribution to many states on the east and west coasts by the 1900s. Nowadays it is commonly seen **breeding** in cities, although it can also be present in farms and residential areas. Even more remarkable is the introduction of about 100 European starlings in New York in 1890, which expanded their distribution throughout North America with an estimated abundance of 200 million individuals. Part of the success of house sparrows and European starlings has been attributed to their ability to outcompete native species for nest cavities, which could result in the decline of native cavity-nesting species.

The role of urban wildlife is particularly important because of two worldwide trends in land use that are changing the representation of urban habitats. First, more than 50% of the human population is expected to be living in urban areas around the world by 2015. This increment in human density will be accompanied by even higher rates of urban sprawl, which will fragment and reduce the representation of natural habitats. Secondly, in some regions of the world there is an increase in the immigration rate to rural areas by people seeking lifestyles that provide closer access to natural areas (ex-urban development). Both trends are causing changes in land use that provide conditions conducive to the colonization of synanthropic species due to at least three factors. First, breeding and foraging resources increase around human settlements due to the presence of food leftovers, nesting substrates in buildings, etc. Secondly, natural predators are thought to be less abundant in cities, which would increase the survival of urban species, although further evidence is needed to support lower predation risk in cities. Thirdly, urbanized landscapes modify environmental conditions that minimize climatic fluctuations throughout the year, such as an increase in temperature (heat island effect) and water availability due to irrigation. These three conditions create similar urban environments in different regions of the world, which leads to homogenization of wildlife – an increase in the similarity of species composition across cities. Homogenization in turn can decrease species diversity at the regional level.

Variations in resource abundance, predation levels and environmental conditions along the rural–urban gradient modify species richness and abundance. Generally, the number of native species decreases, and the number of non-native species increases, with increasing levels of urbanization. Because of these opposing patterns, the overall number of species tends to peak at intermediate degrees of urbanization. This inverted U-shape pattern has been found in birds, small mammals, lizards and butterflies. In birds, a few synanthropic species tend to dominate urban communities due to their extremely high densities relative to other habitat types. These birds are usually ground-foraging seed eaters or omnivores that have adapted to nesting in human substrates. In mammals, synanthropic species that reach the highest densities are often found inside buildings.

Urban sprawl can modify ecological relationships, such as predator–prey interactions. Fragmentation of natural habitats reduces the size of the remnant patches, which can decrease the densities of top-predators, or drive them to local extinction. For instance, in coastal southern California, coyote populations have dwindled due to the high degrees of urbanization around native sage-scrub habitat. The lack of this top-predator increases the abundance of native (raccoon, grey fox) and non-native (domestic cat, opossum), low-level predators, a process known as **mesopredator** release. This intensifies the negative effects of habitat fragmentation on native scrub-breeding birds because low-level predators, especially the domestic cat, have high abundances in small-sized remnant patches, thereby increasing local bird mortality due to **predation**.

The overlap in spatial use by humans and wildlife in urbanized areas generates different types of conflicts. The overabundance of some species can damage private and public property, increase road danger and spread diseases. For instance, the accumulation of pigeon faeces can block rainwater drainage systems, decrease the aesthetic value of buildings – particularly those of cultural relevance – and increase slippery footing on walkways. Deer collision with vehicles is probably enhanced by increasing deer abundance, expanded road networks, greater traffic load and high average vehicle speeds. This results in around 1.5 million deer–vehicle collisions yearly in the USA. Finally, urban wildlife species that are hosts of infectious **diseases** (e.g. West Nile virus, avian influenza, Lyme disease, etc.) can increase the chances of transmission to humans in the presence of vectors. Wildlife managers and public health officials have developed various strategies to minimize the risks of transmission by **culling** different species or reducing the availability of resources (e.g. water for mosquito breeding).

In conclusion, urban wildlife encompasses a diverse set of species that require to be managed in different ways according to their degree of association with humans. Despite conflicts, the presence of wildlife in cities not only brings ecological but also psychological benefits by providing humans with the opportunity to experience the natural environment. To maintain these benefits, it is important that the diversity of native vegetation is enhanced in urban areas. (EF-J)

See also: Conservation; Exotic species invasion; Wildlife management

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Urine

Urine is an aqueous solution of waste materials from metabolic processes in the body. Blood passes through the kidneys, where it undergoes filtration. Metabolites are secreted along with water into the ureter. The urine then travels down the ureter into the bladder, where it is stored until the animal urinates – expelling the urine out of the bladder through the urethra. From a physiological aspect, the production of urine is important in **homeostasis**, to maintain the water balance within the body. With dehydration, water is conserved as blood passes through the kidneys and urine volume decreases and becomes more concentrated. With subsequent rehydration, water will be removed in larger quantities and urine volume and dilution will both increase.

From welfare and behaviour aspects, urine can have an important role in intra- and interspecific **communication**; it can contain **stress** markers that can be collected non-invasively; and it can impact **welfare** in relation to hygiene and air quality. Mares' urine is also used in the manufacture of the drug used in **oestrogen** replacement therapy, and there have been concerns about the welfare of the horses involved.

Urine and communication

Chemicals contained within urine, and sensed by the olfactory system and the **vomeronasal organ** (VMO), can convey a variety of information that can have an effect both within and between species. Urine can convey information about individual identity, social **dominance**, territorial limits, reproductive status, predator/prey proximity and even emotional states, such as **fear**. One source of information about individual identity is most probably conveyed by soluble antigens of the major histocompatability complex (MHC) reacting with bacterial flora to produce volatile compounds that give the urine a characteristic odour. Another mechanism involves major urinary proteins (MUP), which bind and release volatile compounds, and have been well described in rodents.

Experimental studies have shown individual **recognition** using urine in many species – for example mice, rats, bank voles, hamsters, lynx and pigs. For social dominance, **androgen** hormones and metabolites appear to be an important element in conveying information; and in rodents, relative dominance may be conveyed by the quantity of urine scent marks left within a **territory**. More dominant mice make more urine marks, whereas subordinate mice make fewer marks. Territorial marking by many species often includes urination around territorial boundaries, in combination with visual markers such as scratching. Within domestic species, territorial urine spraying in cats can become a problem behaviour that necessitates intervention to remedy.

Urine has long been known as a conveyor of information about reproductive status. Male urine, as noted above, can convey information about territory and dominance, and can act as an advertisement or attractant to females seeking a mate. Female urine can contain information about stage of **oestrus**, and thus a female's receptivity for mating. A number of urinary volatiles have been shown to peak during oestrus in a variety of species. A characteristic male response to female urine, particularly obvious in ungulates, is that of **flehmen**, a certain type of lip curling thought to facilitate use of the vomeronasal organ.

There are a great many studies that have shown that urine from a predator species can be detected and discriminated by prey species, which subsequently alter aspects of their behaviour, presumably to decrease risk of predation. The most common predator species used have been felids, canids and also humans. The most common prey animals tested have included rodents and lagomorphs, but also marsupials and ungulates. Behavioural strategies that may occur in response to predator odour include decreases in activity and behaviours such as **grooming** and **reproductive behaviour**, shifts to a more strategic location and increases in vigilance. Temporal patterns of behaviour may also change with alteration of feeding times.

Urine and stress markers

One of the major problems with gathering physiological data relating to responses to stress is that the collection of such data may itself be a **stressor**. For example, collection of blood for stress hormone analysis will either involve the implantation of an indwelling venous catheter under anaesthetic or **restraint** of the conscious animal and insertion of a needle to draw the blood sample. Both of these methods can be considered invasive and, thus, there has recently been an upsurge in experimental work looking at alternative body fluids, such as saliva and urine, which can be collected in a much less invasive way.

Among the compounds analysed in urine and used as stress markers are cortisol, cortisone, **epinephrine**, **norepinephrine** and immunoglobulin A (IgA). The use of urine collection has been especially popular in studies involving **companion animal**s, such as cats and dogs undergoing boarding at catteries and kennels, and in **laboratory animal**s undergoing experimental procedures. It has also been used in a number of studies on welfare in pigs. Ideally, samples are collected as the animal urinates freely (voluntary voiding).

Urine and welfare in animal housing

Animals other than those that are free-ranging are, to a greater or lesser extent, constrained in terms of elimination behaviour. The degree of constraint will largely depend on the degree of spatial restriction – pigs in a small pen will be more constrained than pigs in an enclosed paddock. Ordinarily, most animals will choose to separate themselves from their faeces and urine and may allocate specific areas of their habitat for elimination. For domestic species, **housing** invariably disrupts normal eliminative habits and, thus, animals may be unable to separate themselves from their own waste. This can impact the animals' welfare, either by forcing them to be exposed to substances that may be ordinarily avoided, by exposure to situations that challenge comfort and **thermoregulation** or