45 The European starling

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Biological overview

General biology

The European starling (*Sturnus vulgaris* L.), henceforth the starling, is a medium-sized song-bird with a length of about 20 cm, belonging to the family Sturnidae, sub-order Oscines, order Passeriformes. Starlings are native to most of temperate Europe and western Asia. Northeastern populations migrate in autumn, with some birds over-wintering in Iberia and Africa. Starlings were introduced to Australia (late 1800s), New Zealand (1862), North America (1891) and South Africa (1890); the species is currently estimated to inhabit 30% of the earth's land area, excluding Antarctica (Feare 1984).

Use in research

Benefits

Starlings are a readily available and robust species, settling fast in captivity and usually remaining in good health. Their gregarious nature allows group housing at relatively high densities, and they have simple dietary requirements. For many experimental purposes starlings are an ideal size, being large enough to handle easily, but small enough to allow natural behaviour such as flight in captivity (eg, Witter *et al.* 1994). Being naturally inquisitive, starlings are easy to train on operant tasks using autoshaping procedures (eg, Bateson & Kacelnik 1995). Starlings can readily be brought into breeding condition by manipulation of day length, and will both sing and court in captivity (eg, Heimovics & Riters 2006; Meaden 1979). However, they are hard to breed in captivity.

Types of research

Due to the range of benefits outlined above, starlings are currently among the most popular passerine bird species used in laboratory-based biological research (Asher & Bateson 2008). They were first used for studies on avian infectious diseases over 25 years ago (Cooper & Needham 1981; Cooper 1987), and are currently a widely used model species in many areas of behavioural research including foraging decisions, mate choice and social learning (eg, Fernandez-Juricic *et al.* 2004). Starlings have been useful subjects for the neurobiology of both hearing and song learning/production (eg, Langemann & Klump 2001). They have also been important for understanding the environmental (photoperiod and temperature) control of breeding and moult and endocrine control of reproduction and the stress response (eg, Dawson 2001; Nephew & Romero 2003). Visual and auditory discrimination testing have been performed on starlings (eg, Swaddle & Ruff 2004) and studies of flight mechanisms and aerodynamics (eg, Ward *et al.* 2004). The widespread use of starlings in laboratory experiments has led to a recent increase in research on the laboratory welfare of this species (eg, Maddocks S.A. *et al.* 2002; Matheson *et al.* 2008).

Size range and lifespan

Basic biometric data for free-living British starlings are shown in Table 45.1. It is important to realise that the mass of individual birds will vary depending on time of day (a bird can lose 10 g on a long winter night (Tait 1973)), season (birds can be as much as 15 g heavier in winter than summer), current diet (birds eating more plant food will have a longer gut (Al-Joborae 1979)), and cage size (birds will lose flight muscle in smaller cages). In studies where control of weight is important, birds should be weighed at the same time of day (preferably before it is light in the morning when the gut is empty), and baseline weights should be established immediately prior to the start of a study (eg, Barnett *et al.* 2007).

Free-living adult starlings (ie, at least 1 year of age) have an average annual survival rate of around 45%, with most birds dying during the annual breeding season. However, survival should be much higher in captivity where birds are protected from starvation, hypothermia, predation and certain diseases. Maximum recorded longevities for free-living birds vary between 15 years 3 months (North America) and 21 (Germany) ~~years~~ (Klimkiewicz 2007).

Social organisation

Starlings do not have a strong social structure, but are gregarious throughout the year, tending to form larger and denser feeding flocks in winter. They form communal roosts in winter that can comprise up to one million birds.

Dominance hierarchies are established in captive flocks, with males dominant to females and adults to juveniles. Birds may jockey to defend preferred perching positions or feeding sites, and fighting involving grappling with feet and bill stabbing can occasionally occur. During the breeding season birds will defend a territory immediately around the nest site with males chasing away other males up to 10 m from the nest. Both monogamous and polygamous mating systems have been reported. Pair bonding does not occur until the weeks immediately before laying. Both sexes feed the young.

Reproduction

Starlings are cavity nesters and are usually colonial breeders with nests as little as 1 m apart. Females breed at 1 year of age, males not till 2 years. In England, first clutches are initiated between early April and late May (Joys & Crick 2004). Eggs are pale blue or white-spotted and 30 mm × 21 mm and 7 g (BTO Nest Record Scheme data). They hatch asynchronously, with the last egg hatching up to 24 h after others. Basic reproductive data are shown in Table 45.2. Chicks grow fast reaching their adult weight within two weeks of hatching.

Starlings go through a complete moult once each year, following breeding, with juveniles moulting their distinct grey–brown, spotless, plumage at the same time. New feathers are tipped with white or buff giving a spotted appearance that is less apparent by the following breeding season as the pale feather tips wear off.

Table 45.1 Biometric data for free-living British starlings (British Trust for Ornithology 2005). Cells show: mean ± sd (range).

Variable	*Male*	*Female*	*Juvenile*
Wing length (mm)	132.6 ± 3.1 (135–137)	129.5 ± 3.3 (132–135)	130.2 ± 4.2 (122–136)
Mass (g)	86.95 ± 9.97 (76.00–100.0)	82.50 ± 9.27 (72.00–95.00)	81.83 ± 7.59 (70.00–95.00)

Table 45.2 Reproductive data for starlings.

Variable	*Mean ± sd*	*Range*
Clutch size (number of eggs)	4.60 ± 0.94	2–9
Incubation (days)	12.38 ± 1.61	10–16
Fledging (days)	20.50 ± 3.25	15–26

Normal behaviour

Starlings are opportunistic and adaptable foragers, but forage predominantly on the ground in open areas of short grass. They are adapted for terrestrial foraging with powerful legs for walking and a strong, pointed bill for probing into the substrate to locate soil invertebrates. Probing behaviour involves the bird pushing its closed bill into the soil, opening its bill to create a hole whilst rotating its eyes forwards to gain binocular vision of the contents of the hole (Figure 45.1). Hawking of flying insects has also been observed. Starlings often feed up to 20 miles from their winter roost sites, and have relatively long and pointed wings adapted for fast flight across open country. Starlings can be tame and approachable in gardens, but are generally more wary in rural areas.

Starlings are highly vocal, with both sexes singing except in the breeding season when only the males sing. They have a complex song, incorporating mimicry, and are open-ended learners extending their repertoire throughout life.

Sources

The vast majority of starlings used in laboratory research are caught from the wild either as adults or juveniles (Asher & Bateson 2008). The advantage of juveniles is that they are easier to catch and may adapt to captivity better. However, they also typically have higher parasite loads, and are more prone to developing symptoms of avian pox following capture. A number of methods can be used to catch starlings. Walk-in traps and funnel traps can be very successful, especially if live decoy birds are used. However, the ethical and legal considerations of the latter strategy need to be carefully considered. Mist nets and baited spring-loaded whoosh nets have also been used successfully. Adult birds can easily be captured roosting in nest boxes prior to the start of the breeding season.

Hand raising chicks is extremely time-consuming, but can be achieved successfully provided chicks are at least 4 days old at the time they are taken from the nest. Hand raising chicks of less than 4 days is reported to be unsuccessful.

Captive breeding is generally unsuccessful (but see Meaden 1979). Starlings will attempt to breed if housed in mixed-sex aviaries with nest boxes. However, the chicks usually die soon after hatching due to the lack of availability of appropriate food. A possible solution to this problem is

Figure 45.1 Distinctive probing behaviour of a starling~~, from Feare (1984)~~. From left to right the bird searches for indication of a prey item; lowers its head pushing its closed bill into the soil; it opens its bill to create a hole whilst rotating its eyes forwards; then raises its head to complete the movement. Reproduced from *The Starling* by Feare, Christopher (1984), by permission of Oxford University Press.

to use ~~of~~ a large portable aviary that can be moved around natural pasture during the night so that a constant supply of fresh invertebrates is always available to the birds.

Conservation status

The International Union for the Conservation of Nature and Natural Resources places the starling in the category of Least Concern. However, the number of starlings has fallen rapidly in the UK since the early 1980s (Robinson *et al.* 2005) leading to upgrading of the species' UK conservation listing to Red (>50% population decline). Starlings are rated as SPEC category 3 (declining) in Europe. In the UK starlings are protected under the Wildlife and Countryside Act 1981, which makes it illegal to intentionally kill, injure or take a starling, or to take, damage or destroy an active nest or its contents. In England a licence is required from Natural England to catch and hold starlings. In the USA, starlings are not protected under American wildlife conservation laws due to their status as both an introduced species and an agricultural pest.

Laboratory management

General husbandry

Enclosures

Captive starlings are successfully kept in a wide variety of enclosures of different sizes and shapes. Where possible, group housing in large, outdoor aviaries is always preferable. Advantages include reduced feather damage, greater space and lower maintenance, but individuals are less easy to inspect and capture. Where birds have to be kept in smaller cages, a minimum space requirement of $1\,m^3$ for a singly housed bird was recommended by the Joint Working Group on Refinement (JWGR 2001b). However, this latter volume was not chosen on the basis of any scientific evidence, and represents a much larger cage than the median of $0.42\,m^3$ revealed by a review of current practice with this species (Asher & Bateson 2008). Within the volume range of $0.14–1.00\,m^3$ measurements of stereotypic behaviour patterns show that the environmental enrichment present in a cage may be more important in determining starling welfare than cage volume (Asher ~~et al. submitted~~). Thus, while larger cages are preferable if all else is equal, there is currently little evidence to suggest that welfare of birds is significantly greater in cages of $1.00\,m^3$ volume than in smaller cages down to $0.14\,m^3$. At all volumes, long-shaped cages that allow for flight are preferable to squarer cages or taller cages (Asher *et al.* ~~submitted~~).

Environmental provisions

Cages should be equipped with adequate perches for all birds so as to reduce competition (Boogert *et al.* 2006). Plenty of high perches should be provided because birds will tend to spend most of their time on the highest perch available. In aviaries it is advantageous to have some moving perches since this will help maintain agility. In smaller cages, particularly when birds are singly housed, perches should be fixed because birds seem more fearful of moving items in this environment. Perches of varying thicknesses and textures (natural branches are ideal) will help maintain healthy claws and feet and provide a variety of substrates for bill-wiping (Witter & Cuthill 1992). Perches should not be located directly over food and water dishes to avoid fouling and possible spread of pathogens.

Bathing is probably important for feather maintenance (Brilot *et al.* ~~submitted~~) and appears to be a strong behavioural need in this species. Starlings will attempt to bathe in their drinking water unless suitable baths are provided. Trays of bathing water at least 20 cm in diameter and not more than 3 cm deep should be provided, and will need to be replaced daily due to fouling.

Nest boxes should not be provided in mixed-sex aviaries because they are likely to provoke aggressive nest defence and may encourage unsuccessful breeding attempts.

Environmental enrichment

Provision of environmental enrichment reduces the incidence of behavioural stereotypies in starlings, and may be more important in determining the welfare of caged starlings than cage size *per se* (Bateson & Matheson 2007). Starlings will choose to work for food by searching for it in a substrate such as sand even if the same food is freely available (Inglis & Ferguson 1986; Bean *et al.* 1999). This contrafreeloading behaviour may suggest a behavioural need to perform natural foraging techniques (Kacelnik 1987), which can be met in captivity by providing a substrate for starlings to probe. Ideally the entire floor of the enclosure should be covered with a substrate such as bark chippings, but if this is not possible, trays of bark chips or turf should be provided that are large enough not to allow aggressive defence by a single bird (Gill 1995; Gill *et al.* 1995).

Protective foliage cover in the form of evergreen trees or branches is likely to reduce perceived predation risk in starlings and may be important in reducing anxiety (Lazarus & Symonds 1992) and encouraging birds to use other available enrichment.

Feeding/watering

Starlings are omnivores eating both animal (predominantly insects and their larvae, but also other non-insect invertebrates) and plant material (soft fruits in autumn and seeds and cereals in autumn and winter) at all times of year. In captivity starlings can be kept indefinitely on commercial poultry or game bird starter crumbs or dry cat or dog food, provided the protein content is at least 30%. This diet should be provided *ad libitum* and can be supplemented with live invertebrates (eg, mealworms) and low-sucrose fruit such as cherries and grapes; the Sturnidae are unable to digest sucrose (Avery *et al.* 1995). Live insect prey can be placed in the probing substrate to encourage natural foraging behaviour. Insoluble grit does not appear to be required by starlings.

Drinking water should be available at all times, and should be changed at least once a day. Use of gravity dispensers for both food and water will help to reduce fouling.

An adequate number of feeders and water bottles should be provided to reduce aggressive interactions.

Social housing

Captive starlings prefer to be in proximity to conspecifics (Vasquez & Kacelnik 2000), and can be housed at relatively high densities as long as adequate roosting perches and food dishes are provided so that all birds can use these simultaneously (Boogert *et al.* 2006). Groups of 4–12 birds are recommended. It is better to keep several birds together in a larger cage, even if this is at a reduced space per bird.

It is feasible to house starlings individually for experimental purposes; however, if possible auditory and visual contact with other birds should be maintained.

Identification and sexing

Individual identification

Starlings can be individually identified with leg rings (bands) of either plastic or aluminium. Ring size 'C' (diameter 4.3 mm, weight 0.14 g) is usually appropriate for a starling. Split plastic rings are fitted with the tool provided with them, whereas metal rings will require specialist ringing pliers (Redfern & Clark 2001). Rings should be large enough to move freely on the starling's leg but not too large to fall over its foot. Rings are available printed with numbers and also in a range of colours to aid identification of birds without the need for catching. Up to two rings can be accommodated on each leg if a large range of colour combinations is required.

Sexing

Starlings are sexually dimorphic and can be accurately sexed from external features alone (see Table 45.3). Juveniles can be more difficult to sex based on plumage; however, 98% can be correctly classified based on iris colour alone (Smith *et al.* 2005a).

Physical environment

Temperature and humidity

Starlings can withstand a wide range of temperatures and humidity as evidenced by their geographic distribution, and will thrive in outdoor aviaries (in the UK climate) provided that some shelter is available. Inside it is typical to maintain laboratory temperatures at 14–20°C; however, deviations from this range are unlikely to cause problems. Ambient temperature is known to affect foraging decisions (Bateson 2002) and fat storage (Cuthill *et al.* 2000).

Photoperiod

Photoperiod is extremely important in starlings because, like other temperate-zone species, they use the shape of the annual change in day length to control the time of breeding and moult (Dawson 2007). The short days of winter render birds photosensitive such that when days lengthen, the neuroendocrine changes leading to gonadal maturation and breeding are stimulated. Starlings held on 11L:13D will retain mature gonads indefinitely. Prolonged exposure (>30 days) to long days results in a photorefactory phase, gonadal regression and finally moult. In starlings held on 13L:11D the gonads will remain regressed indefinitely and birds will never come into breeding condition. Moult duration can be reduced from 119 days for birds held on constant long days of 18L:6D to 92 days by gradually reducing day length by 1 h/week from 18L:6D to 12L:12D; however this acceleration is bought at the expense of reduced final feather quality (Dawson 2004). Following a period of long days, photosensitivity in starlings can be reinstated by a period of 25–35 days of 8L:16D (Goldsmith & Nicholls 1984).

For birds housed indoors, either the daily transition between light and dark should ~~ideally~~ be gradual in order

Table 45.3 Sexually dimorphic features in starlings.

Variable	*Male*	*Female*	*Accuracy in juveniles?**
Colour of base of bill	Grey–blue	Salmon pink	100%, but only in the breeding season (when males have yellow bills)
Lightness of iris colour relative to dark chocolate brown pupil	Either dim ring, visible with careful observation or so dark as to be indistinguishable from pupil	Either much lighter with a highly distinct ring or lighter with a clear ring	98% classified correctly using this feature alone
Throat and chest feather length	Mostly long and thin	Range from 50% long and thin, 50% short and wide to mostly short and wide	93–94%
Throat and chest feather tip shape	Range from 50% round, 50% V-shaped to mostly V-shaped	Mostly rounded	81–89%
Mass	Heavier: ≥78 g	Lighter: <78 g	70–72%
Tarsus length	Longer: ≥29.3 mm	Shorter: <29.3 mm	65-67%
Speckling (density of pale feather tips)	Fewer to no spots	More spots	Not a useful trait in juveniles

*Figures are taken from an analysis in Smith *et al.* (2005a).

to allow birds to find a roosting site for the night, or a dim nightlight should be provided.

Quality of light

The frequency at which a flickering light source is perceived as continuous is believed to be higher in birds than in humans (>100 Hz vs. 50–60 Hz), leading to concern that starlings may be able to perceive the flicker from conventional low-frequency fluorescent lights (100 Hz in Europe and 120 Hz in the USA) and cathode ray tube monitors. In preference tests, starlings prefer high-frequency (>30 kHz) over low-frequency (100 Hz) lighting, indicating that they can detect a difference (Greenwood *et al.* 2004). Myoclonus is induced in starlings exposed to fluorescent lighting and cathode ray tube monitors flickering below 150 Hz (Smith *et al.* 2005b). Birds are less active and have higher basal corticosterone levels under low frequency lighting, suggesting that they may find it more stressful (Smith *et al.* 2005c). Starlings also show changes in mate choice in low- and high-frequency lighting, becoming less consistent in the preferences in low-frequency conditions (Evans *et al.* 2006). It is therefore recommended that, if natural light is not available, rooms are lit with high-frequency fluorescent lights.

Most birds, including starlings, have an additional retinal cone type tuned to UV wavelengths meaning that if they are housed in laboratories without UV light they may be deprived of visual information usually available to them in the outside world. There is some evidence to suggest that starlings may prefer a light environment containing UV (Greenwood *et al.* 2002), and that being housed in a UV-deficient light environment causes higher basal corticosterone levels and changes in behaviour (Maddocks A.A. *et al.* 2002). It is therefore recommended that starlings are housed in rooms with full-spectrum lighting.

Hygiene

The main disadvantage of starlings as an experimental animal is the large quantities of droppings (faeces and urates) they produce. The floor covering will need to be replaced daily in smaller cages, but in larger aviaries less frequent cleaning will be necessary. Cleaning can be stressful for birds, particularly those in cages, but stress can be reduced if husbandry is conducted as quietly as possible, ideally by a familiar person, at a similar time each day (Rich & Romero 2005). It may also help if birds are provided with cover in which they can hide.

Starlings can carry human pathogens and there is therefore a potential risk of infection from their droppings. However, a recent analysis on bacteria present in free-living starling droppings showed that most did not belong to the specific types most often found in humans. The authors concluded that starlings are unlikely to present a major source of infection for humans (Gautsch *et al.* 2000). Nevertheless, appropriate precautions should be taken by humans working with this species. Some laboratories routinely screen incoming starlings for common pathogens including *Salmonella*, *Yersinia* and coccidia.

Health monitoring and quarantine

Quarantine

Recently acquired starlings should be kept isolated from existing laboratory stock for at least 2 weeks to establish as far as is possible that birds are free from infectious diseases and to allow screening for zoonoses and treatment for parasites (see later in this chapter).

Bill and claw trimming

Starlings' claws and bills are adapted for walking and probing in soil and can become overgrown in captivity where they are not naturally abraded. Provision of rough wooden or sandpaper-covered perches can help (Cuthill *et al.* 1992), but usually birds will need to be caught and their bills and claws trimmed with nail clippers every few months. Overgrowth of the upper mandible will result in feeding and preening problems. It is important to check regularly that leg rings have not become too tight (see also Dietary related health problems).

Laboratory procedures

Handling

Capture by hand is possible in smaller cages. Since birds will not fly in the dark it is often easier to turn off the room lights and use a small torch to locate birds. In larger cages or outdoor aviaries a net (with padded edges) will be necessary. Birds will usually fly towards the light, and an indoor aviary can easily be emptied by turning off the lights and allowing the birds to fly into an adjacent lit room. Starlings can be trained to enter a small transport cage by reinforcing this behaviour with a preferred treat such as mealworms. Cotton drawstring bags are ideal for transporting starlings short distances. A recommended procedure for holding a starling is shown in Figure 45.2.

Training procedures

Captive starlings can rapidly be habituated to familiar humans if human visits are associated with beneficial con-

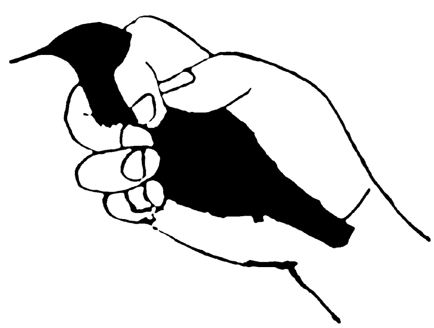

Figure 45.2 A recommended way to hold a starling: the bird's head is held between the index and middle finger with its back in the palm of the hand. The ring finger, little finger and thumb rest across the bird's closed wings to prevent them from flapping.

sequences such as provision of mealworms or water baths. It is not unusual for well habituated birds to take mealworms directly from humans. However, if birds are to be released to the wild, consideration should be given as to the possible adverse consequences of extensive habituation to humans.

Starlings can be easily trained to perform responses including hopping on perches, flying through mazes, probing holes through paper, going through push-doors, pecking lids off wells/dishes, and pecking illuminated keys or touchscreens. Pecking illuminated keys for food reward can be trained using standard auto-shaping procedures (for details see Bateson and Kacelnik 1995). Other behaviour patterns such as hopping between perches or using their feet to remove the stopper from a food container will need to be trained by gradual shaping with positive reinforcement.

Birds will learn to work for preferred treats such as mealworms without prior food deprivation. However, if birds are being reinforced with their normal diet it may be necessary to restrict their food intake, either by removing *ad libitum* food a few hours prior to the training session, or by feeding a restricted daily ration. If the latter approach is adopted, it is important to monitor birds by daily weighing (eg, Barnett *et al.* 2007). Birds maintained at 90–95% of their free-feeding mass will typically work well in operant experiments, and greater weight reduction is not recommended in this species. Given the possible temporal variation in free-feeding mass (see earlier), new baselines will always need to be established immediately prior to the start of an experiment.

Monitoring methods

Weighing

Birds can be weighed either by catching and placing in a cloth bag or clear plastic cone, or by training birds to come to a balance in their cage for mealworms. The balance can either be connected to a computer or read directly (a video camera or binoculars can be used for this in the case of shy birds).

Removal of blood

For a general review of procedures for removal of blood from laboratory birds (specifically chickens) see JWGR (1993). Recommended procedures for removal of blood from chickens should be extrapolated to starlings with extreme caution due to the large size difference between the species. Ideally, advice should be sought from researchers with first-hand experience with either starlings or another similarly sized bird species. In starlings, small blood samples (of the order of 0 ml) are most easily taken from the alar (ie, wing or brachial) vein. Use of the jugular vein is not recommended due to the risks of accidentally puncturing the nearby carotid artery. Use of alcohol for site preparation is not recommended, because it causes cooling, and the consequent vasoconstriction can make the alar vein hard to locate. Up to four 0.1 ml samples have been taken in a 60-minute period (with no subsequent resampling) without problems.

Administration of substances

For general principles and summaries for specific protocols see JWGR (2001a). The easiest injection site on a starling is the pectoral muscle (the largest muscle in the body), but care should be taken, especially if repeated injections are required, because damage to this muscle can cause impairment of flight (Cooper 1983). For substances that can be administered by mouth, feeding birds injected mealworms should be considered as a low-stress approach (eg, Barnett *et al.* 2007).

Anaesthesia

Starlings can be successfully anaesthetised for up to 2–3 h with inhalation agents. Isofluorane, for example, is used at 5% for induction and 1.5–2.5% for maintenance (eg, Bee & Klump 2004). Injectable agents can also be used (Cooper 1987).

Euthanasia

Alternatives to euthanasia should be considered where possible. It is common practice (and indeed sometimes a requirement of licensing bodies such as Natural England) to release wild-caught starlings following research that does not involve any invasive procedures. Ideally birds should be given a period (eg, 2 weeks) in a large aviary to build-up and exercise their flight muscles prior to release either near the site of original capture, or at another location frequented by wild starlings.

For general principles of euthanasia, see Chapter 17 and Close *et al.* (1996). A summary of methods of euthanasia appropriate specifically for birds is provided by Close *et al.* (1997). A range of different procedures is used for euthanasing starlings, the most common being cervical dislocation and concussion by striking the head on a hard surface followed by cervical dislocation. The latter methods have the advantage of being quick but require confidence on the part of the handler. Overdose of anaesthetic (eg, pentobarbital injected intraperitoneally) is also possible.

Common welfare problems

Health

This chapter is not the appropriate place to present a full review of all the health problems that can occur in starlings, and for more information readers should consult an avian veterinary text (eg, Altman *et al.* 1997; Ritchie *et al.* 1997; Rupley 1997). The internet is also a source of useful sites aimed at pet owners containing health advice specific to starlings. Here we present the most common health problems reported in a questionnaire sent to researchers in both

Europe and North America with extensive experience keeping starlings in the laboratory.

Dietary related health problems

Hyperkeratosis characterised by raised overgrown scales on feet and legs, overgrown beak and nails and poor feather condition is common in captive starlings (Figure 45.3). In extreme cases scales can grow over the leg rings. Hyperkeratosis appears to be caused by diets that are too low in protein, as is the case for some poultry foods and softbill diets designed for fruit-eating Mynahs. It is important to check the protein content of the basic diet used for starlings (see Feeding/watering section for details).

Haemochromatosis, also known as iron storage disease, is a cause of mortality in some of the Sturnidae when they are kept in captivity, and could be related to dietary factors influencing the bioavailability of iron (Sheppard & Dierenfeld 2002). Cause of death appears to be heart failure or liver disease. Recent feeding experiments with European starlings suggest that a diet containing 34–125 ppm of iron is optimal for preventing accumulation of iron in the liver. Alternatively, adding a phytate (inositol), tannic acid, or both to readily available food stuffs may be a practical alternative to feeding low-iron diets (Olsen *et al.* 2006). However, despite the evidence that European starlings will accumulate iron in their organs, there is no evidence that birds fed long-term on the basic diets recommended earlier in the chapter commonly develop iron storage disease. Therefore, the authors conclude that concerns about haemochromatosis in European starlings are probably exaggerated.

Parasites and infectious diseases

Parasites and infectious diseases are not thought to be a major cause of mortality in free-living starling populations (Feare 1984), and captive starlings rarely have disease problems if husbandry is good. However, the species is host to a wide range of parasites with infection rates in free-living birds being higher in juveniles than adults and peaking in the summer, and it is good practice to treat incoming birds for endo and ectoparasites.

Figure 45.3 A laboratory starling with hyperkeratosis. Note the poor feather condition and specifically the heavy, overgrown bill and thickened scaley legs.

Ectoparasites include feather lice, ticks and mites. These can be vectors of disease in addition to producing clinical signs of anaemia, feather loss and skin lesions. Ectoparasites can be treated with ivermectin applied topically to the back of the neck. Starlings are recorded hosts of many endoparasites including nematodes, trematodes, cestodes and acanthocephalans. The gapeworm (*Syngamus trachea*) is a long red nematode that attaches to the trachea of birds. The worms cause bleeding in the throat and can block the trachea. Starlings infected with gapeworm can often be heard coughing. Nematode worms in starlings can be treated with the following drugs: fenbendazole (by addition to feed), flubendazole (by addition to feed), ivermectin (by mouth) and levamisole (by addition to drinking water).

Avian pox is a viral disease that produces wart-like lesions on the bird's head, particularly around the eyes and the base of the bill. Badly affected birds may need to be euthanased, but most usually recover without treatment. It is common for birds to develop the disease shortly after capture from the wild. Juvenile starlings seem particularly susceptible to pox, but survivors appear to become immune, and captive adults rarely develop the disease.

Aspergillosis is a common fungal infection of starlings causing clinical signs ranging from mild debility to sudden death. It is usually secondary to immunosuppression from chronic stress or other primary diseases, and can also occur in the presence of high concentrations of the fungus in the environment. Clinical diagnosis of aspergillosis is difficult and prognosis is poor.

Behavioural

The most frequently reported abnormal behaviour pattern exhibited by caged starlings is the somersaulting or flipping stereotypy (although incidences of stereotypy are relatively low compared with other captive birds). This appears to be most common in birds housed in small barren cages, and can be reduced by adding enrichments to the cage or returning victims to a larger aviary.

Aggression and persistent harassment can occasionally become a problem in some group-housed birds. This will sometimes result in feather loss. In such cases birds should be carefully monitored and separated if necessary.

Polydypsia leading to watery diarrhoea occasionally occurs in captive starlings. This can be caused by birds trained on operant schedules erroneously associating their own drinking with reinforcement with food. Removing the bird from the operant schedule and adding oat flakes to the diet may help.

Feather damage, including complete loss of the tail, is common in birds housed in wire mesh cages. Although this is unsightly, it is unlikely to be a welfare problem unless birds are about to be released, in which case it could affect flight performance.

Further reading

Asher and Bateson (2008) provide a recent review of current practice in laboratory husbandry of European starlings. Feare (1984) is the best general source on the biology of European starlings although is mainly focused on free-living birds. Meaden (1979) provides details of captive care and breeding of many European bird species including the starling, and Perrins (1994) is a good review of general biological information, especially geographical distributions and song.

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