birds should be closely observed for aggressive interactions during the breeding period. Removal of males from groups during this time may be necessary. Birds should not be maintained in groups of more than 12 birds in a single aviary.

Recommendations:
- Keep different species separately.
- Do not maintain groups of more than 12 birds and observe groups closely for aggressive encounters.

24.5.4 'Natural' conditions

To maintain tits under 'natural' conditions, birds should be housed in outdoor aviaries exposed to the weather, but with shade and windbreaks. Small trees and undergrowth should also be provided. Indoor pens could also be used and provided with these features. Feeding in both situations should be as it is described for birds kept in cages in the laboratory.

Recommendations:
- Keep wild-caught birds in outdoor aviaries where conditions permit, and provide small trees and undergrowth, shade and windbreaks.
- Feed birds kept in outdoor aviaries the same diet as those housed in laboratory cages.

24.6 Training and rewards

Tits have been trained in the laboratory to perform a variety of different tasks, mostly those that have tested their abilities to learn and remember different kinds of information. Invariably the birds are rewarded with small food items (rather than other kinds of reward such as water or an opportunity to see or hear a conspecific); typically a small piece of peanut or sunflower seed. Some degree of food deprivation is usually involved to increase motivation, but any requirement to do so should be questioned and food should never be withheld for more than 3.5 h. If there is a delay to onset of training or testing, birds should be given a small number of nuts, seeds or wax moth larvae in the intervening period.

Recommendations:
- Question any requirement to deprive birds of food during training programmes.
- Provide birds with small amounts of food if there is a delay to the onset of experimental training or testing and the birds are food deprived.
- Do not withhold food for more than 3.5 h.

24.7 Potential health and welfare problems

- Claws growing too long—claws should be shortened by clipping, not sandpaper.
- Vitamin A deficiency—correct this with carefully calculated and measured supplements of vitamin A (see 24.4).
- Moulting problems—house birds outside or inside with daylight light bulbs. Use appropriate day lengths, if birds are housed indoors (see 24.2.1, also 9.3).
- Stereotypies—some flight stereotypies may develop, e.g. somersaulting backwards off the perch. These can be prevented by providing larger caging, environmental stimulation and the opportunity for flight, e.g. at least access to a larger area for restricted periods (see 24.2, 24.5).
- Abraded feathers—decrease human activity around cages or aviaries. Provide more perches and larger caging (see 24.2, 24.5.1).

24.8 Additional information

The online user group TitNet is a discussion forum for the biology and behaviour of the Paridae. To obtain further information, send a message to listserver@relay.doit.wisc.edu containing only the line info TitNet, leaving the subject line blank.

25 Corvids

Corvids are considered to be among the most intelligent of birds. They have a much higher brain weight to body weight ratio than average for vertebrates, as well as a larger than expected brain-cell density. Their skill at hiding and subsequently recovering large quantities of stored food indicates exceptional spatial memory and learning abilities.

Shell-dropping is one example of intelligent opportunistic behaviour being used to obtain food, and many species have been observed to use tools, e.g. long twigs, when foraging. Imitation learning is also commonly observed, which enables new foraging techniques to spread rapidly throughout the local corvid population. Play is frequently seen; for example aerobatics, the dropping and catching of twigs, and hanging upside-down from perches. It is not surprising, therefore, that corvids have often been used in laboratory experiments designed to evaluate cognitive abilities such as spatial memory, number sense and concept formation.

25.1 Natural habitat and behaviour

The 115 species that comprise the family Corvidae are among the most adaptable and successful members of the order Passeriformes. Corvids have a worldwide distribution; being absent from only the Arctic, Antarctic and some oceanic islands. They are found in a range of habitats, from forest and woodland to steppe, tundra, and even desert (Cramp & Perrins 1994). The corvids encountered in the UK include the jay (*Garrulus glandarius*), magpie (*Pica pica*), chough (*Pyrrhocorax pyrrhocorax*), jackdaw (*Corvus monedula*), rook (*Corvus frugilegus*), carrion crow (*Corvus corone*) and raven (*Corvus corax*). Most have a generalized diet including a wide variety of animal and plant food often obtained by scavenging. The concealment of surplus food for later use is a characteristic behaviour pattern of the whole family.

Corvids nest in trees, on rock ledges or in holes. Most species construct nests composed mainly of twigs and muddy earth. The eggs are mostly blue or green with olive green and blackish markings. Neonatal young are downy or naked and are fed regurgitated food by their parents. The pair-bond is strong in corvids, being sustained throughout the whole year and probably until the death of the partner in the majority of the species. Family bonds are also strong, with post-fledgling care and associations between both adults and young and between siblings lasting for several months.

Flight is characteristically strong with steady wing-beats, although some (e.g. the carrion crow) perform aerial displays and others (e.g. the raven) glide, soar and tumble. The gait is often a hop or 'gallop' but most species can also walk and run. The feet are used to hold down food items to be torn apart by the bill, which is typically stout and strong with a slight hook. Most species drink by dipping the bill into the water and then raising the head. Dust-bathing has not been recorded, even in the desert species. 'Anting' behaviour has been noted for several species, which may involve both direct application of ants to the plumage using the bill, and indirect application involving the stirring up of an ants nest with vigorous movements of forward posturing wings and/or a fanned tail.

25.2 Housing and space requirements

Corvids usually adapt well to captivity as long as they are subjected to minimal disturbance and are maintained by the same animal care staff. The ideal aviary is a long tunnel measuring about 20 m long by 6 m wide and 3 m high at the apex of the tunnel. The floor should be grass and the frame covered in strong flexible netting with the first metre from the floor having an additional layer of protective wire netting. A sheltered end should be provided with a range of natural branches serving as perches. An area of bark fragments that can be raked over and replaced should be situated under these perches and foliage provided at the other end of the aviary for additional shelter (see Inglis & Hudson 1999).

Smaller aviaries can be used to house individual birds. These should be timber framed with wire netting and at least 6 m long with shelter at one end. Natural branches serving as perching areas should be provided at both ends of the aviary and the floor under these areas should be either concrete that can be hosed down, or large pebbles, to a depth of 30 cm, that can be raked over; corvids also like to turn stones over.

Corvids should not be housed indoors or in cages unless there is a strong scientific or veterinary justification for doing so. If it is considered to be necessary to maintain birds

indoors, rooms should be dry and well-ventilated with a temperature range of 21–24°C and relative humidity at 55 ± 10%. Cages should be at least 1 m by 2 m by 1 m high so that environmental stimulation can be provided (see Section 25.5) and birds can hop between perches and perform short flights.

Recommendations:
- House corvids outdoors in large, timber framed aviaries wherever possible.
- If corvids must be housed indoors, ensure that cages are large enough to permit short flights and the addition of enrichment items.

25.3 Breeding and rearing

Corvids are difficult to breed in captivity and it is generally easier to obtain adults or large young direct from the wild as required (see Section 6.1). If birds are taken as adults and a veterinarian considers them to be in good health, it may be possible to release them at the site where they were caught (N.B. it is essential to read Section 13 before planning this).

If captive breeding is to be attempted it is necessary to provide a box about 60 cm square and 15 cm deep in the shelter of the aviary. This box should be about 0.5 m below the shelter roof (Meaden 1979). The floor of the box should be covered with thin beech or birch twigs, and more twigs should be provided in the unsheltered part of the aviary, where the rain can keep them supple. Once nest building has started moss, animal hair, wool and feathers should be provided. The birds will also require a supply of damp mud that will be used to bind the nest structure together. If birds are reluctant to nest, artificial nests can be constructed using 16 gauge mesh and thick conifer cuttings. Once the eggs have hatched the animal protein content of the diet should be increased; day-old chicks, mice, minced offal and bits of fish will be readily taken. In addition, calcium lactate, Casilan and Complan are valuable supplements (Meaden 1979). Basic information on breeding seasons in some species of corvid are set out in Table 9 below, but further research and expert advice will always be necessary when planning breeding programmes.

Recommendations:
- Obtain adult corvids from the wild rather than breeding, if possible.
- Always thoroughly research breeding seasons, behaviour and basic requirements when planning to breed corvids.
- Ensure that appropriate nesting materials, food and supplements are supplied as required.

25.4 Diet

Wild corvids eat mainly insects and larvae such as ground dwelling beetles and moth caterpillars. However, they are opportunistic foragers and the range of food items taken can include small mammals, bird eggs and nestlings, frogs, slugs, snails, worms, fruit, berries, nuts, cereal grains and household waste. As already mentioned, food storing is a common behaviour when there is an abundance of food. The bird holds the food

Table 9 Breeding seasons in corvids (Harrison 1975)

Species	Breeding season	Eggs in clutch	Incubation period (days)	Chicks tended by	Fledging age (days)
Jay *Garrulus glandarius*	Late April–early May	5–7	16–17	Both parents	19–20
Magpie *Pica pica*	Early April	5–8	17–18	Both parents	22–28
Rook *Corvus fructilegus*	Late March–early April	3–4	29–30	Both parents	29–30
Crow *Corvus corone*	Late March	4–6	18–20	Both parents	28–35
Jackdaw *Corvus monedula*	Late April	4–6	17–18	Both parents	28–32
Chough *Pyrrhocorax pyrrhocorax*	Late April–early May	3–4 (lost clutch may be replaced)	17–23	Both parents	Around 38

item in the bill or throat, pushes the bill into a suitable hiding place, ejects the food with the aid of the tongue and withdraws the bill. The cached food provides a reserve that can be recovered during periods when food is less abundant, and some species (e.g. jays) are thought to rely largely on stored food such as acorns throughout the winter.

In the laboratory the main diet for corvids is usually composed of 50% dog food and 50% dog biscuit. However, this should be frequently supplemented with a range of other items. For example a favoured food supplement is a mixture of turkey crumbs moistened with milk and added to grated raw root crops such as swede, turnip, carrot and parsnip. Cereal grains, invertebrates such as maggots and mealworms and dead mice or chicks should also be provided on a regular basis. Fruits and nuts (e.g. apple, banana, grapes, sultanas, acorns, beech mast) can also be offered. Corvids tend to drink often and should be supplied with ample sources of water from shallow troughs.

Recommendation:

- Provide a varied diet in a manner that allows the birds to search for at least part of their food.

25.5 Environmental stimulation

The highly developed spatial memory and learning abilities observed in corvids, together with the many instances in which spontaneous play has been observed, suggest that it is especially important to provide environmental stimulation for these species.

25.5.1 Good quality environment

Corvids respond well to a varying environment in terms of the range of objects that can be investigated and manipulated. Perches at a range of different levels should be provided and toys, including tennis balls, toys designed for Psittacines, and shiny objects.

Corvids like to bathe in water rather than dust baths and normally perform this behaviour standing in shallow water. The bird initially places the head and breast towards the water and then shakes the bill and wings from side to side, transferring water on to the head and breast. In addition the tail is lowered into the water and the wings are beaten strongly, showering water onto the back. After bathing, birds will retreat to a spot where they can dry themselves. In captivity a water trough, grit bowl and water bath are required to allow natural drinking and bathing behaviour. Some individuals will bathe until they become waterlogged, so careful monitoring may be necessary.

Recommendations:

- Supply and continually change a range of objects that can be investigated and manipulated.
- Provide sufficient perches for each bird, within a sheltered area if birds are housed outdoors.
- Make sure that there is a water bath shallow enough for the birds to stand in.

25.5.2 Foraging and caching behaviour

At least part of the diet should be hidden and scattered in the substrate to encourage foraging, and a grass area can be kept for the purpose in outdoor aviaries. Food can also be hidden in rotten branches and tree stumps. Indoors or outdoors, birds can be provided with a 'play box', i.e. a deep plastic box filled with chipped bark or coca mulch to hide live invertebrate food such as mealworms. A number of static objects that can be used to cache food should be provided, such as short lengths of plastic pipe or half-broken flower pots.

Recommendations:

- Encourage foraging by hiding part of the diet and provide objects suitable for caching food.
- In outdoor aviaries, leave a grass area for foraging.

25.5.3 Group size and composition

Corvid flocking behaviour varies between species. Rooks and jackdaws can be highly social, nesting within a few metres of each other, having small territories and foraging in flocks. Ravens and magpies, however, are far less social and tend to forage alone, although they will share a territory with a breeding mate. It is thus essential to research the

social behaviour of each species to avoid causing social stress and possibly aggression.

When kept in captivity corvids display dominance and form a social hierarchy. This is most apparent during feeding, where subordinates have to wait their turn at the feeding dish. Females are generally lower in the hierarchy than males, although during the breeding season a female can increase in rank, particularly if she is paired with a dominant male. The extent to which these social behaviours occur in the wild is unclear for several species. Flocking species can be kept in groups of 5–10 individuals.

Recommendations:
- Thoroughly research the social behaviour of each species.
- Always keep social, flocking species in groups.

25.6 Health care

See Section 11.2 for general guidance on health care and disease prevention. Most captive corvids are caught in the wild and brought into the laboratory rather than having been bred in captivity. During the initial 3 weeks following capture, all new birds should be placed as far away from other birds as possible to minimize the risk of infection. Established stock should always be cleaned out before new birds are introduced. When the birds first arrive they should be checked for parasites (e.g. worms, ticks and fleas). Each bird should be weighed and individually identified by, for example, a numbered leg ring.

It should also be remembered that corvids, like other wild birds, can carry a number of diseases transmissible to humans such as erysipelothrix, salmonella and chlamydia (Inglis & Hudson 1999). Scrupulous personal hygiene and adherence to the following safety codes is essential.

(i) Adequate protective clothing should be worn at all times; in particular, face masks and gloves should be worn when cleaning aviaries.
(ii) All cuts, scratches and abrasions should be covered with waterproof dressings before entering aviaries.
(iii) Hands and forearms must be thoroughly washed with antiseptic soap after handling corvids and cleaning aviaries.
(iv) Staff should undergo a course of anti-tetanus injections and regularly receive booster injections.

Recommendations:
- Quarantine new birds for 3 weeks.
- Clean out established birds before new ones are introduced.
- Check and treat all new birds for parasites.
- Carry out regular health checks.
- Ensure that staff take adequate safety precautions when working with corvids.

25.7 Recommended reading

- Goodwin D (1976) *Crows of the World*. London: British Museum (Natural History)

26 The starling, Sturnus vulgaris

The starling has been used as a model species in a diversity of behavioural investigations apart from, and often because of its popularity in, field studies. Because it can subsist on pelletted livestock feed, and is both inquisitive and a rapid learner, it has been used in many laboratory studies of foraging behaviour, learning and perception. Amongst birds, it is second only to the pigeon (albeit a distant second) in use in experiments involving operant (or instrumental) conditioning, where the bird works for food rewards in a 'Skinner box'. On account of its large vocal repertoire and capacity to learn new songs throughout its life, the starling is a model species in studies of learning and neural plasticity. Its vivid coloration and the fact that its visual system is well understood have led to its use in behavioural studies of visual perception, signalling and mate choice. Again, because its natural breeding ecology is well understood, it has been extensively used in investigations of photoperiodic control of reproduction and the field of behavioural endocrinology in general.

In all cases, the starling has been favoured because of its robustness in captivity and