

Bearded Vulture European Endangered Species Programme (EEP): guidelines for housing Bearded Vultures in captivity

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INTRODUCTION

The international Bearded Vulture breeding network (EEP – European Endangered Species Programme) is a collaboration between zoos and similar institutions, breeding centres, and private partners. Between 1978 and 2013, 422 juveniles were reared successfully as part of the programme. The offspring reared are used for re-introduction projects in Europe – in the Alps, Andalucía, and the Cévennes. Working in collaboration with the Vulture Conservation Foundation (VCF), the ultimate aim of the programme is to establish a European metapopulation of Bearded Vultures, creating gene flow between the existing isolated autochthonous populations in Europe (in the Pyrenees, Corsica, and Crete) and with populations in North Africa and in Asia.

Between 1978 and 2013, the programme lost 120 birds. These birds died between the ages of 1 and 54 years old. Of these, 40 birds (33.3%) died either directly or indirectly as a result of issues related to the aviary in which they were housed. The causes of death for these 40 birds were: aspergillosis (n= 24 birds), trauma (n= 13), and foreign bodies (n= 3). Ten of these died as juvenile, immature, or subadult birds, and only 11 (27.5%) had successfully reproduced.

The principal aim of these guidelines is to help to improve housing conditions for Bearded Vultures, thereby improving the welfare and thus survival of these birds. Currently, the average age of death for captive Bearded Vultures is 27.1 years old at specialised Bearded Vulture breeding centres, but only 16.0 years old at zoos and private institutions. This means that there is significant room for improvement at zoos and private institutions, if an average lifespan comparable to that achieved at the specialised centres is to be achieved.

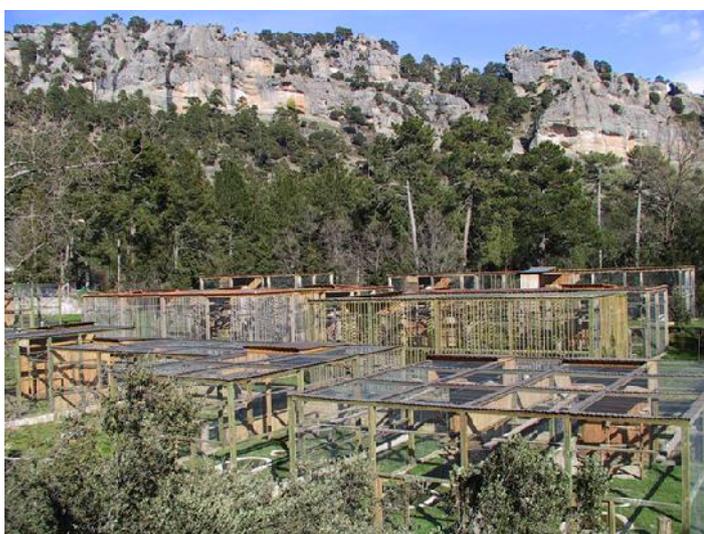
These guidelines for housing Bearded Vultures in captivity are based on more than 35 years of experience of keeping and breeding this species in captivity. They have been made possible thanks to the wonderful collaboration and exchange of information between all of the EEP partners.



In 2013, the EEP included 36 (mainly European) zoos, 3 large specialised breeding centres (red dots), 2 smaller specialised breeding centres (green dots), and 3 private breeders, representing a total of 155 birds.

GUIDELINES FOR HOUSING BEARDED VULTURES IN CAPTIVITY

Because pair formation in Bearded Vultures can be complicated and dangerous, the EEP decided that it was necessary to create a distinction between centres dedicated exclusively to breeding (zoos and private centres) and centres dedicated to breeding and pair formation (Specialised Breeding Centres: SBCs). The role of the former is to house already established pairs and to breed the maximum number of offspring from them, while the latter are responsible for establishing new pairs. The SBCs also take in new founders (injured birds from the wild), adopt chicks, house problematic birds, and create a genetic reserve by receiving specimens from all of the genetic lineages that make up the EEP. It is important that these centres have specialised staff who are dedicated exclusively to the centre and are present during all hours of daylight, especially during the breeding season and pair formation. Specialised staff also means that detailed information about the behaviour of individual birds can be collected. This allows any anomalies or changes in normal behaviour to be detected quickly. Management can therefore be adapted quickly to suit the birds' needs, thereby maximising reproductive success. The breeding centres that receive established pairs and juvenile birds, however, only need to monitor the birds and the reproductive cycle.



Guadalentín Breeding Centre (Andalusia, Spain), one of the three large Specialised Breeding Centres.

Due to the complexity of the work undertaken there, the SBCs are closed to the public. Aviaries in the SBCs are designed to suit only the requirements of the species and the proper management of the birds. At centres that are open to the public, aviaries also need to be adapted to factor in the additional stress this causes the birds. The required safety distance can be achieved by increasing aviary size. However, regardless of the type of centre, the species requirements are the same. These are outlined below.

THE AVIARIES

1. Dimensions

It is well known that aviary size has no direct influence on reproductive success. It does, however, have an indirect effect that depends on the type of centre. Birds of prey housed in centres that are open to the public need bigger aviaries in order to be able to maintain a certain distance from visitors and thus maintain the freedom from anxiety they require to be able to breed. In centres that are closed to the public, the size of the aviary can be considerably reduced.

There are many examples in the literature of several different species of birds of prey (Harpy Eagles (*Harpia harpyja*), Bald Eagles (*Haliaeetus leucocephalus*), White-tailed Eagles (*Haliaeetus albicilla*), Rüppell's Griffon Vultures (*Gyps rueppellii*), Himalayan Griffon Vultures (*Gyps himalayensis*), and King Vultures (*Sacoramphus papa*)) breeding successfully in aviaries of various different sizes (Asakura et al., 1978; Fentzloff, 1983; Hancock, 1973; Johnson & Gayden, 1975; Schlee, 1988, 1989, 1994; Todd & Meachan, 1974). This has also been observed in Bearded Vultures. The first successful captive breeding of this species took place in 1916 in the Sofia Royal Zoological Park, where the aviary measured only 6 x 7 x 8m and didn't even have a nest (the egg was laid on the floor and was incubated successfully). The same pair mated annually until 1928, raising 9 chicks in total (Schumann, 1928, 1929). The famous breeding pair at the Alpenzoo Innsbruck (Pechlaner, 1978) were housed in an aviary measuring 12 x 6 x 6m. Bearded Vultures also bred in a 600m², 10m high exhibition cage at the Tierpark Goldau in Switzerland.

Experience with Bearded Vultures has shown that there is a relationship between breeding success and the sense of security experienced by pairs. Aviaries should be deep and high enough to provide the distance birds need in order to be able to escape. This distance reduces stress, which negatively influences productivity and lifespan. Hancock (1973) and Carpenter et al. (1987) state that, when breeding bald eagles in captivity, the only aviary dimension that influences breeding is height. This is also the case for the Cinereous Vulture (*Aegypius monachus*) (Tewes et al., 1998). In his studies on geese, the ethologist Dr. Konrad Lorenz demonstrated their inability to judge distance. Instead, the geese were always guided by size. When the imprinted goslings walked with Lorenz, their adoptive father, they always maintained the same distance from him. As soon as he bent down, the chicks ran towards him, closing the distance. Lorenz concluded that when he bent down, thereby reducing his size, the chicks thought that he was further away and reacted by moving towards him, without realising that the distance separating them hadn't changed. This means that if birds are housed in aviaries with high perches, the angle of vision from a high perch causes people on the ground to appear much smaller to the bird than they actually are. For the birds, this signifies that they are further away. High perches therefore provide them with a prudent escape distance. It is important to determine the minimum height birds require in order to feel they have an adequate escape distance inside their aviary. However, this height is limited by the need to be able to quickly access the nest to handle its contests when required.



Providing adequate height (min. 4m for Bearded Vultures) and avoiding direct eye contact (staff wear a cap) mean the bird feels secure, and staff can carry out tasks inside the aviary (outside the breeding season).

As mentioned above, the optimal size of an aviary depends on the type of centre. We now know that if birds are managed correctly, the appropriate dimensions for an aviary housing a breeding pair of Bearded Vultures at a **Specialised Breeding Centre** that is closed to visitors can be reduced to 6 x 12 x 4m, while a communal aviary housing 6-8 juveniles¹ can be reduced to 6 x 16 x 4m.

The aviaries at the three large SBCs are also constructed according to a uniform design so that birds transferred between these centres can adapt rapidly to their new circumstances.



Aviary size for pairs of Bearded Vultures at **Specialised Breeding Centres** or centres without visitors can be reduced to 6 x 12 x 4m. Vallcalent Breeding Centre (Catalonia, Spain).

At **Centres or Zoos where birds are exposed to the public**, it is important to increase the aviary size, especially the height, to provide them with more security (minimum height of 5m).



Two different models of Bearded Vulture aviary at **centres/zoos where birds are exposed to the public**. Left: a 20 x 10 x 5m high wooden frame aviary (Barcelona Zoo, Spain). Right: a huge iron frame aviary (Alpenzoo Innsbruck, Austria).

However, as aviary size increases, so does the probability of injury caused by birds flying into the aviary structure. This is particularly the case with open view aviaries, during fights between the pair, or when staff enter the aviary. When staff are checking nests, for example, birds may fly away in fear

¹ The minimum aviary size must respect the regulations of the country in which it is built.

and hit the side of the aviary. To prevent this type of accident and related deaths, we recommended adding visual obstacles, such as wooden laths (4 cm wide by 2 cm thick), to the aviary sides, every 20-25 cm.



Wooden laths (4cm wide by 2cm thick) every 20 cm to prevent injuries caused by birds flying into the side of the aviary (Bearded Vulture aviary at the Parc Animalier des Pyrénées, France).

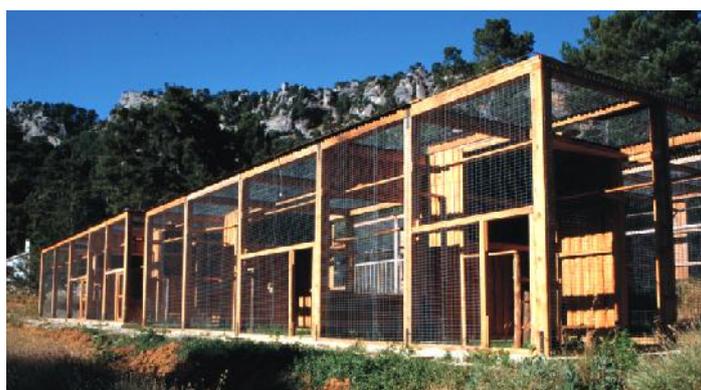
Summary:

- ☞ **Aviary size in centres not open to the public, such as the Specialised Breeding Centres, can be reduced to 6 x 12 x 4m.**
- ☞ **Aviaries exposed to the public should be at least 5m high. Visual obstacles (e.g. wooden laths every 20-25 cm) help to prevent collisions with the aviary sides.**

2. Materials

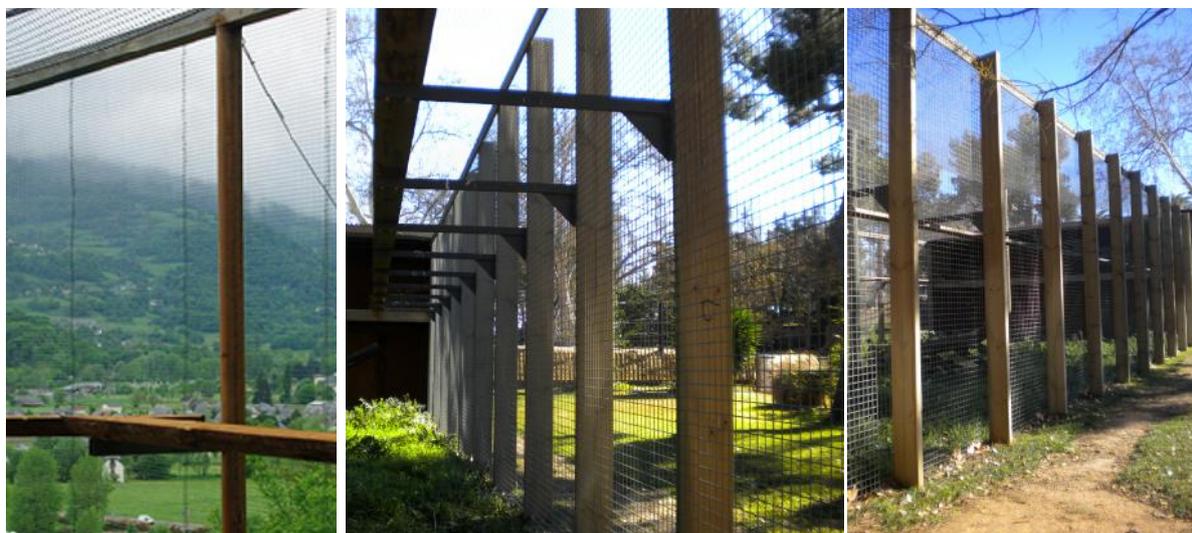
2.1. Framework

The use of “hard” materials for the framework and walls of aviaries has caused injuries and deaths in many bird species, due to collisions with the wire mesh or frame. There is one report of a Bearded Vulture dying in this way when a fledgling attacked its mother and another of a male dying as the nest was being checked.



Guadalentín Breeding Centre (Andalusia, Spain). All the aviaries are wooden and follow the same design as the other two large specialised breeding centres.

In order to minimise this kind of injury, “soft” materials, such as wood, are recommended. If a metal structure is chosen, only round pillars or square pillars with rounded edges should be used. If a metal structure is used, we recommend installing the mesh on the inside, thereby preventing direct collisions with the structure.



Left: a Bearded Vulture metal aviary built using round pillars and square beams with rounded edges for the crossbeams. Centre and Right: wooden aviaries with mesh installed on the inside. If this technique is used, metal pillars are also an option.

The insides of the aviaries should be free from any metal or wooden reinforcement structures that could lead to collisions. Frightened birds fly “blind”: they do not look where they are going, because they are looking in the direction from which the perceived danger is coming. There is one report involving a successfully breeding pair of Bearded Vultures that had been housed together for ten years in the same aviary. One day, the female banged a branch that she had been playing with against a platform, creating a loud noise. The male, spooked by the noise, collided with the only dry tree in the aviary and died instantly.



There should be no reinforcement structures inside the aviary. Frightened birds fly “blind”: they do not look where they are going, because they are looking in the direction of the perceived danger.

2.2. Mesh

It has been noted that frightened birds can injure or kill themselves by flying against the sides of aviaries, as in the cases mentioned above. In another instance, a bird died after flying into the side of

a glass enclosure. This is why aviaries should be constructed using welded elastic wire mesh. Glass should never be used in enclosures. Furthermore, the mesh size must prevent the entry of any small predators, such as martens (*Martes sp.*) and genets (*Genetta genetta*). There is one report of a chick being injured by a genet in the nest and another of a 14-day old chick being taken from under its mother by a Beech Marten (*Martes foina*).



Welded wire mesh with a mesh size of 2.5 x 2.5cm will also prevent problems caused by rats or small carnivores:

- these can steal food and provoke fights between the pair for food. In birds that are not well harmonised, this can be very dangerous and even lead to deaths.
- if rats are being exterminated, poisoned rats may die inside the aviary. If these are eaten by the birds, this can lead to birds being poisoned. There are four reports of this happening.

Mesh with a wire thickness of 2mm, fixed in such a way that it doesn't strain against the framework, provides sufficient elasticity to prevent injuries caused by birds colliding with the aviary sides.



Left: welded elastic wire mesh with a wire thickness of 2mm and a mesh size of 2.5 x 2.5cm, which should prevent injuries due to collisions with aviary sides and protect against small predators and rats.

Bearded Vultures play with anything they find in their aviary, chasing butterflies and even nibbling wood. They also exhibit the peculiar behaviour of swallowing anything colourful or shiny or anything that resembles their habitual food (e.g. screws, tool handles, brushes, and pieces of hosepipe). Three birds are known to have died after swallowing foreign objects left behind in their aviaries. However, they are also capable of regurgitating small objects, including in one case a dummy egg of the size used for this species. This playful behaviour led to one bird escaping from an aviary built using intertwined wire mesh after it was able to open a sufficiently large gap in the mesh. This is why it is important that the mesh is welded.

It is important that any wood that has direct contact with the bird (e.g. nest platform, perches, and steps) is not treated with any toxic substances, as there is a risk that a bird might swallow splinters of wood when nibbling and be poisoned.



To prevent intoxication, wood that is in direct contact with the birds (e.g. nest platform, perches, and steps) should not be treated with any toxic substances.

The floor of the aviary should preferably be covered with grass. According to Carpenter et al. (1987), artificial floors require at least an annual disinfection, whereas natural floors do not. Furthermore, food does not get dirty through contact with the floor, and birds do not injure themselves when they land on the floor. When landing on a gravel floor, one bird cut its claw (authors, personal observation).



Natural floors do not require annual disinfection and prevent food from getting dirty.

Summary:

- ☞ To prevent accidents caused by birds colliding with the framework and the sides of the aviary, “soft” materials, such as wood and welded elastic wire mesh, are recommended.
- ☞ The inside of the aviary should be free of any reinforcement structures that could lead to collisions.
- ☞ A mesh size of 2.5 x 2.5cm prevents the entry of small carnivores, such as martens and genets, and rats to the aviary. Rats can steal food or cause intoxication if poisoned rats die in the aviary and are eaten by the birds.
- ☞ Mesh with a wire thickness of 2mm, fixed so that it doesn’t strain against the framework, should give the mesh sufficient elasticity to prevent injuries caused by collisions with the sides.
- ☞ Wood that is in direct contact with the bird (e.g. nest platform, perches, and steps) should not be treated with any toxic substances.

3. Aviary Facilities

More than 30 years of breeding this species in captivity has shown that reproductive success depends more on the size and location within the aviary of aviary facilities than on the size of the aviary itself.

3.1. Perches

As mentioned above, birds (because of the peculiar fact that they are guided by size and not distance) feel safer when they have high perches. However, the perch should never be higher than the nest. A bird that is being observed by another from above the nest, even if it is another bird of the same species, feels threatened. If the nest is placed below perches, incubation can be negatively affected. For the same reason, it is important that the path providing access to the aviary is always below the level of the nest.



Perches should never be higher than the nest, because incubating birds feel threatened if they are observed from above the nest.

So that “individual distance” between birds can be maintained, it also helps if perches are installed throughout the entire aviary. This distance is defined as the agreed distance at which animals are attracted to members of their own species, and below which animals of the same species repel each other (Wilson, 1980; Drickamer et al., 2002), and it is vitally important during pairing. In aviaries containing only one nest and one perch, pairing is complicated by the fact that individual distance must be broken suddenly, often resulting in attacks. When perches are installed throughout the aviary, the birds can move towards each other gradually, breaking down the individual distance little by little.



By installing perches throughout the aviary, pairing birds can move towards each other gradually. Subordinate birds can escape from attacks by the other and can choose to sit on a perch where they feel safer.

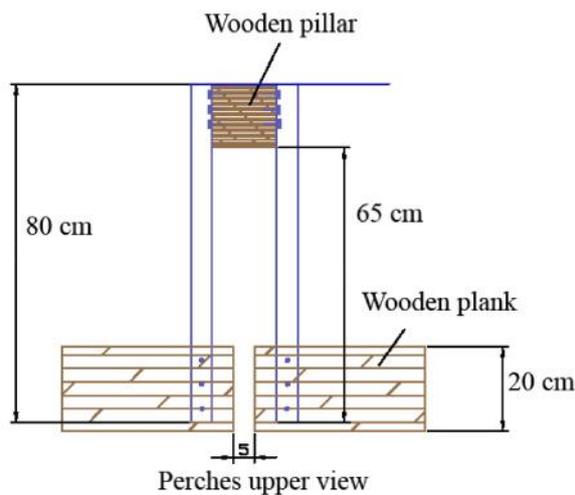
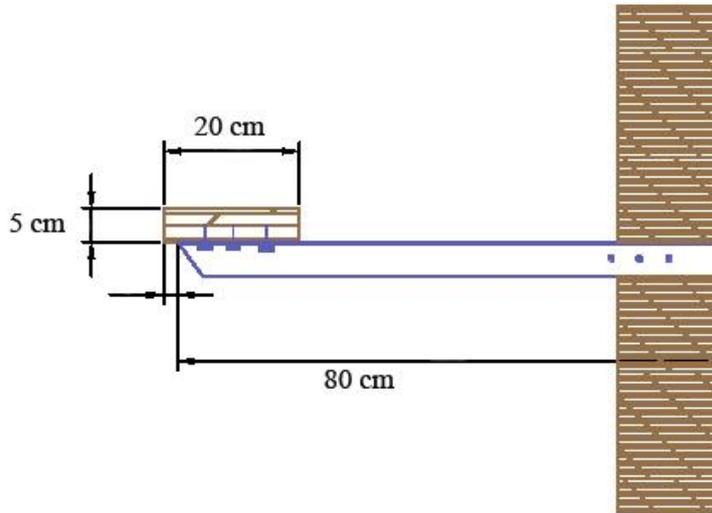
What's more, in non-established pairs, subordinate birds can escape from attacks by the other and can also choose to sit on a perch where they feel safer. In aviaries with few perches, subordinate birds are forced to spend most of their time on the floor, where they feel threatened and consequently become more stressed.

Moreover, in aviaries with more perches, there is less of a risk that birds will fly into the mesh when they are disturbed or when they become violent (e.g. during attacks or when handling is taking place in the aviary). With very nervous birds, it is sometimes necessary to install visual obstacles to avoid these collisions, as mentioned above (wooden laths, 4cm wide by 2cm thick, every 20 cm). Perches should never be installed across aviaries, for the same reason that reinforcement structures should not be present within aviaries. Frightened birds fly "blind": they do not look where they are going, because they are looking in the direction of the perceived danger. They can therefore collide with obstacles.



Avoid installing perches across the aviaries. Birds that are frightened (e.g. during attacks or when handling is taking place in the aviary) fly "blind" and can collide with obstacles.

To prevent tail feathers from rubbing against the mesh, perches must be installed at least 60cm away from it. As Bearded Vultures are cliff breeders, perches need to be adapted to suit the anatomy of their feet in order to prevent the formation of bumblefoot. Perches should be flat and around 20cm wide, so that the birds' feet are completely supported. Perches also need to be rigid enough to prevent them from bending during copulation on the perch. This would cause the birds to feel insecure and to abandon copulation. To be sufficiently rigid, perches should be at least 5cm thick. In addition, perches should be installed in such a way that talons cannot become trapped in the gap between perches, by leaving a 5cm gap between perches or by installing them one above the other.



As Bearded Vultures are cliff breeders, perches must be adapted to suit the anatomy of their feet. Perches should be flat and 20cm wide. To be sufficiently rigid, they should also be at least 5cm thick. To prevent tail feathers from rubbing against the mesh, perches should be installed at least 60cm away from the mesh. They should also be installed in such a way that talons cannot become trapped in the gap between perches, by leaving a 5cm gap between perches or by installing them one above the other.

Summary:

- ☞ Perches should be installed throughout the aviary, at least 60cm away from the mesh and never higher than the nest.
- ☞ Perches should be flat, 20cm wide, and at least 5cm thick.
- ☞ Perches should be installed either one above the other or leaving a 5cm gap between perches.
- ☞ **Avoid installing perches across the aviaries.**

3.2. Steps

Because Bearded Vultures are soaring birds of prey, it is impossible for many of them, especially females and older birds, to access perches through flapping flight. Steps make it much easier for the birds to transport material to the nest (an important behaviour during the breeding season that reinforces the pair bond) and to bring food to the perches, where it can be handled more easily than on the floor. Steps should be a minimum of 20cm wide and 4-5cm thick, with a maximum height of 45-50cm between them (this height should be adapted to suit the flying abilities of individual birds).

During the breeding season, birds become more nervous and irritable and are more susceptible to disturbance or changes in the routine of the centre. Bearded Vultures will tolerate visitors outside the breeding season. However, during the breeding season this tolerance is much reduced. This has also been observed in other birds of prey (Asakura et al., 1978; Dathe, 1970; Fentzloff, 1983; Maestrelli & Wiemeyer, 1975; Todd & Meachan, 1974; Wiemeyer, 1981).



Bearded Vultures, as soaring birds, need steps to access perches. Spiral steps (20cm wide, 4-5cm thick, 45-50cm high, and 150cm long) allow the birds to transport material to the nest as well as to carry food to the perches.

Aggressiveness also increases during this period and increased territorial behaviour may be observed. Nest monitoring during the breeding season must therefore be done very carefully. Entering the aviary with a foreign body, such as a hand ladder, can irritate the birds and lead to the loss of the clutch/chick or to collisions with the aviary sides. In order to avoid this type of accident, it is important to install fixed, permanent ladder structures to which the birds can become accustomed.



Left and centre: Two types of ladder for nest monitoring. As these structures are fixed and permanent, the birds can become accustomed to them. *Do not use hand ladders – birds find these threatening, as foreign bodies. Birds may react aggressively, which can lead to the loss of the clutch/chick, or with fear, which can lead to injuries caused by collisions with aviary walls.*

Summary:

- ☞ **Spiral steps (20cm wide, 4-5cm thick, 150cm long, and with a height of 45-50cm between them) are the best option to allow Bearded Vultures to access perches.**
- ☞ **To allow nest monitoring by staff, fixed, permanent ladder structures should be installed, to which the bird can become accustomed.**
- ☞ **Avoid entering the aviary with hand ladders. Birds find these threatening, as foreign bodies, and may react aggressively or with fear.**

3.3. Feeding places

For birds to feel relaxed in their aviaries, it is important that they are familiar with the working practices of the centre. We therefore recommend installing a 90 x 90 cm feeding place in each aviary, close to the door and away from the nest, where food can be placed every day at the same time from outside the aviary. Familiarisation can occur to the extent that some individual parent-reared birds will, after being fed by staff for a certain amount of time, actually take food from their hand through the mesh.

In aviaries housing a greater number of birds (juvenile aviaries), several feeding places should be installed in different parts of the aviary, to allow each bird to eat above the floor and at a certain distance from the others, which is essential for subordinate birds. Feeding places can be made of wood or stone.



Feeding places should be installed near the door and as far from the nest as possible. Food should be placed in these every day, from outside the aviary.

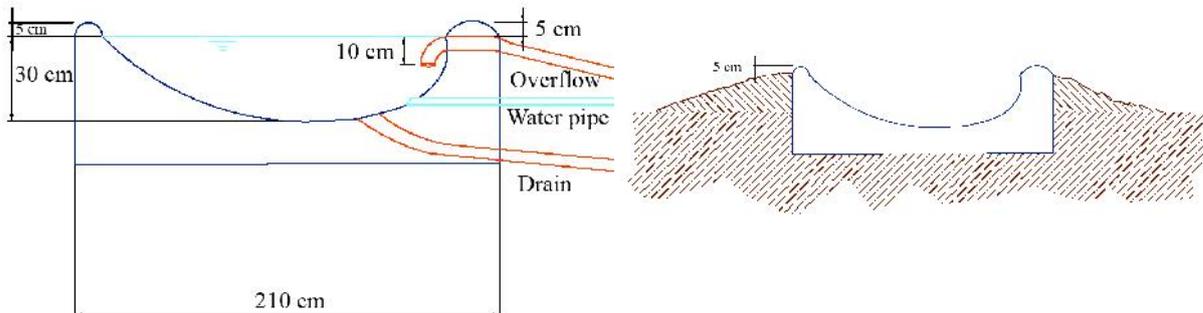
Summary:

- ☞ **Install feeding places near the door and as far from the nest as possible.**
- ☞ **Food should be placed in these every day, from outside the aviary.**
- ☞ **Do not enter the aviary to feed the birds. They could react aggressively, especially during the breeding season.**

3.4. Drinking bowls

All birds of prey drink and bathe regularly. During egg formation, females drink large quantities of water.

Anxiety during the incubation period is one of the main causes of egg loss in Bearded Vultures, a factor that has also been observed in the Bald Eagle (Carpenter et al., 1987). It must be taken into account that birds become more nervous, aggressive, and sensitive during the breeding season; a fact that has been mentioned by many researchers studying the breeding of other large birds of prey. The most vulnerable time is the incubation period and the first few days of the chicks' life. Keepers have also been attacked during this time (Asakura et al., 1978; Gerrard et al., 1979; Johnson & Gayden, 1975; Maestrelli & Wiemeyer, 1975; Schumann, 1928; Todd & Meachen, 1974; Wiemeyer, 1981; Wylie, 1973). Loss of eggs due to anxiety caused by staff entering aviaries every day to clean and fill drinking bowls can be avoided by installing a system that provides a continuous supply of drinking water, with a mechanism that allows it to be regulated from outside the aviary. The same system is used in the captive breeding of falcons (Cade et al., 1977). The drinking bowls should be big enough to allow the birds to bathe (210 x 130cm wide and 30-35cm deep) and should have a soft access ramp to allow individuals with physical defects to leave them easily.



Drinking bowls should have a soft access ramp and should be big enough to allow the birds to bathe (210 x 130cm wide and 30-35cm deep).

Summary:

- ☞ **Drinking bowls should have a soft access ramp and be big enough to allow the birds to bathe (210 x 130cm wide and 30-35cm deep).**
- ☞ **Drinking bowls should have a mechanism that allows them to be regulated from outside the aviary.**

3.5. Mud baths

The fact that Bearded Vultures can develop the peculiar habit of bathing in mud rich in iron oxide is well documented (Caussimont et al., 1995; Frey & Roth-Callies, 1994; Margalida, 2000; Negro & Margalida 2000; Xirouchakis, 1998). Although the reason for this behaviour is still unknown, various hypotheses exist (Arlettaz et al., 2002; Negro et al., 1999; Negro et al., 2002). One of these hypotheses is that this behaviour is used as a signal of status (Negro et al., 1999). It has been observed that birds in captivity regularly carry out this activity and that the frequency of it depends on the weather and on how often mud is provided. Furthermore, the intensity of the resultant feather colouration correlates with the age and sex of the bird, with older individuals and females displaying more intense pigmentation (Frey & Roth-Callies, 1994). Mud baths are only used when birds do not feel threatened and are interrupted if birds are disturbed. Given that birds in a breeding programme spend their whole lives in captivity and that they must be kept in good physical and psychological condition, it is advisable to offer them all available means of developing as many innate behavioural patterns as possible. We therefore recommend installing a mud bath in each aviary where mud rich in iron oxide can be provided every 15 days (except during the breeding season).

Baths should be bowl-shaped and preferably made of concrete. They should measure approximately 1m in diameter, and be 10cm deep. Mud should be mixed with water until it achieves the consistency of a creamy liquid.



Bearded Vultures acquire their reddish colour by bathing in mud rich in iron oxide. In order to allow this peculiar behaviour to develop, a mud bath should be installed in each aviary (100cm in diameter and 10 cm deep). Mud should be free of any toxic substances.

Before being given to the birds, mud from any unknown source should be analysed to detect any possible toxic substances, such as heavy metals or other organic contaminants, that could affect the health of the birds. This is important because individuals that are just developing the habit of mud-bathing will test the consistency of the mud with their beaks and swallow it (Frey & Roth-Callies, 1994). In one zoo, two birds died of lead poisoning after being given mud with a high lead content.

Summary:

- ☞ **Mud baths should be installed in every aviary (100cm in diameter and 10cm deep).**
- ☞ **Use only mud free of any toxic substances (heavy metals or other organic contaminants).**

3.6. Nests & Platforms

The dimensions of nests in successful bird of prey breeding programmes are extremely varied (Hancock, 1973; Gilbert et al., 1981; Maestrelli & Wiemeyer, 1975; Todd & Meachan, 1974; Wylie, 1973). However, all studies emphasise the fact that the nest must be located in the most secure part of the aviary. It must therefore be installed at the end of the aviary that is furthest away from the door. Furthermore, given that Bearded Vultures are cliff breeders, the nest should be closed on all sides except the front, in order to simulate a cave. The nest itself should measure 1.3m by 1.3m.



Different types of nest for Bearded Vultures. The nest should be closed on three sides to simulate a cave and should be located in the most secure part of the aviary, as far away as possible from the door.

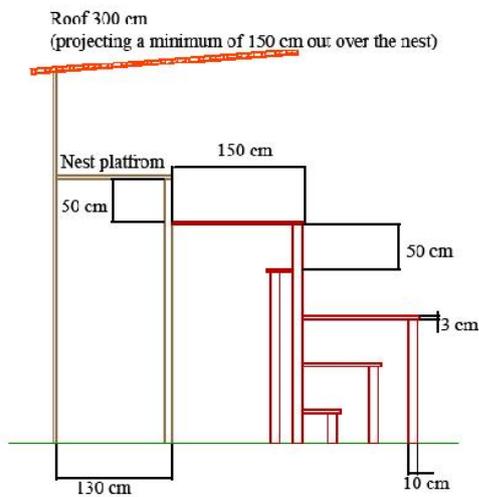
Bearded Vultures are also a territorial species that defend a maximum territory of approximately 200-500m surrounding the nest (Bertran & Margalida, 2002; Brown, 1988; Grubac, 1987; Hiraldo et al., 1979). This territorial behaviour may have serious repercussions during pair formation. It is important, however, that the mate of the incubating bird carries out a territorial defence function, so that the incubating bird remains as undisturbed as possible and can dedicate itself exclusively to incubation. This behaviour has also been observed in the Bald Eagle and the White-tailed Eagle, with males usually defending the territory (Asakura et al., 1978; Fentzloff, 1983; Johnson & Gayden, 1975; Maestrelli & Wiemeyer, 1975). A platform measuring 3 x 1.3 x 0.9m, at the same height as the nest, provides sufficient space for the bird that is not incubating to be at its mate's side, while keeping watch over the territory (the aviary). In this way, behaviour is clearly divided between the pair.



The nest platform (optimal size 3 x 1.3 x 0.9m) should be wide enough to provide space for the bird that is not incubating to sit beside its mate, while keeping watch over/defending the territory (the aviary). In this way, behaviour is clearly divided between the pair.

A comparative study of a pair and a male that incubated successfully on his own, that was carried out at the Guadalentín breeding centre, showed that the male was far more susceptible to disturbance than the pair, thus demonstrating the importance of having a mate to defend the nest (Llopis et al., 1999, 2000, 2001, 2002a, 2002b, 2003, 2004). The platform also provides shelter for the 'defending' bird in bad weather.

At the start of the Bearded Vulture breeding programme, several eggs were lost when the nest got wet and/or because the nest was poorly constructed. Building a roof that projects out over the nest by at least 1-1.5m solved this problem.



The roof should project 1-1.5m out over the nest platform, to prevent the nest from getting wet.

In several cases, especially when pairs had no previous nest building experience, bird of prey eggs have been found outside the nest, either on the platform after one side of the nest collapsed, or lost at the bottom of the nest, between branches. The latter were sometimes broken by the adult birds walking over the branches. This occurred with a pair of Harpy Eagles in Los Angeles Zoo (Todd & Meachan, 1974). This type of accident can be prevented by building a wooden nest frame, covering the bottom with tree bark to provide a firm base, filling the nest with suitable lining materials such as washed wool appropriately sized branches.



For avoiding the loss of the clutch is important to build a firm structure. A wooden frame, fulfil it with tree bark, give the nest a firm base. The nest self should be covered with washed wool and adequate size branches.

With Bald Eagles, it is advisable to position nests in such a way that incubating birds have no visual contact with any birds other than their own mates. This prevents conflict originating from the territorial behaviour displayed by pairs of Bald Eagles housed in different aviaries (Maestrelli & Wiemeyer, 1975). The same is true of the Bearded Vulture. If nests are built facing South/South East, then incubating birds will also be protected from any adverse weather from the North.

Occasionally, the high potential aggressiveness of this species, particularly during the breeding season, can result in fighting between pairs. These attacks are often linked to a change in the physical appearance of one of the birds (there are currently 7 pairs in the EEP that display this behaviour). It seems that birds that are wet (from bathing or being in the rain) are not recognised by their mates. Building several caves, two physically separated nests, or a platform that runs along the width of the aviary (6m) and is divided into two will allow the subordinate bird to be able to protect itself in the event of bad weather and to dry itself without being seen by its mate.



The subordinate bird must be able to protect itself in the event of bad weather. Two caves, two physically separated nests, or a platform running along the width of the aviary and divided into two satisfies this requirement.

The nest is usually destroyed by the pair or its offspring at the end of the breeding season. It is therefore very important that at the start of each breeding season (from September onwards), **breeding pairs** are offered suitable nesting material (e.g. washed wool and appropriately-sized branches) daily, in small amounts. This is important in order to give the birds enough time for nest construction and to optimise stimulation and synchronisation of the pair. Nest building behaviour is

strongly linked to weather conditions. Therefore, nesting material should only be offered on days when it is not raining. It is very important, however, that **pairs that have never produced any eggs** are offered new nesting material, following the guidelines above.

Summary:

- ☞ Each aviary should have at least one nest measuring 1.3 x 1.3m.
- ☞ The nest should be installed in platform or cave that is wide enough (optimal size 3 x 1.3 x 0.9m) to provide space for the bird that is not incubating to sit.
- ☞ The nest itself should have a firm structure: a wooden frame, filled with tree bark, covered with washed wool and appropriately sized branches.
- ☞ To prevent the nest from getting wet, the roof should project out 1-1.5m above the nest platform.
- ☞ Each aviary should contain two caves, two physically separated nests, or a platform running along the width of the aviary and divided into two, to provide the subordinate bird with somewhere to shelter in bad weather.
- ☞ To stimulate pair bonding, offer the birds appropriate nesting material daily and in small amounts.

3.7. Vegetation

As already mentioned above, frightened birds fly “blind”: they do not look where they are going, because they are looking in the direction of the perceived danger. Falcon breeders also advise keeping the centre of the aviary clear of obstacles to prevent accidents (Cade et al., 1977). In Bearded Vultures, there are three documented cases of collisions with obstacles (as of 2013). In all three cases, the obstacle was a tree. One bird suffered a minor injury when a branch went through its patagium, while the other two birds died. For this reason, it is advisable to keep the centre of Bearded Vulture aviaries clear of any vegetation and other obstacles.



To prevent injuries caused by collisions, the centre of the aviary should be free from any vegetation, trees, or other obstacles.

Summary:

- ☞ **Keep the middle of the aviaries free of any vegetation, trees, or other obstacles.**

3.8. Access to the aviary

The access route to the aviary must be clearly visible to the birds. This means that if it is necessary for staff to enter the aviary, the birds can see them approaching beforehand and won't react with fear. This can be achieved by constructing a single access door located in the part of the aviary that is furthest away from the nest. This has also been recommended by other authors (Carpenter et al., 1987). In addition, to prevent birds from escaping as staff enter the aviary, it is important to install a security cabin with a double door system, where the doors open inwards.



The entrance to the aviary should be clearly visible to the birds and placed as far away as possible from the nest. To prevent birds from escaping, it is important to install a security cabin with a double door system, where the doors open inwards.

Summary:

- ☞ **The entrance to the aviary should be visible to the birds and as far away from the nest as possible.**
- ☞ **Install a security cabin with a double door system to prevent birds from escaping. The doors should open inwards.**

3.9. Positioning of facilities within the aviary

It has been observed that incubating birds are more relaxed when the drinking bowl, mud bath, and feeding platform are placed in parts of the aviary that are visible from the nest, because they can maintain visual contact with their mates while the latter carry out other activities. As has been mentioned above, it is important that the birds are familiar with the working practices of the centre. That is why access to the aviary and feeding places should be as far away as possible from the nest and clearly visible from the nest, so that incubating birds can “supervise” human activity.



Placing the facilities in the aviary in such a way that they are visible from the nest makes incubating birds more relaxed.

Summary:

- ☞ **The facilities in the aviary – drinking bowl, mud bath, feeding place, and entrance – should be placed where they are visible to the incubating bird.**

3.10. Visitor control

As mentioned above, the optimal size of the aviary depends on the type of centre. Birds housed in centres that are open to the public need bigger aviaries, particularly in terms of height (minimum 5m), in order to provide them with more security. However, as the size of the aviary increases, the probability of injuries caused by birds flying into the sides also increases. In addition to installing wooden laths, building a visitor observatory can reduce the incidence of this type of accident.



Different types of observatory to control visitors and minimise stress for the birds.

Summary:

- ☞ **By installing visitor observatories, stress is minimised for the birds and the probability of injuries caused by flying into the sides is reduced. Aviary size can also be reduced.**

4. Aviary layout

At the breeding centres, aviaries are laid out in such a way that birds are able to see birds in other aviaries. This strengthens the relationship between pairs, as they instinctively protect their territory from neighbouring birds and therefore channel some of their potential aggression (which increases during the breeding season) towards other birds and not towards their own mates, as has occurred with isolated pairs. Furthermore, it has been observed that in centres housing several pairs of birds, younger pairs will begin to reproduce at a younger age, stimulated by witnessing their more experienced adult neighbours. In the SBCs, where approximately 55 birds are housed, the average age of a bird when the first egg is laid is 8.07 ± 1.79 years ($n=29$, 13 males and 16 females). In zoos, however, the average age is 10.90 ± 4.75 years ($n=58$, 29 males and 29 females). In California Condors, it has also been observed that allowing pairs to see each other encourages the development of reproductive behaviour (Arnold, 1993).

However, as mentioned above, direct visual contact from the nest between neighbouring pairs can lead to birds neglecting incubation due to being more concerned with defending their territories.

In order to provide the birds with the breeding stimulus of observing neighbouring breeding pairs, while at the same time giving them enough privacy to incubate successfully, we recommend building wooden walls between aviaries to prevent neighbouring birds from having direct physical contact

with each other. There should be one wall at ground level, and one wall at the height of the perches. The rest of the aviary wall can be kept as mesh only.



In order to stimulate breeding behaviour in neighbouring reproductive pairs, without disturbing their breeding behaviour, we recommend closing off only the parts of the aviary where neighbouring birds could have direct physical contact.

Summary:

- ☞ **When constructing aviaries in such a way that neighbouring birds can see each other, close off only the parts of the aviary where the birds could have direct physical contact with each other.**

HOUSING OF THE BIRDS

At the start of the Bearded Vulture breeding programme, the founders were housed in several different zoos. Some of the pairs had reproduced successfully in these zoos (Almaty Zoo, Innsbruck, Moscow, and Wassenaar), but the majority had not. After being transferred to the Specialised Breeding Centre, most of the birds that had not bred previously and most of the birds with

psychological and physical problems began to reproduce. Currently, all founders and/or individuals with physical defects are moved to centres with specialised staff where appropriate management can take place and suitable pairs can be established.

It is well known that in the larger birds of prey, particularly during the breeding season, pairs will defend their territory and can attack and even kill other birds (of the same species or other species of birds of prey) sharing the same aviary. For this reason, Carpenter et al. (1987), in their compendium on the captive breeding of eagles, recommend that each pair be housed in a separate aviary to prevent intra- and interspecific attacks. It is well documented that it is necessary to remove any birds that are not part of the breeding pair from the aviary at the start of the breeding season, for Bald Eagles, King Vultures, and Lappet-faced Vultures (*Torgos tracheliotus negevensis*) (Johnson & Gayden, 1975; Mendelsohn & Marder, 1989; Schlee, 1994). There are also reports of losses of kites, at Tama Zoo (Tokyo) and several Bearded Vultures at Schönbrunn Zoo (Vienna) were killed by a pair of White-tailed Eagles during the breeding season (Antonius 1933, 1934; Asakura et al., 1978; Fiedler, 1970). In 2002, a male Bearded Vulture at the Tierpark Friedrichsfelde (Berlin) died after being attacked by eagles housed in the same aviary. At Dresden Zoo, when a successful breeding pair had to be moved to a communal aviary while work was carried out on their own aviary, they immediately stopped laying eggs and within a year the male had died of aspergillosis, a disease that is related to physical condition. Psenner (1976) suggested that one reason why Bearded Vultures were not reproducing in zoos was because they were kept in communal aviaries.

Griffon Vultures and Cinereous Vultures breed in colonies. For this reason, they can also breed in groups in captivity (e.g. at ZooBotánico Jerez and Prague Zoo) and in acclimatisation aviaries for reintroduction projects (in France and Italy) (Quevedo & Pithart, personal communication; Genero & Perco, 1995; Terrasse, 1995). However, the Bearded Vulture does not breed in colonies and is extremely aggressive when defending its territory against other Bearded Vultures and other birds of prey. When birds in captivity find no outlet for this potential aggression, they can turn it on their mates. In some cases it is necessary to temporarily separate the pair. These attacks may take place on a regular basis or occur unexpectedly after several years with no problems. Attacks can also happen after one of the pair has been bathing and is not recognised by its mate due to its wet plumage. These attacks can be extremely dangerous and the birds can be injured, disabled (3 reported cases), or even killed (6 reported cases). To prevent this type of attack, we recommend introducing a corvid, such as a raven, crow, or magpie, to be the target of this potential aggression. Aggression will therefore be deflected away from the bird's own mate.

Currently all pairs of Bearded Vultures in the programme are housed separately. Only juveniles, up to 3 years of age, can be kept in communal aviaries. Once they have formed pairs and started to display territorial behaviour, pairs are immediately separated from other birds.

Summary:

- ☞ **Each pair should be housed separately, away from other conspecifics and other large birds of prey, to prevent intra- and interspecific attacks.**
- ☞ **Introducing corvids to the aviaries can help with pair bonding in Bearded Vultures.**

HAVE ANY FOREIGN OBJECTS BEEN LEFT IN THE AVIARY?

Unlike all other vultures and most eagles, Bearded Vultures play with anything they find in their aviary, chasing butterflies and even nibbling wood. They also exhibit the peculiar behaviour of swallowing anything colourful or shiny or anything that resembles their habitual food (e.g. screws, tool handles, brushes, and pieces of hosepipe). Three birds are reported to have died after swallowing foreign objects left behind in their aviaries. However, they are also capable of regurgitating small objects, including in one case a dummy egg of the size used for this species.

Nevertheless, it is very important, after finishing the repair or construction of an aviary, to remove all tools and metal remains, such as nails, screws, and pieces of wire. A useful way of detecting metal remains is to scan the ground with a magnet.



To ensure that all metal remains are removed from the aviary, we recommend scanning the ground with a magnet.

Summary:

- ☞ **After any repair or construction work in the aviary, make sure that all tools and metal remains are removed from the aviary. Bearded Vultures can swallow these and die as a result.**

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