EAZA Best Practice Guidelines

Vietnam pheasant (*Lophura edwardsi)*

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Preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country.

Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

Summary

Vietnam pheasants (*Lophura edwardsi*) are probably extinct in the wild, making the survival of this species dependent on the birds in human care. To best prepare future generations of Vietnam pheasants for reintroductions back into the wild, it is important to allow the birds in our care to express natural behaviors by creating a stimulating environment and creating opportunities for them to parent rear their offspring. This process should start in European zoos.

This species is easy to hold in a zoo setting. It thrives in well planted enclosures where it's non-destructive behaviour will leave all plants intact. Vietnam pheasants can easily be mixed with a wide variety of birds, making them the perfect candidates for any South-East Asian themed aviary or Tropical hall. For a tropical species they are surprisingly hardy, only needing a dry and draft free shelter in a temperate climate. The male's beautiful shining blue plumage, white crest and red facial skin and the hens willingness to parent raise chicks makes this species an attractive species for zoo visitors. The story behind this species' demise and the current efforts to return it back to the wild add a high educational value.

The EAZA (European Association of Zoos and Aquaria) Galliformes TAG (Taxon Advisory Group) and Vietnam pheasant EEP (European Endangered Species Programme) have set the goal to actively take part in the ongoing conservation actions for this species. By sharing our gathered knowledge about Vietnam pheasant husbandry we hope to help our partners in Vietnam to establish a healthy population of these beautiful animals in Vietnam and to help give this species a second chance in the wild.

Acknowledgements

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This document is dedicated to the Author of the first Husbandry Guidelines and longtime EEP coordinator for the Edwards's pheasant, Alain Hennache (†). His immense dedication towards this species has been of incredible value for the future survival of this species, both in human care as in the wild.

We also want to remember and honor our friend Dr. Tobias Rahde (†) who left us far too early. Tobias worked as curator of birds in Berlin Zoo and he was a key member of the Vietnam pheasant recovery team, working hard to find funds for the ongoing activities in Vietnam. Through Tobias's efforts Berlin Zoo was the first zoo to support Viet Nature and, in a big way, helped build the bridge between the ex situ and in situ community.

Contents

Section 1: Biology and field data

1.1 Taxonomy

Class: Aves

Order: Galliformes

Family: Phasianidae

Subfamily: Phasianinae

Tribe: Phasianini

Species: *Lophura edwardsi* (J. Fleming 1822)

Common names: Vietnam pheasant, Edwards's pheasant, Vo Quy's Pheasant,

What was previously referred to as two different species, the Edwards's pheasant *Lophura edwardsi* (with blue central tail feathers) and the Vietnamese Pheasant *Lophura hatinhensis, (*with white central tail feathers) is now treated as a single species named Vietnam pheasant *Lophura edwardsi*. The respective phenotypes will be referred to as "type *edwardsi"* and "type *hatinhensis*". (Kapic *et al.* 2020)

The Edwards's pheasant (*Lophura edwardsi*) was described for the first time by Oustalet in 1896 from four skins (3 males and 1 female) which were sent to the Natural History Museum in Paris by Reverent Father Renauld, a French missionary who had collected some new birds in the mountains of Quang Tri Province (Oustalet 1896). These four skins remained the only evidence of the pheasant until 1923 when Jean Delacour went on the first of 7 expeditions on which he collected a total of at least 64 birds. These birds were collected in Quangtri and Thua Thien Huê provinces, notably in the region of Thua Luu - Hai Van Pass where a forest station was located providing the necessary logistics for field work. This place is situated a few kilometres away from the actual Bach Ma National Park.

The Vietnamese pheasant (*Lophura hatinhensis)* was described in 1975 from one male specimen which was superficially similar to Edwards's Pheasant (*L. edwardsi)* but with white (instead of dark metallic blue) central tail feathers. Like *L. edwardsi* it is poorly known and highly threatened in the wild. Its status as a species has rarely been questioned despite its curious distribution and dubious morphological distinctiveness. To elucidate the taxonomic status of *L. hatinhensis* Hennache *et al.* (2012) examined the morphology of captive birds of both taxa and analysed mitochondrial DNA. These lines of evidence demonstrated that birds exhibiting the *L. hatinhensis* phenotype probably represent inbred *L. edwardsi*. As such, BirdLife International no longer recognizes *L. hatinhensis* as a separate species. Its apparent recent appearance alongside wild populations of *L. edwardsi* might be taken as evidence that wild populations of this species were also highly inbred and possibly close to extinction. (Hennache *et al*. 2012)

1.2 Morphology

Description (Delacour 1977)

Male

A short white crest, some feathers mixed with black; rest of the body plumage dark blue, the feathers having large, silky blue fringes; lower back, rump, tail-coverts, and scapular with subterminal deep black and terminal metallic blue borders; wing-coverts alike, but the outer border green; secondaries dark blue; primaries brownish black; tail blue, straight, the central pair of rectrices rounded, not pointed nor longer than the second and third. Iris reddish-brown; face wattles scarlet with two large lobes above and below; bill whitish green, blackish at base; legs crimson. The young male assumes the full adult plumage during its first year, only slightly less brilliant.

Length: 580-650mm; wing: 220-240mm; tail: 240-260mm; tarsus: 75mm; weight: 1100g

Fig. 1: Male Vietnam pheasants; Top type *edwardsi;* Bottom type *hatinhensis* © Hubert Fryca

Female

No apparent crest. General colour chestnut brown, the head and the neck greyer, the mantle redder; three central pairs of rectrices and primaries dark brown, the others black; the whole plumage very finely and inconspicuously vermiculated with black, and the shaft of the feathers light brown. Iris hazel brown; bill horny brown; legs scarlet.

Wing: 210-220mm; tail: 200-220mm; weight: 1000g

Fig. 2: Female Vietnam pheasants; Top type *edwardsi*; Bottom type *hatinhensis* © Hubert Fryca

Downy chick

Crown and nape chestnut brown with a blackish line down the middle; face pale fulvous, chin lighter; an irregular blackish line from eye to nape; back dark brown with whitish buff lines on the sides, broader near the rump; wings dark brown with a whitish buff band on the secondaries; breast and sides pale chestnut; rest of the underpart buff. Legs crimson.

Fig. 3: Chick Vietnam pheasant © Klaudiusz Muchowski

Immature

Head and neck greyish brown, the throat pale fulvous; body feathers chestnut brown, finely vermiculated with black; feathers of mantle with two subterminal dark spots; wing-coverts greyish black at the base, chestnut streaked with black near the end with a blackish V-shaped subterminal marking.

Fig. 4: Immature Vietnam pheasants © Hubert Fryca

Fig. 5: Immature Vietnam pheasants, left male, right female © Hubert Fryca

Hybrids

Hybrids with Swinhoe's Pheasant were detected in the Vietnam pheasant's captive stock using DNA analysis. After some back-crossing with the true Vietnam Pheasant it is very difficult to detect hybrids based on morphological characteristics. Nevertheless, often, the downy chicks of hybrids have lighter legs, not crimson but pink or greyish pink, and the lines on the sides of their back are almost white, not whitish buff.

Eggs

Rosy to creamy buff, with small white pit spots; clutches generally contain four to seven eggs measuring on average 45 by 36 mm; incubation 21-22 days, during natural incubation this may, exceptionally, be up to 26 days.

Fig. 6: Vietnam pheasant egg © Sarah Patterson

1.3 Physiology

Exact information for Vietnam pheasant is not available. Poultry have a body temperature between 40.5°C - 42°C, Heart rate of 200 – 400 beats per minute and respiratory rate of 15 – 30 breaths per minute.

1.4 Longevity

No record from the wild. In human care, 10 to 12 years; some records of birds living up to 22 years.

1.5 Conservation status/Zoogeography/Ecology

The Vietnam pheasant is classified as Critically Endangered because the lack of recent records suggest that the remaining wild population is likely to be extremely small and severely fragmented, with all subpopulations tiny. Declines have been driven by high levels of hunting pressure and lowland forest deterioration. Further surveys are urgently needed to identify and protect any remaining populations.

Fig. 7: Historic distribution map for Vietnam pheasant © Birdlife International

Lophura edwardsi is endemic to central Vietnam. Known historically from four provinces (Ha Tinh, Quang Binh, Quang Tri and Thua Thien Hue), it was described as locally fairly common. Individuals were recorded near to the Phong My Commune, Thua Thien Hue, and also near the Huong Hiep Commune, Quang Tri (Le Trong Trai *et al.* 1999). Several other individuals were found in the Quang Tri and Thua Thien Hue Provinces, but the last confirmed recent record was in 2000, where one male was confiscated from a hunter and held in human care in the Hai Lang District Forest Protection Department, Quang Tri. Between 1964 and 1994 there were >30 records of the species with another record in 1999 (R. Safford *in litt.* 2015). In 2009 a possible female was recorded near Hai Van Pass, but there are doubts about the identification (A. Hennache *in litt.* 2012) as the tail of this bird was uniformly brown, as in silver pheasants. In 2011 dedicated camera-trap surveys for the species in two relatively undisturbed sites, Khe Nuoc Trong Watershed Protection Forest, Quang Binh and Dakrong Nature Reserve, Quang Tri failed to record the species (Le Trong Trai *in litt*. 2012). *L. 'hatinhensis',* previously described as a species, is actually a mutation of *L. edwardsi* that has been observed at either end of, and within the known range of *L. edwardsi* (Hennache *et al.* 2012, J. Eames *in litt.* 2012). In 1923 and 1990 imperial pheasants (*Lophura imperialis*) were caught in Vietnam (2 birds and 1 bird respectively). Described as a species in 1924 by Delacour and Jabouille, later research lead by Alain Hennache showed that they were actually an occasional hybrid between silver pheasant (*L. nycthemera*) and the Vietnam pheasant (*L. edwardsi)* (Hennache *et al.* 2003). The occurrence of birds showing inbred characteristics since the 1960s, crossbreds with other species and the lack of recent records is an indication that any remaining populations, should they exist, are extremely small, fragmented and declining.

It was presumed that the species inhabited damp mountain forests up to an estimated 600 m, favouring thick underbrush and lianas. However, all early collecting localities were in the forested level lowlands, and there is no evidence that it can live above 300 m. It used to be most abundant in areas with thick undergrowth and liana covered hillsides (N. Brickle *in litt*. 2004). Records in the 1990s came from lowland areas which have been selectively logged (N. Brickle *in litt.* 2004). (Source: BirdLife International (2018) Species factsheet: *Lophura edwardsi*)

1.6 Diet and feeding behavior

Unknown in the wild. Probably like other pheasants they would have a very varied diet, including seeds, berries, flower buds, leaves and other plant materials; also earthworms, millipedes and termites and other insects. In similar species foraging seems to occur in early morning and late afternoon. Feeding by scratching the ground with their feet to uncover food items, as well as slow walking and pecking. (McGowan *et al.* 2018)

Fig 8: foraging male Vietnam pheasant © Hubert Fryca

1.7 Reproduction

Unknown in the wild. The only available information is from captive birds. In human care the Vietnam pheasant usually breeds when two years old, despite some males and females proving to be fertile when one year old. The nest site is usually on the ground. In Europe, laying starts in the middle of March. The

time between eggs is between 36- and 48hrs. Clutch size is four to seven eggs, despite some females have been reported to have laid 10 eggs. This supra-numerous laying may result from domestication or from a bad checking of the nest which had not been monitored carefully on a daily basis; then the female laid one clutch of 6 eggs and had a short gap of a few days before going on to lay a further 4. A second laying (and sometimes a third) can occur if the eggs have been taken or destroyed. Interval between two clutches: around two weeks.

Eggs are rosy to creamy buff, with small white pitted spots. 45 x 36mm. In human care they are synchronous incubators, so incubation only starts when the clutch is complete. Incubation time is between 21 and 22 days. (Hennache 2001)

1.8 Behaviour

Unknown in the wild. The information given bellow are generalizations from other phasianids or experiences learned from keeping the species in human care.

1.8.1 General behaviour

The daily routine of phasianids generally follows a simple pattern. After descending from the roost, birds feed, before retiring to shelter during the middle of the day, reappearing to feed in the late afternoon. During the evening birds retreat to roost in trees. (McGowan *et al.* 2018)

Fig 9: Roosting Vietnam pheasant hen with chicks © Hubert Fryca

1.8.2 Social behaviour

It is difficult to guess whether Vietnam pheasants flocked into groups in the wild as there is much variation within phasianids on this account. In some species both sexes remain solitary throughout the year, only associating to copulate. This variation could be a result from a compromise between protection from predators and conspecific males, on the one hand, and access to mates, on the other. In closed forest habitats, where females can be concealed by vegetation, males do not need to guard them, and as a result many more species are solitary. There are exceptions to this generalized scheme, such as the Crested Fireback (*Lophura ignita*), an inhabitant of primary rain forest, which can be seen in flocks of up to ten individuals. (McGowan *et al.* 2018) In human care Vietnam pheasants are mostly kept in pairs, where they will almost always move in each other's vicinity. Some males aid in the raising of chicks; incubation, however, is only done by the female. There have been successful tests where this species was flocked in the same aviary, however all males and females were siblings (both from different parent pairs) which were raised together. The addition of more birds was impossible. (Butler pers. comm. 2016)

Fig 10: a pair of Vietnam pheasant foraging together © Hubert Fryca

1.8.3 Movements

The Vietnam pheasant is probably a sedentary species as most species in their family are fairly sedentary, or completely so. They use the same habitat throughout the year, and do not utilize separate areas for different activities, such as nesting, or feeding. (McGowan *et al.* 2018)

1.8.4 Sexual behaviour

Vietnam pheasant display is simple and less complicated than for some other Lophura species. The male just whirs its wings, raises its crest and fluffs the feathers of the back. (Hennache 2001)

Fig. 11: Vietnam pheasant wing whir ©Hubert Fryca

1.9 Predation

The Vietnam pheasant, like all Galliformes species, was probably preyed upon by a wide variety of mammals, birds of prey and reptile species like snakes and monitor lizards. Female Vietnam pheasants use their brown plumage as camouflage when foraging through the forest and when incubating eggs. Phasianids generally roost on overhanging branches to avoid ground dwelling predators. (McGowan *et al.* 2018) In the wild, some pheasant species roost close to the trunk of a tree, perhaps to get some shelter if it is windy, whereas other species roost at the end of thin branches, almost certainly so that they become aware of the approach of a predator. It is not yet known what are the roosting preferences of this species, a subject which needs to be further researched.

Fig. 12: Male Vietnam pheasant in vegetation © Hubert Fryca

Section 2: Management in Zoos and Aquariums

According to Keith Howman (President Emeritus of the World Pheasant Association) any account of the captive breeding of the Vietnam pheasant (Edwards's pheasant) has got to start with the account given by Jean Delacour himself. "Two pairs were placed in flights of 5,5m by 3m, with a large shelter at the back, the other one sharing a large pen with Rheinart's crested argus, also just arrived. They spent the following winter without any artificial heat and proved perfectly hardy despite the fact that they came from a tropical country. They were fed like most other pheasants on grain, mash, and green food. On March 23rd 1925, the pair in the large pen commenced laying and thus appeared the first Edwards's eggs ever seen. Four others followed at two day intervals and were entrusted to a Bantam hen. After 21 days five chicks hatched, a very short period of incubation for this genus of pheasants as the eggs of the closest relative, Imperial and Swinhoe's pheasants, have incubation periods of from 24 to 25 days. Ten days later five more eggs were laid. They hatched on May 16th. Another clutch of four followed but were infertile.

The second pair laid only two eggs on April 25th and May 2nd and the third pair did not lay. A few losses of chicks were experienced and finally four cocks and three hens reached maturity. At the same time three hybrids between a cock Edwards and a hen Swinhoe were raised. They were intermediate between the parents, the cock more like a Swinhoe, the hen more like an Edwards in plumage, and they proved fertile. The chicks were not hard to rear in coops, being let out in the field several hours a day after a week or so. More were raised in 1926 and the following years. A few wild caught birds were brought over now and then for a change of blood. The species became thoroughly established in human care and from Clères, Edwards's pheasants were distributed around the world. They are numerous today in America and in Europe." (Howman 1997)

Fig 13: Male Vietnam pheasant © Hubert Fryca

Almost a century later, the Vietnam pheasant is still regarded as an easy species to maintain and breed in human care. For a species that originally occurred in a tropical environment it is surprisingly winter hardy. In most climates it will thrive in an aviary with an adjoining shelter that provides cover from the rain and draught. The diet can be kept relatively simple on a basis of pellets, seeds, vegetables and some animal protein like insects or egg food. The species can be mixed with a wide variety of other species, making it an attractive species for zoo managers. Parent raising is recommended by the studbook and does not tend to be a challenge, females normally incubate their eggs when given the chance and are good mothers to their chicks.

2.1 Enclosure

Most often the species is kept in pheasantry-style aviaries where they have access to an inside and outdoor enclosure. The following description is suitable for an adult pair of Vietnam pheasants. The species, however, can also be kept in larger mixed exhibits or walkthrough aviaries. Because the management of larger enclosures can sometimes prove challenging, it is still best to link them with an indoor enclosure or separation area where the birds can be fed and trained to go in on cue.

Fig. 14: Vietnam pheasant in enclosure with adjacent indoor enclosure © Jan Dams

2.1.1 Indoor enclosure

The indoor enclosure protects the birds from cold, heavy rain and wind. The indoor housing doesn't need to be heated in a temperate climate, however a small heating source like a heating lamp may be useful below 0°C. (Hennache 2001) The indoor enclosure can be built from building bricks, concrete or wood and should be built on a strong foundation. It is important that the indoor enclosure lets in lots of light, is well ventilated and can be kept dry and clean. Using material in the roof which allows light to enter, or install large windows on the front side to create a comfortable environment for the birds. If the windows are see-through they should be covered in mesh to prevent the pheasants from flying into them. Painting the inside of the walls white will also provide a lighter environment for the birds. The floor should be easy to clean like smooth concrete or tiles which can be covered with a layer of sea sand or other sand that does not hold clay and has been washed clean. For biosecurity reasons it is better to only use a thin layer of sand which can easily be cleaned on a regular basis. Providing a solid floor will also help to keep out mice and rats.

Each keeper access door should have a footbath to disinfect shoes between different aviaries. Ideally, this footbath can be placed between the two doors of the safety porch so that the birds do not have access to it, but the keeper will tread in it every time he/she enters the aviary.

Placing the highest perch within the entire enclosure inside the shelter will stimulate the birds to roost here. Leaving on a nightlamp may also stimulate the birds to go and sleep inside, protecting them from harsh weather, night predators and other disturbances like fireworks. In regions where the winters are very dark it is also necessary to add extra lighting to elongate the photoperiod up to 12 hours, so the birds have enough time to feed. Do take care not to overstimulate the birds, providing more than 12 hours of strong light and heating over 20°C can trick the birds into believing the breeding season has started, something that should be avoided as much as possible.

Fig 15: Indoor enclosure at Weltvogelpark Walsrode with several perches © Jan Dams

If several aviaries are going to be built in a block it is always better to build them on just one side of the building or separate the indoor enclosures on opposite sides by a closed keeper corridor to avoid draught within the building. Building a keeper corridor is always advisable, taking away the risk of birds escaping when keepers access the aviary.

Fig 16: Outdoor enclosure linked with indoor enclosure (with see-in window) at Plzen Zoo © Jan Dams

2.1.2 Outdoor enclosure

Covering the first 1,5m on top of the aviary starting from the indoor enclosure will provide the birds a dry and somewhat draught free place to enjoy the outdoor enclosure even during very bad weather. Although Vietnam pheasants have been known to “enjoy” rain it is always good to offer different options. There should be a perch in this section on which the birds can safely spend the night. Do note that it is always better if the birds roost in their indoor enclosure, but if birds refuse to sleep indoors it is good to have this option available.

When designing an aviary it is always useful to add the possibility to split the aviary into two sections when the birds need to be separated (e.g. when the hen has chicks and the male responds aggressively towards them). (Hennache 2001) An aviary which can be split into two sections is vital for new pairs of Vietnam Pheasants; many females have been killed by prospective mates being introduced to each other too quickly. The creation and introduction of new pairs should only take place during the winter months when breeding urges are not present. This is a studbook requirement. When planning a row of pheasant aviaries next to each other it is useful to add sliding doors (40cm*40cm) between the adjoining enclosures to increase the flexibility. The possibility to separate the inside from the outdoor enclosure with hatches should always be included.

Ideally the outdoor enclosure should be easily accessible with a wheelbarrow or an articulated loader to allow easy cleaning and redecorating. Having panels on the front of the aviary that can be swung open will be a great help to the keepers. When the birds are locked in their indoor enclosure the aviary can be thoroughly cleaned and larger decoration materials (e.g. big rocks, new perches, plants) can be placed without causing any stress to the birds.

Fig 17: Nicely decorated outdoor enclosure at Weltvogelpark Walsrode, the front panel swings open for easy redecorating © Jan Dams

If the adjacent aviary also houses a pair of Vietnam pheasants or another pheasant species it is important to have a 60cm closed separations like stone walls or wooden boards between the enclosures. This to reduce the chances of males fighting with each other and injuring themselves, or of males trying to mate with the female in the adjacent aviary. When pacing against a metal mesh the beak and facial skin can become bloody and damaged due to the constant rubbing on the mesh. Males that are too fixated on the male next-door causes continuous stress for the birds and may also produce reduced fertilization results. It is important that the males are unable to sit on top of the separations, which would take away the function of the separations. Also, for this reason it is important never to have perches next to each other in two adjacent aviaries.

Ideally the aviaries are faced towards the South-East so the birds can enjoy the morning sun, or in the opposite direction from which rain and wind comes. For birds that are kept on show at least two sides of the aviary should be kept “blind”, so no visitor is able to approach the aviary from those sides.

2.1.3 Pest control

Vietnam pheasants are prey animals for a variety of predators. Predation by predators that slip into the aviary or kill birds through the mesh should be avoided at any cost. To provide the birds with a safe environment, several preventive measures can be taken during the construction of the aviary.

The outdoor enclosure should be built on a strong foundation which is dug at least 50 cm deep to avoid predators digging their way into the aviary. Otherwise metal mesh (≥1,8mm wire width and ≤19mm spacings) can also be dug ≥50cm into the ground. Adding an extra strip of ≥20cm metal mesh horizontally at the bottom on the outside of the aviary will add extra security against digging predators like foxes.

Fig. 18: Metal mesh dug into the ground © Jan Dams

Ideally the aviary should be covered with a strong metal mesh (≥1,8mm wire width and ≤19mm spacings) through which rats, weasels, snakes or other predators cannot crawl. Try not to pull the wire on the top of the aviary too tight so that is has some “bounce” when a bird flies into it. The species is primarily ground dwelling, but is capable of strong, explosive flight. Individuals typically crouch and freeze at the first detection of a threat, and then fly once threats become acute.

If the aviary is made from soft netting it is important to at least make the bottom 1m out of stronger material like metal wire or stone wall. On the bottom part at least 2 lines of electric wire should be placed next to the wall and 2 more lines should be placed at a distance of 15cm and 30cm from the wall to prevent ground predators from jumping on the soft netting (e.g. grey squirrels, civets). For the latter it is also important to avoid having trees, fences or other large objects near the aviary from which the intruders can jump onto the soft netting.

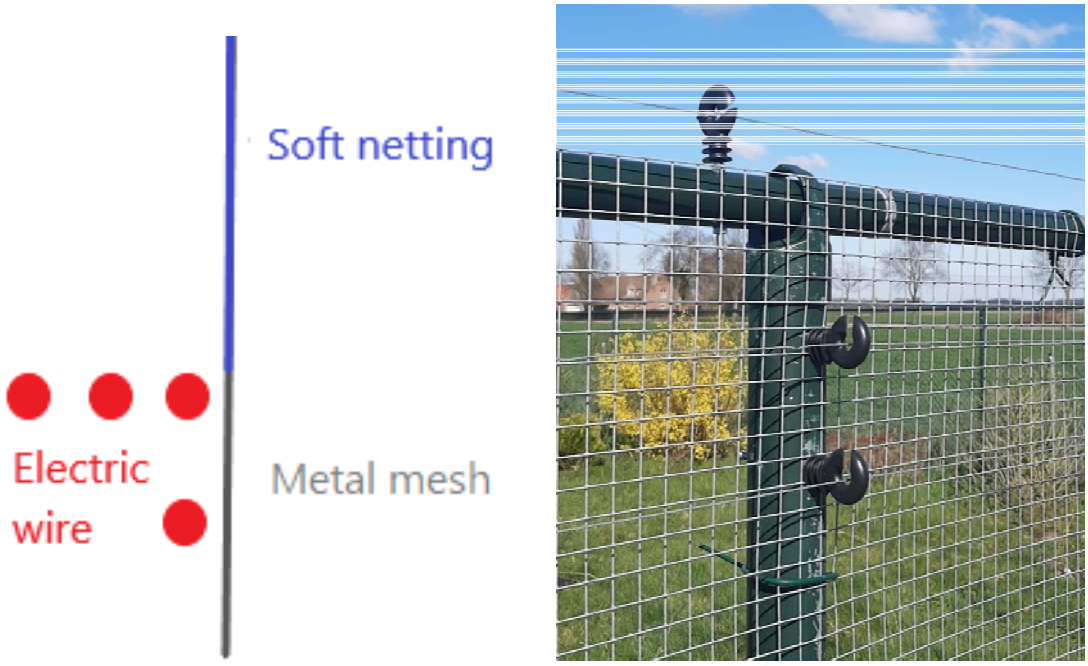


Fig. 19: Two different ways to position electric wires to protect against climbing predators. © Jan Dams

In areas where there is much pressure from avian predators, a double ceiling can be a solution to prevent birds from being killed through the net. The safest option would be to add a separate net about 40cm above the top of the aviary, but even adding several lines of fishing wire above the top of the aviary has proven successful to deter hawks and owls. If a double aviary roof is used, the pheasants should not be able to enter this space, the extra net can also have a much larger mesh opening (up to 10cm) as its sole purpose is preventing raptor strikes.

In areas where snakes occur it is important to take protective measures against these animals. To prevent snakes from entering under the fence a 10cm deep metal mesh with a very small mesh opening (0,5mm) can be installed around the base of the perimeter of the facility. This can be added to the mesh that stops digging predators from getting in. To deter snakes from entry higher up an extra 1m high fence (0,5mm mesh opening) should be installed at a 30-45° angle from the outside wall of the enclosure and sealed to the bottom edge of the structure.

It is necessary to inspect the aviary for holes in or around the fences daily. Rats, weasels and polecats can cause serious havoc in an aviary and kill adult birds.

If rodenticides are required to control pest rodents then legislation that is relevant to your country and area needs to be checked and understood. It is advised that you consult a local pest control expert to ensure you are practicing within the legislation, not causing harm to the environment and are following

the correct method to control the infestation. Different rodenticides have different methods of use and the label should always be read and followed. In general rodenticides should not be used unless there is an active pest rodent infestation like rats or mice that are currently active at the site.

Poison baits for rats and mice should be placed in the surrounding perimeter of the aviary, but never inside the aviary where the birds can access it. The bait must be checked every 7 days and refreshed, if needs be. A search for rodent bodies should also be completed. When the infestation is dealt with the bait must be removed. Mice are grazers so small amounts of bait in many locations is more effective than larger amounts in less locations. Most rodenticides are also dependent on regular feeding over several days at least, so do not let the rodenticide run out or the rodents will recover and become tolerant towards it.

The better alternative to poison bait is setting snap traps in a bird proof box at intervals along a wall floor junction. Both mice and rats have poor eyesight and use muscle memory of wall floor junctions to navigate, so bait traps should always be along these junctions. The traps used should be able to kill in 30 seconds.

The availability of spilled or extra food should be avoided as much as possible. Placing the food dishes inside an easy to clean box will help keep the feeding station hygienic and reduce feeding opportunities for pest species. Feeding daily ratios that are eaten before dusk or removing the food before nightfall and placing new food in the morning will also help avoid mice infestations. The area around the aviaries should be kept as clean as possible, mice and rats will nest under any kind of rubble.

2.1.4 Boundary

Pheasants should always be kept in aviaries made out of a strong material (stone or wooden walls and metal mesh or polyethylene netting). Ideally the mesh should have an as small as possible mesh size to exclude rodents and unwanted predators, but the species can be kept behind a net with a 2.5cm mesh width. To increase visibility for visitors, the mesh should have a dark colour. Standard galvanised metal mesh can easily be painted black using paint rollers. Care should be taken that the wires of the mesh aren't sharp and won't cut into the bird's skin when they come into contact with it. For this reason polyethylene netting is often used to cover the top of the aviary as this minimizes damage when birds fly into the roof of the aviary when spooked. Vietnam pheasants do not have a destructive nature and will not damage netting, wooden structures or ETFE foil cushions. In regards of materials used, it is much more a matter of keeping pest species out the enclosure, then keeping pheasants in.

Pheasants can be kept behind a glass barrier. To avoid accidents, it is best to cover the glass area when the birds are introduced into the exhibit. The glass can be covered with e.g. lime paint or bamboo matting which can be gradually removed. Placing permanent stripes (or alternative decorations) on the window (horizontal or vertically) will also help prevent wild bird strikes against the window.

Fig. 20: Aviary for Vietnam pheasants © Hubert Fryca

2.1.5 Substrate

The substrate of the indoor enclosure should be easy to clean and disinfect, such as concrete covered with sea sand. (Hennache 2001)

The outdoor enclosure should be well drained, there should never be puddles in the aviary, even after heavy rain. Therefore, when working on ill draining soil the top layer (around 50cm) should be removed and replaced by a mixture of course gravel at the bottom and sand on the top. It also helps to make the ground level within the aviary higher than the outside aviary. When working with a solid wall as the foundation for the aviary, drainage holes need to be included, making sure they don't allow access to mice, rats or other vermin into the aviary.

The outdoor enclosure can be planted with grass which can be varied with sea sand, bark, small river stones etc. Grass lawns inside an aviary can be cut with a lawnmower, most birds do not mind this activity at all. Providing a varied surrounding will stimulate the activity/foraging level of the pheasants. Vietnam pheasants will also use dry sand areas for sandbathing. This area should be kept clean and should be changed at least once a year. Changing the entire substrate once a year will help reduce the pressure from

endoparasites. Adding composted bark to the soil will provide a soft surface for the birds to walk on and due to the sour properties of composted bark it will also help reduce the amount of endoparasites in the soil.

In tropical houses or large walkthrough aviaries a fresh layer of composted bark, bark chippings and/or a layer of fallen leaves can be added under the vegetation to provide foraging opportunities for the pheasants. A fresh layer should be added at least once a year to keep the soil healthy. The areas around the feeding station in tropical houses should be kept as clean as possible and soil should also be exchanged on an annual basis. River sand is often used at feeding stations as it is easy to sieve and exchange. Due to an excessive use of water in tropical halls compacted areas can form. These areas should be raked every few days to avoid the establishment of anaerobic bacterial cultures and to help provide a soft underground for the birds to walk on. Good drainage is especially important in tropical halls and the establishment of puddles should be avoided.

Fig 21: Easy to clean feeding station inside tropical hall at Weltvogelpark Walsrode © Jan Dams

2.1.6 Furnishings and Maintenance

Furnishing or other major aviary maintenance should be completed outside the breeding season to avoid disturbances to the nesting hens.

In- and outdoor high perches must be in place to allow roosting at night. (Hennache 2001) Perches are best made using natural wood with different widths to stimulate the toes, moving branches will offer an extra dimension for the birds. Perches should be placed at a minimum of 50cm under the roof of the aviary, otherwise predators like hawks, cats or eagle owls can grasp through the wire, often injuring or killing the bird.

Vietnam pheasants occurred in dense rainforests and also seem to thrive in aviaries that are heavily planted. Adding planting to the enclosure provides a more stimulating environment for the birds as they will also attract insects and spiders which the birds can prey on. Evergreen plants, like bamboo, rhododendrons, thuja, Jupinerus and spurce, will provide cover throughout the year and should be preferred. They will also provide nesting sites for the hens, although the hens tend to lay their eggs in the corners of the enclosure. Plants that carry fruits or berries (like currant bush) will give an extra dimension towards the bird's diet and stimulate natural feeding behavior. Although Vietnam pheasants aren't heavy diggers and will leave most vegetation alone, it can be important to protect the roots of newly planted vegetation, this can be done by placing large rocks at the bottom of the plant.

Fig 22: heavily planted aviary at Weltvogelpark Walsrode with logs and stones, providing a diverse surrounding for its inhabitants. © Jan Dams

An easy technique to create an attractive aviary for visitors and pheasant alike is to work in different vegetation layers. The smallest plants should be placed on the visitor side of the aviary, gradually working up towards the back of the aviary. As birds in the wild are often seen at forest edges, this can be recreated in an aviary or walk through exhibit, in which the visitor path should be seen as a clearance from which you work up. When working this way, it is always important to keep in mind from which view the visitor will look at the enclosure in order to correctly place the smallest plants. This technique will help create depth and provides the birds with a varied environment in which they feel safe, as they will always have the possibility to flee into the provided cover. Using different types of substrate can add additional depth, starting with a lighter type substrate like river sand in the front and changing to bark chippings in the back, a naturalistic row of stones or a tree log can help create this separation between substrates. Making the level of the aviary floor rise towards the back will further increase a feeling of depth. These techniques are often used by Aquascaping artists, from which Takashi Amano is probably the most famous, inspiration from his designs can be found online.

To create a natural aviary, individual plant species should be placed in groups rather than mixing all plant species within the enclosure. A cluster of *Fargesia* bamboo next to a cluster of Portuguese Laurel, Rhododendron or Thuja, behind a cluster of *Skimmia* and/or ferns, filling the faps in the front with a low growing type of *Carex morrowii* and/or ground growing Ivy will provide a nice evergreen scenery. This scenery can be completed using stone boulders, tree roots and tree stems. Plants should be trimmed throughout the year and shouldn't be allowed to overgrow the enclosure. Be aware of branches growing through the mesh, the continuous growth of branches can bend/brake mesh creating openings in the mesh if the branch is removed.

Fig 23: "Amano style" aviary decoration using a variety of substrates, clusters of plants and different vegetation levels at Antwerp Zoo. © Jan Dams

When a new aviary is being decorated and furnished it is important to keep in mind that pheasants produce a large number of droppings which need to be raked and removed from the aviary on a regular basis. Most droppings will be found under the perches on which the birds roost during the night. This area should be easy to rake, like e.g. sea sand. Having the entire aviary overgrown with vegetation will make cleaning a difficult task; for this it is better to have a substrate of sand with large scattered islands that

are heavily planted. A setup like this will also help monitor the birds inside the aviary and increase their display value as the birds will be more visible for the keepers and for also the public.

Running water in the form of a small and shallow river and/or a small waterfall connected to a pond will be very stimulating for the birds and very attractive for the visitors. To create a naturalistic scenery a small waterfall would bring water from the back of the enclosure towards a pond in the center of the aviary. It is, however, important to include the option to drain this water element when parents are raising freshly hatched chicks. The edges should gradually decrease towards the middle of the stream/pond or be filled with stones so the birds can easily get out of the water. Ponds should preferably be situated in the middle of the enclosure and not on the borders next to the wire. If in a fright a bird crashes into the wire and falls into the pond it will most likely die.

Fig. 24: nicely planted aviary for Vietnam pheasant © Hubert Fryca

In some occasions the male can become aggressive towards the female. To help the female avoid the aggressive male some simple elements must be added to the aviary. First, the aviary should be well planted providing lots of cover for the female. Other furnishing like big rocks or tree logs/ roots can be used by the female to get out of the male's sight; with this kind of elements it is important that they do not create "dead ends" where a female can be trapped by the male. If a big tree log or rock is placed against a wall in a sharp angle this can create a space for the male to corner the female, which should always be avoided. The birds should be able to run around big objects within their aviary. "Safety perches" can also be added to the aviary; simply said these are perches where only one bird can sit. These can be attached to the wall or can be a single upright standing post or log. The male will not be able to land next to the female and harass her. In the indoor enclosure wooden boards can be added for the female to hide

under. These boards can be placed in an angle next to a wall or can be put on top of 4 bricks of about 10cm high for the female to crawl under. Again, it is important that there are no dead corners and the female can get out of both ends.

Daily maintenance should include the removal of unwanted vegetation, faeces and moulted feathers by raking the outside and indoor enclosure. When needed, plants should be watered, this can be done from the inside of the aviary or through the wire. Making this cleaning process a daily ritual will habituate the pheasants towards the keepers. Linking the daily maintenance with a positive experience, like scattering some mealworms on the freshly cleaned soil, will further increase this habituation process. When aviaries are only cleaned once a month the birds will become stressed by the keeper's presence, which may result in the disturbance of incubating females.

During the cleaning process birds should always be given enough space so they can walk around the keeper. When working with aggressive or stressed animals it may be useful to lock the birds in the inner - or outdoor enclosure, depending on where the keeper will work. Birds can be lured into a separate enclosure with the help of positive reinforcement (peanuts, mealworms and blueberries are highly favored reinforcers) or by gently guiding the birds towards it.

2.1.7 Environment

Whenever possible, it is best to build the aviary facing towards the South-East, so it takes in the morning and midday sun. Also consider the main wind and rain direction and point the entrance of the indoor enclosure and the outdoor enclosure in the opposite direction. Building an aviary in a dark and windy place should be avoided as much as possible. Pheasants cannot thrive on a surface that is always wet, this is also the reason why aviaries should not be built under very large trees which take away all the sunlight in the aviary.

Although the species naturally occurred in a tropical region it copes surprisingly well with colder temperatures. The hardiness of the species was already noted by Delacour after his first importation. A draught and frost free indoor enclosure should be available for the birds to retreat in during cold weather and heavy rain. In areas where extreme heat occurs the aviary should be provided with much shade and a cooler indoor enclosure where the birds can escape the heat. An excess of sunlight can be dealt with by planting bushes and trees that provide shade when needed.

2.1.8 Dimensions

Outside enclosure: at least 15m² with a height of 2,5m for one pair

Indoor enclosure: at least 3m² with a height of 3m for one pair (Hennache 2001)

If there is a need to lock the birds inside for longer periods of time due to weather extremes a larger inside enclosure should be provided. The indoor enclosure and aviary should be high enough to provide the birds with the opportunity to perch and should not be lower than 2,5m for the keeper's comfort (Heijboer

1990). To stimulate the birds to roost inside, the indoor enclosure should be higher than the outdoor enclosure. Very high and long aviaries can be dangerous when the bird is flushed and it flies straight into the wire, which can cause neck trauma. In these cases, good furnishing with trees and bushes or the use of soft netting is important. When releasing a bird into a very large aviary it should first be placed in a smaller aviary inside the larger one where it can calmly adjust to its new environment, by opening the door of this smaller aviary the bird can slowly walk into its new home. Food and water should be placed in this smaller aviary and kept there after "release" until the bird is seen eating at the feeding stations in the large aviary.

For birds that are on show, the aviary should be deeper than it is wide, giving the birds as much space away from the visitors as possible. It is also important to avoid narrow, acute enclosure corners where the birds can be herded into by an aggressive male.

2.2 Feeding

2.2.1 Maintenance diet

As described before, pheasants in the wild feed on grains, seeds, berries, fruits, leaves and insects. From dissections of gizzards of wild birds, pheasants tended to have around 33% seeds, 26% grains, 20% insects, 10% leaves/grass and 10% berries/fruits (Heijboer 1990) but this can vary seasonally. It is important to take the amount of protein and plant material/fibre into account when working out a successful diet, especially when comparing the nutritional requirements determined for agricultural animals (table 1). The protein to fibre ratio of zoo housed pheasants will be much lower than those kept for production in farms. Digestive efficiency is also essential, which is why grit or limestone should always be made available. Wild pheasants will eat small stones, which will stay in the gizzard and help grind ingested food. Because of their varied wild diet, they are not known to be particularly difficult to feed. Providing a variety of fresh ingredients with a good quality pheasant pellet usually suffices.

Table 1: Nutrient requirements of Pheasants on a dry matter basis, based on production turkey (Jurgens et al. 2012) and additions from Dr. Shanghze Xie

Nutrient	Maintenance	Breeding
Crude Protein (%)	12	14
Crude Fat (%)	3	3
Calcium (%)	0.5	2
Phosphorous (%)	0.3	0.45
Potassium (%)	0.4	0.6
Sodium (%)	0.12	0.12
Magnesium (mg/kg)	600	600
Manganese (mg/kg)	60	60
Zinc (mg/kg)	40	65
Iron (mg/kg)	50	60
Copper (mg/kg)	6	8
Selenium (mg/kg)	0.2	0.3
Vitamin A (IU/kg)	4000	4000
Vitamin D3 (IU/kg)	400	400
Vitamin E (mg/kg)	40	55

Besides the pheasant pellet; greens, fruits and sprouted seeds should also be offered. Greens can include cabbage, grated carrot, red beet, dandelion, clover, chickweed, nettles, etc.. When feeding greens, it is very important that you are sure they are not contaminated with herbicide, also it is important to rinse them prior to feeding. A variety of fruits can also be offered to the birds, such as apple, pear and all sorts of berries. Do take care to not overfeed birds fruit and only feed them as extras.

Sprouted seeds, especially sprouted pulses, will provide a very healthy addition to the diet. Sprouted seeds and pulses increase nutrient bioavailability while reducing anti-feedant secondary compounds (antifeedants are organic compounds produced by plants to inhibit attack by insects and grazing animals). A variety of seeds and pulses are preferred to provide a variety of amino acids since these, independently, are incomplete sources of protein. When sprouting seeds, a specific protocol is necessary to avoid mould (table 2). If this protocol cannot be followed, it is recommend to feed dry and raw seeds and pulses, rather than risking mould toxicity. There are commercial machines (e.g. Easygreen Automatic Sprouter) available that can also do this automatically for you.

It is best to offer the greens and sprouted seeds in the morning and only offer so much that the birds will have completed them before noon, so the food doesn't go bad when kept in the open over a longer period. If there are still greens that have not been eaten at the evening feed, these need to be removed and not left overnight. Whereas pellets can be left overnight. A very small and controlled amount of insects like mealworms, crickets or Morio worms may also be fed in the morning to attract the pheasants and to help conduct a headcount and physical checks. If they come down for greens, then insects are not required in the maintenance diet.

Table 2. Protocol of sprouting seeds to prevent mould

Sprouting seeds	
Day 1	Soak in cold water for 24 hours
Day 2 7:00	Sieve seeds with and rinse in fresh water until the water is clear and odourless, place in dry bowl
Day 2 11:00	Rinse the seeds thoroughly with fresh water until the water is clear and odourless, place in dry bowl
Day 2 15:00	Rinse the seeds thoroughly with fresh water until the water is clear and odourless, place in dry bowl
Day 2 19:00	Rinse the seeds thoroughly with fresh water until the water is clear and odourless, place in dry bowl
Day 3 7:00	Rinse the seeds thoroughly with fresh water until the water is clear and odourless, feed to birds

As an evening headcount and check, some grains and seeds can be provided; there are special mixtures for pheasants which have a high level of pulses and have very low levels of fat containing seeds, which is important for keeping the birds lean and healthy. Again, only feed as many seeds as will be eaten within a very short time, giving a second opportunity to check the health of the birds. To enhance keeper-bird interactions one peanut can be given every day as a treat, pheasants will get used to this routine and will come running to the keeper to get their peanut, allowing a direct health check. Do be cautious that the peanuts are stored dry and dark, so they do not become mouldy.

It is very important to not overfeed pheasants and don't give them too many treats like insects, peanuts, corn or sunflower seeds. The basic food should be a high-quality pellet which should be offered *ad libitum*, dry and changed out daily. When the main part of the diet is such a pellet, adding extra vitamins and/or minerals to the diet (except the insects) or water should not be necessary. Greens, fruits and seeds should be given as a supplement next to the basic diet.

Fig 25: Seed and vegetable mix at Weltvogelpark Walsrode © Jan Dams

2.2.2 Breeding Diet

During breeding season, the pheasant pellet used should be switched to a breeding pellet. Insects can also be added to the diet to increase the protein content as well as giving the psychological stimuli to enter breeding mode. Commercial pheasant fabricators often have a "breeder" and "maintenance" pellet. The idea behind this is that hens in particularly need more protein for the production of eggs and for the raising of chicks. In many pheasant species it is seen that birds will have their breeding season during or right after a long period of rain, which tends to create an increase of available insects (i.e. animal protein). The breeder pellet also has a higher percentage of calcium, which is good for the egg production in females and helps with the development of bones for the young chicks.

Insects are particularly high in phosphorous and low in calcium which is in direct conflict with egg laying, for this reason their inclusion in the diet must be strictly controlled. If the breeding pellet contains more than 1.6 % calcium an inclusion of 5 g of insects should be no problem (but it is recommended the diet be assessed holistically). Any less calcium or more insects will require calcium supplementation to be added to the vegetables (calcium dusting on insects is largely ineffective unless they are eaten instantly after dusting). Gut loading of insects should always occur.

Colourful vegetables such as dark leafy greens, sweet potato and carrots contain carotenoids useful for egg quality and chick survivability, so their feeding is encouraged.

Table 3: Diet component suggestions based on weight

Standard feed	February – July: breeder pellet (60%) August – January: maintenance pellet (60%)
Produce	Morning: 10 % Leafy vegetables (cabbage, kale, etc.), 10 % root vegetables (carrot, beetroot, sweet potato, etc.) Evening: 15 % Germinated seeds and pulses 5% fruit
Extras	Grit Insects: during breeding season only

2.2.3 Diet in preparation for reintroduction to natural habitat

For future reintroduction, dependency on pellets should be decreased. Providing more natural foods in a larger environment to get the birds used to foraging and catching live prey. A decrease in amounts of pellets should be matched with an increase in diversity of food types. More seeds and grains, both germinated and not, fruits, grasses, bushes. It will be important to make an effort to increase the diversity of insects as well beyond just mealworms and crickets. Within the aviary, fresh local insects can be obtained by having a light bulb, sited away from the roosting perch, which comes on after the birds have roosted. It will attract insects which will burn on the hot light bulb and fall to the ground, providing local food first thing in the morning. The sizes of fruits should also be modified slowly to one that is not cut into cubes or strips. The pheasants must learn to negotiate larger food items as well. Birds being prepared for release should not be fed at the same time every day since food in the wild is not always available at the same time of the day. Provided that the birds are in a well-planted aviary, this should provide some food and by not feeding the birds first thing in the morning, they learn to look much more assiduously for food within the aviary, simulating wild requirements.

2.2.4 Method of Feeding

Food should be offered in a dry location that is easy to clean, ideally the indoor enclosure. Because pheasants have the tendency to “dig” in their food bowl, food bowls should be strong, heavy and easy to clean (stainless steel or ceramic bowls). Also for this reason, it can be useful to put the entire food bowl in a box or large flowerpot saucer, which should be easy to clean, to avoid spilled food from getting spread throughout the enclosure.

Fig. 26: Feeding box for pheasants at Zoo Antwerp. © Jan Dams

The birds should have constant access to a dry pellet and can additionally receive morning (greens) and evening (seeds) feeds. The area around the food bowl should be cleaned during every feed.

Food bowls should never be placed under perches to avoid droppings contaminating the food. To avoid contamination from droppings produced by wild birds, the food bowl should be placed in a covered section of the aviary.

Greens can be offered whole or chopped. When suspended with a metal wire with a blunt end, entire pieces of leafy vegetables can be good enrichment for the birds. Be careful not to create a noose on which the birds can get caught when the vegetables are finished.

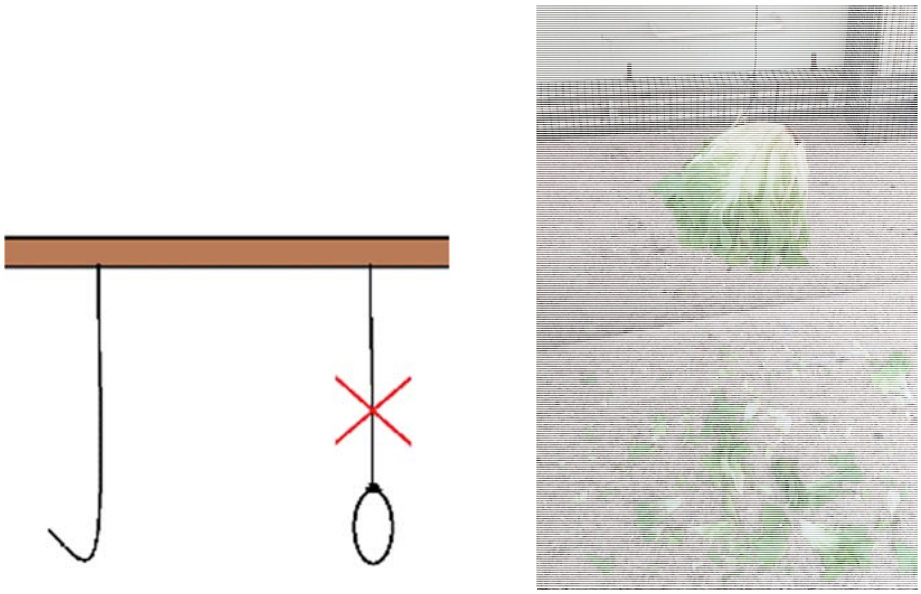


Fig. 27: Suspending greens © Rik Dams & Jan Dams

2.2.5 Water

Fresh water should be provided each day in a heavy and easy to clean bowl. Light bowls will be easily tipped over by pheasants, spilling water throughout the indoor enclosure. Make sure there is no development of mould under the water bowls, changing the position of the water bowl every day and keeping the area around the water bowl clean will reduce the chances of mould development.

Water bowls should never be placed under perches to avoid droppings contaminating the water. To avoid contamination from droppings produced by wild birds the water bowl should be placed in a covered section of the aviary.

2.3 Social structure

The social structure of the Vietnam pheasant in its original range is not known because the species was never observed before it disappeared in the wild. In human care the species is normally kept as a pair year-round. Birds tend to behave as pairs, eating and roosting together, with the male keeping in contact with the female through soft calls year round.

Fig. 28: A pair of Vietnam pheasants © Hubert Fryca

Once formed, pairs can be kept together their entire life. Keeping the species in a trio will probably result in the forming of one pair which will exclude and possibly result in the other female being attacked. One private breeder in the US has kept this species in a group containing sibling males and sibling females (both from different nests) which have produced several clutches of fertile eggs. Introducing birds into this group was not possible. Usually, the resident male begins to chase young males around October, and this is the time to remove them. Hens begin to chase their daughters a little later than this, but they will not allow them to be present as the breeding season approaches.

During the breeding season there is quite some variation between males as to how they will respond towards chicks. The behaviour might even change between seasons by the same male. Some males ignore the chicks, some will aid in the rearing process and guide the chicks through the enclosure and other males will actively chase and kill chicks. A family group containing the adult pair and chicks is possible, but it is best to remove the offspring during autumn.

Single sex groups can be kept together for longer times if space allows it and if there are no potential partners nearby. Especially male groups should be closely monitored during the start of the breeding season (March-May) for potential aggression. Only birds that are placed together as chicks can be kept in such single sex groups, it is impossible to form them with adult birds.

Birds can be housed alone for a longer period in an environment that provides enough stimulus.

2.4 Sharing Enclosure with Other Species

For breeding purposes, it is preferred to keep the birds separated from other species. However, for on show aviaries, mixes with other species are normally not a problem with this docile species. It is important to try and keep the food of the species they are mixed with out of their reach. A too high protein diet, which is required for many insectivores or carnivores, will have negative health effects on pheasants. Providing food plates on a higher level will help restrain the pheasants from eating the food for other birds.

Vietnam pheasants have been kept with a wide variety of species, ranging from passerines, parrots, pigeon's, doves, ducks and even other Galliformes like quails. The only recorded problems were with Nicobar pigeon (*Caloenas nicobarica*), Chinese bamboo partridge (*Bambusicola thoracica*) and white-winged ducks (*Asarcornis scutulata*). To increase the chances of a successful mix, it can be advisable to mix them with species that: don't spend much time on the aviary floor, are faster than Vietnam pheasant and make sure the species has a different colour. The success when mixing different species is quite often dependent on the individuals; when trying a new mix always be extra alert and take the time to observe the animals. Even then, a peaceful mix during the winter can become a warzone during the breeding season. It is important to keep a good eye on all the individuals throughout the year and have a separation space ready when needed. Birds such as mynah's that are likely to attack the pheasant's eggs or even chicks during the breeding season should not be housed with Vietnam Pheasants.

When chicks from other species in the aviary are going to fledge it is advisable to lock up the pheasants until the fledglings are flying around with confidence.

Fig. 29: Hen Vietnam pheasant with Northern cardinal (*Cardinalis cardinalis*) © Hubert Fryca

Table : Possible suitable species that could be kept together with Vietnam pheasants, restricted to Asian species

Glossy ibis (*Plegadis falcinellus*)	Monitored by person
Eurasian spoonbill (*Platalea leucorodia*)	Monitored by person
Purple heron (*Ardea purpurea*)	Monitored by person
Little bittern (*Ixobrychus minutus*)	Monitored by person
Double wattled cassowary (*Casuarius casuarius*)	EEP
Baer's pochard (*Aythya baeri*)	EEP
Scaly-sided merganser (*Mergus squamatus*)	EEP
Spot-billed pelican (*Pelecanus philippensis*)	EEP
Red-crowned crane (*Grus japonensis*)	EEP
Black-naped fruit dove (*Ptilinopus melanospilus*)	ESB
European turtle dove (*Streptopelia turtur*)	Monitored by person
Mauritius pink pigeon (*Nesoenas mayeri*)	EEP
Grey-capped emerald dove (*Chalcophaps indica*)	Monitored by TAG
pink-necked green pigeon (*Treron vernans*)	Monitored by TAG
Green imperial pigeon (*Ducula aenea*)	Monitored by TAG
Pied imperial pigeon (*Ducula bicolor*)	Monitored by TAG

Eastern superb fruit dove (*Ptilinopus superbus*)	Monitored by TAG
Red-vented cockatoo (*Cacatua haematuropygia*)	EEP
Purple-naped lory (*Lorius domicella*)	EEP
Chattering Lory (*Lorius garrulus*)	ESB
Mitchell's lorikeet (*Trichoglossus forsteni mitchellii*)	EEP
Lord Derby's parakeet (*Psittacula derbiana*)	Monitored by person
Black bulbul (*Hypsipetes leucocephalus*)	EEP
Spotted laughingthrush (*Garrulax ocellatus*)	EEP
Blue-crowned laughingthrush (*Garrulax courtoisi*)	EEP
Red-tailed laughingthrush (*Trochalopteron milnei*)	EEP
Silver-eared mesia (*Leiothrix argentauris*)	EEP
Red-billed leiothrix (*Leiothrix lutea*)	EEP
Emei Shan liocichla (*Liocichla omeiensis*)	EEP
Grosbeak starling (*Scissirostrum dubium*)	EEP
White-rumped shama (*Copsychus malabaricus*)	EEP
Asian fairy-bluebird (*Irena puella*)	EEP
Java sparrow (*Lonchura oryzivora*)	EEP

2.5 Breeding

Vietnam pheasants come into breeding age at 1-2 years old. The onset of spring and increasing daylight will probably be stimulating enough for the pair to get into breeding condition. However, insects like crickets or mealworms can be used to stimulate breeding behaviour. When the species is kept inside a climatized house, an increase of artificial rain and a temperature rise could help stimulate a pair to reproduce.

2.5.1 Mating

To create a good pair bond, it is advisable to introduce new pairs before the end of December. Introductions later in the season can create friction between a pair if the male gets in breeding condition before the female. This can result in the death of one of the birds (most often the female) due to aggression from one of the partners (most often the male). When forming a new pair, a younger bird should never be introduced to an adult before it reaches adult size (around 1 year old).

Introductions should be closely monitored and birds should be separated if aggressive behaviour continues over longer periods of time. Note that even if no physical contact is made, birds that are constantly chased will suffer and can eventually die from such stress. (Bailey *et al.* in prep.) If this aggressive behaviour persists after several tries, it is recommended to split the pair and try an alternative pairing (in consultation with the EEP Coordinator).

During the first days of introduction it can be useful to have several food and water bowls spread throughout the enclosure to make sure both birds have access to food and water. Especially when the enclosure consists of an inside and outdoor enclosure, both areas should have a food and water bowl until it is certain that both birds have found the actual food and water bowl.

It is best to introduce both birds to each other in adjoining aviaries separated by a soft wire so they can make visual contact. After one week the birds can be introduced to each other with somebody keeping an eye on them. If it is not possible to open the door between the two adjoining aviaries it is always better to place the male in with the female, and not the other way around. This way the female will have the home advantage. In extreme situations, the primary feathers on one wing of the male can be clipped so the female can get to safety on higher perches, where the male can't reach her, but this should be a last resort. Adding extra structures like bushes, large rocks, or as a last-minute resource: wooden boards and leafed branches placed against the sides of the enclosure, where the female can hide behind from an overenthusiastic male, will help calm down the introduction.

When the birds do not settle down (nervous pacing against the mesh) or they fail to breed (failure to nest or repeated production of infertile eggs over several breeding seasons) pair compatibility should be re-evaluated in consultation with the EEP coordinator.

2.5.2 Egg Laying and Incubation

Vietnam pheasants lay their eggs in a shallow hole in the ground under some cover. For the safety of the hen and the eggs, it is best to try and get her to lay eggs in a nest inside the indoor enclosure, where she is protected from bad weather. A nest can be very simple, just 4 wooden boards, each measuring around 30cm long and 5cm high, nailed together. This nest can be placed in a corner of the aviary (preferably in a dry spot: in the indoor enclosure or under an overhang) and filled with sand. To provide cover for the incubating female the nest can be covered with conifer branches or bamboo. Moss and grass can be placed in the nest for the female to create her nest in. Also make sure that there are no egg sized rocks in the vicinity of the nest as they have a tendency to get dragged into the nest by the female, where they can damage the eggs.

Fig. 30: Use of a wooden framework filled with sand, covered with green conifer branches by an incubating hen Peacock pheasant. © John Corder & Jan Dams

In large tropical halls or walk through exhibits the hen will probably find a suitable nesting place within some dense vegetation.

Once the female has selected a nest, she will create a shallow hole into the ground in which she drags a minimal amount of nesting material which is found in the vicinity of the nest. There should be no rocks, branches or other hard objects in the vicinity of the nest that can cause a breaking hazard for the eggs. Some females have the tendency to lay their eggs spread throughout the aviary. This behaviour could be a sign that the female somehow feels stressed, possibly due to disturbance of the male or keepers that work inside the aviary. A lack of a good nest site where the female feels safe could also be a possible cause. Each of these points should be addressed to halt this behaviour. (Bailey *et al.* in prep.) Providing several nesting possibilities allows the hen to choose where she feels most comfortable.

Vietnam pheasants lay 4-7 eggs per clutch with 36-48hrs intervals. (Hennache 2001) When the female is not disturbed during the egg laying process, either by the male or keepers, she will start incubating the eggs when the last egg of her clutch is laid. Removing or separating the male from the female because of unwanted behaviour (e.g. he keeps chasing her although she wants to lay an egg) during the egg-laying process will have a limited effect on the fertility level during this clutch as spermatozoids survive for over a week when transferred to the female.

If the eggs are destroyed or taken away for artificial incubation the hen will often lay a second or even third clutch. When hand-rearing is advised by the EEP coordinator, a maximum of three clutches a year should be the rule. To stop a prolific female from laying, the last clutch can be left to parent raise, the nest can be destroyed and/or the male could be moved to another aviary. It is important to note that egg laying females should never be caught as the stress can cause the egg to break internally or the female can get egg-bound. Hens should be closely monitored throughout the laying season for reproductive issues such as being egg-bound. If a hen has not laid for several days and is looking “off” in her behaviour (i.e., lower food consumption, fluffed feathers, drooping wings), she might be egg-bound. The first reaction should be to place the hen in a warm and quiet place in hope that she can naturally lay the egg, ideally a heating lamp can be placed in the indoor enclosure so the hen doesn’t need to be caught. If she is unable to lay the egg it should be manually removed by vet staff. Hens that have recovered from being egg bound have continued to lay normally; however, this condition must be monitored closely.

Fig. 31: Nests hidden between plants in outdoor enclosures © Jan Dams & Sarah Patterson

Some birds have the tendency to break the eggs. Once they have learned that eggs contain a nutritious fluid that can be reached by pecking open the scale, it is very difficult to unlearn this behaviour. In this case eggs should be collected as fast as possible after laying, it is incredible how predictable birds tend to lay their eggs and how easily a good keeper with a keen eye can rescue eggs. Most pheasant species lay their eggs early in the evening. A good CCTV installation can help with this. Besides this, the behaviour can be discouraged by placing dummy eggs inside the enclosure. Use several dummy eggs and move them around in the aviary. If the dummy eggs are just added to the enclosure and left on the same place, the birds will start to regard them as furnishing and the effect will disappear. The urge to break eggs can also come from a shortage of calcium or boredom, providing extra broken seashells, chalk and keeping the birds busy with greens will aid against this behaviour. Filling eggs with distasteful foodstuff like mustard is an often described remedy, but this practice should not be recommended and is seldom successful. If eggs keep disappearing, pest species like snakes, rodents or other feral animals should be kept in mind. Exchanging freshly laid eggs with dummy eggs and incubating the eggs in an incubator while the female incubates the dummy eggs will provide the opportunity to place eggs that have internally pipped back under the mother hen for parent rearing.

Incubation will start once the clutch is complete, before this time the nest may have an untidy appearance and eggs can seem to be laid randomly in each other's vicinity. It is important to be patient and allow the female enough time for her to complete her clutch and start incubating. Incubation time is between 21-22 days, but incubation periods of up to 29 days have been recorded. During incubation, it is important that the female is not disturbed and has access to food and water. Broody hens will sometimes leave the nest to eat and drink, eggs can be left unattended for up to an hour. Males do not take part in the incubation process. If the birds are habituated to regular checks inside their aviaries and the hen is calm, nest checks can be done with caution.

If during the natural incubation process suddenly one or several eggs roll out of the nest it is important not to place them back without checking the eggs first. If an egg is damaged or if the embryo died because of the lack of warmth, the chances of the egg rotting are high, which will be detrimental for the rest of the clutch. The egg should be placed in an incubator and observed for 48hrs, if after this time the egg is in good health (no damage to the shell and the embryo is alive) the egg can be placed back under the hen.

During extreme weather conditions it might be best to switch the eggs with dummy eggs and put the real eggs in an incubator if the female is incubating in the outdoor enclosure. Calm hens will normally not be bothered by such a switch. Once conditions normalize, the eggs can be placed back under the incubating female.

As with all pheasant species, the hen continues to sit on the chicks for about a day as they hatch. This allows all the eggs to be hatched, even if they do this at slightly different times. Most importantly, it allows the hen to develop a relationship with her chicks so that they know her calls when they leave the nest and they can locate her in the dense forest. The chick's yolk sac is also absorbed during this time under the hen.

Artificial incubation

In some situations, e.g. bad weather forecasts, it is best to switch the eggs with dummies and place the eggs in an artificial incubator. Once chicks have internally pipped they can be placed back under the incubating hen. **Eggs should only be collected for hand rearing if the studbook keeper has given a specific recommendation to do so**. In general, artificial incubation and hand rearing should only be a last resort.

Collecting and storing eggs

When the eggs are collected for artificial incubation the eggs should be removed from the nest as soon as possible after they are laid. Replacing the eggs with dummy eggs will stimulate the female to keep laying in the same nest. Dummy eggs should have a similar size, colour and weight. Filling infertile eggs with plaster will create excellent dummy eggs.

Eggs should ideally be handled with latex-gloved hands, thoroughly disinfected hands or, when collecting, by wrapping it in a clean paper towel. Never carry more than one egg in the same hand to avoid breakage. When carrying several eggs over a short distance they should be placed in a container which is filled with a clean, non-sticky, soft material (e.g. bird seed, rice, river sand). Eggs should not be shaken; abrupt and strong movements will cause internal membranes to break which will create problems during the incubation process. Because of this it is better to carry the container with the eggs by hand to the incubator, rather than placing it on a food cart, bicycle rack or inside a car.

After collecting the eggs, they should be candled to check for cracks. When there are no air-bubbles inside the egg and the egg-yolk is intact, cracked eggs can be repaired using nail polish or white glue, which can be placed over the crack. If a larger area is dented a piece of paper towel can be glued to the shell to seal the cracks and provide support. If a large area of the egg is to be covered with glue for repair, extra attention should be taken to make sure the egg achieves the proper weight loss and the repair does not impede the hatching process. Generally, no more than 25% of the egg's surface should be covered. Care should be taken to make sure the glue is completely dry before setting the egg for incubation. (Bailey *et al.* in prep.). Extra attention should be given to these eggs as they have a tendency to die-off more easily than other eggs, which could be a danger to the rest of the clutch when they rot inside the incubator. If available, they should be placed in a separate incubator.

Fig 32: single egg in a primitive nest © Sarah Patterson

When collecting a contaminated egg, the bulk of the dirt should be removed without touching the surface of the egg and the egg should be left to dry. When dry, the dirt can be removed very carefully with sandpaper or a small knife. Always use fresh pieces of sandpaper for different eggs. Care must be exercised not to scratch the eggshell cuticle at all during the sanding, because deep scratches can create entries into the egg which will lead to contamination of the egg. Because of the need to avoid scratches, a thin film of soiling and/or staining may still be left on the eggshell. (Bailey *et al.* in prep.) When collecting a dirty egg, it is important to store and incubate this egg separately (as with cracked eggs). The dirt should not be cleaned from the egg with a moist tissue because this will block the egg's pores and allow further contamination of the egg by forcing soil into the pores of the eggs.

Egg disinfection is never advised. Getting eggs wet, even with a disinfectant, increases the ability of microbes on the egg surface to penetrate the pores and cause infection. The chances of a visibly dirty egg hatching are larger than when the egg is disinfected. Egg disinfection is only advised if there is a significant history of shell-borne infection, and then only with a product and protocol made specifically for this purpose. Eggs that have been disinfected with Betadine solution or chlorhexidine disinfectant often show excess weight loss due to removal of the cuticle layer. If disinfection is truly necessary current research shows that a specific protocol using 3% hydrogen peroxide is safer and quite effective. (Kasielke and Lynch, pers. comm.)

Collected eggs should be stored in a room with a constant temperature between 13°C and 15°C and relative humidity between 70 and 80% (ideally a cellar or wine refrigerator) in anticipation of gathering the full clutch. Airconditioning might be necessary to achieve these parameters in warmer regions. When eggs are stored with the air cell up it is not required to turn the eggs. Eggs should be placed back under the female (or in the incubator) when the clutch is complete. It is important to keep this time as short as possible, after a period of 7 days of storage the hatchability of the eggs will decrease.

Eggs that have been partially incubated by the female (no matter how short the incubation time) should be placed in the incubator immediately.

Record keeping

To prevent mix-ups, it is important to mark all the eggs individually with a soft lead pencil or felt-tipped pen. The information written on the egg can be very diverse, some experts will write the lay-date, species name, egg weight and enclosure number on the egg. Others only place a single number on the egg and write down all the other information in a separate logbook. To avoid breaking the egg, the air chamber should be avoided when writing on the egg as this seems to be the most sensitive spot on the egg.

Essential information that should be kept on a separate data sheet for each individual egg includes (but is not limited to): egg number, date laid, sire and dam, enclosure number, egg condition, egg weight and egg measurements. Weighing- and candling data should always be recorded (see section: **Egg weighing and calculation of projected weight loss**).

Incubator settings (incubator temperature and relative humidity) should also be recorded every day. To make sure the turning mechanism of the incubator is fully functional, the position of the egg number on the shell should be recorded every time the incubator is opened.

Setting up an artificial egg incubator

There are two kinds of egg incubators, still air and forced air. In a still air incubator, the eggs are placed at the same height and the temperature inside the incubator is set on the highest point from the horizontally laying egg. Forced air incubators use fans to create the same temperature throughout the incubator and are the most used model. Manufacturers like Grumbach®, R-Com®, AB® and Inca® produce high end forced air incubators.

Fig 33: Grumbach® and inca ® forced air incubator © Grumbach® & inca ®

When planning the construction of an incubation room, it is important to provide places for several incubators. Incubators with different relative humidity settings (dry <35%RH, regular ~ 50%RH and moist >65%RH) should be available for an optimal incubation process. At least one separate incubator should function as hatcher. The hatching process produces quite some dust due to the drying of the down and dirt from the egg membranes and eggshells, which could possibly infect the other eggs in the incubator. A separate incubator should be used for dirty and cracked eggs.

The incubators should be placed in a room with a constant temperature between 15°C and 18°C, a constant relative humidity and should not have drafts. Strong temperature and humidity fluctuations in the incubator room will have an effect on the temperature and humidity within the incubator, which will be detrimental for the incubation process. Sun shining through a window directly on the incubator will also have an effect on the temperature inside the incubator, causing it to rise and possibly kill embryos, and should be avoided. The incubators should be placed on a flat and stable surface. Shocks or vibrations are lethal for developing embryo's and must be avoided. It is very important to maintain strict hygiene protocols within the incubation room and disinfect the entire room and incubators before and after the breeding season. After and before the breeding season the incubator should be thoroughly disinfected according to the guidelines provided by the manufacturer of the incubator. No other materials beside the incubators should be allowed inside the incubation room, when possible it is better to place the hatcher in a different room.

Before eggs are placed inside an incubator, it should be run for at least two days without eggs to check all the parameters.

The most important tools inside the incubator room are the thermometer and hygrometer, because the entire incubation process is highly dependent upon these parameters.

Temperature: for safety reasons each incubator should hold at least two ethanol-filled thermometers besides the digital thermometer that is built into most incubators. At the end and start of each breeding season all thermometers should be placed in the same incubator, thermometers that deviate by 0,5°C or more should be re-calibrated or brought to a garbage dump for recycling.

For Vietnam pheasant eggs the temperature should be set around 37,4°C. Fluctuations in temperature should be avoided as much as possible, especially temperature rises can be fatal for embryos when they exceed 38°C. Cooling down the eggs once a day is still common practice, but does not have a scientifically proven advantage and is not deemed necessary. On the same line, taking the eggs out of the incubator for a few minutes on a regular basis to check the development does not seem to have a negative effect.

Humidity: the hygrometer measures the relative humidity within the incubator. Hygrometers should be checked at least twice a year to see if they still give the right measure, this can be achieved by wrapping the hygrometers in a wet towel. If the hygrometer does not read 100%, it should be adjusted accordingly or brought to a garbage dump for recycling if this is not possible. Some more recent incubators now use electronic digital humidity controllers, which are usually very reliable.

The relative humidity of the incubator should be set according to the weight loss of the egg, this process is explained in the section: Egg weighing and calculation of projected weight loss. When the egg is collected (as soon as possible after hatching) it should be weighed immediately. Do not wait to weigh the egg just before placing it in the incubator because the egg will also lose some weight during storage. Over the course of its 21-22 incubation period the egg should lose approximately 15% of its initial weight. This weight loss is achieved by evaporation of water from inside the egg during the embryo's development. If this weight loss is not achieved the chick will not have enough space in the air-chamber to successfully hatch, if the egg loses too much weight there will be a deficiency of water/liquid inside the egg to allow normal development. See section (**Egg weighing and calculation of projected weight loss**).

Next to setting the temperature to 37,4°C and adjusting the relative humidity inside the incubator according to the weight loss of the eggs, the eggs need to be turned 90° over its horizontal axis at least 9 times every day in opposite directions. Because many commercially available incubators fall short of an adequate turning radius it is important to include two daily additional 180° turns, which can be done by hand. It is important to change the turning direction (left or right) every time an egg is turned to avoid restricting the chalazae (cords that hold the yolk in the centre of the egg). Most modern incubators will automatically turn the eggs. It is important to check constantly whether the turning mechanism is working correctly and whether the needed turning radius is achieved. Some experts add a separate mark on the egg and add the position of the mark on their notes when checking the incubator. Turning the egg is important for a complete development of the chorioallantoic membrane, which is crucial for normal development. Besides this, if the egg isn't turned the embryo may stick to the eggshell and the blood-rich outer layer of the allantois may attach itself to the embryo and eggshell. This may lead to abnormal development and/or embryonic death.

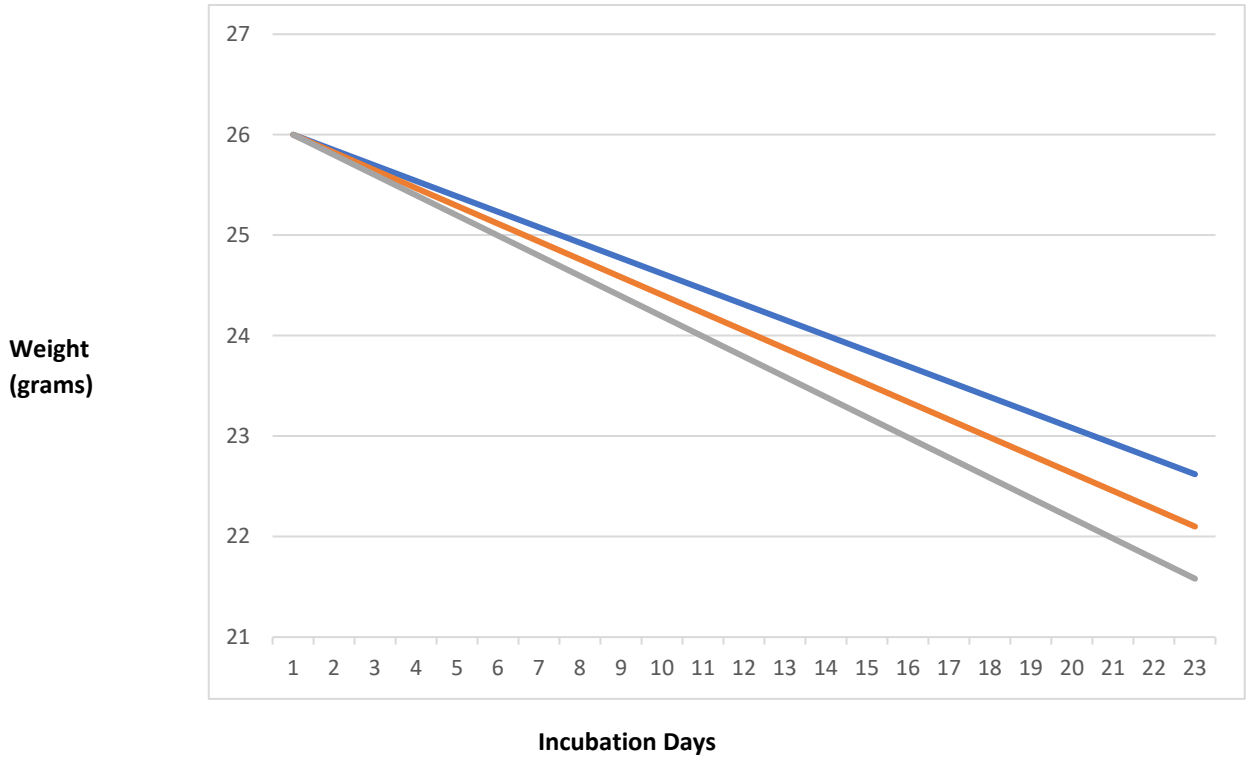
Incubator temperature, relative humidity and the turning mechanism should be checked at least twice every day during the incubation process. It is important to write down all the different parameters in a separate log for each clutch/egg. Checking the temperature, relative humidity, egg position daily and regularly weighing the eggs and checking their position on a graph depicting the 15% weight loss will be important to successfully incubate eggs artificially.

Egg weighing and calculation of projected weight loss

To optimally follow the developmental process, the eggs should be weighed at least every 2 days during the incubation process. If the weight loss is higher than the 15% line then the humidity inside the incubator should be increased, if the weight loss is beneath the 15% line then the humidity inside the incubator should be decreased. This estimate is made by calculating the projected weight loss of an individual egg. When working with a large number of eggs it is easier to have several incubators with different relative humidity settings (e.g. dry incubator = 35% RH, normal incubator = 50% RH, wet incubator = 65% RH), so the eggs can be shifted between incubators according to their individual weight loss graphs.

The projected weight loss can easily be calculated using Microsoft Excel. The initial weight (IW) and incubation days (ID, for Vietnam pheasant 22 days) should be placed in the excel sheet. The initial weight should be taken as soon as possible after the egg is laid because when the eggs are stored they will also lose weight. The end weight (EW) can be calculated for each projected weight loss percentage (13%, 15% and 17%) by multiplying the IW with 0.87 for 13%; 0.85 for 15% and 0.83 for 17%. By subtracting the EW from the IW, the total weight loss (TWL) is calculated. By dividing this TWL by the number of incubation days (ID) we get the expected daily weight loss (EDWL).

Using this information, a projected weight loss table can be created that shows the lines between which the weight loss should progress. By using the initial weight and subtracting the EDWL the weight of the egg for each weight loss percentage is produced for the first day of incubation. To calculate the weights for each day, the projected weight of the day before should be subtracted with the EDWL, as can be seen in the table below. For optimal use, this data can be put in a graph.



Graph 1: Blue is the 13% projected weight loss line, orange is the 15% projected weight loss line and grey is the 17% projected weight loss line.

Table 4: calculating projected weight loss

Initial weight:	IW	**Incubation days**	ID

Projected weight loss %	**End weight (EW)**	**Total weight loss (TWL)**	**Expected daily weight loss (EDWL)**
13	= (IW*0,87)	= (IW-EW13%)	= (TWL13%/ID)
15	= (IW*0,85)	= (IW-EW15%)	= (TWL15%/ID)
17	= (IW*0,83)	= (IW-EW17%)	= (TWL17%/ID)

Days	**13% projected weight loss**	**15% projected weight loss**	**17% projected weight loss**
0	IW	IW	IW
1	= (IW0-EDW13%)	= (IW0-EDW15%)	= (IW0-EDW17%)
2	= (IW1-EDW13%)	= (IW1-EDW15%)	= (IW1-EDW17%)
3	= (IW2-EDW13%)	= (IW2-EDW15%)	= (IW2-EDW17%)
4	= (IW3-EDW13%)	= (IW3-EDW15%)	= (IW3-EDW17%)
5	= (IW4-EDW13%)	= (IW4-EDW15%)	= (IW4-EDW17%)
6	= (IW5-EDW13%)	= (IW5-EDW15%)	= (IW5-EDW17%)
7	= (IW6-EDW13%)	= (IW6-EDW15%)	= (IW6-EDW17%)
8	= (IW7-EDW13%)	= (IW7-EDW15%)	= (IW7-EDW17%)
9	= (IW8-EDW13%)	= (IW8-EDW15%)	= (IW8-EDW17%)
10	= (IW9-EDW13%)	= (IW9-EDW15%)	= (IW9-EDW17%)
11	=(IW10-EDW13%)	= (IW10-EDW15%)	= (IW10-EDW17%)
12	= (IW11-EDW13%)	= (IW11-EDW15%)	= (IW11-EDW17%)
13	= (IW12-EDW13%)	= (IW12-EDW15%)	= (IW12-EDW17%)
14	= (IW13-EDW13%)	= (IW13-EDW15%)	= (IW13-EDW17%)
15	= (IW14-EDW13%)	= (IW14-EDW15%)	= (IW14-EDW17%)
16	= (IW15-EDW13%)	= (IW15-EDW15%)	= (IW15-EDW17%)
17	= (IW16-EDW13%)	= (IW16-EDW15%)	= (IW16-EDW17%)
18	= (IW17-EDW13%)	= (IW17-EDW15%)	= (IW17-EDW17%)
19	= (IW18-EDW13%)	= (IW18-EDW15%)	= (IW18-EDW17%)
20	= (IW19-EDW13%)	= (IW19-EDW15%)	= (IW19-EDW17%)
21	= (IW20-EDW13%)	= (IW20-EDW15%)	= (IW20-EDW17%)
22	= (IW21-EDW13%)	= (IW21-EDW15%)	= (IW21-EDW17%)

Candling eggs

When the egg is being weighed, the status of the embryo can be checked by candling the egg with a special “cold light” lamp which allows visualization of the developing embryo inside the egg. Candling lamps are commercially available. Be cautious when handling the eggs and try to minimize the candling time. When an embryo is suspected to have died, it is important to place this egg in a separate incubator; rotten eggs inside an incubator should be avoided at all times. Embryos that have died can be recognised as a

brown/red spot that doesn't have any veins or reduced veins and doesn't show any movement. Quite often there is a "blood ring" around this spot, which looks like a reddish hollow circle. When slowly rocking the egg, the embryo of a dead egg will rock from side to side, whereas a fertilized embryo will move less. An unfertilized egg stays clear throughout the incubation process. Clear eggs or eggs from which the embryos have died should be opened to check for mortality causes and whether the egg was fertile. Egg fertility can be checked by looking at the germinal disk (Blastoderm). If the germinal disk is full white the egg was infertile. If the germinal disk has a yellow circle at its centre this means it was fertile.

Table 6: stages of embryonic death *Chicken Incubation = 21 days, taken from Attwater's prairie chicken ACM. (Bailey et. al., in prep)

Stage of death	Days of Incubation	Characteristics
EDE **(Early Dead Embryo)** **H&H Stages 1-19**	Chicken: up to 3-4 days*	• Some blood visible, tail, wing buds forming and eye pigment visible (in older eggs) • Allantois beginning to form towards end of period • Generally shows as a blood ring.
MDE **(Middle Dead Embryo)** **H&H Stages 20-39**	Chicken: 4 - 14 days	• Limbs elongating, distinct joints, egg tooth present • Feather germs and leg scales • Generally shows as a partially developed embryo, looks sloshy on candling and no veining present – blood gathering at outer edge of chorioallantois
LDE **(Late Dead Embryo)** **H&H Stages 40-45**	Chicken: after 14 days	• Well-developed embryo • Drawn down • Shows no movement on candling, no veining
DIS **(Dead in Shell)** **H&H Stage 45-46**	Chicken: after 20-21 days	• Externally pipped or partially hatch embryo

Fig. 34: Embryo development display at National Museum of Scotland. © John Corder

Setting up a hatcher

Two days before the calculated hatching date the egg should be moved to a hatcher which runs on the same temperature as the normal incubator. Inside this incubator the relative humidity should be kept at around 65%. A lower relative humidity can cause the egg membrane to dry out, making it impossible for the chick to turn inside the egg so it can't hatch out of the egg. When the egg has internally pipped (when candling a shadow is visible inside the egg chamber, this is the beak trying to make a hole in the eggshell) the eggs should be removed from the rollers, placed on a substrate that provides grip for the newly hatched chicks and the turning of the eggs can be stopped. If chicks hatch on a slippery substrate like newspapers or the bottom of a synthetic incubator this can cause the legs to spread, old towels or rubber anti-slip mats are often used for chicks to hatch on. Wait until the chick has completely dried and is vigilant before placing it in a hand rearing box.

Chicks from different clutches should not be hatched in the same incubator to avoid confusion about the heritage of the chicks. If only one hatcher is available a division between the eggs should be installed. Disused ice cream containers with the base removed can be used to keep different clutches of eggs/chicks separate during hatching.

Fig 35: divisions in Grumbach ® incubator to separate different clutches. © Jan Dams

Hatching

The time between internal and external pip shouldn't exceed 24hrs, and the same goes for the time between external pip and the actual hatching. If this time is heavily exceeded, assistance may need to be given for the chick to hatch. During assisted hatching it is important to make sure the egg membrane is kept moist and no blood veins are broken. The blood veins in the egg membrane can be made visible by dropping (sterile) water on it, like Ringer's solution. As long as blood runs through these veins, the chick is not ready to hatch. Only remove small pieces every time the egg is handled and allow the possibility for the chick to hatch on its own. A possible reason for a failure to hatch is that the chick is mal positioned within the egg. Freshly hatched chicks can be kept in the hatcher up to 24hrs post hatch and should only be moved when they have completely dried. Once the chick is moved to the rearing station it should be weighed and the umbilical seal should be disinfected with antibacterial cream (e.g. Fucidin®).

It was already mentioned but the importance can't be stressed enough: the eggs need to be hatched on a surface on which the chicks won't slide. Old towels or rubber anti-slip mats are both suitable surfaces for chicks to hatch on. Too smooth surfaces will cause the chicks to develop splayed legs, in many cases this problem can be aided by tying the two legs back together using adhesive tape. The tape should be removed every second day; if the legs still spread a new tape must be placed.

Fig. 36: Fixating splayed legs: a piece of tape should be cut to the appropriate length and the chick's legs should be held in normal position and pressed on the tape that is held by a second person or placed on a table. The tape can then be gently pressed on the legs and closed between the legs. Caution must be taken not to cut of the blood flow of the legs. © Rik Dams

2.5.3 Development and Care of Young

Parent rearing

Fig. 37: Hen with chicks © Klaudiusz Muchowski

When parent rearing, the hatching of the eggs is the time to be the most careful. If the female has chosen to incubate her clutch in the indoor enclosure, she can be easily shut inside and kept there until the chicks are running around confidently. If she is incubating the eggs outside it is important to look at the weather forecasts around the hatch date. If the forecasted weather is dry, there is no need to worry. However if the forecasts predict rainy/windy weather, it is best to keep a close eye on the hen and lock her up together with the chicks in the indoor enclosure once she starts walking around with the chicks. In this last case, picking up the nest she incubated in and placing it in a corner in the indoor enclosure can help stimulate the hen to sit on her chicks. Providing an extra heat source like an infrared lamp can also help the chicks during their first hours of life.

When parent rearing, it is important to observe the behaviour of the male and the female. A minority of males are aggressive towards the chicks and need to be removed from the enclosure, most males will just ignore the chicks while some will aid in the raising. Hens can become very nervous during the raising process so providing them with as much rest as possible is important. Inexperienced hens will sometimes have difficulties raising their first clutches; to help her as much as possible the following measures can be taken:

- When parent rearing the chicks, the hen should be kept inside the indoor enclosure during the first 14 days. If this is not possible the hen should at least have a dry and draft free shelter she can retreat to. If the chicks hatch during a cold period, an extra heating lamp can be added to the

enclosure for extra heat. The best place to hang a heating lamp is near a corner where the hen can easily settle under it.

- During the first weeks it is important to remove high perches which aren't accessible for the chicks or to provide ladders/sloping branches so the chicks can climb up towards the perches. Hens will have the tendency to roost on perches after the chicks have hatched, sometimes leaving the young chicks defenceless on the aviary floor. Since roosting happens in the late evening, often keepers are not present to check that the hen has taken all her chicks up onto the roosting perch. This can be a vital time, usually at around 6 – 8 days, so keeper supervision for these evenings can be important.
- When there is a large water element (e.g. pond, waterfall, river stream) in the enclosure this should be drained if possible. If draining is not an option, making sure the edges aren't steep or slippery will help the chick get out of the water if it falls in.
- Make sure food and water are easily accessible to the chicks; a feeder that is 5cm high can be perfectly suitable for the adult birds, but chicks won't be able to reach the food in the first few days. Placing stones in an open drinking trough will prevent chicks from drowning in the shallow water.
- Avoid keeping the hen and her clutch next to an aggressive/ nervous bird.

Fig. 38: A "ladder" to help chicks reach hens that roost high up © John Corder

Hand-Rearing

Hand-rearing may be necessary for a variety of reasons, such as rejection by the parent or the inability of some birds to incubate their own eggs. **Hand-rearing should, however, only be conducted with the agreement of the studbook keeper. As a rule parent rearing is the first choice**. When hand-rearing, it is always better to create small groups to allow social interaction. Keeper contact should be kept to a minimal to avoid imprinting.

The hand-rearing facilities are described from day zero up to fully fledged. The basic food for chicks contains a minimum of 90% pheasant rearing pellet/crumble, 8% greens and 2% insects. Greens are mixed through the pellets to make the food more attractive for the chicks and can contain: carrot, kale, romaine, peas and should be finely cut/grated when presented. Insects need to be dusted with a mineral powder to increase the nutritional value and will help the chicks to start feeding.

Fig 39: Heka hand-rearing box at Weltvogelpark Walsrode © Jan Dams

Day 0-1

Once the chicks have dried up in the incubator, they should be placed in a box which contains a heat source and has a floor that provides grip and is easy to clean (e.g. 3M matting, old cloth towels, rippled rubber matting). The box should be large enough to fit a heating lamp and provide the chick with enough room to move away from the heating source, but small enough that there is no chance for the chick to die of hypothermia. A box measuring 60cm long, 50cm deep and 50cm high should suffice for a maximum of 5 chicks. Feeding and cleaning the box should be made possible through the front of the box, which should be made of mesh allowing optimal ventilation. An open top rearing box will give a bird of prey perspective from the keeper, scaring the chicks during every procedure. Adding a separate hatch on the bottom of the box facilitates the exchange of the substrate, decreases the risk of an escape when cleaning the box. Splash proof ceramic heating lamps are optimal heating sources, historically infra-red heating lamps were readily used. A 100watt lamp is ideal for the raising of pheasant chicks. The lamp should be placed at such a height that chicks cannot touch the lamp with their heads and temperature wise: will sit at the edge of the reflector cap. If the chicks are directly under the lamp this means they are cold and the lamp needs to be lowered. If the chicks are far away from the lamp the chicks are probably too hot and the height of the lamp should be increased.

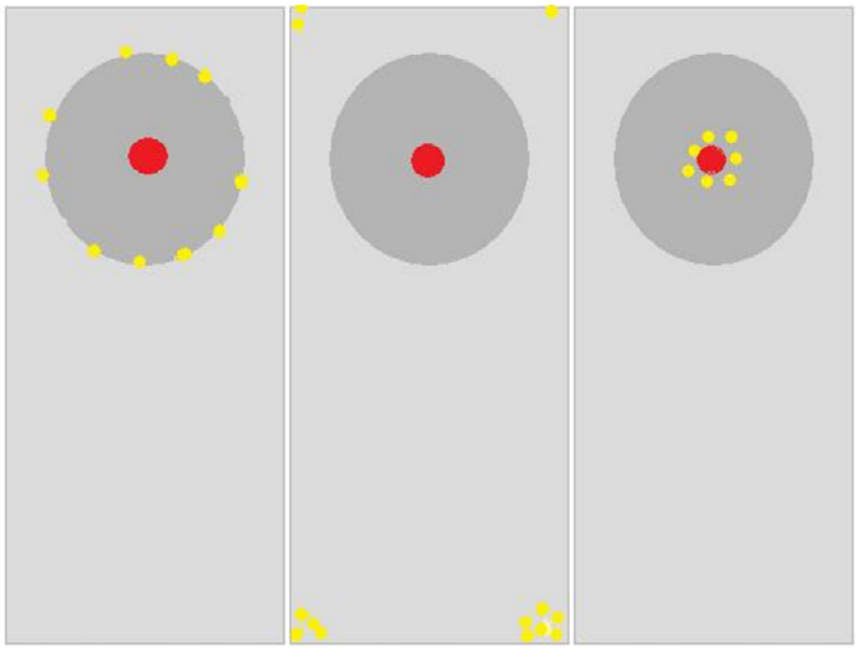


Fig. 40: deciding on heating lamp (red dot) height dependent on chick (yellow dots) behaviour. Darker grey area is the reflector cap. Left: ideal, middle: heating lamp too low, right: heating lamp too high © Rik Dams

An initial goal is to set the temperature at the edge of the lamp at around 35°C, every week the temperature can be lowered by 1,5°C until a temperature of 26,5°C is reached.

Heating plates for chicks are becoming increasingly popular as a heat source when hand rearing young pheasants. These heating plates are set on a height that the backs of the chicks touch the heating plate when they crawl under it. Best is to place the plate sloping towards the back of the rearing box. Care must be taken to check that sleeping and thus lying chicks still can touch the plate. To obtain this, the back side of the plates should be approximately 2 cm above the ground level. The height of the front side can vary from 6 to 8 cm. The height needs to be adjusted when the chicks grow.

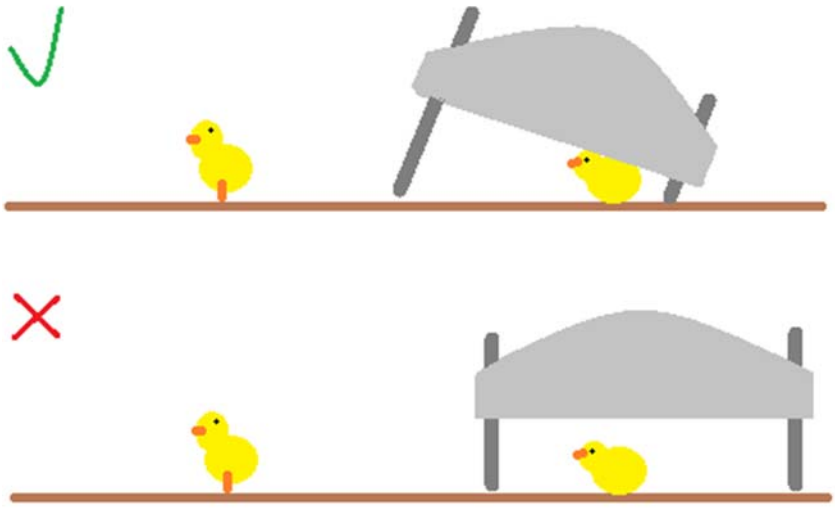


Fig. 41: Top: chicks that are resting still touch the heating plate. Bottom: heating plate is set too high. © Rik Dams

To provide the chicks with optimal grip the box can be lined with rubber anti-slip matting or old/rough towels. The mats or towels should be changed out every day, giving the keeper the chance to check the droppings, these should be firm, not stinky and liquid. To reduce stress on the young chicks their hand rearing boxes should have two separate section which can be closed off from each other. In this way the chicks can be locked in one section while the other is cleaned.

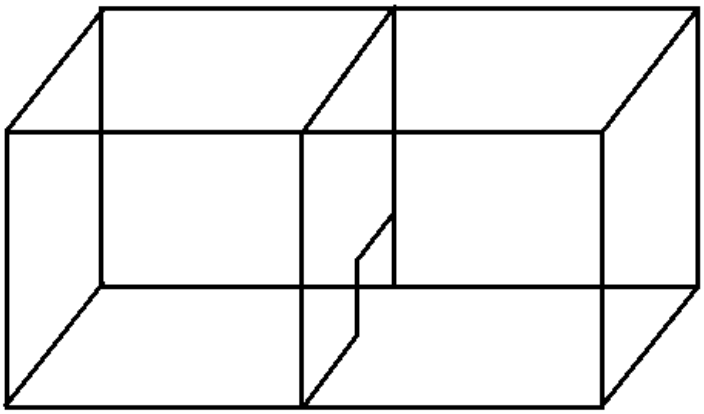


Fig. 42: hand rearing box with division © Rik Dams

Day 2-4

Food and water should be accessible after 24hrs, by this time the chicks should be completely dry and actively running around. When available commercial pheasant-chick starter crumb should be provided to the chicks, these mixtures are normally high in protein (up to 20% protein) and have added calcium. If this is not available a mixture of crushed seeds (maize, millet and barley), crushed boiled seeds and pulses and smashed boiled egg can be provided, to provide the added calcium a mineral powder can be added to this mix. Food should be available *ad libitum* and should be switched out at least twice every day. Grit (small stones and crushed clamshells) should always be available. Once swallowed, grit will remain in the gizzard for a longer time and will help grind the food ingested by the birds.

Food should be presented in an easily accessible shallow bowl and spread on the floor of the hand rearing box. To stimulate the chicks to feed, greens and mealworms can be mixed with the pellets. Normally Vietnam pheasant chicks will start feeding on their own. In the rare occasion that chicks don't start to feed on their own, there are several techniques to stimulate this. Taking a mealworm with tweezers, soaking it in water, dipping it in the food provided for the chick and then holding this in front of the chick will teach it the taste of the food and help it to learn to feed on its own. A different version is soaking your fingertip or a small paint brush in water, dipping it in the starter food and holding it in front of the chick. This should be repeated 4 times spread throughout the day. Even easier is adding a companion chick, a freshly hatched chicken or quail chick, which normally start feeding on its own and when doing so teaches the young pheasant how to eat. Only use this technique when you are a 100% sure that the companion chick does not carry any diseases and will not bully the other chicks.

The young chicks need to be stimulated to drink. Placing shining marbles in the water will not only prevent the chicks from drowning, but will also aid them in finding water as they like to peck at the shining marbles, bringing them to the water. During the first day water can also be given to the individual chicks with the

aid of a syringe or a small paint brush. Holding a drop of water in front or on the side of the chick's beak will stimulate it to drink.

Curly/Crooked toes

When hand rearing pheasants, curly or crooked toes can appear. When untreated this will result in strongly mutilated adult birds that will suffer their entire life. For males the condition can also have a negative effect on their ability to fertilize eggs.

Curly toes will most often appear in artificially incubated chicks and are present right after hatching. The cause of this can be that the diet of the parents was deficient in vitamin B2 or that the temperature in the incubator was too high. However, it can also be the result from wrong humidity around the time of hatching or when the chick takes much longer trying to emerge from the egg and its feet and legs get forced into un-natural positions in its struggle to rotate and get out.

Crooked toes can appear at a later stage and this condition will worsen as the bird grows. This condition can occur if the chick is being hand reared on a surface that is too smooth and doesn't provide enough grip or as a result of inbreeding. It can also occur as a result of stress, this can even happen to adult birds.

Although not always, crooked and curly toes can easily be straightened by splinting the toes with a piece of hard plastic cut in to the shape of the feet or with a metal wire twisted into the form of the bottom of the feet with two pieces facing sideways and one piece facing forwards. The chicks will have some trouble walking with these strange objects on their feet but will soon adjust. To help them find some grip the nails of the feet should stick over the splint.

Fig. 43: Splinted toes with metal wire and adhesive tape. © Rik Dams

Using adhesive tape, the splint can be taped to the feet, forcing them into the correct position. Be careful not to restrict the toes too strongly, tying of the bloodstream which will cause the toes to become necrotic. It is important to remove the tape at least every two days, after the chick is left to run around for 5 minutes it can be evaluated whether the toes are staying in the correct position or if the toes should be placed back in a splint. Due to the growing of the chick the splint should be adjusted every time it is replaced. In non-severe cases it can sometimes be enough to just use adhesive tape on a single toe to help straighten it.

When the chicks are kept on a too smooth surface the legs of the chick can spread. Raising the chicks on a rough woollen cloth, old towel, rubber anti-slip mat or on synthetic grass will help prevent this condition. When you do have chicks with splayed legs it is worth to try and pull them back together by binding together the legs with a piece of adhesive tape. Chicks will be able to walk around with this piece of tape between their legs surprisingly well. It is important to change the tape every two days and re-evaluate the need to place a new one. This process is explained on page 45.

It is important to note that twisted toes are virtually never seen in parent-reared chicks, so twisted toes are a sign that we have not incubated or hand reared properly. Where chicks exhibit twisted toes at the time of hatching, these deformities can often be reduced or removed totally by allowing the chicks to have access to a grass substrate and an electric hen to keep them warm when required. Somehow, this natural surface seems to encourage twisted toes to straighten within a couple of days.

Fig. 44: An electric hen on grass to help chicks with twisted toes © John Corder

Day 5 - 14

As the chicks grow, they will need to be given more space. After around ten days the chicks should be moved to a larger indoor enclosure (approx. 2m*1m*2m), which still contains a heating lamp.

The starter crumble pellet should be mixed with growth pellet to habituate the chicks to eat the larger pellets. The feeding bowl can gradually become larger. A gravity water dispenser or a larger water bowl can be introduced.

Fig. 45: Gravity water dispenser. © Google images

Day 15 – Day 60

The chicks should now be eating the growth pellet which should, at this stage, be the only pellet that is provided. The number of feedings should still be 2 feedings, one in the morning and one in the evening.

Once the chicks are fully feathered, they can be moved to a combined inside and outdoor enclosure, where they still have access to a heating lamp. The indoor enclosure should contain several perches which the chicks can use to roost. During nights and when bad weather is forecasted (temperature below 15°C, rain, etc.) the chicks should be locked into the indoor enclosure. The ground in the indoor enclosure can be covered with sand, which should be the first introduction to sand for the chicks. To avoid chicks eating sand and the stomachs getting compacted with it, the food dish should be placed in a plastic box or on either a wooden plate or a piece of cardboard. The outdoor enclosure should be planted so that the birds feel safe.

Evaluating chick health

Throughout the rearing process chicks need to remain lively and alert. Reduced mobility, fluffing up feathers and prolonged closing of the eyes are clear signs of a chick in bad condition. The following points should be checked when one or several chicks are found in such condition (Bailey et. al., in prep):

- Failure to eat: make sure all chicks are eating independently. If this is not the case offer water and food to the chick.
- Availability of food and water
- Is the heat source still functional? If the chick is sitting very far from the heat source, has its beak open and is it pumping air, then the temperature should be reduced. If the chick is sitting directly under the lamp and if all the chicks are sitting very close to each other, then the temperature should be increased.
- Is the chick injured?
- Do the companions chase the chick? Never put more than 5 chicks in the same box and only put chicks that are about the same age together.
- Sand impaction: Placing a shallow container or a wooden board under the food bowl will prevent food falling on the sand. Food that has fallen on the sand can stick to the sand and become ingested when eaten by the chicks, leading to gastrointestinal tract impaction, and possible death.
- Grass impaction: In the wild, pheasants will normally forage by browsing on vegetation that is rooted and offers resistance, resulting in small pieces of vegetation being torn off. Therefore, if vegetation supplements are offered, under no circumstances should large sections of fibrous materials (e.g., large leaves, long grass stems and blades) be offered. Failure to chop these food items into smaller, bite-sized (no larger than approximately 2 cm) pieces may result in gastrointestinal tract impaction, and possible death.
- Insect overfeeding to chicks: Although chicks are primarily insectivorous in the wild, commercially available insects are not nutritionally balanced. Feeding too many of these insects can cause metabolic bone disease (MBD) or leg rotations. Additionally, the keratin shell can cause impaction in young chicks.

2.6 Population management

The history of the Vietnam Pheasant EEP dates back to the middle of the 1970s, when the World Pheasant Association (WPA) decided to establish the first studbook, with Dr. Tim Lovel as coordinator, and to start a breeding programme. This included an exchange of birds between the UK and the USA. At the same time, in Vietnam, the home of the Vietnam pheasant was being devastated by war, and in particular the Annam Provinces, where it lived on the border between North and South Vietnam. The use of defoliants, followed by deforestation linked to the intensification of agriculture, reduced the original primary forest to scrub. Between 1988 and 1992, Birdlife International and WPA organised several expeditions to locate the species, without success. In 1992, at the WPA Lahore Symposium, the Vietnam pheasant was declared probably extinct in the wild. The only surviving birds were therefore those in human care. The scientific community was roused to action, and WPA decided to resuscitate the international studbook which had been abandoned at the beginning of the 1980s.

In 1994, WPA gave Han Assink and Alain Hennache the responsibility for the International studbook, taking over from Tim Lovel, called to other duties, and asked Alain Hennache to present a proposal for an European Endangered Species Programme (EEP) to the European Association of Zoos and Aquaria (EAZA). The proposal to establish an EEP was accepted in July 1994, as well as the nomination of Alain Hennache (Clères) as EEP Coordinator. Hennache retired in 2009. Between 2008 and 2011 Julie Levrier (Clères) was the official EEP coordinator. In July 2012 Tomas Kapic (Prague Zoo) took over the studbook. In 2016 Dr. Tobias Rahde (Zoo Berlin) took over the international studbook (WAZA) from Chris Holmes (Houston Zoo) who ran the ISB since 2013.

Close cooperation still exists between the EEP and the World Pheasant Association. WPA is an associate member of EAZA. Within WPA the European Conservation Breeding Group (ECBG) is the group that coordinates all conservation breeding efforts through several Focus Groups. There is a special Focus Group for the Vietnam pheasant. A group of enthusiastic WPA members are maintaining a WPA studbook from which all data are included in the ISB.

Since the beginning of the studbook it was clear that there may come a time that a reintroduction of the captive bred birds back to its original range would be needed to save the species. To increase the chances of a successful reintroduction, the aim was to retain as much genetic diversity as possible. With the use of programs that calculate mean kinship and inbreeding coefficient, optimal pairings were made, using the limited ancestral data that was available and making estimated guesses where necessary.

The captive stock of the Vietnam pheasant has a very small genetic base (Hennache 1997). The founder population is derived from 28 specimens, of which only 6–8 were females, collected between 1924 and 1930, and never subsequently supplemented with wild birds. Trying to increase the genetic diversity of the captive population some breeders produced crossbreds with Swinhoe's pheasant (*Lophura swinhoii*) and Silver pheasant (*Lophura nycthemera*).

In an attempt to exclude these hybrids and analyse genetic diversity within the captive population Hennache (1999) analysed D-Loop mitochondrial DNA from 130 birds. 85 hybrids were found and expelled from the studbook. But analyses were made using mitochondrial DNA so only hybrids in the maternal lineages could be excluded. All captive Edwards's pheasant morphs analysed had the same haplotype at D-Loop mitochondrial DNA so they were probably derived from a single female, after an important bottle

neck that occurred between 1942 and 1947. In 1994, 4 pairs of Vietnam pheasants type "*edwardsi"* were sent to Hanoi Zoo by WPA at a time when the species was believed to be extinct in the wild. A couple of years later, one wild male was rescued and taken to Hanoi Zoo, where it bred with one of the UK females, thus bringing the first new genetic material to the captive population for around eighty years. At the same time, Hanoi Zoo received a number of Vietnam pheasants type "*hatinhensis*" and implemented a breeding programme for these birds, at that time believed to be a new pheasant species. Several pairs of birds of the type "*hatinhensis"* were donated to WPA in Europe by Hanoi Zoo and a register of these birds was developed by WPA. Interestingly, the DNA of the wild male contained haplotypes from both type *"edwardsi"* and type "*hatinhensis"*, but type "*hatinhensis"* had a wider genetic base of haplotypes than type "*edwardsi"*. (Randi *et al.* 1997)

Fig 46: cooperation of EEP with Hanoi Zoo. Pictured left to right: Antonin Vaidl, Tomas Kapic, Dang Gia Tung. © Prague Zoo & Hanoi Zoo

In recent years, a cooperation between Biogenomics (University of Leuven) and the World Pheasant Association has been set up to further study the genetics of the Vietnam pheasant's captive population. Biogenomics has developed primers for polymorphic microsatellite loci for the Vietnam pheasant (*Lophura edwardsi*). In an effort to further exclude hybrids from the studbook and learn more about the overall genetic make-up of the studbook population all birds are being subjected to genetic testing using feather samples. To get a better idea of what a genetically healthy population of Vietnam pheasants looks like, museum samples are being included into this study with the help of the Centre for Research and Conservation (CRC, Royal Zoological Society Antwerp).

The data received from the Microsatellite analysis, which also gives information about the genetic make-up of each bird, allowing the studbook keeper to calculate genetic "distances" between all birds, is also being incorporated into the studbook to further improve the quality of the studbook recommendations.

The goal of the EEP is to reach a population of 180 birds which are held by EAZA member institutions + Hanoi Zoo (which is an approved non-EAZA EEP participant). Together with WPA-ECBG private holders, birds in the SSP (Species Survival Plan from the Association of Zoos and Aquariums in America) and birds that are held in specialized breeding centers in Vietnam the total managed population of Vietnam pheasants should reach between 400-500 individuals. All these birds should be managed within the International Studbook (ISB).

The Long Term Management Plan for the Vietnam Pheasant EEP (Kapic *et al.* in prep.) states that the following roles can be assigned to ex situ management in the conservation of *Lophura edwardsi*:

Direct conservation roles (IUCN SSC 2014):

- Ark: It is possible that the Edwards's pheasant is already extinct in the wild, and if not, it is highly likely that any remaining subpopulations are extremely small and under severe threat from predominantly hunting pressure, but also further habitat degradation. It is therefore recommended to maintain, and optimally manage, the already large ex situ population to preserve options for future conservation strategies, including functioning and as a source for individuals for reintroduction or reinforcement.
- Source for population restoration (reintroduction and/or reinforcement): Because the wild population is either extinct or extremely small and fragmented, it is considered unlikely that the species will successfully recover without reintroduction and/or reinforcement. Using the ex situ population for this purpose is already included in the current Edwards's Pheasant Action Plan (2015-2020) (Pham Tuan Anh and Le Trong Trai 2015) and is a key element in reaching the stated aim of establishing a sustainable wild population of Edwards's Pheasant in the wild by 2030, in 2-3 sub-populations. A feasibility study for reinforcements or reintroductions is aimed to be completed by 2020.
- Research into the species' biology and ecology: Since extremely little is known about the species' biology and ecology, the ex situ population will be used to carry out research that:
    - Generates knowledge that is required to make progress in other parts of the action plan (for example, determine optimal perch height, optimising age of release in function of imprinting and learning, etc.).
    - Teaches as much as possible about the basic biology of the species.
    - Tests tools and methods that are, or may be, required in the conservation of the species: for example: investigate the logistics (permitting, air transport etc.) of, and experiment with, egg transport, which probably is needed initially, when parent reared birds are key, but may be useful at a later stage when higher numbers are required for the 2nd and 3rd breeding sites.
    - Uses technologies acquired from reintroductions of other similar pheasant species to generate a release plan.

Indirect conservation roles:

- Education/flagship: This endemic species (which is also a victim of agent orange) has the potential to become the National Bird of Vietnam, which would give it a high cultural and conservation profile. It can be used at the education centre in Quang Binh Province, Vietnam to raise awareness and obtain behavior change regarding overexploitation of forest products and hunting, not only of Edwards's pheasant but a whole spectrum of flora and fauna, and associated disturbance and habitat degradation.
- Fundraising: Raising awareness among non-range state zoo visitors about the plight of the Edwards's pheasant and other fauna and flora it shares its environment with, can help to raise funds from host institutions and/or visitors to support ex situ and in situ conservation actions.

2.7 Behavioural enrichment

Providing an aviary that contains a variety of furnishings like fruiting trees and bushes, rocks, tree stems, running water and different kinds of substrates is some of the best enrichment that can be given to a pheasant. Especially areas that are covered in leaf litter (be cautious that this doesn't start to mould) are favoured and will give the birds a space where they can scratch and dig looking for insects or other food items. Dry sandy areas will be used for sandbathing.

Suspended leafy vegetables like kale will also give Vietnam pheasants a good possibility to tear off edible pieces and elongate their foraging time. Placing novel objects like lumps of grass or branches will always be inspected and provide some distraction for the birds. Raking in seeds into a dry sand-bed will give the birds the opportunity to perform natural foraging behaviour.

Fig 47: Freshly planted and decorated aviary at Weltvogelpark Walsrode with several foraging opportunities for the inhabitants. © Jan Dams

Vietnam pheasants also respond well to training using positive reinforcement and have been trained to enter transport boxes or stand on scales for weight measurements.

2.8 Handling

Individual Identification and Sexing

Vietnam pheasants should be banded with a 12mm band. On the leg band, the following information should be present: year of birth, serial number from the institution, band size and individual number for each bird. This information should be provided to the studbook keeper who will give the bird its studbook

number. The studbook number, institutional ID and the information on the band should be kept in a registrar at each individual institution together with other observations about the animal (veterinary reports, breeding results, pairing, etc.).

Eggs should be numbered so that the parentage may be tracked and each individual egg can be identified. During the rearing process chicks from different clutches should be kept separately. If this is not possible, individual chicks can be given flexible rubber bands until the chick is old enough for a closed leg band.

If an open band is used, it is important to make sure that the ends of the bands are as close to each other as possible and that there is no gap. This to reduce the chance of the bands getting entangled with any exhibit furnishing (e.g. mesh).

As a general rule, males should have the metal band placed on their right leg and the female's band should be placed on her left leg ("Right for Rooster and Left for Lady"). Immature males can be distinguished from the females as soon as the darker feathers of the adult plumage will start to show. Also, males tend to have spurs and longer legs compared to females who are spurless.

Electronic identification chips can be placed into the pectoral muscles of the birds, but this should be done by a qualified veterinarian.

2.8.1 General Handling

During cleaning, keepers need to keep note of where the birds are and allow them to walk around them. It is important never to stare at the birds when in the enclosure as this will make them nervous. When approaching the birds, they tend to first press themselves against the ground and then burst into flight, for this reason it is important to keep some distance from the birds. Once they press themselves against the ground it is time to step back.

Vietnam pheasants tend to keep to themselves and will normally not approach keepers. However aggressive males can harm keepers with their spurs. To avoid injury to the keeper or the animal, aggressive males should be switched off exhibit before entering. Vietnam pheasants can easily be trained with the use of mealworms or peanuts as enforcers. Box training is also possible but is not ideal as pheasants tend to be quite nervous when they are confined in a small space. If neither of these options succeeds a last resort can be to catch the aggressive bird and put it in a transport box during the maintenance of the aviary.

2.8.2 Catching/Restraining

Capture time should be limited to the coolest times of the day. If the transfer is within house, the transfer is best done in the morning so the bird can be kept under surveillance in its new enclosure throughout the rest of the day. Capture can be done by hand, but a net will make it quicker and easier. Nets should have deep bags which are made from a strong but flexible material like solid cotton cloth or small-sized mesh. The rims of the net should either have soft cushions or be made from a somewhat flexible metal

wire. A black cotton material is best, as the bird in the net cannot see outside and therefore is less aware of what is happening to it, so it relaxes much more.

Fig. 48: Padded nets using black cotton material for the bag © John Corder

If possible, pheasants should be caught in the indoor enclosure. Capturing pheasants in the outdoor enclosure is often more difficult because of the furnishing and there is a high risk of the bird crashing into the wire, damaging the beak and/or head with a risk of killing itself. Ideally the bird that needs to be captured is isolated in the indoor enclosure, away from other animals in the same aviary. Capture for transport should be as quick and efficient as possible. The longer it takes to catch a bird, the higher the chances of a bird getting injured. To reduce the risk of injury it is better to anticipate where the bird is going and at the last moment, hold your net in front of the animal as it goes in this direction, letting it walk/run or fly into your net rather than cornering the animal and smashing a net over it. The chances of trauma or death will be much smaller with the first technique. When catching birds with more than one person, make sure to have a good communication about who is going to catch which bird; do note that this may change over the course of the catching.

When the bird is netted, the net should be pressed to your chest with the opening of the net pointing towards you. Hold the net with one arm and reach into the net with the other arm. Another technique is to press the opening of the net against the floor and then reaching into the net to grab the bird. Never fixate the bird with anything else then the legs or the body, taking hold of the wings, tail or the head will lead to a loss of feathers or an injured/dead bird. One of the safest ways to hold a pheasant is to grab both legs overhand from the front, with one finger placed between the legs to prevent the legs from rotating in the hand. The bird is then brought against the holder's torso, with the other hand resting over the bird's wings. The advantage of this restraint technique is that even if the bird's wings temporarily escape restraint (which they are prone to do), the bird is still safely under control as long as the legs are restrained. (Bailey *et al.* in prep.)

Fig. 49: How to hold a pheasant for examination or changing aviaries © John Corder

When captured, birds can go into stress cardiomyopathy. Once you feel that the breathing decreases, muscle tension loosens, the eyes start closing and the beak is open, it is important to immediately put the bird on the ground and let it rest until it recovers.

Box training should be attempted to reduce the stress of capture and transportation. Calm birds easily learn to enter a box when treats are placed inside.

2.9 Transportation

When transporting Vietnam pheasants by air travel IATA Live Animal Regulations need to be followed. (IATA, 2020)

Pheasants should be transported individually, placing several birds in one crate will always end up in pheasants getting injured or worse. Especially the height of the transport box is very important because pheasants have the tendency of flying straight up when they are under stress. A pheasant can cause itself serious harm when it repeatedly crashes into the top of a transport box. Therefore, the height should be minimized to allow the pheasant to stand up but leave minimal space right above the head, making the bird stand in a semi-crouched position. For the same reason soft padding on the roof of the transportation box is absolutely necessary. Good dimensions to transport a Vietnam pheasant are: 60cm*25cm*35cm (Length*Width*Height). A sliding guillotine-style door should be placed on the front of the box. If such a box is not available a cardboard box with airholes cut into the sides is a worthy alternative (although not allowed on airplanes). The floor of the box can be covered with artificial grass or corrugated cardboard topped with a layer of wood shavings to add traction for the birds and which is easily cleaned.

Ventilation is always very important during transportations. Pheasants create an astonishing amount of heat inside a small box. During warm weather a pheasant can quickly overheat inside a badly ventilated box. Placing several ventilation holes on each side of the box will prevent this. When several boxes are placed next to each other during transport it is important to make sure that the ventilation holes aren’t blocked. To avoid overheating transport boxes should never be placed in direct sunlight. When

temperatures exceed 20°C the transport boxes should be placed in an air conditioned surrounding (e.g. car, room). If small fresh-cut branches from a leylandii bush are placed in a travelling box on a hot day, their evaporation can help reduce the temperature within the box.

Because birds have the tendency to calm down in dark boxes, light levels inside the box should be kept to a minimum. Large wire surfaces, like seen in boxes built according to IATA regulations or in standard pet carriers, and ventilation holes must be covered with a breathable fabric such as burlap or shade cloth. These areas should also be covered with mesh that has an opening not larger than 0,5cm to avoid the bird from harming itself. Covering boxes with a non-ventilating material (like cardboard or a thick blanket) to try to decrease light shining into the boxes should always be avoided because this might suffocate the birds.

Fig. 50: Padded roof (top left), guillotine door (top middle), Food & water containers (top right), travelling box (bottom) © John Corder

Once the birds have arrived at their final destination, they should be released as soon as possible into their destination enclosures. If the birds arrive at the destination after dark, they can be released into the indoor enclosure where a light is left on. If no such lighted enclosure is available, it may be best to wait until first daylight to release the birds if the transport doesn't exceed 24 hours and a secure and well-ventilated holding location is available.

When releasing the pheasant, it is again useful to take into account that pheasants have the tendency to burst into flight when spooked. Therefore, it is important never to open the box in the direction of the long end of the aviary but open the crate in the indoor enclosure 30cm away from the wall with the

opening of the transport box pointing towards this wall. Do not flush the bird out of its box, but let it walk out calmly. When a bird needs to be released in the outdoor enclosure follow the same procedure and place the box near the outer fence, preferably near some bushes which the bird can run into for cover. As an extra safety measure, bamboo matting can be attached to the outside of the aviary, this will not only prevent the birds from flying into the mesh but will also provide the opportunity for the birds to discover their new surroundings with some extra cover.

When placing birds into a new environment make sure that food and water is both available in the inside AND outdoor enclosure. Only when you are certain that the birds have found the entrance to the indoor enclosure and are eating inside should the feeders in the outdoor enclosure be removed. CCTV can be a very helpful tool and can be the difference between knowing or assuming.

2.10 Safety

Vietnam pheasants tend to be docile birds, but males can be aggressive and possess spurs that can cause serious harm. When working with aggressive birds it is best to shift them to a different enclosure before doing any maintenance work or feed and water the pheasants.

When a keeper is pecked or stabbed with a spur, the wound should be disinfected as soon as possible.

2.11 Veterinary: Considerations for health and welfare

Vietnam pheasants are a very hardy species. Birds show almost no signs of illness until their condition is extremely degraded, making recovery challenging. Therefore, disease prevention through good quarantine, husbandry and hygiene practices is vital. Keeping the feeding and drinking area clean, removing faeces on a daily basis and changing out the substrate at least once a year (or more) is also extremely important in this regard. Newly arrived birds or birds that show signs of sickness should be isolated and tested.

Many of the clinical signs of diseases or disorders in Vietnam pheasants are similar in appearance. A bird that is compromised or ill may show the following signs:

- Lethargy
- Lack of interest in food
- Heavy or difficulty breathing
- Weight loss
- Change in activity patterns
- Change in stool (increased or decreased production, consistency, color, etc.)
- Regurgitation
- Lack of normal gait or locomotion
- General “fluffed” appearance

As with most bird species, signs may be masked until the disease process is advanced. All keepers should be aware of "normal" behavior in order to determine if a bird's behavior is changing. Sudden behavioral change is easily recognized; more subtle changes in behavior can be indicators of problems or issues and thus must be recognized to provide the best care for the birds. (Bailey *et al.* in prep.)

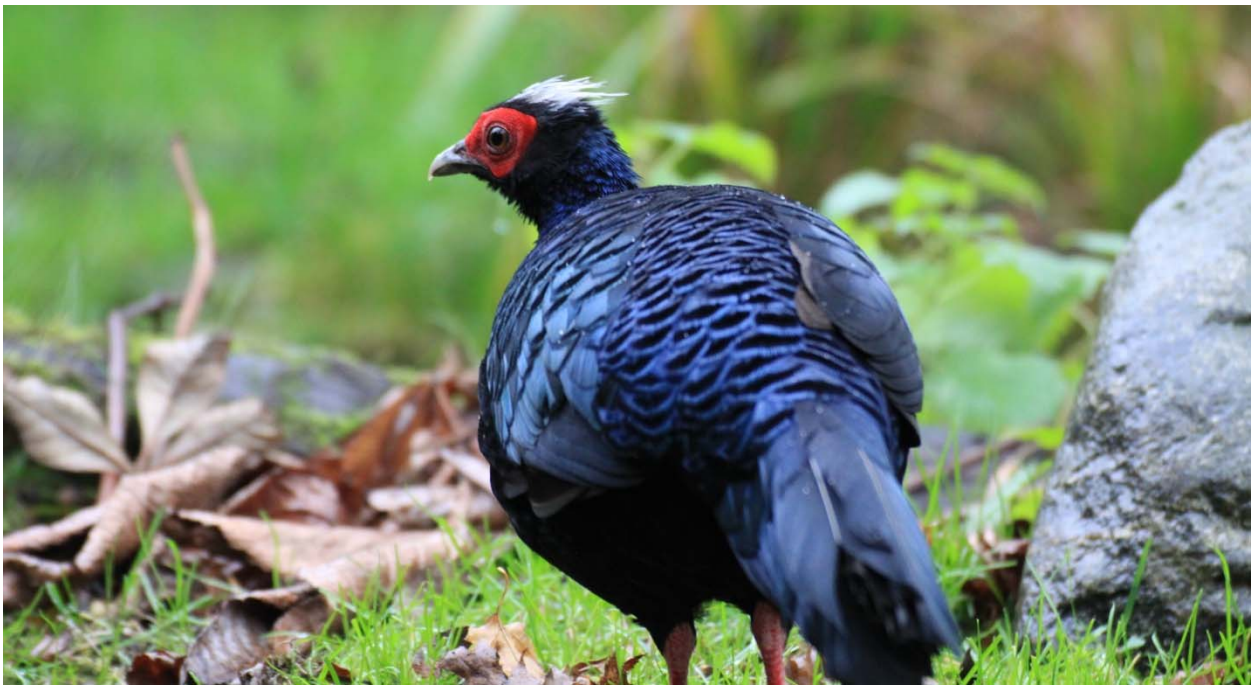


Fig 51: Healthy looking male Vietnam pheasant © Hubert Fryca

Quarantine

Any bird entering a new collection should be placed in quarantine for a recommended period of 30 days, even if the bird appears healthy and there has been no history of infectious disease at the collection of origin. Quarantine should take place in a suitable enclosure that is separated from the main collection and should be maintained by keepers that otherwise do not come into contact with birds. Local regulations on quarantines can differ among countries so it is advised to check requirements with the respective local authorities. (Owen 2017)

During the quarantine period faecal samples should be taken at least 3 times to check for internal parasites.

Infectious diseases

Vietnam pheasants do not appear particularly susceptible to any infectious diseases in captivity. However, in theory, they can be infected by the full range of diseases summarized in Coles (2009).

Clinical signs of infection, regardless of the pathogen or organs affected, include dehydration, lethargy, diarrhea, increased respiratory effort and weight loss. As with most other avian species, death can ensue quickly. Therefore, diagnostic tests including serum/plasma biochemistry and complete blood count should be performed at the first observation of abnormalities and early treatment with antibiotics,

antifungals and anti-parasitics can be effective (the right jugular vein is preferred for collecting blood; no more than 1% of the bird's body weight should be collected).

Collection of faecal samples for faecal parasitology and bacteriology screening can be achieved even in mixed species aviaries. Therefore, these tests should be performed 2 to 4 times annually, with deworming performed based on these results. The most common endoparasites found are coccidia and strongyloides (*Capillaria* and *Syngamus*), although positive faecal parasitology results are rare.

Aspergillosis occurs especially among young birds up to 2 years (Hennache 2001). Laboured breathing and weight loss are the first signs. The infection can be prevented by avoiding accumulations of rotting plant matter such as old straw. Aspergillosis can also be activated by stress in young birds that have been dominated by siblings or other young stock. Giving the birds more space and additional perches can offer some opportunities to move away or hide from more dominant birds, and can often reduce these pressures.

Avian tuberculosis has also been reported within the EEP (Hennache 2001). Again, good hygiene can prevent this disease. It is especially important to pay close attention to newly arrived birds, because the disease also seems to be stress induced.

Non-infectious diseases

Egg binding has been observed in this species. The clinical signs are non-specific and similar to the ones listed for infectious diseases. Coelomic palpation can reveal presence of an egg, but radiographs of the coelom may be required to determine the size and position of the egg to help plan the best treatment option. Unless the egg is extremely malformed or large, manual extraction through lubrication and gentle massage is usually sufficient. After removal of the egg, investigation of underlying husbandry and medical causes of egg binding should be performed to prevent recurrence.

Exertional (capture) myopathy can also be a problem when there is prolonged stress associated with capture and restraint. Clinical signs are weakness and inability to stand shortly after capture. Serum/plasma biochemistry frequently reveal high levels of creatinine kinase and a stress leucogram on complete blood count. Treatment includes intravenous fluids to prevent renal compromise, rest in a warm, dark, quiet, stress-free area and supportive care as required. The prognosis of exertional myopathy can be unpredictable, but if treatment is started early and renal compromise is avoided, the chances of a full recovery is fair.

Head trauma is one of the main causes of death reported in the EEP (Hennache 2001) mainly due to injury from mate or self-inflicted injury after a transfer. Precautionary measures must be taken to reduce stress when changing a bird in a breeding pair. The female must be monitored carefully during the breeding. Scalping injuries range from very minor lacerations requiring no treatment to large wounds that expose the entire cranium. These larger wounds can be sutured closed with absorbable suture or glued closed with tissue glue. They do not typically require treatment with antibiotics. Cere and carpi injuries are usually abrasions, and can be cleaned and treated with topical antibiotic ointment.

Section 3: References

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