the animals can be diverted into either of two compounds to the south of the building, or into the holding yard to the east. The latter measures about 50 × 30 m, while the two other compounds are 26 × 18 m and 12 × 7 m respectively. All are enclosed by a post-and-cable fence similar to that around the main enclosure. A low timber barrier by the fence separating yards from enclosure was intended to stop animals sparring through the fence, but appeared to be unnecessary and when broken was not replaced. The compound floors are 15·2 cm reinforced concrete and drained; the holding yard is large enough to be left grassed.

An access road to the building was required in time for the animals' delivery. As they were to arrive in large crates on 18 m long low-loader transporter vehicles and were to be unloaded by crane, a particularly large turning area was laid out beside the holding yard into which the rhinos were first to be released. This also proved valuable later, whenever animals have been moved to other zoos. For speed and economy the road and turning area were constructed in 15·2 cm thick weak concrete, using large aggregate. When building work was complete, they were surfaced with tarmac.

The planned timing was achieved, and the enclosure, holding yard and access road were all ready when the convoy of transporters arrived on 5 August 1970. The rhinos began occupying the indoor quarters on 20 October, and everything was completed by 18 December, ten months after the brief had been received.

Manuscript submitted 20 July 1978

Moats and ditches at London and Whipsnade Zoos

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Previous editions of the *Yearbook* have contained several articles dealing with the various types of barrier used round zoo animal enclosures. The merits and defects of the various systems have been discussed and the philosophy behind their design promulgated, the general principles being particularly well covered in the article dealing with the moated and fenced enclosures at Frankfurt Zoo (Scherpner, 1971).

Rather than cover the same ground we have confined our attention to a review of the moats and ditches used as barriers at Whipsnade and London Zoo, some of which have been in use for many years while others have still to be fully tested. As the older buildings are demolished many of the original barriers have disappeared, but the information represented by their overall dimensions can still provide a useful guide to the jumping and climbing abilities of the animals which have been contained by them. Before starting this review we would point out that the details and dimensions of any barrier must be examined within the framework of the other features of the particular enclosure and the climate of the country concerned. Growing trees and shrubs may provide a way out of an enclosure, and when water freezes, or snow falls, the deepest moat is no longer a barrier.

BEARS

The oldest moats at London are those in front of the bear enclosures on the Mappin Terraces, which were inspired by Carl Hagenbeck's scenic panorama at Hamburg and completed in 1914. The Terraces have been successful in containing the animals, although for most of them the bare concrete surfaces are now no longer considered a suitable habitat.

There are two widths of moat, the smaller being 335 cm wide with a vertical wall of 320 cm on the public side and 350 cm on the animal side (Fig. 1a). An 83 cm high concrete wall with a 30 cm rail on top runs between the public walkway and the moat; the enclosure level is some 137 cm above the level of this walkway. The larger moat is 396 cm wide, 320 cm high on the public side and generally 380 cm on the animal side (Fig. 1), although some sections of this wall are only 308 cm high. The average height of the wall surrounding the enclosure is 320 cm. The wider moats were intended to serve as barriers to the Polar bears *Thalarctos maritimus*, although these animals have also been exhibited in the other enclosures. Other bears which have been kept include the Eurasian brown bear *Ursus arctos*, the American black bear *Euarctos americanus*, the Spectacled bear *Tremarctos ornatus*, and the Asiatic black bear *Selenarctos thibetanus*. The moats are also used as runs when transferring animals between enclosures.

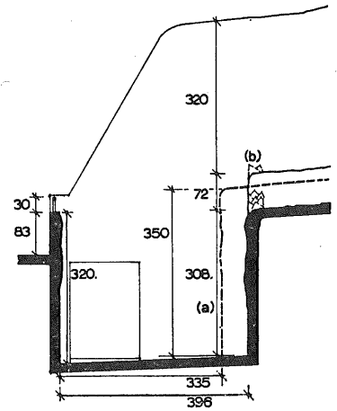


Fig. 1. Moat to bear enclosures (London, 1914): heavy line shows width of moat for Polar bears; broken line (a) shows moats for Brown and American and Asiatic black bears; (b) sharp stones added to discourage begging.

The row of angular stones (Fig. 1b), laid along the top of the wall on the enclosure side, is the only addition to the original design. This rather unsightly feature was added when the zoo banned the feeding of animals by the public. It was found that visitors could not resist the rows of begging bears sitting along the edge of the moat, and the stones were added to discourage this practice.

GIANT PANDA

Giant pandas *Ailuropoda melanoleuca* have been kept at London Zoo for many years, the earlier specimens housed in existing structures, including the old Lion House. The first exhibit designed specifically for this animal was constructed in 1949 and consisted of a 13 m diameter circular enclosure with concrete block walls some 205 cm high. In 1959 a new and larger enclosure approximately 13 × 19·8 m was constructed for the ♀ panda 'Chi-Chi'. This had a 274 cm high artificial rock wall at the back with 203 cm walls round the sides, formed from standard precast concrete retaining wall units with an *in situ* concrete ring beam round the top to keep the units in line. Later, in connection with efforts to provide breeding facilities for Chi-Chi and Moscow Zoo's 'An-An' (Brambell, 1974), the old rhinoceros enclosures were adapted. The tops of the existing concrete retaining walls were cut back at ground level and a new vertical brick wall built on top (Fig. 2a), giving a total height of 240 cm on the animal side and 100 cm on the public side. A rail was run along the top of this wall to discourage children from sitting on it and the additional height stopped any physical contact between public and pandas. A dividing fence, 243 cm high, ran between the two enclosures, the bottom two-thirds of which were covered with mesh to allow some contact between the two animals, with vertical plywood panels along the top to stop them climbing over.

The present panda pair 'Chia-Chia' and 'Ching Ching' are housed in temporary quarters in the Sobell Pavilions, in a section originally intended for small and medium sized monkeys. The enclosures are surrounded by a light mesh, only 3·25 mm in diameter with an aperture of 100 × 40 mm. The pandas have shown remarkable climbing abilities and have fully exploited the facilities provided in this building (Toovey & Brambell, 1976), using the original climbing frames and the additional ladders and posts added for their benefit. In view of the Giant panda's now proven climbing ability, it must be assumed that the walls in earlier enclosures were successful only because of their smooth surfaces.

RHINOCEROSES

Several types of moat have been used round the various rhinoceros enclosures at London, the first of which was constructed in 1958 and was the one which was later adapted for pandas. In its original form it consisted of precast concrete retaining wall units set in the ground to form a wall 175 cm high with a mesh panel on top to protect the public (Fig. 2). The enclosure itself was grassed except for the bottom of the slope

rising from the 150 cm wide moat, which was finished in rough textured concrete to prevent erosion. A wide ditch ran between the two animal enclosures, in the centre of which a barrier was formed from 175 cm high oak posts, 30 cm in diameter and positioned at 75 cm intervals (Fig. 2b).

The dimensions of the original moat, having proved satisfactory, were copied when the new enclosures attached to the Elephant and Rhinoceros House were constructed in 1965. The external rhinoceros moat consists of a 335 cm wide ditch with a 175 cm high brick wall on the public side and a 32° textured concrete slope on the animal side (Fig. 3). It was originally thought that the rhinoceroses, both White *Ceratotherium simum* and Black *Diceros bicornis*, would not venture down into the moat, but it was soon

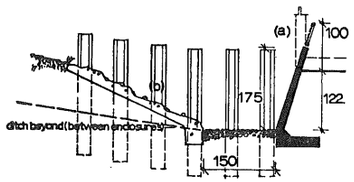
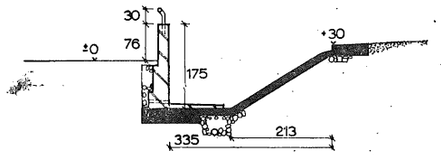
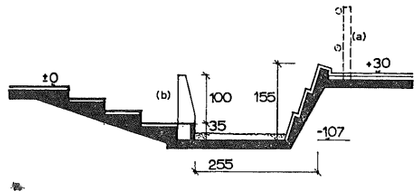


Fig. 2. Rhinoceros enclosure (London, 1958) later adapted for Giant panda (1966), now demolished. a. vertical brick wall 240 cm high added for Giant panda; b. oak posts as division between rhinoceros enclosures (later removed).

found that they could easily negotiate this obstacle, so that the moat merely serves as an extension to the enclosure, with the brick outer wall forming the barrier. On the public side the wall is 76 cm high with a 30 cm rail on top. Visitors can touch the animals when they are in the moat.

The internal moat is much smaller, being approximately 255 cm wide, with a 155 cm high stepped brick-faced wall on the animal side (Fig. 4). A row of 135 cm high concrete posts, with 18 cm gaps between, runs between the public area and the moat. One serious defect associated with this moat is the lack of a permanent exit in the event of an animal falling in. When the original brief for the building was prepared, the successful breeding of rhinos was a much rarer occurrence than today. Allowance was made for young animals by the provision of





Figs 3 and 4. Dry moat to external (above) and internal (below) rhinoceros enclosure (London, 1965). 4a. temporary 135 cm high post-and-rail barrier for young rhinos; 4b. concrete bollards between public area and moat.

floor sockets into which temporary posts and rails could be erected along the edge of the moat as a bar to their falling in (Fig. 4a). Owing to recent changes and improvements in management and breeding, these now remain up most of the time.

At Whipsnade the rhinoceros enclosures are much larger, and a cheaper form of moat construction, which followed the existing contours of the ground and consisted of a sloping wall of old railway sleepers, had to be used (Fig. 5) (see Toovey, pp. 270–274). Following the general excavations, the sleepers were laid at an angle of 60° and held in position by a concrete strip along the bottom and a rail, tied back into concrete blocks with 18 mm metal rods, along the top. The resulting wall height works out at approximately 205 cm, with the ground level on the public side being 35 cm below this. Elsewhere a 150 cm high fence is used, consisting of 150 × 150 mm timber posts at 275 cm intervals with 9 mm diameter galvanised cables set at varying heights.

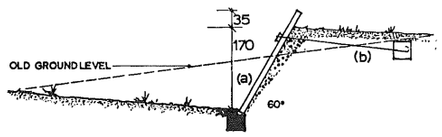
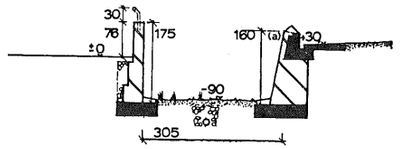
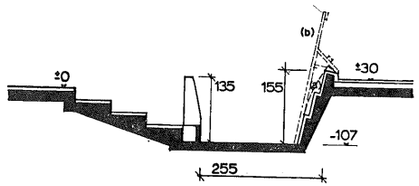


Fig. 5. Dry moat to rhinoceros enclosure (Whipsnade, 1970). a. railway sleepers; b. 18 mm metal ties.

ELEPHANTS

As previously noted, the rhinoceros enclosures at London adjoin those for the elephants and the details and dimensions of their moats are similar in many respects. The external elephant moat is 305 cm wide with a 175 cm high brick wall, topped by a 30 cm rail on the public side and a 160 cm wall on the animal side (Fig. 6). The rail on the outer wall stops children sitting on it and gives additional height in the event of an animal falling into the moat. The ground level of the enclosure is some 30 cm higher than the public viewing level and then slopes up to the building. Originally the top of the wall on the animal side was finished with a square section, but to discourage the elephants from standing on the edge of the moat and begging for food, this was changed to a sloping, pointed section (Fig. 6a). The benefits of a policy of banning the public from feeding the animals, apart from a better diet, have been described (Crompton, 1970). Unfortunately such a policy is difficult to enforce, and although the moat has proved a fairly effective barrier, it would have been more successful if it had been a little wider. At the moment trunk and hand can just meet and this led to the death of one animal, which while begging for food on the edge of the moat was nudged in by a jealous companion. It fell awkwardly and although the bottom of the moat is covered in grass, broke some bones. This accident illustrates how easily





Figs 6 and 7. Dry moat to external (above) and internal (below) elephant enclosures (London, 1965). 6a. top edge modified to discourage elephants from standing on wall; 7a. steps filled in and top modified; 7b. additional 137 cm high steel post-and-rail barrier.

zoos can create potential hazards in their efforts to provide open enclosures for the animals and better viewing for the public.

The internal moats for the elephants are identical to those for the rhinos, being 255 cm wide with a 155 cm stepped brick wall on the animal side and concrete bollards on the public side of the moat (Fig. 7), and again without a permanent way back into the den. This moat has proved to be the least successful in the zoo and has been modified several times. The first defect proved to be the stepped section of the wall on the animal side, the ledges of which had been designed to support a temporary structure to enable any animal falling into the moat to climb back out again, but in fact encouraged the African elephant *Loxodonta africana* to climb down. This problem was overcome by filling in the steps and forming a sloping, pointed top, similar to the modification carried out in connection with the external moat (Fig. 7a). Several changes of policy then occurred which radically altered the whole concept of having a moat at all. It was decided that it would be better if the elephants were left unchained, and at the same time experiments with artificial insemination (Nevill *et al.*, 1976) suggested the possibility of breeding elephants, a factor that had not been considered when the building was originally designed. Moreover, the possibility of an animal falling into the moat was a risk no longer acceptable. To overcome this problem a 137 cm barrier, constructed from 125 × 63 mm steel channel rails with similar posts set at 198 cm intervals (Fig. 7b), has been erected. If this barrier proves successful the moat will cease to act as an animal barrier, although it will still keep the public away from the animals.

The elephant moat at Whipsnade seems to have been more successful. It is 350 cm wide at the top, with a 155 cm log-faced wall on the animal side and a 125 cm high brick wall on the public side (Fig. 8). The bottom of the moat is filled with

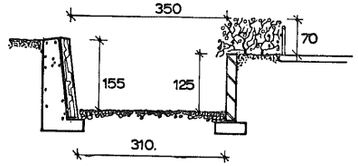


Fig. 8. Dry moat to elephant enclosure (Whipsnade).

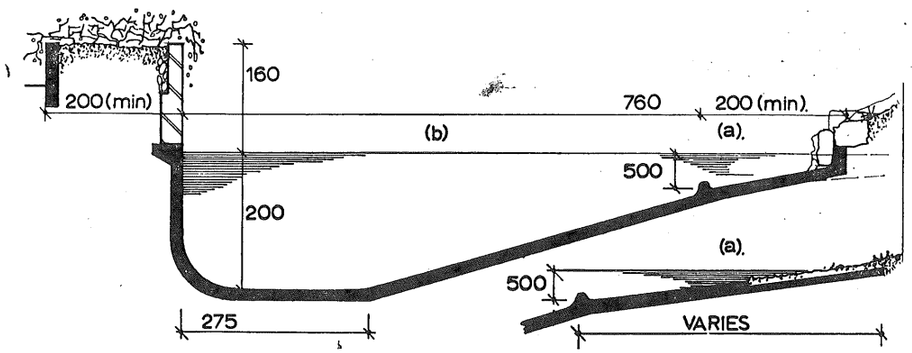


Fig. 9. Moat to lion enclosure (London, 1976). a. shallow safety area of moat with ledge (shown in detail, lower right); b. critical jumping distance 760 cm.

loose gravel and there is a 90 cm width of 70 cm high planting between the moat and the path on the public side. The combined dimensions of the moat and planting, amounting to some 440 cm, means it is impossible for the public to feed the elephants by hand and reduces the risk of animals falling into the moat. The rear fences of the enclosure are formed from 175 × 100 mm metal posts set into the ground at 157 cm intervals with three 60 mm diameter horizontal metal tubes forming a barrier 176 cm high.

LIONS

One of the newer moats at London is in front of the lion *Panthera leo* enclosure in the New Lion Terraces which were completed in 1976. This moat was based on similar ones in Europe and the United States and consists of a 760 cm width of water, which acts as the security barrier, with a shallow area, of varying width, beyond (Fig. 9). The shallow area is intended as a safety zone, particularly for young animals, and has a ledge between it and the deep water to stop them sliding beyond their depth. In some parts the shallow section forms part of a 'beach' (Fig. 9a), which then slopes down to a 275 cm width of 200 cm deep water, with a 360 cm high wall on the public side of the moat. A planting bed, with a minimum width of 200 cm, runs between the public path and the edge of the moat. The solid walls of the buildings at the rear of the enclosure have a minimum height of 450 cm, and at the sides are 470 cm high mesh panels, some vertical with an overhang, the others inclined inwards at an angle of 22½° to avoid the use of an overhang. The mesh is made from 4·88 mm wires and has 190 × 100 mm apertures.

UNGULATES

Some animals, which are not normally dangerous to the public and which respect a moat as the boundary to their territory, can be kept behind quite small barriers (Scherpner, 1971). The moats at London which illustrate this are those round the paddocks attached to the Giraffe and Cattle Houses. These have held many species, including llama *Lama glama,* guanaco *L. guanicoe,* alpaca *L. pacos,* vicuna *L. vicugna,* Bactrian camel *Camelus ferus* dom., Arabian camel *C. dromedarius,* giraffe *Giraffa camelopardalis,* yak *Bos mutus* dom., European bison *Bison bonasus,* American bison *B. bison,* zebra *Equus burchelli* and *E. grevyi,* onager *E. hemionus onager* and Przewalski horse *E. przewalskii.* The moats between the animal paddocks are only 305 cm wide and 95 cm deep (Fig. 10), with steps on each side to allow animals to climb out in the event of an accident. Many of the animals could cross these barriers, but in practice rarely do so. A ♂ European bison invaded the yak's territory but was repulsed and young onagers have crossed into the Przewalski horse paddock. After 15 years the only addition to the security arrangements has been the erection of a low timber rail around the giraffe paddocks to warn these long-necked animals when their feet are near the edge of the moat (Fig. 10a).

The moat between the animals and the public is the same width, 305 cm, as the one between the paddocks, but is 120 cm deep and has steps on the

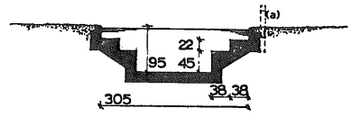


Fig. 10. Moats separating ungulate enclosures from one another (London, 1963). (The moats between animals and public are deeper (120 cm) and stepped on animal side only.) a. low timber rail around giraffe paddock only.

animal side only. Beyond the moat is a strip of planting some 90 cm wide which keeps children away from the water and at the same time forms an additional, visual, barrier to the animals, none of which has ever escaped into the public areas. An incident which illustrates how conscious many of the animals are of the boundaries of their territory took place when the Giraffe House was being rebuilt. While the main section of the building was being altered the giraffes were housed in the side wings, the animals being allowed out into the paddock in front of the building, which was also divided by a fence between the two sections. When the time came to move the giraffes back into the main building the dividing paddock fence was removed and the animals encouraged to walk back over to their new quarters. This they were most reluctant to do and for several days some animals refused to cross the line where the dividing fence had stood.

SMALL MAMMALS

Most zoos have a number of smaller exhibits and at London there are several of these enclosures, some of them quite old, which have housed a wide variety of animals. One of the oldest was built in 1905 and is now used for Canadian beavers *Castor canadensis,* although it has also contained otters and Red pandas *Ailurus fulgens*

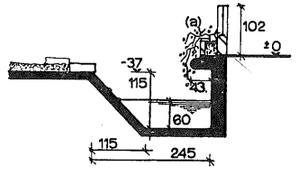


Fig. 11. Moat to beaver enclosure (London, 1905), also used formerly for otters and Red pandas. a. windows, walls and planting added 1971.

Fig. 12. Wall to otter enclosure (London, 1969).

in the past. The original barrier consisted of a 115 cm deep moat with a 43 cm overhang; the average depth of the water for aquatic animals is about 60 cm. A brick wall, with glass panels and a planting strip facing the moat, was added in 1971 to keep the public away from the moat edge (Fig. 11).

The present Otter Exhibit was constructed in 1969, and is surrounded by a 170 cm high brick wall with flush pointing to prevent animals gaining a toehold. (Fig. 12). The walls have rounded junctions at changes in direction to avoid 90° angles that might assist a climbing animal. The Canadian otter *Lutra canadensis* has been successfully contained by this barrier. Adjoining the Otter Exhibit is an old pool that was originally built in 1912. Now containing coypu, it has a 125 cm wide moat and a 90 cm high wall with a 25 cm overhang (Fig. 13). For many years this exhibit was used without any trouble, when a combination of blocked overflows and the water supply being left on all night caused the water level to rise to the top of the wall and allowed the occupants (beavers) to escape. To avoid a repetition of this event and to conform to regulations regarding the keeping of coypu *Myocastor coypus,* the enclosure is now surrounded by a 112 cm high meshed fence, the top section of which has a solid panel to stop these animals climbing out (Fig. 13a).

The Californian sealions *Zalophus californianus* are kept in their enclosure by 130 cm high meshed fences and brick walls, with a rail on top, of similar height. This barrier has proved quite

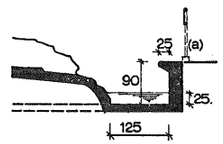


Fig. 13. Moat to coypu enclosure (London, 1912), also used formerly for beavers. a. 112 cm high meshed fence added to prevent animals climbing out.

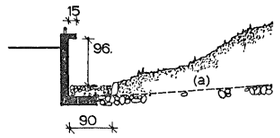


Fig. 14. Wall to Prairie marmot enclosure (London 1965), now demolished. a. wiremesh below ground level (over drainage media) to prevent escape by digging.

sufficient with the exception of one area where some rocks came too close to the wall, in the past allowing some animals to escape.

Another old enclosure, now demolished, contained Prairie marmot *Cynomys ludovicianus*. The surrounding wall was 96 cm high with a 15 cm overhang (Fig. 14), and again a metal rail along the top to discourage people from sitting on it. This enclosure had the usual mesh below ground level (Fig. 14a) and was more successful in stopping the marmots from escaping than the old enclosures at Whipsnade, which lacked this feature.

Lastly we should mention the series of ditched enclosures which were constructed in the early 1930's at Whipsnade. These vary from 200 cm to 250 cm in width and from approximately 180 cm to 197 cm in height (Fig. 15), and over the years have retained onagers, Przewalski horses, camels, various deer, and many other animals. It should be noted that most of the enclosures are extremely large and the occupants have plenty of space to take evasive action in times of stress, so reducing the likelihood of their needing to cross the barriers. More recently some of these species have been moved to enclosures where a post and rail timber fence forms the main barrier, strengthened on the enclosure side by a narrow ditch excavated in the stony clay soil. This feature breaks the charge of aggressive animals and extends the jumping distance required to clear the barrier. The system appears to be effective, but as it has only been in use for a few years it is perhaps too early for proper assessment.

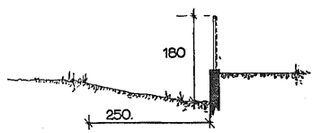


Fig. 15. Typical ditch to ungulate enclosures at Whipsnade (1930's).

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Manuscript submitted 22 May 1978

studbooks

Studbook for the Edwards' pheasant

Lophura edwardsi

in captivity

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In 1975 the World Pheasant Association was granted permission by IUCN and IUDZG to form a studbook for the Edwards' pheasant *Lophura edwardsi*. There were several reasons why this species was selected for the survey, the most extensive devised for any bird species (Lovel, 1977). In the wild its status was unknown, but it was believed to be vulnerable due to its restricted range in Central Vietnam (Delacour & Jabouille, 1925), the difficulty of observing it in its natural habitat (Delacour, 1977), and the effects of warfare and of herbicidal spraying (Hickey, 1974).

In captivity its numbers were more plentiful, but imprecisely known. The species was becoming increasingly difficult to breed reliably. Many eggs were infertile. In America many ♂♂ had a reduced or absent white crest, and in the UK virtually no ♀♀ were being produced. The increasing difficulty and expense of moving birds from country to country appeared to be causing isolation of the available genetic material, and it seemed that unnecessary inbreeding might be adding to the problems; the danger of this has recently been well reviewed by Kear (1977) and Bouman (1977).

METHODS

After a preliminary survey in 1975 to assess the likely response, which was favourable, a questionnaire in English was sent to all known breeders in 1976, and in English, German and Dutch in 1977, asking for details of their stock and breeding results. When the completed form was returned, a serial number was allocated to each individual bird and a studbook card was issued together with a leg ring, both bearing the serial number. Wing bands were offered as an alternative, but were universally disliked. The rings used were open ones, since the difficulty of ringing young chicks with closed rings was considered insurmountable. In 1976 the rings bore only the serial number, but in 1977 an improved design in heavier gauge metal was used, and in addition all young birds bred in that year had the prefix 77— before their serial number. The same will be done in 1978 and subsequent years.

RESULTS

No major collection refused to co-operate, and many volunteered the names of other breeders previously unknown to us. However, several breeders known to keep the species have not replied, either through pressure of work, dislike of filling in forms, or fears that their hobby was becoming increasingly regulated and controlled.

The results are shown in Tables 1 and 2. For reasons of space it is not possible to give details of each collection individually, and therefore they are summarised country by country. The studbook is however open to all who wish to obtain more detailed information (for the address, see p. 424); indeed several breeders have asked how best to pair up a bird, or how to locate other breeders. [Collections (mainly zoos) which have replied to the *Yearbook* census are listed on p. 392. Ed.].

Table 3 shows the breeding results for 1977. It is clear that infertility is a major problem, for only 41% of eggs laid were rated fertile by the breeders. However, once hatched the proportion of chicks reared was gratifyingly high. Adult pairs are not included in Table 3 if they produced no eggs, or if their owner did not incubate the eggs laid. This has been a disturbing trend recently in the USA, where Federal legislation has made it extremely difficult to sell young birds of an endangered species across state boundaries. Some breeders ate the eggs – one even ate the birds he had bred, and suggested to the Federal authorities