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THE rearing of grouse and quail for enjoyment, profit, or stocking in the wild has been an important aspect of grouse and quail biology. The very presence of chukar and gray partridges in North America, the occurrence of ruffed grouse in Newfoundland and Nevada, the presence of bobwhites, scaled quail, and California quail in Washington, and many other examples are ample testimony to the potential value of careful propagation and release programs. Between 1938 and 1968 a total of 110,663 bobwhites, 18,136 other native quails, 7,977 grouse, and 50,568 chukar partridges were released under Pittman-Robertson programs in the United States (based on a recent summary provided by the Bureau of Sports Fisheries and Wildlife). An additional but unspecified number of gray partridges was also part of the release program. Yeatter (1935) estimated that more than 260,000 of these birds had been released in North America by the 1930s.

The problems of keeping and breeding grouse in captivity are distinctly different from and much greater than those of propagating quails and partridges, and as a result relatively few persons have succeeded in keeping and breeding grouse in large numbers or with consistent success. This is largely a reflection of the greater sensitivity of grouse to various poultry diseases and parasites that are transmitted by ground contact, forcing the game breeder to keep the birds on wire-bottom cages where they can have no direct contact with the ground or their own droppings. A summary of

the diseases and parasites of grouse and quails has been provided by Bump et al. (1947) and Stoddard (1931), respectively, although the treatments recommended have been greatly modified in more recent years.

Flieg (unpublished ms.) has summarized the difficulties of keeping grouse (and, to a lesser extent, quail) on the ground and the treatment or preventative measures for the most commonly encountered diseases and parasites. These include coccidiosis, enteritis, caecal worms, blackhead, and capillaria worms. Coccidiosis is caused by a protozoan parasite (*Eimeria*) that is a serious problem with both quails and grouse, but it can be prevented by adding Amprolium to the diet at the rate of three-fourths cup to twenty-five pounds of feed and can be treated with Sulmet. Intestinal inflammation, or enteritis, can be avoided by adding NF-180 to the food in the amount of one ounce per twenty-five pounds of food, although this reduces male fertility and therefore must be discontinued during the breeding season. Caecal worms (*Heterakis*) are probably more serious in grouse than in quail because of the more highly developed caeca of grouse, and a serious infection can be lethal. The use of Hygromix at the rate of one ounce to twenty-five pounds of food serves as an effective treatment for these worms as well as most other worm parasites. A related infection is enterohepatitis or blackhead (caused by *Histomonas*), which is often carried by *Heterakis* and affects both the liver and digestive tract. A preventive measure is Emtryl at the rate of three teaspoons per twenty-five pounds of feed, and higher doses can be used for treatment.

Probably the worst enemy of grouse in captivity is the cropworm (*Capillaria*), which, although not usually a serious threat to wild grouse, may cause severe losses in captive birds. It has been reported in the ruffed grouse, rock ptarmigan, sharp-tailed grouse, and pinnated grouse (Braun and Willers, 1967). It is apparently less serious in quail but has been reported to occur (Hobmaier, 1932). Flieg reported that one ounce of vitamin A premix to twenty-five pounds of food may be used to prevent and partially control cropworm, while a much more dangerous drug, Task, will serve as a more thoroughly effective treatment if used with extreme care.

Pullorum disease, a bacterial infection caused by *Salmonella*, and aspergillosis, a fungus disease of the respiratory tract, are other serious problems for the person who keeps grouse and quail. Both of these present difficult treatment problems, but Flieg reported some success in treating *Salmonella* infections with antibiotics such as Neomycin and Cosa Terramycin. Aspergillosis and similar fungal diseases may be avoided by adding copper sulfate to the drinking water or by treatment with a product of Vineland Poultry Laboratories called Copper-K, a combination of acidified copper sulfate and synthetic vitamin K (Allen, 1968). Staphylococcus infections can sometimes

be treated effectively with Tylocine and B-complex vitamin preparations (McEwen, Knapp, and Hilliard, 1969).

Many of these problems can be avoided or minimized by keeping the birds on wire, but this poses new problems of providing grit and dusting places for feather maintenance and if the floor is unsteady may also reduce the probability of effective fertilization during copulation. The absence of natural vegetation for hiding and nest-building may further inhibit reproductive success in birds maintained on wire-bottom cages.

General principles of breeding game birds, especially quail and partridges, have been summarized well by Greenberg (1949). It is impossible to summarize all of the points made by him in the space available here, and only a few highlights might be mentioned.

EGG CARE AND INCUBATION

Eggs should not be held longer than a week before being placed in the incubator, and during storage they should be kept at a temperature of between 50 and 60 degrees Fahrenheit and a relative humidity of about 80–90 percent. Placing the eggs in plastic bags during storage improves their hatchability (Howes, 1968; Kealy, 1970), and they should be stored with the pointed end down. Tilting them or turning them daily during the preincubation storage period is also desirable. Incubation may be done in either a still air or forced air incubator, with the latter being generally preferred although considerably more expensive. In either case, the eggs should be rotated ninety degrees every three to six hours, or at a similar regimen, until the last few days of incubation when they are moved to hatching trays. Ideal incubation temperatures differ with the incubator type. Romanoff, Bump, and Holm (1938) stated that the ideal temperature for incubating bobwhite eggs is 103 degrees in still air incubators (60–65 percent relative humidity) during the first two weeks, and 99.5 degrees in forced air incubators (similar relative humidity) during that period. During the last two or three days of incubation the temperature should be slightly higher (0.25 to 0.5 degree) for best results, and there should be an increase in the availability of fresh air. Depending on the species, the final humidity should either be somewhat lower or higher than earlier in incubation, with higher humidity generally recommended for quail eggs. Chukar and gray partridge eggs are usually put in a still air incubator for the last few days (103 degrees) at a slightly higher humidity.

In their studies of prairie grouse, McEwen, Knapp, and Hilliard (1969) found that hand-turned incubators were unsatisfactory for grouse eggs and recommended using an incubator with automatic turning and a temperature

for the first three weeks of 99.75 degrees F., with a wet-bulb reading of 82–86 degrees F. After the eggs are placed in the hatching incubator, they are held at a temperature of 99.5 degrees F. and a wet-bulb reading of 90–94 degrees F. Moss (1969) reported that ptarmigan eggs could successfully be hatched in a still air incubator provided that the humidity was held as high as possible. Bump et al. (1947) reported that still air incubators were preferred over forced air models for incubating ruffed grouse eggs. They recommended an incubation temperature of 103 degrees F. for still air models and 99.5 degrees for forced air machines, and a 60–65 percent relative humidity, with eggs being turned three to four times a day during the first twenty days. During the last few days of incubation the humidity and temperatures should be maintained at these same levels.

CHICK CARE

Following hatching, chicks must be provided with supplemental heat, either in the form of broody hens as foster mothers or artificial brooders. For artificial brooders, newly hatched chicks should initially be exposed to a brooder temperature of 95 degrees F., which is gradually reduced so that by the time the birds are about two weeks old the brooder temperature is around 70 degrees F. Newly hatched chicks should be provided with a high-protein food such as chick starter and in addition may benefit from finely cut fresh green leaves such as lettuce, endives, or dandelion. For many delicate species, the availability of live insect food such as meal worms (*Tenebrio*) may be crucial in inducing the young to begin eating. Shoemaker (1961) found that coating the worms with a vitamin-mineral concentrate avoided weakness in the legs (perosis), generally thought to be related to manganese deficiency. Dellinger (1967) indicated that he was able to stimulate feeding in harlequin quail chicks by sprinkling Purina Startina with hard-boiled eggs and finely chopped greens on a paper towel, to which he added small live and chopped up meal worms. For water, he recommended jar lids filled with water and marbles, with one-half teaspoon of Furacin or Terramycin added per quart of water as a disease preventative. Coats (1955) dipped meal worms into egg yolk or corn syrup, then dusted them with high protein starter mash, to initiate chick feeding.

Problems that might be encountered in the raising of grouse chicks have been discussed by a number of writers, including McEwen, Knapp, and Hilliard (1969), Fay (1963), and Bump et al. (1947). Fay recommended an initial brooder temperature of from 100 to 105 degrees at chick-level. He used various game bird starter feeds, as well as limited amounts of fresh green material. He also added soluble Terramycin to the drinking water

at the rate of one teaspoon of powder to two gallons of water. McEwen, Knapp, and Hilliard found that water could effectively be provided to young chicks without the danger of drowning by using dripping siphon tubes at the eye-level of the chicks. The rate of dripping can be controlled by clamps, and the water falls through the mesh floor to be caught below the cage.

Howes (1968) recommended vaccination of young chicks for bronchitis and Newcastle disease if the birds were kept near other poultry by adding the vaccine to the drinking water. He also advised vaccination against pox.

Cannibalism, the pecking of chicks by one another, is frequently a serious problem, especially where crowding is necessary. Such pecking may be reduced by providing sufficient grit, a source of greens or other roughage at which the birds can peck, and a balanced diet. Trimming of the beak may also be necessary to prevent serious damage or even death when pecking becomes a major problem.

CARE AND HOUSING OF ADULTS

In the case of quail, considerable numbers of adults can usually be maintained in fairly small pens, although breeding is no doubt more successful when paired birds can be individually housed. The well-known McCarty pens, described by Greenberg (1949), provide a proved method for housing and breeding quail, chukar partridge, and gray partridge and are probably also suitable for certain grouse. Bobwhite quail can be effectively housed in such breeding compartments with two females per male; in spite of their monogamous pair bonds under natural conditions two females will readily tolerate each other in captivity. Recently a technique for artificial insemination of bobwhites has been developed (Kulenkamp, Coleman, and Ernst, 1967) which has produced fertility and hatchability rates as high as those achieved with natural mating.

Minimum space requirements for grouse are considerably greater than those for quail, because of both the generally larger sizes of the birds and their reduced social tolerance. McEwen, Knapp, and Hilliard (1969) recommended that at least thirty square feet of floor space per bird was required for minimizing conflicts among prairie grouse. Thus, a five-by-eighteen-foot pen would accommodate a maximum of one male and two female grouse, and a ten-by-eighteen-foot pen could serve for up to four or five birds. It is important when keeping grouse to provide enough natural cover or artificial hiding places for the female to retreat to when the male begins to become highly aggressive during the breeding season (Moss, 1969). McEwen,

Knapp, and Hilliard (1969) recommended the use of dusting boxes (with 5 percent Rotenone powder added) to control external parasites.

Probably the most complete summary of the problems of maintaining grouse in captivity is that provided by Bump et al. (1947) for the ruffed grouse. No doubt many of the techniques described for the ruffed grouse are equally applicable to other species. They found that breeding pens measuring 6 by 8 feet wide and 3 feet high were adequate for a single pair of grouse, with one end of the pen enclosed and the other end open wire mesh. They also noted that up to twenty birds could be maintained in pens measuring 8 by 32 feet, especially if ten-inch-high cross-boards were placed at 4-foot intervals to help establish territorial boundaries. A wintering flight pen measuring 25 by 110 feet was judged able to hold up to three hundred full-winged grouse and was constructed around a service room that facilitated feeding and watering the birds.

Greenberg (1949) has summarized the techniques generally used for the propagation of chukar and gray partridges. Elevated wire mesh breeding pens that have a three-by-eight-foot bottom area and are attached to a coop measuring forty by thirty-six inches are recommended for gray partridges. One of these breeding pens is presumably designed for a single pair of partridges, but in all likelihood an extra female could be added without seriously affecting fertility. Studies on chukar partridges summarized by Christensen (1970) indicate that a breeding ratio of three females per male was as effective as using only one or two females per male. Ground pens were generally more satisfactory than elevated ones with wire floors. Fertility and hatchability of eggs from birds that were two years old were higher than in those of younger birds.

Artificial lighting will stimulate earlier and increased egg production in chukar partridge as well as in most American quail species. Studies on the bobwhite (Kirkpatrick, 1955; Kirkpatrick and Leopold, 1952) indicate that artificial illumination of seventeen-hour photoperiods with as little as 0.1 foot-candles will produce egg-laying in bobwhites in from fourteen to forty-four days after the initiation of such lighting. Observations in my laboratory indicate that the scaled, Gambel, and California quails are also stimulated into reproductive activity by increased photoperiods.

RECORDS OF INITIAL PROPAGATION OF GROUSE AND QUAILS

Some species of American quails have been kept in captivity for so long that the earliest date of their propagation under such conditions is unknown. This would certainly apply to the bobwhite, Gambel quail, and California

quail. Audubon quoted an account by John Bachman of an early success in propagation of the bobwhite in captivity, presumably in the early 1800s. Seth-Smith (1929a) reported that the scaled quail was first bred in London in 1913 and that the black-breasted bobwhite (*Colinus virginianus pectoralis*) was bred in 1912. This race of bobwhite and the elegant quail were first imported for the London Zoo in 1911 (*Proceedings Zoological Society of London*, 1912, p. 3). He also noted that the California quail had often been bred in English aviaries, and the elegant quail had also been bred in the London Zoological Gardens. The elegant quail was first bred there in 1912 (*Proceedings Zoological Society of London*, 1912, p. 911), probably its first propagation in captivity. The harlequin quail was perhaps first bred in France, in 1911 (Seth-Smith, 1929a). In the United States it was probably first bred by J. S. Ligon.*

The barred quail was apparently first imported into England in March of 1927 (*Proceedings Zoological Society of London*, 1927, p. 490) and was first imported into the United States in 1933 by K. C. Beck.† There is no definite record that either importation resulted in the birds' breeding. F. E. Strange obtained a pair of wild-caught birds in 1967, and these laid eggs during the next four years, with chicks first being hatched and reared in 1967.

Avicultural data on the remaining species of native quails are limited. The mountain quail has doubtless been kept in captivity for many decades, but I can find no definite record of the earliest breeding success in captivity. Grinnell et al. (1918) reported unsuccessful breeding attempts in the early 1900s, and F. E. Strange‡ first bred mountain quail in the 1930s, as did Ezra (1938). Recent summaries of mountain quail breeding techniques were provided by Schlotthauer (1967) and Bateman (1968).

For the endemic species of Mexican quails there is little information as to the extent of importation and propagation. The black-throated bobwhite was not listed by Seth-Smith (1929a) as having by then been imported into England, and the first record of importation into the United States that I know of was by C. H. Epps, Silverhill, Alabama, in the late 1960s. In 1970 I exported ten of these birds from Mexico, and during the same year F. E. Strange obtained three additional birds from a Mexican source. I have since hatched and reared young of this species.

I can find no record of the singing quail's having been exported from Mexico, and I know of only one instance of its ever having been kept in a zoo. A young bird was brought to the zoo at Tuxtla Gutierrez, where

*F. E. Strange, 1971: personal communication.
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it lived about three or four months.*

The spotted wood quail has probably only rarely been imported into the United States and has apparently never been bred in captivity. There was a single bird in the National Zoological Park in the late 1960s,† and F. E. Strange obtained a pair from Mexico in 1970. They are fairly commonly kept as cage birds by natives in some parts of Mexico, and one individual lived for twelve years in the Tuxtla Gutierrez zoo.‡

There are even fewer records of tree quails' being successfully exported from Mexico. John O'Neill§ informed me that he once saw and photographed a bearded tree quail in the Houston, Texas, zoo, and a buffy-crowned tree quail is presently in the San Diego zoo. I successfully exported five bearded tree quails from Mexico in 1970, and they are now in the care of F. E. Strange, Torrance, California. In 1971 one of these pairs constructed a nest and laid a total of sixteen eggs, from which six young hatched and four were raised, the first known breeding of any tree quail in captivity.

As an index to the relative frequency of quail breeding in captivity, the number of successful propagations listed in the first ten volumes of the *International Zoo Yearbook* have been totaled. These include fifty-two breedings recorded for the California quail, forty-one for the bobwhite, nineteen for the Gambel quail, seven for the scaled quail, and two each for the mountain and harlequin quails. During the same period only two North American species of grouse were reported bred, with two breedings each recorded for the willow and rock ptarmigans. Obviously, these records are highly incomplete and exclude all the private aviculturalists, who are responsible for most of the successful breedings of these birds, but they do provide at least a rough measure of the relative ease of propagation for these species.

Records of successful propagation of North American grouse are far fewer. Perhaps the earliest record of any grouse's being successfully maintained in captivity is that of W. L. Bishop (quoted by Bendire, 1892), who kept spruce grouse in captivity for some time. At present, very few spruce grouse are in captivity, and the only recent rearing success was reported by Pendergast and Boag (1971).

Blue grouse are seen in captivity almost as infrequently as spruce grouse, and the earliest report of successful rearing of this species I am aware of is that of Simpson (1935). Smith and Buss (1963) hatched and reared four blue grouse through their juvenal stages, while Zwickel and Lance (1966)

*M. Alvarez del Toro, 1970: personal communication.
†Kerry Muller, 1970: personal communication.
‡M. Alvarez del Toro, 1970: personal communication.
§1970: personal communication.

hatched and reared twenty-seven chicks from eggs taken in the wild.

A few records of sage grouse propagation exist, including those of Batterson and Morse (1948) and Pyrah (1963, 1964), who hatched and raised birds from eggs taken in the wild.

Ruffed grouse have probably been raised in captivity more frequently than any other grouse species. Edminster (1947) reviewed the history of this species' propagation in captivity and noted that the first instance of rearing birds from eggs taken in the wild came in 1903 but that A. A. Allen developed the basic techniques needed for successful propagation during the 1920s. Later work by the state game biologists of New York resulted in the rearing of nearly two thousand grouse, including birds of the tenth generation.

Success in rearing and propagating ptarmigans has been quite limited. Seth-Smith (1929b) indicated that willow ptarmigan and the related red grouse were successfully reared in England during the early 1900s, but that the rock ptarmigan had only rarely been kept in captivity. By that time, the pinnated grouse, sharp-tailed grouse, and ruffed grouse had also been maintained in captivity in recent years (Carr, 1969), with rock ptarmigan having been reared from eggs to maturity, and the willow and rock ptarmigans surviving well in captivity after having been caught as adults in the wild. Moss (1969) has described techniques used for hatching and rearing ptarmigan from eggs taken in the wild. He reported success in breeding captive stock over a several-year period, so that breeders four or more generations removed from wild birds have been obtained.

One of the earliest persons to propagate pinnated grouse in captivity was J. J. Audubon, who obtained 60 wild-caught birds in Kentucky. He indicated that many of these birds laid eggs, and a number of young were produced. The history of recent attempts to propagate prairie grouse has been summarized by McEwen, Knapp, and Hilliard (1969), who noted that it is only recently that any real success has been attained with pinnated grouse and sharp-tailed grouse. They have maintained individual greater prairie chickens and sharp-tailed grouse in captivity many years, with one male sharp-tail at least seven years old still vigorous and breeding, and one male pinnated grouse attaining six years of age. From more than forty-four hundred eggs laid by captive birds, 375 pinnated and sharp-tailed grouse were reared by them. Some of the greatest success in rearing prairie grouse in captivity has been by Lemburg (1962). He has been rearing sharp-tailed grouse since 1960 and greater prairie chickens since 1965, and he began raising lesser prairie chickens in 1966. During the last few years he has raised an average of 60 to 70 prairie grouse per year, and in some years has raised as many as 100 birds.