Restoration of *Chlamydotis undulata macqueenii* (Houbara Bustard) Populations in Saudi Arabia: A Progress Report

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Abstract

During the last two decades *Chlamydotis undulata* (houbara bustard) has declined drastically throughout its range, due primarily to over-hunting and severe habitat degradation. The threatened extinction of local populations led the National Commission for Wildlife Conservation and Development of Saudi Arabia to implement ex- and in-situ conservation measures: (1) a captive breeding program initiated in 1986, which achieved production of a self-sustaining breeding flock as well as a surplus for reintroduction by 1992; (2) establishment of a 13,775-km² protected area around the last known breeding population in Saudi Arabia; (3) studies of wild birds, to determine densities, feeding ecology, and habitat requirements; and (4) studies on different release techniques (adult releases, sub-adult releases, feather-cut sub-adult releases, and covey releases), carried out since 1991 within the 2,300-km² fenced and protected area of the Mahazat As-Sayd reserve.

Introduction

Restoration of *Chlamydotis undulata macqueenii* (houbara bustard) populations forms part of the National Commission for Wildlife Conservation and Development's conservation plan to restore the former biological diversity of Saudi Arabia (Child & Grainger 1990). This broadly distributed species is separated into three subspecies (Cramp & Simmons 1980): *Chlamydotis undulata undulata* inhabits the North African range; *Chlamydotis undulata flaviaventurae* occurs only on the Canary Islands; and *Chlamydotis undulata macqueenii*, of interest to Saudi Arabia, appears from Sinai to Western Mongolia.

During recent decades, populations of houbara have declined drastically throughout the entire distribution range (Collar 1980). Over-hunting and severe habitat degradation appear to be the major causes of the decline. Although the species has been able to survive a long tradition of falconry in Saudi Arabia, the widespread availability of modern fire arms and four-wheel drive vehicles has made even the most remote populations vulnerable to hunting and has contributed significantly to their alarming decline over the last twenty years. Overgrazing of the fragile desert flora by domestic livestock has caused massive loss of habitat for houbara. The official World Conservation Union category for the houbara is vulnerable, which includes populations that are seriously depleted or decreasing due to over-exploitation or other factors, and that are at risk of becoming endangered if causal factors continue unchecked (World Conservation Union 1990).

The great cultural value of the houbara in Saudi Arabia and concern about the possible extinction of local populations prompted the National Commission for Wildlife Conservation and Development to take conservation measures: the identification of suitable habitat, habitat protection and ecological and behavioral studies of free-ranging populations; and the foundation of a captive-breeding population, with studies on the reproduction biology of the species and the feasibility of eventual reintroduction or restocking programs.

The houbara bustard restoration program has the long-term goal of securing self-sustaining populations of houbara within a network of managed sites in Saudi Arabia. The program has two components: the conservation of wild houbara and the reintroduction of captive-bred birds.

At the beginning of the program little was known about the biology and actual status of houbara in Saudi Arabia. *Chlamydotis undulata macqueenii* is probably a partial latitudinal migrant from the Nile Valley to Mongolia. The houbara breeding in Central Asia are migratory,
whereas breeding populations in the Middle East, and perhaps partially also those from Pakistan, are non-migratory but carry out short-range movements in response to varying food supply and rainfall (Cramp & Simmons 1980). The houbara is adapted to desert environments, preferentially inhabiting undulating, flat, arid plains, steppes and semi-deserts, often with little cover except for open or scattered desert shrubs and receiving between 50 mm and 200 mm annual rainfall, mainly in the winter (Mendelsohn et al. 1979; Coles & Collar 1980; Mendelsohn 1980; Haddane 1985; Mian & Dasti 1985). The reproductive cycle of wild houbara is still largely unknown. Timing of nesting appears to be quite variable across the breeding range but is concentrated in the spring months. Eggs are generally found between March and June, with laying occurring earlier in more southern and western localities (Dementiev & Gladkov 1968; Mendelsohn 1980; Lavee 1988). Some authors have suggested that rainfall is important to trigger reproduction; in Israel most houbara do not breed after winters with little or no rain (Mendelsohn 1980). Age at first breeding is not known (Cramp & Simmons 1980), although sexual maturity is thought to be reached after two years (Mendelsohn 1983). Houbara bustards are reported to produce only one clutch of one to four eggs, laid on alternate days (Heim de Balzac & Mayaud 1962; Chécopar & Hue 1978; Mendelsohn 1980; Urban et al. 1986). A replacement clutch may be laid if the first is lost (Cramp & Simmons 1980). The mating system of the houbara is not well known, and it has been variously described as monogamous (Dementiev & Gladkov 1968), polygamous, and promiscuous (Collins 1984). The clutch is incubated by the female alone. Although the chicks are precocial and nidifugous, the female feeds them on insects bill-to-bill for a period of about two weeks.

Ecology and Status of Houbara in Saudi Arabia: Field and Captive Studies

Most field studies have been done in Harrat al-Harrah Reserve, which contains the only known population of breeding houbara in Saudi Arabia (Fig. 2). In late 1991, personnel at the National Wildlife Research Center initiated a study of seasonal changes in houbara density, overall population size, and habitat utilization within the reserve, in order to determine whether the habitat protection provided by the reserve had resulted in a growing population, and also to identify habitat features important to houbara. This latter information was considered essential in guiding the selection of areas for protection and possible release sites for reintroduction of captive-reared birds. Inter-seasonal changes in the number of houbara seen in the reserve (a decrease in spring and early summer) suggest the presence of two sub-populations, resident and migratory. Records of breeding attempts are few: between 1987 and 1992 only eight houbara breeding attempts were recorded in the reserve, although the status of the so-called resident population is not certain, it has been suggested that in years of good rainfall more houbara may remain to breed in al-Harrah than in dry years. Low densities of birds and large inter-annual variations in rainfall suggest a low potential for an increase in population size. It is possible that Harrat al-Harrah retains a remnant population of houbara by virtue of its remoteness and inaccessibility. Future work will attempt to answer the following questions: where do the houbara that over-winter in Saudi Arabia come from, and is there a clear distinction between resident and migratory populations? Satellite and conventional field and tracking studies are planned.

The former breeding range of the houbara in Saudi Arabia is known (Jennings 1988). What is less certain is the degree to which habitats within this range have
been damaged by agriculture, and their potential for recovery following the removal of grazing pressure. Studies on the process of habitat recovery are required.

Very low densities of houbara in Saudi Arabia meant researchers were unable to collect data on its mating system and breeding biology. Fortunately the captive-breeding stock may function as a substitute for wild populations in basic research on breeding biology. When a bird species is bred in captivity, however, knowledge of the factors triggering reproduction are of major importance. The following reproductive parameters of captive females housed in outdoor cages were examined during five successive years (1990–1994): annual cycle of laying, age at first laying, clutch size, and laying capacity (Saint Jalme et al. 1995). Inter-annual variations in the reproductive parameters, rainfall, and ambient temperature were examined with reference to the proximate factors synchronizing breeding activity. Despite inter-annual variation in the onset and termination of laying, houbara housed in outdoor cages showed a seasonal breeding pattern. Laying began in January each year. Females generally stopped laying in May, except in years with good spring rainfall, when clutches were laid until July. Because the optimal conditions for reproduction throughout the breeding range of houbara are at least partially predictable, our belief is that the species has developed an endogenous annual rhythm. Photoperiod does not seem to be a proximate factor synchronizing gonadal activity, but ambient temperature and rainfall could act as subsidiary synchronizers, with relatively low temperatures during winter facilitating gonadal maturation, and abundant rainfall modulating the reproductive period and allowing new clutches to be laid.

Age of first reproduction seems to be lower in captive-bred birds than in free-ranging birds: between 1989 and 1993, 2% of all females laid at the age of 1 year, 23% at 2 years, 62% at 3 years, and 82% at 4 years. Eighteen percent of the females seem to be unable to adapt to captive conditions and do not lay at all.

The percentage of adult laying females (females that laid in the previous year) was around 85% every year except during the 1994 reproductive season, when only 42% laid. This low percentage of females reaching sexual maturity in 1994 may be due to a particularly warm and dry winter.

When eggs were collected every day and females were not permitted to incubate, clutch sizes were be-
tween one and four eggs, and inter-clutch interval around 10 days. The laying capacity—the mean number of eggs laid per laying female—increased with age. The mean number of eggs laid by female *Chlamydotis undulata macqueenii* increased from 1.7 to 1 year old, to 11.8 for birds aged more than 3 years. Nevertheless, there was great variability in the number of eggs laid within each age class. The maximum number of eggs laid by one female in a reproductive season was 30 for the subspecies *macqueenii* and 20 for the subspecies *undulata*.

**Habitat Protection**

Saudi Arabia currently has only one protected area established primarily to protect remnant populations of resident houbara. The 13,775-km² Harrat al-Harrah reserve was declared a Special Nature Reserve in 1987. It is located in northwestern Saudi Arabia, near the Jordan border. Hunting is forbidden, and grazing livestock have been reduced to only camels. The reserve is patrolled daily by light aircraft and on the ground by rangers stationed at eight camps throughout the reserve. It was chosen to protect possibly one of the last breeding populations of houbara in Saudi Arabia (Child & Grainger 1990), but evidence suggests that in the 6 years since reserve creation the number of residents in Harrat al-Harrah has not increased. As recently as the spring of 1993, houbara breeding was recorded in Al-Khunah, a gazelle reserve of over 20,000 km² south of Harrat al-Harrah (Fig. 2).

Also available for migratory houbara is the Mahazat as-Sayyid reserve, a 2300-km² fenced area established in 1989 to ensure complete protection against hunting and grazing (Fig. 2). Although the vegetation was severely overgrazed by domestic livestock, since protection it has recovered remarkably. Arabian oryx and sand gazelle have been successfully reintroduced (Greth & Schwede 1993), and populations of breeding birds such as *Torgos tracheliotus* (lappet-faced vultures) have also increased since protection.

The objective is now to establish and manage a network of suitable reserves, situated close enough together to allow natural dispersal between sub-populations of houbara. Currently scheduled for protection and use as possible houbara reintroduction are four areas within the houbara's former breeding range.

**Captive Breeding**

As an ex-situ conservation measure, a captive breeding program was initiated in 1986 at Taif, Saudi Arabia (latitude 21.15°N, longitude 40.41°E, altitude 1450 m). The breeding stock held at Taif originated from Baluchistan and Algeria. Because the species is known to lay a replacement clutch, authorization was obtained from the two governments concerned to collect eggs from breeding populations at the beginning of the reproductive season, to minimize any possible detrimental impact on the wild populations. A total of 103 chicks of the Asian subspecies *Chlamydotis undulata macqueenii* and 129 chicks of the African subspecies *Chlamydotis undulata undulata* were collected for the breeding stock. The latter subspecies was to be used as experimental birds to improve captive management and as surrogate mothers in release experiments.

Captive propagation of houbara has proven to be a difficult task. After one year of infertile eggs, breeding success was achieved in 1989 with the production of 17 chicks. The captive breeding program achieved a self-sustaining captive population of houbara in 1992, permitting release experiments to begin. Production increased to 285 chicks in 1993, from 75 laying females. In 1994 fewer females laid, however, and only 94 chicks were produced. This success was obtained mainly as a result of artificial insemination, together with egg pulling, which meant up to 10 replacement clutches (30 eggs) could be laid by a species known to lay only one or two clutches of two to four eggs each year.

In the absence of reliable information on the natural mating system, several “natural breeding” management techniques were tested: pairs, heterosexual groups of different sizes, and heterosexual groups in which females were allowed selective access to males through special doors. All of these experiments have yielded poor results: only 20% to 50% of eggs laid are fertile.

To improve production it was therefore necessary to try artificial insemination techniques. Semen was collected using a dummy female presented to a displaying male (Fig. 3). When the male tried to copulate, the manipulator collected the semen. Immediately after collection, the sperm was diluted and analyzed for concentration and motility and then inseminated directly into the vagina. With improved insemination techniques, levels of fertility rose from 50% in 1989 to 85% in 1993. A study conducted in 1992 showed that best results are obtained when inseminations of more than 10 million spermatozoa are performed every 4 to 5 days (Saint Jalme et al. 1994).

After testing several incubators and incubation techniques, we achieved a hatchability level of about 65%, which is 15% lower than when eggs are naturally incubated by females. This difference between artificial and natural incubation is due largely to higher levels of mortality in the last 4 days before hatching.

Despite the success of the captive breeding program, certain problems have yet to be solved. At present we are unable to account for the high incidence of deaths occurring during incubation. Incubation at higher altitudes could be partly responsible for these deaths. “Natural breeding” techniques have failed to give satis-
factory results. As in many breeding programs the problems are behavioral in origin (Holst 1993). Because of the labor-intensive nature of artificial insemination, we will continue to explore natural breeding techniques.

The low percentage of laying females observed in 1994 illustrated two problems encountered when a bird species is bred in outdoor cages: the importance of understanding the proximate factors synchronizing gonadal development and the importance of correctly siting a captive-breeding facility to avoid the large expenses involved in creating artificial climatic conditions. Whereas we have developed hypotheses concerning the environmental factors that may synchronize gonadal development in houbara, experiments in controlled conditions are necessary to test these hypotheses; these are planned for 1995. The captive breeding center in Taif was built at the southern limit of the breeding range of the houbara, with the result that in some years environmental conditions for reproduction may be far from optimal. Moreover, the altitude of the facility (1450 m) may induce artificial incubation problems. Two other captive breeding programs of houbara were initiated in 1993, one in Abu Dhabi and one in Morocco. As at Taif, the decision as to where these facilities were built seems not to have taken into account the environmental factors required for optimal production of eggs.

Release Experiments

Experimental releases of captive-bred houbara (the Asian subspecies *Chlamydotis undulata maqueenii*) took place in Mahazat as-Sayd Protected Area. As a preliminary experiment in 1991, four adults and sub-adult houbara were hard-released directly from captive breeding into the reserve. The stated aim was to determine the main problems encountered by captive-bred released houbara. After only 1–3 days all birds were killed by foxes. Following their release, birds exhibited a running behavior most likely linked to stress after the long period they had been in captivity. Little feeding behavior and no anti-predator behavior were observed. Even in suitable habitat, these captive-bred houbara had difficulty adapting to new environmental conditions, including finding food, orienting themselves spatially, avoiding predators, and probably also resisting microbial infection. This result prompted the construction of a 4-km² mammalian-predator-proof enclosure within which captive-bred houbara could be released and become accustomed to their new surroundings in the absence of mammalian predators. All released birds were fitted with backpack-mounted, solar-powered transmitters, and their movements were tracked from a light aircraft as well as from the ground. Three different releasing techniques were tested.

Feather-cut Sub-adult Release. We translocated 3–5 months old houbara with feathers cut on one wing. Birds were kept inside pre-release cages (Fig. 4) for several weeks before being released in the enclosure. Because new feathers grow about 1 year after hatching, houbara remained confined in the pre-release enclosure for at least 7 months, during which time they become adapted to the natural habitat. Of the 13 feather-cut sub-adults released between summer 1992 and early 1993, six were killed by eagle-owls or eagles inside the fox-free enclo-
sure. One died from a pox virus infection, and another for an unknown reason after having flown out of the enclosure. Three were killed by mammalian predators soon after they left the enclosure. Only two were successfully reintroduced and joined flocks of free-ranging, captive-bred houbara in the reserve.

Covey Release. Nine coveys totaling 18 chicks accompanied by pinioned adult females were released inside the pre-release enclosure. This method was designed to allow females to pass information to young about feeding techniques, food choice, habitat utilization, and predator avoidance. Two chicks died inside the pre-release cages, and another was removed from the experiment because of a pox virus infection. Eventually, eight coveys totaling 15 chicks were released. Eleven chicks died: five flew over the fence soon after release and were quickly killed by mammalian predators; two were killed by unknown predators (probably ravens) inside the pre-release enclosure, and three contracted a disease after release. Five of these birds left the enclosure and successfully integrated into flocks of reintroduced houbara in the reserve.

Subadult Release. We translocated captive-bred, 2-month-old birds from the breeding center to the reserve. In this design houbara are kept inside pre-release cages for 2-4 weeks before being released into the 4-km² enclosure. Because their feathers are not cut, they can leave the enclosure as soon as they are released. One sub-adult male was released in September 1992, and 24 were released in 1993. The bird released in 1992 was followed over 7 months but was lost either due to transmitter failure or because it migrated. Among the 24 birds released in 1993, 12 died from predation and two from a pox virus, and 10 became established in different parts of the reserve.

The results of the release experiments showed that, out of the four release techniques tested, release of subadults gave the best results. Predation by birds of prey during the period when the birds are flightless caused us to abandon feather-cut releases. Coveys showed a high dependence on supplementary food, and the hoped-for apprenticeship of feeding techniques, food choice, habitat utilization, and predator avoidance from the females proved to be a failure. Sub-adult birds were able to feed themselves in a short time after release. The two major causes of death were disease and predation by mammals. In order to solve the first problem, studies on the efficiency of different vaccinations are underway. Predation by mammals occurred most often in the immediate vicinity of the houbara enclosure and always a short time after birds left the enclosure. Work has begun to artificially decrease the density of red foxes and feral cats in the immediate vicinity of the houbara enclosure. Nevertheless, houbara may learn predator awareness only by direct experience with potential predators, and so experiments on predator training are also planned for 1995.

Conclusion

According to the guidelines of international conservation authorities, reintroduction programs should be considered only if the factors that caused the decline are entirely removed and if there are no other methods.
available to restore endangered populations (World Conservation Union 1987; Dowell 1990; Ounsted 1991). It is clear that for houbara the causes of the decline have not yet been removed, especially in the case of the migratory population. Houbara continue to be hunted throughout their range, even in countries where the species is officially completely protected. Conservation of remaining wild populations requires a multifaceted approach, encompassing habitat improvement, protection from hunting, public education, and international cooperation and research. Nevertheless, with the houbara’s major significance in Arabian tradition and culture, its captive propagation has served as a hallmark for wildlife conservation throughout the country. In September 1993, an international symposium was organized in Saudi Arabia with the aim to review the progress and future direction of the houbara program (Abuzinada & Seddon 1994). Workshop participants drafted recommendations that have become the basis for a conservation strategy for houbara (Seddon et al. 1995).

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LITERATURE CITED


World Conservation Union (IUCN). 1990. IUCN red list of threatened animals. IUCN, Gland, Switzerland, and Cambridge, United Kingdom.