Influence of Group Size and Neonatal Handling on Growth Rates, Survival, and Tameness of Juvenile Houbara Bustards

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The influence of group size, sex, year, and environmental enrichment on growth of a large sample of captive-bred houbara bustards was examined, as well as the influence of regular handling on survival. Growth rates of chicks kept in groups of eight were depressed compared with chicks in groups of five. Differences in growth rates between males and females were not significant at fledging (~35 days), but were so by 80 days, although interindividual variation still precluded reliable sexing by body mass at this age. Growth rates varied between years, suggesting that management practices may affect growth, and potentially the reproductive performance of birds. Survival of birds receiving extra handling, mainly in the form of regular weighing, was significantly higher than that of birds receiving little handling. The effect of environmental enrichment on tameness was also assessed. Tameness is desirable in the captive flock, where stress is perceived as a major impediment to reproductive performance, preventing the successful collection of semen from males and insemination of females, delaying recruitment, and causing nonbreeding among both sexes. Extra handling and environmental enrichment was applied to a sample of chicks, and tameness of juveniles was assessed in a variety of ways (open field test, subjective assessments), but no significant difference was found between the enriched birds and a control group. The enrichment protocol might be improved by increasing the period of time during which birds were handled and associating handling with food rewards, although the time required to carry out such a protocol may be constrained when large numbers of chicks are produced.


Key words: *Chlamydotis undulata* macqueenii; environmental enrichment; hand rearing; captive propagation; growth rates

INTRODUCTION

Captive breeding of houbara bustards is a relatively recent development, instigated on the Arabian Peninsula and in Morocco in response to declining and extir-
pated local populations, and a desire by governments or private individuals to rees-
establish or reinforce populations. In Morocco, captive breeding aims to supplement
populations of the subspecies (Chlamydotis undulata undulata) to allow sustainable
harvesting by Arab falconers, whereas reintroductions of the Asiatic form (Chlamydotis
[undulata] macqueenii) on the Arabian Peninsula aim to restore wild populations
within the former range of the species. Mate choice in wild houbara bustards takes
place in a dispersed lek system. This is difficult to replicate in a captive environ-
ment, and results in low fertility and hatchability of eggs [Saint Jalme and van Heezik,
1996]. Hence, most reproduction in captive populations of houbara bustards is artifi-
cial: artificial insemination, egg pulling, artificial incubation, and hand-rearing [Saint
Jalme and van Heezik, 1996]. At the National Wildlife Research Center (NWRC) in
Saudi Arabia, a founder flock of houbara bustards was established between 1987 and
1989, and first chicks hatched in 1989. Ten years later, in 1999, 303 chicks hatched
from eggs laid by 91 females.

In wild birds, growth rates can vary within species in response to variations
between chicks and the quality of their parents, as well as food availability and
quality [Coulson and Porter, 1985; Boag, 1987; Cooch et al., 1991; Sedinger and
Flint, 1991; Sedinger et al., 1995; Nisbet et al., 1995; Robinson and Hamer, 2000].
Differences in growth in some species result in differences in first-year survival
and in future breeding propensity and fecundity [Sedinger et al., 1995; Christensen,
1999]. Among captive-bred birds, the way in which young birds are managed, as
well as variation in the size of cohorts (which may influence management prac-
tices), have the potential to affect growth and possibly future reproductive per-
formance. For example, improved husbandry techniques have been shown to result
in increased growth in captive-reared sandhill cranes, Grus canadensis [Ellis et
al., 1992; Gee and Hereford, 1995, in Whitmore and Marzluff, 1998]. In the
houbara bustard flock, differences between cohorts of females in rates of recruit-
ment into the breeding population as well as survival of eggs [van Heezik and
Ostrowski, 2001] suggests that the rearing environment may be playing a role in
influencing subsequent reproductive performance. Measuring growth rates then
becomes important for identifying management-related sources of variation and
ultimately in determining whether growth rates influence future reproductive per-
formance. In this study, chick growth was examined, and the influence of the
following parameters on growth rates: 1) “group size,” because sizes of groups
of chicks during rearing has increased as a result of increased production; 2)
“sex,” with the aim of determining whether individuals can be reliably sexed
before fledging; and 3) “year,” to determine whether management practices were
affecting growth rates.

The effect of regular weighing on survival of chicks and juveniles was also
examined. Although regular weighing provides valuable information on growth, in
recent years chicks and juveniles in the NWRC flock have not been weighed during
much of their growth for two reasons: 1) increased production of chicks has resulted
in less time available for monitoring individuals’ body mass and behavior and 2) a
perception that capturing juveniles for weighing increased the risk of their dying
from traumatic injuries sustained during capture. Regular weighing, which is the
only form of regular neonatal handling of healthy chicks, previously occurred through-
out the fledging period, but was reduced to a period encompassing the first 8 to 12
days of growth, and then once again at fledging, when juveniles are transferred out
Survival is an important economic aspect in the captive breeding of houbara bustards, which is an expensive process. For example, the estimated NWRC budget required for producing houbara bustards in 1999 equates to each chick being worth US$5,690 at hatching. By the end of the first year, approximately 73% of hatched chicks had survived, increasing the value of a 1-year-old bird to US$7,795. These values can increase substantially if the flock experiences a warm winter [van Heezik et al., in press], when production may be reduced by more than 70%, whereas resources invested in the captive breeding remain much the same. Because posthatching mortality reaches a peak during the first 6 months [van Heezik and Ostrowski, 2001], efforts to reduce mortality during this period potentially have the greatest impact on overall survival in the captive flock.

Finally, we examined the influence of neonatal handling and environmental enrichment on tameness and growth rates. Artificial breeding requires calm individuals, habituated to the presence of humans and the manipulations required for artificial reproduction. Presently, only a proportion of animals in the houbara bustard flock are tame enough to be useful as breeders. For example, among the 24 female 6-year-olds and the 23 female 4-year-olds present in the captive flock in 1999, only 33% (n = 8) and 52% (n = 12) laid eggs in 1999, respectively. Managers believe that stress is the primary factor influencing the likelihood of whether captive houbara bustards lay, although there is no quantitative evidence to support this belief. In poultry, environmental enrichment, in the form of extra handling (as little as 20 seconds/day) and the introduction of novel objects into rearing cages, produced calmer birds with faster growth rates, increased resistance to bacterial infections, and improved antibody response to antigens [Jones and Hughes, 1981; Gross and Siegel, 1982; Jones and Waddington, 1992]. We raised a group of houbara bustards exposed to similar types of environmental enrichment, with the aim of producing tamer birds.

**METHODS**

**The Rearing Protocol**

In the captive flock, male houbara bustards display from November through June, peaking in February and March. Egg laying by females may start as early as January and continues until June, with a median laying date in mid to late March, depending on environmental variation, and a median date of hatching in about the third week of April.

Newly hatched houbara chicks were transferred from the incubation unit into the rearing unit, where they were individually fed with pellets, fresh alfalfa, and mealworms. Chicks were housed initially in groups of two to five individuals, in small Plexiglas boxes (77 x 52 cm). Chicks between 8 and 12 days of age were placed in larger groups of between five and eight individuals and housed in large Plexiglas boxes (90 x 200 cm). Individual feeding ceased at this stage, and food was presented in a feeder. After 10 days to 2 weeks, chicks were moved in these same groups to a room (1.93 x 3.0 m) with access to an outside run (3.0 x 6.7 m). Between 30 and 40 days of age, chicks were moved out of the rearing unit and into communal cages in the breeding unit (3.5 m²). Group size was defined as the number of chicks in a group while housed in the large Plexiglas boxes.
Growth and Survival

In 1998 and 1999, a sample of houbara bustard chicks (n = 194 at hatching) was weighed daily between hatching and 8 to 12 days of age, and thereafter every 2 days until about 35 days of age. Weights were subsequently taken at approximately weekly intervals thereafter, until about 80 to 100 days of age. Survival was monitored continuously. Another group of birds (n = 324) was weighed daily between days 8 to 12 after hatching, weighed again when transferred between the rearing unit and the breeding unit, and in some cases weighed one more time toward the end of the year.

Slopes of the linear or near-linear parts of the growth curve were calculated for each individual for the time period 8 to 35 days after hatching, when chicks were housed in the rearing unit, and also for 8 to 80 days after hatching, which included time spent in communal cages outside of the rearing unit. Analysis of covariance was carried out on slopes, after having determined that distributions were normal, and the assumption of homogeneity of slopes was satisfied.

Sex was determined in 1999 using a DNA-based identification technique conducted at the National Avian Research Center in the United Arab Emirates (M.-A. d’Aloia, unpublished data), and in 1998 after assessment of body mass and plumage at 1 year of age. Adult houbara bustards are sexually dimorphic in size and plumage. The number of chicks in each size group was as follows: 14 in groups of 5, 18 in groups of 6, 65 in groups of 7, and 15 in groups of eight. All groups comprised a mixture of males and females, and sex was entered as a covariate into the model comparing growth rates of chicks from different-size groups.

Survival analysis was used to compare survival of birds receiving minimal handling to that of birds receiving extra handling for the period in the rearing unit, and for the period between leaving the rearing unit and the end of the year. Survival analysis allows the use of data from birds that drop out of the experiment before the end of the time period of interest (in this case translocated for release) (SYSTAT, V.9). Survivor functions were generated and compared using the stratified Cox model. Chicks dying before 14 days of age were excluded from the analysis, because allocation into the two treatments occurred only after this age.

Environmental Enrichment

In 1998, a group of 20 chicks received extra handling between hatching and 30 and 38 days of age. Extra handling took the form of two 2-minute sessions each day, during which time chicks were caught, weighed, and handled gently. Also, brightly colored novel objects that were harmless, washable, and durable were placed inside these chicks’ cages, and changed daily until chicks were moved into the larger rooms with an outside run. Planks, blocks of wood, and rocks were arranged inside their rooms to create a more complicated spatial environment. These were supplemented with colorful plastic objects that were changed every few days.

The tameness of this group was assessed in a number of ways.

1. At fledging (30–40 days of age), birds were transferred out of the rearing unit and into cages in the breeding unit. The response of each individual to being in a new cage on its own was recorded on video during 3 minutes from the moment of initial introduction to the new cage (open field test). Behavior was transcribed at 5-second intervals: the amount of time spent in
each quadrant of the cage in relation to the position of the observer; whether the birds pecked at food positioned centrally or at plants growing inside the cage; whether the birds called persistently; and whether they ran. Each bird was ranked from 1 (calm) to 3 (agitated). Birds scoring “1” spent at least 25% of their time in the quadrant containing the observer, spent no time running or calling, and were observed to peck at plants or alfalfa at least six times. Birds scored “3” if they spent any time running, called for more than a third of the time, and spent more than half of their time in the quadrant furthest from the observer. Birds scored “2” if their behavior fell between these extremes. Both the videotaping and the transcription of data were done by the same individual (YvH).

2. In October, technical staff and bird keepers who had regular contact with the birds made a joint subjective assessment of tameness of males of the cohort (n = 43), based on their experience with the birds during the previous months, to select a sample for reintroduction. Males that had not habituated well to their keepers, and continued to alarm call and attempt to fly in the presence of humans, were judged as being insufficiently tame to perform well in the captive flock. The proportions of selected males (those judged as not being tame) from enriched and control groups were compared.

3. In December, the calmness of birds remaining in the breeding unit and housed in individual cages (n = 54) was assessed by one independent observer, during one afternoon, who ranked each bird on a scale of one (calm) to three (least calm), depending on their willingness to approach and take offered mealworms. Birds that had been regularly weighed were combined with the enriched group (both having had regular contact with humans), because sample sizes in individual groups were too small for a $\chi^2$ analysis.

RESULTS
Parameters Influencing Growth

Growth between 8 and 80 days after hatching was linear. Slopes of the linear or near-linear parts of growth curves have been used to describe growth rates [Nisbet et al., 1995; Beekman et al., 1999; Robinson and Hamer, 2000], and were appropriate in this study because data were collected only during the linear phase of growth.

When data from both years were combined, there was no significant difference between slopes of males and females between 8 and 35 days of age (analysis of covariance, with timing of hatching, year, and group size as covariates; n = 117, n.s.). Differences became significant when slopes from 8 to 80 days were compared (analysis of covariance [ANCOVA], n = 107, $P < 0.001$), with slopes of females being significantly smaller than those of males (Fig. 1). Sex was therefore entered as a covariate in subsequent analyses.

There was no difference between years in growth between 8 and 35 days (ANCOVA, n = 117, covariates; sex, timing of hatching, group size), but growth in 1999 was slightly faster than in 1998 when comparing slopes calculated between 8 and 80 days (n = 107, $P = 0.042$; Fig. 2).

Chicks in different-size Plexiglas groups, ranging in size from five to eight, had significantly different growth rates during their time in the rearing unit (8–35 days, ANCOVA, covariates; timing of hatching, year, sex, hatching weight; n = 103,
A multiple-comparison test indicated that the significant difference lay between growth rates of chicks in groups of five and groups of eight. This difference did not persist among growth rates calculated between 8 and 80 days of age (n = 93, n.s.).

**Survival of Weighed and Control Birds**

Survival in the rearing unit was higher among chicks that were regularly weighed (Tarone-Ware $\chi^2 = 12.868$, df = 1, $P < 0.001$, 76.7% survival of 324 control birds, 94.3% survival of 194 regularly weighed birds). Higher survival among weighed
birds persisted throughout the period between leaving the rearing unit and the end of the year, even though weighing after leaving the rearing unit was neither systematic, frequent, nor continued until the end of the year (Tarone-Ware $\chi^2 = 4.773$, $df = 1$, $P = 0.029$, 83.9% survival among 279 control birds, and 91% survival among birds that had been weighed more frequently). Survival of the two groups during the entire period (hatching to the end of the calendar year) is shown in Fig. 4.

**Environmental Enrichment**

Growth rates of birds in the enrichment treatment did not differ from those of regularly weighed birds (ANCOVA; covariates = sex, hatch weight, timing of hatching; 8–35 days, $n = 61$, n.s.; 8–80 days, $n = 59$, n.s.).

Behavior of the three groups (enriched, regularly weighed, control) during the open-field test did not differ ($\chi^2 = 2.98$, $df = 4$, $n = 54$, n.s.). The proportions of

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males selected for reintroduction in October on the basis of being judged less tame were the same as the proportion selected from the control group ($\chi^2 = 0.0$, n.s., 55% of 22 control males, 55% of 11 enriched males). During the December assessment, birds were scored from 1 (calm) to 3 (frightened), and no difference was found in scores between control ($n = 32$) and enriched ($n = 22$; including regularly weighed) birds ($\chi^2 = 1.109$, df = 2, n.s.).

**DISCUSSION**

Several factors were found to affect growth rates of captive-reared houbara bustards: sex of birds, year hatched, and size of groups. Adult male houbara bustards are larger than females, to the extent that differences in foot size can be used in the field to sex adults from their footprints [Maloney, 2001]. Body masses of male and female chicks were too variable to show a significant difference by fledging (35 days), but were significantly different among growth rates calculated during the period 8–80 days. Body mass is thus an unreliable indicator of sex before fledging, and could still be inaccurate up to 80 days of age because there was considerable variation among individuals. A more accurate method that can be used from hatching is a DNA-based method (M.-A. d’Aloia, unpublished data), which was tested on several of the chicks in the sample, although it requires specialized expertise and equipment, and sufficient funds.

Juveniles in 1999 grew slightly but significantly faster than juveniles in 1998. The difference between the years was not significant during growth until fledging (8–35 days) but became significant for growth rates calculated between 8 and 80 days, suggesting that management practices may have affected postfledging growth.

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**Fig. 4.** Survival of captive houbara chicks receiving extra handling (regularly weighed) and minimal contact (control), up until the end of the calendar year.
The factors causing this difference are unknown, but could include poorer quality food, or differences in housing that may influence stress levels, affecting appetite, access to food, or assimilation of food. Comprehensive documentation of management protocols is necessary before conclusions can be drawn.

Chicks kept in groups of eight had slower growth rates up until fledging than chicks in groups of five, although compensatory growth had virtually extinguished this difference among growth rates calculated for the period 8 to 80 days. Small chicks may suffer particularly during the transition from being offered food individually, to feeding independently from a feeder. Further studies are required to determine whether these early differences in growth rates have long-term effects on reproductive performance. Differences between cohorts of females in rates of recruitment and survival of eggs suggest that some aspects of the rearing environment are influencing future reproductive behavior [van Heezik and Ostrowski, 2001]. Fledging weight in captive zebra finches *Poephila guttata* has been shown to influence the number of eggs subsequently laid [Haywood and Perrins, 1992], and differences in growth in some species result in differences in first-year survival, future breeding propensity, and fecundity [Sedinger et al., 1995; Christensen, 1999]. Potential relationships such as these deserve attention, because the implications concern the future productivity of the captive population.

Houbara bustards that were regularly weighed had a reduced risk of mortality during their time in the rearing unit and up to 1 year thereafter, even though weighing became less frequent after the birds left the rearing unit, continuing for only 2 to 3 months. The mechanism by which survival is improved is not clear. Causes of death for many of the individuals were not known, and among known causes there was no drop in incidence of any one particular cause of death. Regularly weighed birds may become more accustomed to handling and human presence, and consequently less flighty and less prone to death by trauma. Trauma is the primary cause of death in the captive flock, and peaks in the first year of life [van Heezik and Ostrowski, 2001]. In poultry, extra handling and environmental enrichment reduced avoidance and fear of humans, improved growth efficiency, and increased resistance to *Escherichia coli* infection and the antibody response to antigens [Jones and Hughes, 1981; Gross and Siegel, 1982; Jones and Waddington, 1992; Jones, 1993]. Fearfulness in chickens can elevate corticosterone levels [Beuving and Vonder, 1978] and produce escape/avoidance responses that may increase the risk of self-injury in cages [Jones and Waddington, 1992]. Habituation to humans may decrease the physiological effort required to respond to human contact, and those resources may then be used for responding to environmental stressors [Gross and Siegel, 1982].

Weighing on alternate days also allows frequent assessment of each bird’s health. Immediate measures can then be taken to assist individuals that start to lag in their growth, before the risk of mortality becomes high despite veterinary intervention. Closer monitoring may have contributed to the improved survival in this study, but interventions did not occur sufficiently frequently to explain the difference between the groups. Whatever the mechanism, regular weighing improves survival and provides data that are essential for monitoring the growth of cohorts.

**Effects of Extra Handling and Environmental Enrichment**

We found no differences in tameness between enriched and control groups, and enriched birds did not grow faster than regularly weighed birds. Hence, the enrich-
ment treatment failed in its objective—to produce calmer birds more suitable for captive breeding. A more effective protocol might incorporate food rewards, and longer periods of handling and association with keepers. Handling of orange-winged Amazon parrots *Amazona amazonica* produced tamer birds, but handling periods were considerably longer; between 10 and 30 minutes/day until fledging [Aengus and Millam, 1999]. The technique in parrots is recommended as a low-labor, low-technology alternative to artificial rearing as a means of taming birds and thereby improving their adaptation to life in captivity. However, when large numbers of chicks are being produced, such as by the houbara flock, sufficient handling to effect a difference may be very time consuming, and would be worthwhile only if there was strong evidence suggesting that tameness and breeding performance of captive birds was improved.

**CONCLUSIONS**

1. Regular weighing of houbara bustard chicks and juveniles significantly improves survival.
2. Growth of chicks in groups of eight was significantly slower than growth of chicks in groups of five. Growth rates varied between sexes and between years.
3. Environmental enrichment, as practiced in this study, did not produce calmer birds.

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