A SURVEY OF CAUSES OF MORTALITY IN CAPTIVE, CAPTIVE BRED RELEASED, AND WILD BORN HOUBARA BUSTARDS (*Chlamydotis undulata*) IN SAUDI ARABIA

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Introduction

The houbara bustard (*Chlamydotis undulata*) is a medium-sized bustard of slender appearance, measuring 55-65 cm and weighing from 900-2400 g. The breeding distribution of the species range from Canary Islands though North-Africa, the Arabian peninsula east into Mongolia. Of all the bustards the houbara is the most adapted to desert environment. In the zone of distribution of the species, annual rainfall rarely exceeds 200mm.

In the 1980 summary of the world status of the houbara bustard, it was listed excessive hunting, overgrazing, agricultural development as probable reasons for the houbara bustard population decline. For the past twenty years, the species has significantly declined in at least 15 of the 20 countries in its range.[2]

Beginning in 1986, a houbara bustard captive breeding program was undertaken by the National Commission for Wildlife Conservation and Development in order to return this extirpated species to the Saudi Arabian land. Previous experiments have shown that hand-reared houbara bustards are most suitable for captive breeding.[4] Therefore, it was decided that the breeding flock should mostly comprise hand-reared birds. For this purpose, five expeditions to different houbara breeding areas were undertaken. Eggs and one-day old chicks were collected in 1986, 1987 and 1988 in Algeria (*undulata* subspecies) and Pakistan (*macqueenii* subspecies). Additionally, a releasing program was set up in Mahazat As-sayd, a fully protected fenced area of 2,300 km^2 from where domestic livestock have been totally excluded in 1989. First release of captive-bred houbara bustards were conducted in the area in 1991 by the NWRC.

Material and methods

Survey data included individual animal records, pathology records and population data from the NWRC computer database system. Pathology records were reviewed, and pathological findings were tabulated by etiological findings. From 1989 to 1994, 370 (167 subadult/adult birds and 203 neonate/juvenile birds) carcasses or remains of captive-born and wild-born birds were collected, and full post-mortem examinations were conducted at the National Wildlife Research Center of Taïf. Additionally, 58 carcasses or remains of captive bred released birds were also examined.

Results

Post-mortem results on captive birds Analysis of post-mortem examinations performed between 1989 and 1994 on captive-born birds showed a marked decrease of mortality rate

both in sub-adult/adult (>1 yr-old) birds and neonates/juveniles (<1 yr-old). The mortality rate among sub-adult/adult birds dropped from 22.1% in 1989 to 4.3% in 1994 (Fig.1), and among juveniles/neonates, from 56% in 1989 to 19.8% in 1994 (Fig.2). No statistical differences of mortality rate were observed neither between males and females nor between *undulata* and *macqueenii* sub-species. Among juveniles/neonates, 28% (n=57) of deaths were due to infectious diseases, 29% (n=59) to accidental traumas, 7.9% (n=16) to ventriculus impaction and perforations, 14.4% (n=29) to neonatal diseases, 14.4% (n=29) were other cases and 6.4% (n=13) were of unknown etiology (Fig.3). Among sub-adult/adult captive-bred and wild-born birds, 43.7% (n=73) of deaths were due to accidental traumas, 28.1% (n=47) to infectious diseases, 16.8% (n=28) were of unknown origin, 8.4% (n=14) were other cases, and 3% (n=5) were due to foreign bodies and ventriculus perforations (Fig. 4). Evolution of etiologies showed a marked drop of infectious diseases.

Infectious syndromes

Main infectious syndromes (Tab. 1) encountered in juvenile, immature and adult birds were:

-Multifactorial enteritis/peritonitis syndrome involving adult/subadult birds (n=27) associated with several pathogens such as: *Chlamydia psittaci*, an Herpesvirus, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* bacteria.[3]

-Respiratory tract infections, with sinusitis, bronchitis and pneumonia (n=-30), associated with several viral agents such as: Newcastle disease virus, a poxvirus and surinfecting bacteria, *Escherichia coli, Proteus mirabilis*.

-Upper digestive tract infections due to poxvirus (n=8) and trichomonasis (n=3).

-Hepatitis and cholangiohepatitis (n=26) with disseminated necrosis of hepatocytes secondary to sepsis from herpesvirus infection and *Chlamydia psittaci*.

-Interstitial nephritis and glomerulonephritis (n=5) associated with combined bacterial infection.

-Generalized neoplasia (n=3) associated with reticuloendotheliosis virus.

Traumas

It was often difficult to prove the traumatic origin of deaths, as lesions could be very discrete. Complete epidemiological and pathological analyses were usually required. Traumas never occur in birds less than one month old. The youngest bird dead of trauma was 32 days old. After one month of age all birds are vunerable to traumatic accidents. Those particularly susceptible are : stressed birds; non-domesticated birds; birds that have not had their wing feathers cut; birds with only one wing cut (they flip over when jumping). The particular events that precede trauma are: visit of "unknown" people; attempts to catch

the bird; manipulation. Necropsy rarely yield obvious indications. Ecchymoses in the calvarium were frequently observed (86% of all cases), but they were most frequently agonal pooling of blood within the skull and were rarely indicative of head trauma. Sometimes concomitant and associated lesions (wing and leg fractures, luxations) could lead to traumatic-origin conclusion. Most frequently observed lethal traumas were thoraco-lumbar vertebral lesions inducing a medullar compression (n=51), cervical luxations (n=28) and head trauma (n=11). When death was delayed, differential diagnosis had to be done to discriminate between nervous manifestations of some infectious diseases and toxic effects.

Neonatal deaths concerned birds of less than one month of age. They included, anoxic chicks, maternal neglect, yolk sac retention/ infection, dehydration/ emaciation syndrome,infectious related diseases (Fig.5). Yolk sac infection and anoxia were responsible of the majority of deaths during the first week of life.

Incidental findings in wild caught houbara bustards (n=21) included a high infestation with gastrointestinal nematodes (*Harteria rotundata, Histiocephalus choristidis, Subulura brumpti*), cestodes (*Raillietina subgenus parionella* sp. and *Idiogenes otidis*) and evidence of subcutaneous larvae of *Ascaridia* or *Spirurida*.

Post-mortem results performed on captive-bred released birds H

Houbara bustards released in Mahazat as-Sayd reserve were all captive-bred in Taïf breeding center. Between 1991 and 1993, four different experimental release techniques were tested: hard release directly into the wild, feather-cut release in a pre-release enclosure, covey release and subadult release. Results of mortality during the experimental releases performed between April 1992 and November 1994 are presented in Table 2. A total of 47 houbara out of 82 (57%) released in good condition and which did not die for other reasons after release were killed by predators either inside or outside the pre-release enclosure. Out of 47 deaths related to predation, six (12.6%) were due to raptors, two (4.2%) to ravens and 39 (82.9%) to red foxes (*Vulpes vulpes arabica*). Despite all birds were radio-fitted and checked daily, post-mortem examination was often difficult to carry out, as part or all the carcasse can already be eaten. Frequently only feathers and radio-transmitter remained. When fox-predated, carcasses were generally found completely eaten, part of the body could be found buried, transmitter damaged with tracks of bites noticed on it. Footprints were often observed around the remains of dead bird. The way feathers were always cut rather than pulled out of the body was another argument for mammalian predation. Raven predation was observed on very young flightless birds. It occured inside the pre-release fox-free enclosure. Eyes and visceral organs were always eaten first. Raptors predation seemed to occur on debilitated (feather cut) birds. Feathers were pulled out instead of being cut. Distinct beak tracks were visible on feathers.

Diseases have killed directly, or have led to the removal from release experiments, 11 houbara bustards during 1992-94. Five cases were due to a respiratory tract disease (sinusitis, and deep ulcerative bronchitis) caused by a combined infection of a pox virus and opportunistic bacteria. One case was due to a debilitating ocular pox lesion (the bird was

unable to feed). In addition, four birds suffered from an unidentified respiratory tract disease prior to release in 1994. Paramyxovirus type 2 (Yucaipa strain) was isolated from feces. However, as it is often the case, there was no substantial evidence that it was this infectious agent that affect primarly the birds.

Discussion

In the initial planning stages of reintroduction project, a disease and medical problem preventive medicine program should be developed.[1] Diseases and pathology of otidiformes were poorly documented. Many pathological events occured during the first years of captivity in this species allowing the collection of data about infectious agents, traumatism therapy and predation impact. Definition of the diseases in captivity of the species, allowed us to develop a preventive medical program.[5] High rate of traumatic-origin deaths was paradoxally linked to the sanitary effort accomplished during six years. Necessity to handle very stressful birds for medical prophylaxis, construction of non-permissive enclosures to prevent access of wild birds in the breeding unit, and erection of "non-smooth" fences to avoid neighboring wild predators (red foxes, feral cats, eagle owls...) to enter the rearing facilities were responsible of the majority of traumatic deaths. Attempts to captive-breed under intensive conditions and following strict sanitary rules a very fragile species inevitably led to a degree of environmental unadaptation.

Poxvirus infection and subsequent bacterial infection was common in translocated houbara bustards in mahazat as-Sayd reserve. Fifteen cases of confirmed cutaneous pox were observed. This caused 10 (67%) of the birds infected to die either directly from infection (5 cases) or from predation (5 cases). However, 5 birds preyed upon by carnivores out of 10 survivors is not significant when compared to non-infected birds and suggests that pox infection when subsequent bacterial infection was not directly lethal, was not a major problem to captive-bred houbara bustards. Since 1994 vaccination of birds with a different strain (canary strain instead of fowlpox strain) has proved to be more efficient.

Assessment of the primary cause of death in released animals can be very difficult to carry out with certitude, as many predators are known to be also scavengers. Careful attention should be made not to overestimate the proportion of primary predation deaths. In the present reintroduction program, a predator control experiment (trapping and translocation of carnivores) around the pre-release enclosure showed a 36% decrease of general mortality within the controlled area. Comparative mortality with and without predator control was significantly ($Chi2=14.4$, $d.f.=1$, $P<0.001$) decreased during predator control experiment. This results suggests that predation by carnivores was the major primary cause of death among released birds found already eaten.

Conclusions

An effort was made in reviewing the necropsy reports to determine the most significant pathologic findings leading to death. There were many cases that had multiple organ system involvment, making the determination difficult. The incidence of traumatic deaths (29%

of juvenile deaths and 43.7% of immature/adult deaths) may warrant a review of husbandry in rearing situations. In the planning stages of a reintroduction project, the goal of a good preventive medicine program should be to prevent the introduced species from contracting disease from animals indigeneous to the reintroduction area.[6] In the present case satisfactory survival rate among captive-bred released birds tend to prove that medical preparation of the houbara bustards released was successful. Although all released birds were carefully checked for different infectious agents to avoid introduction of diseases into the area's indigeneous animal population, regular disease monitoring of the released population will be carried out in the next years. Furthermore, continuous evaluation of the diseases of other species in the release area will be of great benefit to the overall knowledge of infectious agent exposure to the released houbara bustards.

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Fig 1: Histogram showing evolution of mortality rate (%) among adult/sub-adult captive birds between 1989 and 1994 (number of bird deaths per year divided by the average number of birds in the captive breeding unit each 12 month period).

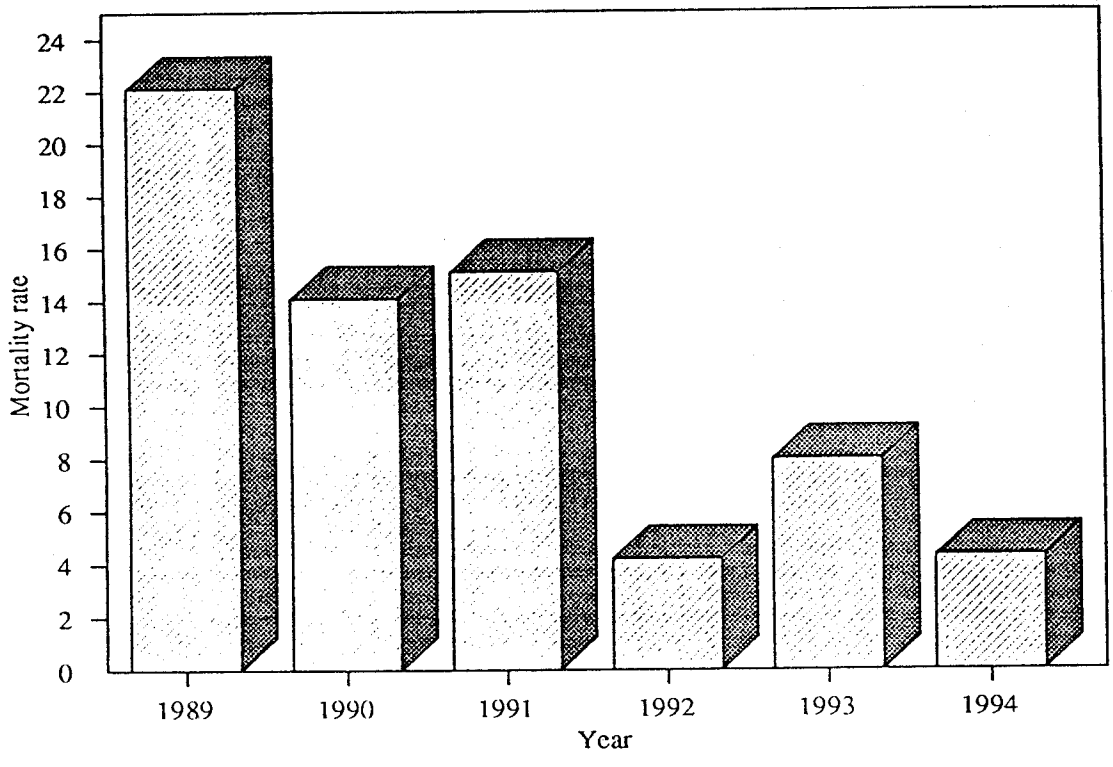


Fig 2: Histogram showing evolution of mortality rate (%) among juvenile/neonate captive birds between 1989 and 1994 (number of bird deaths per year divided by the average number of birds in the captive breeding unit each 12 month period).

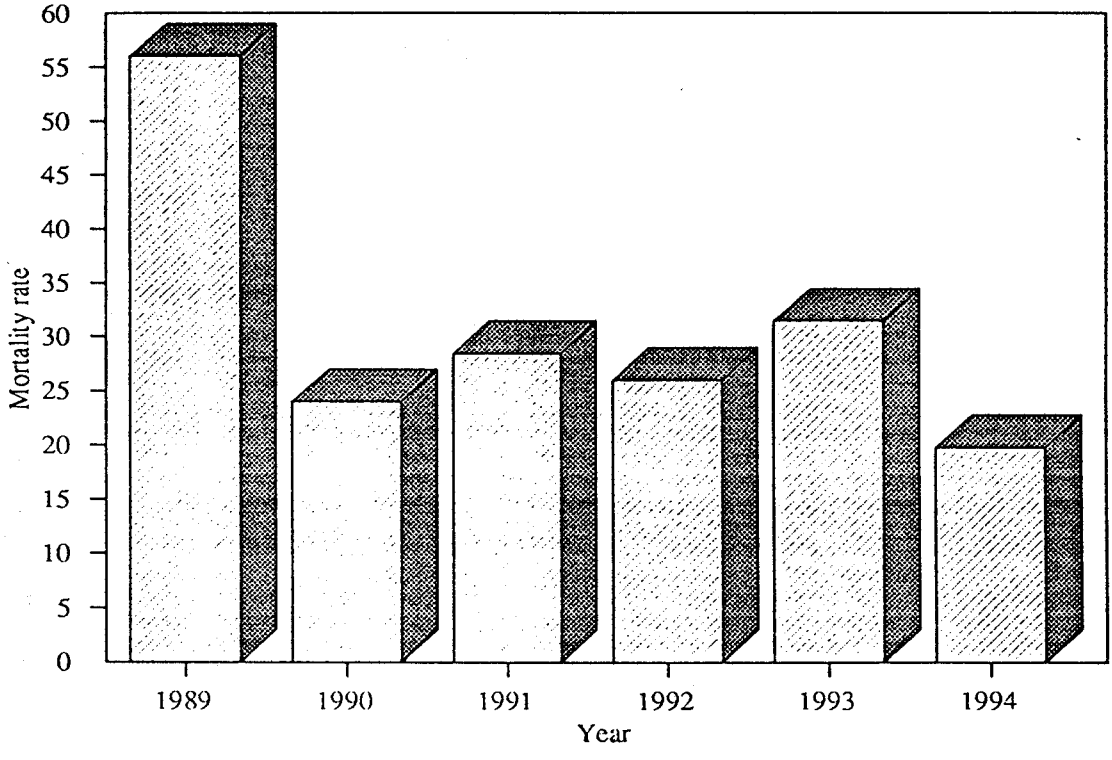
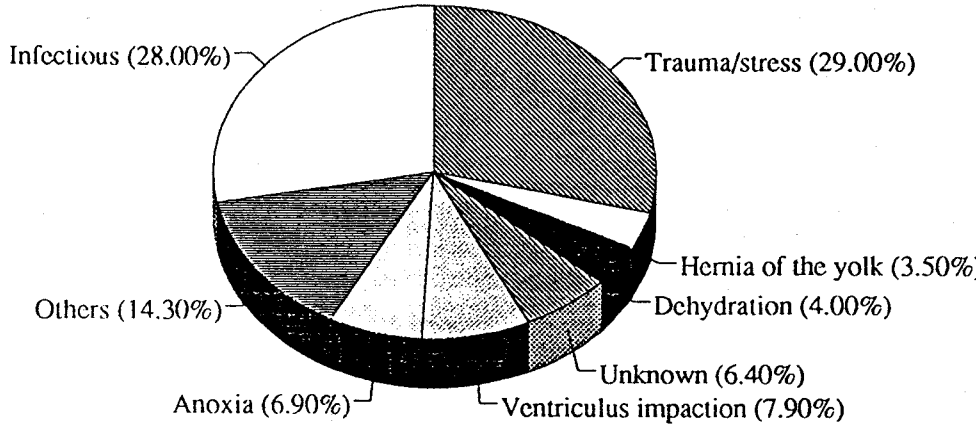
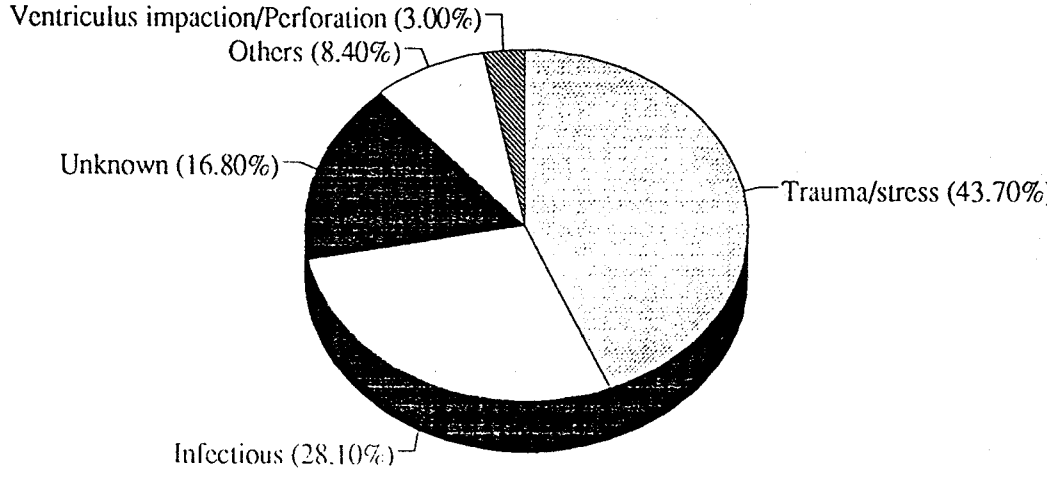


Fig. 3: Summary of causes of death on 203 necropsies of juvenile/neonate captive houbara bustards performed at the NWRC between 1989 and 1994



n = 203

Fig. 4: Summary of causes of death on 167 necropsies of adult/sub-adult captive houbara bustards performed at the NWRC between 1989 and 1994



n = 167

Fig 5: Summary of mortality of captive neonate Houbara bustards between 1990 and 1994, showing etiological distribution during the first month of life.

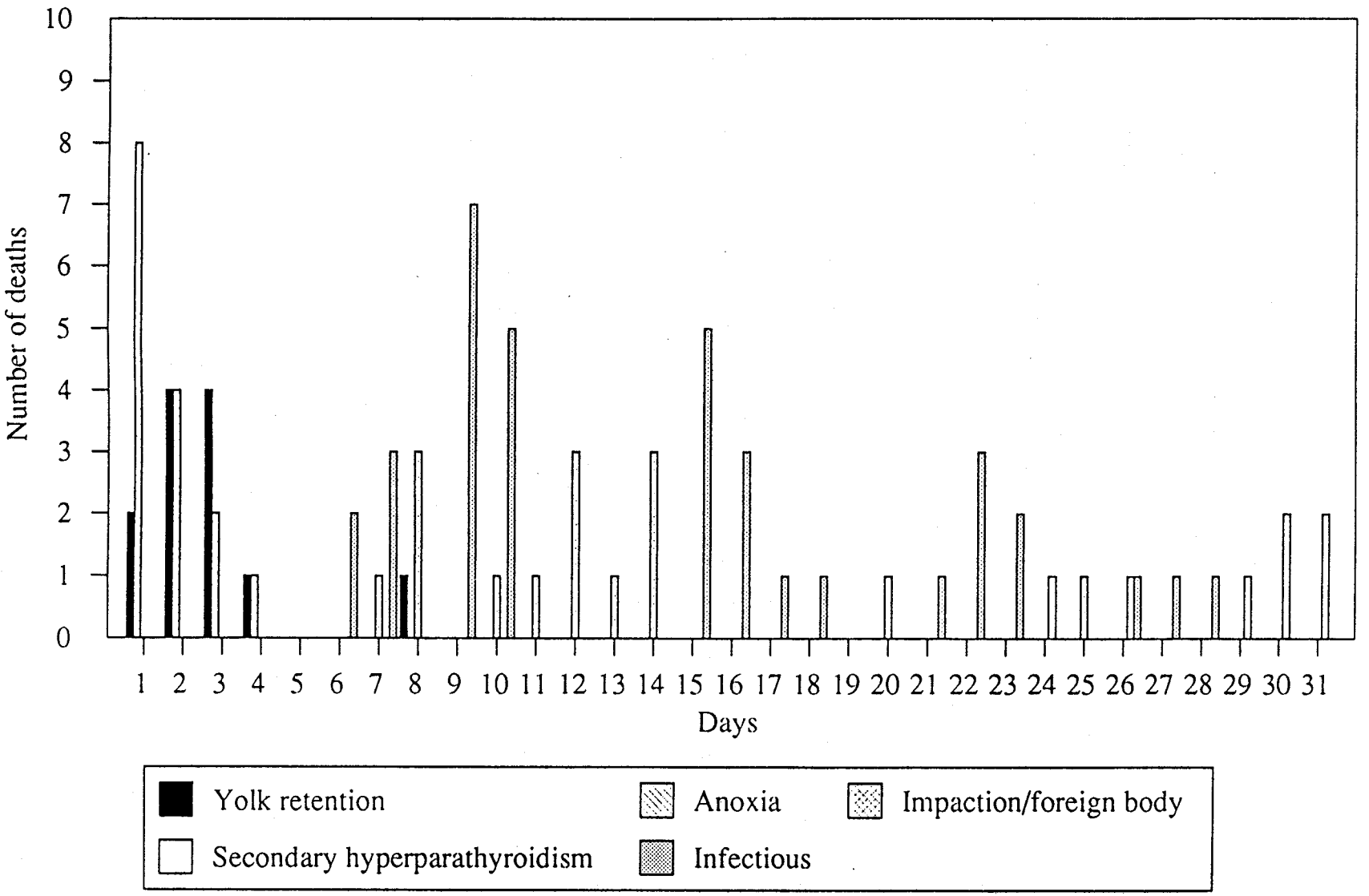


Table 1: Summary of pathology and microbiology findings on 104 necropsies performed at the National Wildlife Research Center and related to infectious syndromes. Each case may have had multiple pathologic findings. A primary finding is defined as either the cause of death or the most significant finding present in a particular case. Findings are listed in order of frequency of primary findings.

PATHOLOGY	INFECTIOUS AGENT	NEONATES (0 - 30 DAYS)	JUVENILES (1 - 12 MONTHS)	IMM. / AD (>1YEAR)
Respiratory tract infection (Sinusitis, bronchitis, pneumonia)	Pox virus Newcastle disease virus *Escherichia coli* *Proteus mirabilis* Other gram- bacteria	7	2	9
Enteritis / peritonitis syndrome	*Chlamydia psittaci* Herpes virus *Pseudomonas aeruginosae* *Klebsiella pneumoniae*	0	3	24
Hepatitis and cholangiohepatitis	Herpes virus Adenovirus *Chlamydia psittaci*	5	1	20
Upper digestive tract infections (Oral mucous membrane lesions)	Poxvirus *Trichomonas sp.*	10	2	1
Interstitial nephritis and glomerulo nephritis	Combined gram-bacteria	2	0	3
Generalised neoplasia	Reticuloendotheliosis virus suspected	0	3	0
Duodenal parasitic impaction	*Railletina sp.*	2	0	0
TOTAL		**36**	**11**	**57**

Table 2: Results of the experimental release of Houbara bustards conducted between 1991 and 1994 in Mahazat As-Sayd reserve.

	HARD	FCS	COVEYS	SUB
N	**5**	**14**	**17**	**74**
Year	**1991**	**1992-93**	**1993**	**1992-93-94**
Failure before release	**0**	**2**	**3**	**15**
Injury	0	1	2	6
Disease	0	1	1	9
Actually released	**5**	**12**	**14**	**59**
Failure after release	**5**	**9**	**9**	**31**
Disease	0	0	0	2
Predation	5 (100%)	8 (89%)	6 (66%)	28 (90%)
Unknown cause of death	0	1	3	1

HARD= Hard release, COVEYS= Covey release, FCS= Feather cut sub-adult release, SUB= Sub-adult release.