Ex-situ Conservation of Malayan Gaur (*Bos gaurus hubbacki*): A Forty-year Summary of Breeding Performance and Lifespan

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Abstract

Studbook data of captive Malayan gaur managed in two Wildlife Conservation Centres (WCC) by the Department of Wildlife and National Parks, Malaysia (PERHILITAN) were analysed for the period 1982-2022. The maximum individual lifespan recorded was 26.2 years for a female and 20.9 years for a male. The average lifespan over four decades decreased from 18.1 years to 9.4 years. The mean primiparity is 3.96 years, which is older than other closely related species. The fecundity of the ten most prolific cows averaged 10.2 calves. Although 53% of cows remained reproductive beyond ten years of age, only 11.6 % produced ≥ 10 calves each, with the remaining cows averaging four calves each in their life-time. The poor breeding performance over the years is closely related to the unsound captive environment, including management practices, human resources, and husbandry. There was a high mortality rate prior to adulthood, with perinatal and yearling mortality accounting for 74% of the total mortality. Traumatic injuries, snake bites, infectious diseases, glyphosate poisoning, mycosis, endoparasites (including protozoa), old age and stressor myopathy contributed to the death of this species in WCC. No congenital defects were observed in all cases. The findings indicated a very strong need to minimize reproductive inefficiencies whilst improving perinatal and neonatal care. Reducing stress and more stringent biosecurity can help reduce mortality in yearlings and adults. Although there is a lack of evidence of genetic problems in the herd, the need for a new founder is crucial, to improve the genetic qualities of the Malayan gaur in captivity.

Keywords: ex-situ conservation, life history, Malayan gaur, Seladang, sustainable captive management

Introduction

The Malayan gaur (*Bos gaurus hubbacki*), locally known as seladang, and the southern-most form of the species, occurring in the humid equatorial zone, is a member of the tribe Bovini, which includes cattle, bison, yak, buffalo, and saola. Thus, in captive conditions, its management, husbandry and mortality would be expected to be comparable to beef and dairy cattle farmed throughout the world. The species is listed as vulnerable in the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (Duckworth et al. 2016). In Peninsular Malaysia,

it is totally protected under Wildlife Conservation Act 2010 [Act 716]. Previously, the Malayan gaur population was widespread in Peninsular Malaysia and was once a popular target of big game hunters from the late nineteenth century (Hubback, 1937; Foendander, 1952; Khan 2014; Khan 2016). Their dwindling population was recognised in the 1960s - 70s (Hislop, 1961; Stevens 1968; Khan 1977; Yusof 1981; Conry 1989). In 1982, the Department of Wildlife and National Parks (PERHILITAN) embarked on *ex-situ* conservation of Malayan gaur (Othman 1999; Khan 2016). Fig.1 shows a small herd of Malayan gaur in a paddock.

Life history analysis of captive populations is essential to provide informed decisions on the genetics, demographics as well as management and husbandry of captive populations of wild cattle. The first published analysis of Indian gaur life history covered wild herds in South India and captive gaur from the largest captive populations at Mysore Zoo and Omaha's Henry Doorly Zoo (Ahrestani et al. 2011). This study provides the first analysis of the life history of captive Malayan gaur, focusing on lifespan, reproductive performance, and survivability.

MATERIALS AND METHODS

The captive Malayan gaur population was established and is managed by PERHILITAN at two 'Wildlife Conservation Centres' (WCC), one in Jenderak Selatan, Pahang (GPS location 3° 38'19.6"N 102°18'24.3"E), the other in Sungkai, Perak (GPS location 4°02'07.8"N 101°21'56.6"E). The Jenderak Selatan WCC is located within the 62,395 hectare Krau Wildlife Reserve while the Sungkai WCC is located within the 2,468 hectare Sungkai Wildlife Reserve. The studbook containing the raw data of 227 individual gaurs was used as the data source for the life-history analysis. The founders of the entire captive population consist of four males and two females, all wild-caught, and the remainder

***Figure 1**. A family of Malayan gaur at Wildlife Conservation Centre in Malaysia.*

(n = 221) were born in captivity between 1982 and 2022. The data recorded for each individual includes identification, sex, house name, origin (wild-caught or captive-born), sire, dam, date of birth (or date of capture for wild-caught), age, transfer location, date of death or last known date alive, and cause of death.

The age of the captive-born is known from the exact date of birth observed by the keepers. All the wild-caught individuals were young calves (Khan 2014) and their age was estimated to be two months old, based on their physical characteristics. The date of birth (estimated for the wild-caught individuals, precise for all captive -born individuals) was used to calculate the first parturition and lifespan. The Population Management x (PMx) software (Lacy et al. 2011) was used to analyse and estimate life expectancy and survivorship. For the life expectancy estimation, individuals that did not survive the first 30 days of life were excluded from further analysis to minimize the influence of neonate mortality. The age-specific survivorship (Lx) which illustrates the probability of surviving from birth to various ages for captive Malayan gaur was also estimated using PMx. Unlike domestic cattle, the captive Malayan gaur have been semi-intensively farmed and, the young remained with the mother for a much longer period than is usual for captive bovids. Mortality was divided into perinatal (within 48 hours after birth), neonatal (2-30 days), calf (1-6 months), weaners (6-12 months), yearlings and adults.

Results

The earliest primiparity recorded was at two years and two months (2.22 years), the latest at 8 years, with a mean primiparity of 3.96 years. Of 43 captive-born females that produced offspring, 25.6 % had primiparity under three years, and 55.8 % had primiparity between age 3 and 5. The remaining had primiparity above the age of 5 years. Except for one cow (SJ00012), which

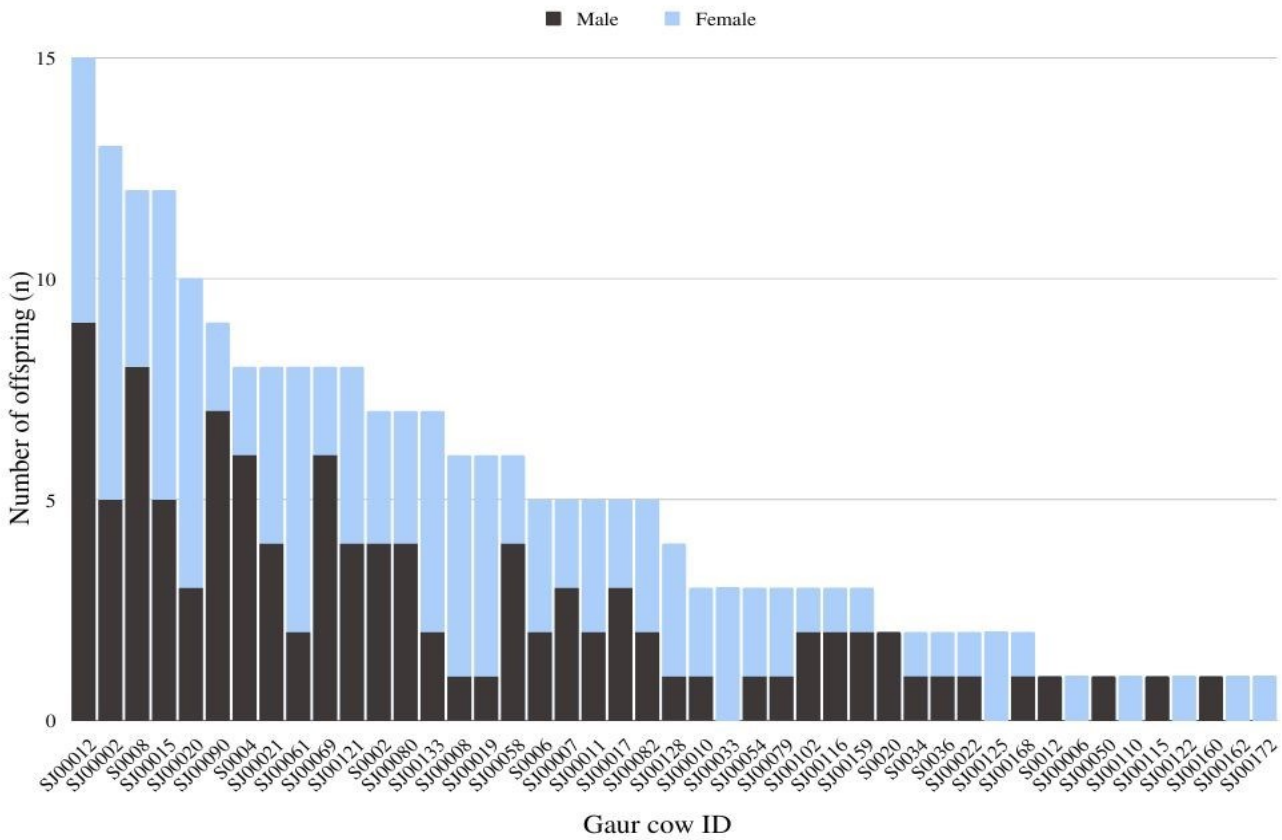

***Figure 2**: The number of Malayan gaur calves produced at the Wildlife Conservation Centres in 1985-2022*

gave birth to her last offspring at the age of 21, no cow gave birth after the age of 19 years. The exception was the eighth calf of the founder pair and gave birth to 15 offspring (9♂, 6♀). This individual was the oldest Malayan gaur to live in captivity and succumbed to respiratory failure at the age of 26 years, 2 months, and 13 days.

The founder pair of captive Malayan gaur produced 13 offspring, with only one death, shortly after birth. The majority of the remaining offspring (n = 10) lived for more than ten years. Since the initial establishment of the WCC in 1982, a total of 45 females (2 wild-caught and 43 captive-born) have produced a total of 221 offspring consisting of 107 males and 114 females (Fig. 2).

Records from the 43 cows who survived to adulthood indicated a marked decrease in the birth rate over the years. The ten most prolific cows produced an average of 10.2 cows in their lifetime. However, in the study, only five cows (11.1%) produced ≥ 10 calves throughout their lifespan. This constitutes a baseline for optimum fecundity for captive Malayan gaur. The remaining cows (n=38) produced an average of four calves (Fig. 3). The 24 cows (55.8%), that surpassed ten years lifespan, produced an average of 7 calves per cow. The average number of calves produced per cow, born within the periods 1991-2000, 2001-2010 and 2011-2020 were 6.6, 4.5, and 2.6 respectively.

The diseases diagnosed at the WCC, included traumatic injuries, envenomation (snake bite), infectious diseases (brucellosis, foot and mouth disease, lumpy skin disease, cowpox), poisoning (glyphosate herbicide), mycotic (aspergillosis), endoparasites (helminths, liver flukes, coccidiosis) and stressor myopathy. Most were fatal. No congenital defects were observed in all cases. Old age also contributed to the death in the WCC. Out of 221 offspring, 35.7 % (n = 79) were dead before adulthood (Fig. 4).

The average life expectancy was calculated to be 10.2 years for males and 9.6 years for females.

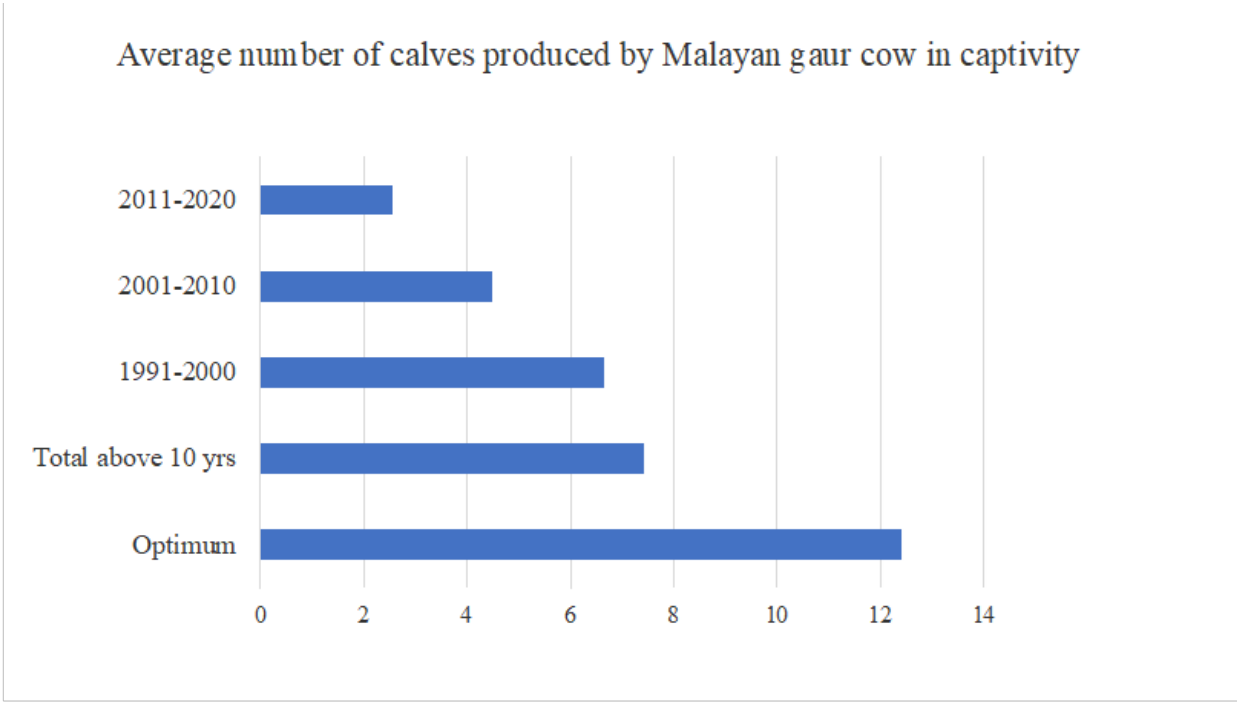

***Figure 3**. The optimum fecundity and average number of calves produced per natural lifespan of a Malayan gaur cow at WCC*

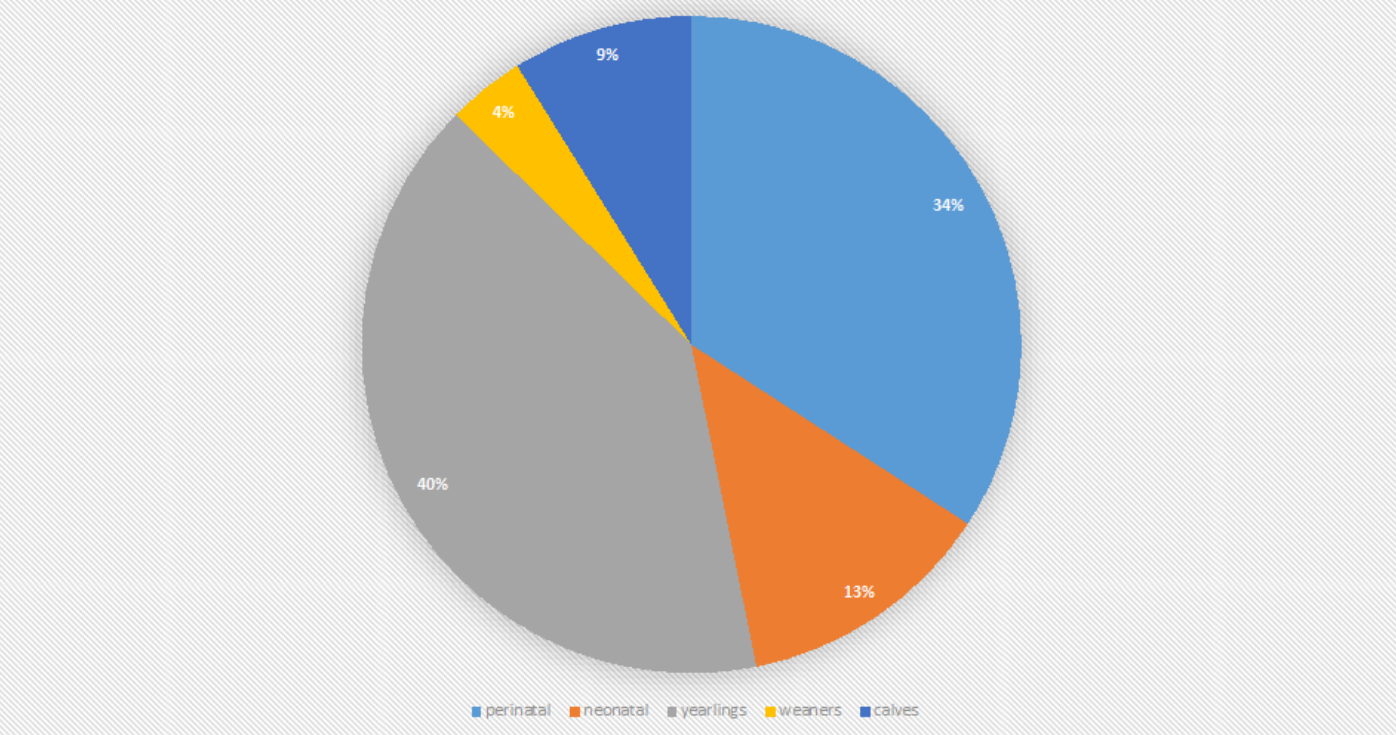

***Figure 4**. Mortality before adulthood of captive-born Malayan gaur*

The age-specific survivorship (Lx) which illustrates the probability of surviving from birth to various ages for captive Malayan gaur was calculated using PMx (Fig. 5). One female is currently thriving beyond the age of 20 years. 10.5% (n=12) of captive-born females live beyond the age of 15 years, and the oldest recorded was 26.2 years. 10.3% (n=11) of males live beyond the age of 15 years, and the oldest recorded was 20.8 years. Currently, the oldest living male and female are 15.9 years and 22.5 years, respectively. The maximum lifespan for wild-caught males is 19.4 years as compared to 17.5 years in females. The minimum lifespan for wild-caught males and females is 9.5 and 8.6 years, respectively.

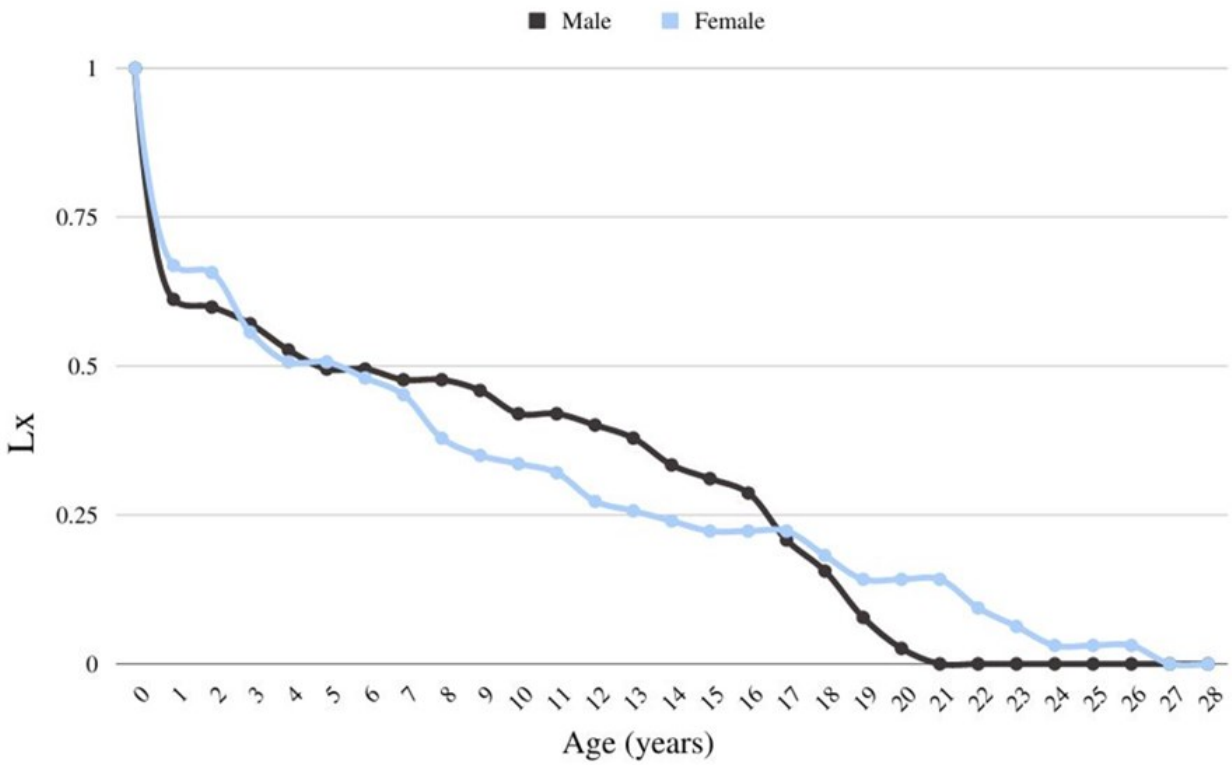

***Figure 5.** Probability of surviving (Lx) from birth to various ages (years)*

Discussion

The wild population of Malayan gaur declined greatly during the twentieth century, due to a combination of habitat (grassland, predominantly along river valleys and in Orang Asli swidden farms) loss and poaching (Conry 1981; Payne et al. 2021). Recent observations on the extreme scatter and scarcity of clusters of wild Malayan gaur, coupled with very small and declining herd size, and apparent low fecundity, give rise to grave concern for the survival of this southern form of *Bos gaurus*. The wild clusters are clearly not increasing in size, strongly suggesting the deleterious effect of infertility or subfertility as a result of ageing and poor nutrition. Similar findings have been seen recently in *Bos javanicus lowi*, the Bornean form of the banteng, in Sabah, Malaysia (Zainal Zahari 2022; Zainal Zahari et al. in press). As shown by the above analysis, captive Malayan gaur numbers are also declining significantly over time, with high calf mortality, low fecundity, and short longevity. Inbreeding depression has been highlighted as a cause of death in neonates (Norsyamimi et al. 2016). However, after re-examining studbook data, history, autopsy reports, management systems, staffing, nutrition, husbandry, biosecurity, and genetics, a more accurate assessment can now be made.

A study of dairy and beef cattle in Finland in 1999-2006 reported congenital malformation in neonates, particularly heart defects (4%) and hydrocephalus (1%). Apart from the congenital anomalies, sporadic intrauterine infection and dystocia are the common causes of neonatal mortality in Finnish calves (Syrjälä et al. 2007). A study on Irish Holstein-Friesian dairy cows on the effect of inbreeding on milk production, calving performance, fertility and body conformation showed only a small impact. There were a 1% higher incidence of stillbirth and 2% higher incidence of dystocia (Parland et al. 2007). In the case of Malayan gaur, more substantiated evidence is required to associate inbreeding depression with neonatal, perinatal, and yearling mortality. To date, there is a lack of evidence to associate the high mortalities with genetic problems.

The number of captive Malayan gaur increased over the years and reached a carrying capacity in the captive facilities around year 2000, but the available resources have remained unchanged. Calf mortality was observed to increase over the years. In addition, poor breeding performance, increasing age at primiparity and shortened life expectancy are factors of concern. The complete absence of congenital defects observed in all the captive Malayan gaur tends to argue against genetics (inbreeding depression) as a major source of concern. Instead, the small number of enclosures and of staff (support staff and veterinarian), and limited food resources, tend to point to management (husbandry, nutrition, biosecurity) as a greater reason for concern.

The present situation is serious but reversible. The problems need to be recognized at the departmental and national level and improving calf survival and optimizing breeding performance would require reprioritization. In the absence of a programme to improve food availability (managed pastures) for the wild Malayan gaur clusters in situ, the importance of ensuring and sustaining a well-managed captive population assumes ever greater importance. Failure to provide pastures for the wild clusters, coupled with a sub-optimally managed captive population, could put the Malayan gaur on the road to become the next species of large mammal to go extinct after the Sumatran rhinoceros.

The average life expectancy (1982 – 2021), for captive Malayan gaur is 10.2 years for males and 9.6 years for females. According to Kohler et al. (2006), the average lifespan of captive mammals is roughly equal to half of the oldest age attained by that species. Life expectancy and longevity of captive ruminants are two useful parameters that may indicate the success of husbandry practices (Müller et al. 2011). However, when viewed every ten years (1982 – 2021), the average life span, showed a gradual shortening, from 18.1 years (1982-1991) to 17.3 years (1992-2001), 14.2 years (2002-2011) and 9.4 years (2012-2021). This decline is especially concerning in view of the observation of 59 mammalian species examined, including *B. gaurus*, 84% lived longer in captivity compared to their wild counterparts (Tidière et al. 2016).

The lifespan of the Malayan gaur in the wild has not been determined, but in this study, the wild-caught Malayan gaur males lived for 19.1 years and females, 17.2 years. In contrast, the oldest recorded captive-born Malayan gaur is 20.9 years for males and 26.2 years for females, indicating that male captive-born Malayan gaur have a shorter lifespan than females. This result is similar to captive Indian gaur in two zoos, where females live longer than males (Ahrestani et al. 2011). Eighteen captive Malayan gaur which were born between 1982 until 2001 lived beyond 15 years of age. In contrast, only eight individuals, born after 2002 survived beyond the age of 15 years. With the increase in the number of Malayan gaur bulls in a captive facility and no increase in facility size or resources, the bulls become very territorial. Clashes between adult and sub-adult bulls are often seen, some with serious wounds or death. Competition for food and space becomes apparent. These stresses would cause an animal to be immune-compromised and becomes more susceptible to diseases, including helminthiasis and other infections (Kumar et al. 2017; Hodgson et al. 2005).

Calf survivability

A total of 221 calves were produced in the WCC by the end of 2022. Total calf mortality accounted for 37% of all recorded deaths in captivity (n=79). Of this, perinatal mortality constituted 34%. This is more than twice higher than the highest recorded internationally in the dairy industries, with the majority of countries, between 5-8% (John, 2013). The high incidence of perinatal mortality in the captive Malayan gaur is quite likely associated with anoxia or trauma, as most calving occurred at night or early morning inside the paddock and was never observed or attended by the keepers. In an international study, based on necropsy findings, the major causes of bovine perinatal mortality are dystocia (approximately 35%) and anoxia (approximately 30%), to a much lesser extent, infections (approximately 5%), congenital defects (approximately 5%) and 15% from other causes (John et al. 2019). Consistently high mortality rates and/or poor fertility may be an indication of failure in monitoring and/or acting on signals of animal performance. This general failure has a wide range of negative consequences for the welfare status of the animals on the farm. In addition, published literature on bovids shows significant influences of environmental factors on calf mortality (Mandal et al. 2019; Sandgren et al. 2009).

In Pakistan, the mortality in neonatal calves has mostly been attributed to infectious agents, immunodeficiency, seasonality, difficult parturition, and faulty management conditions

(Khan et al. 1991). Many research articles report abortion and perinatal mortality varying from 5 to 12% and 2 to 5%, respectively, which surprisingly, is regarded as representing a huge loss of calves (Moore et al. 2021). In comparison, calf mortality in Bali cattle, on Sumbawa Island, Indonesia, ranged from 10–27%, mostly in the older calves (Sriasih et al. 2021). Similarly, in Uruguay, the high preweaning dairy calf mortality risk is 15.2% (Caffarena et al. 2021). Therefore, the high percentage of calf mortality in the Malayan gaur in the WCC needs a serious intervention and the causes need to be redefined and not solely attributed to inbreeding depression.

Diseases of infectious origins were also diagnosed in the WCC. They caused mortality in adults, sub-adults and possibly new-born. They include bovine brucellosis in 2007. Bovine brucellosis is characterised by abortion, stillbirth, reduced milk production, weak fetus and infertility in both males and females (Mukhtar et al. 2013). The movement of infected captive Malayan gaur from an “infected herd” to another, which occurred in 2012, without prior evaluation, including serological test, could transfer the infection to other Malayan gaurs. Thus, all cases of abortion and stillbirth in captive Malayan gaur require thorough investigation. Foot and mouth disease (FMD) was diagnosed in 2008 but all captive Malayan gaur were vaccinated except for two individuals who did not survive. Another FMD outbreak occurred in 2016 but the outbreak was successfully contained without any death recorded (Merawin et al. 2017).

Five calves (2-27 days) in the captive population were trampled or killed by a bull. Two of the calves were one day old. Post-mortem findings included ruptured organs and fractures. Traumatic injuries can be avoided by reducing the herd size (or separating the bulls) in the paddock during the third trimester of pregnancy. Pregnancy diagnosis, especially in the third trimester/late pregnancy can be made visually by an experienced manager. If heavily pregnant cows are isolated, they could be provided with better nutrition and be observed more closely prior to parturition.

The observed incidence of pneumonia and haemorrhagic enteritis is an indicator of infection by pathogens in the perinatal calves. One incident of septicaemia in a calf was also observed at the WCC. This occurred as a result of an ascending infection (bacteria), entering through the umbilical cord (navel), soon after birth. This would result in reduced appetite and fever and if left untreated will lead to death. A few perinatal calves were diagnosed with jaundice and anaemia. One of the differential diagnoses of jaundice in calves is leptospirosis. Coccidiosis was diagnosed and treated in the neonatal calf. Helminthiasis caused the death of two calves, aged one year and two months. Aspergillosis caused the death of a neonatal calf that was hand-raised in the WCC.

Reproductive performance

Published records of captive gaurs elsewhere show that this species reaches sexual maturity between the ages of 2 and 3 (Ahrestani et al. 2011; Castelló 2016). In this study, the earliest first parturition for captive female Malayan gaur was 2 years and 3 months (2.3 years). Only 11 out of 43 captive-born reproductive females had primiparity between the age of 2 and 3. The others were older. The gestation period of the Malayan gaur was estimated as nine months by Hubback (1937). Based on recorded observations at JSWCC from 1986-1995, the

gestation period is about ten months (Zainal Zahari Zainuddin, unpublished observation). Using this information, the earliest sexual maturity of female Malayan gaur in this study is estimated to be 17 months.

Diseases, both infectious and non-infectious will contribute to reproductive failures (Fuerst-Waltl & Fuerst 2010; Fuerst-Waltl & Sørensen 2010; Svensson et al. 2006; Lombard et al. 2007; Gulliksen et al. 2009). Animal welfare must be considered in every livestock production system. Reproductive efficiency is a direct indicator of the health and welfare situation of farm animals. Therefore, low reproductive rates (prolonged anestrus, low conception rates, high reproductive losses, and high percentage of assisted deliveries and/or dystocia) may indicate animal welfare problems (Dadin et al. 2021).

Data accumulated since 1982 indicate variability in breeding performance when compared between different generations. The main parameters observed in the Malayan gaur included delayed sexual maturity, late calving, long calving intervals, erratic conception rates, high stillbirth, and low fecundity. In captivity, the optimum fecundity in Malayan gaur averaged 12 calves/natural lifespan. This was based on the five cows that survived beyond the age of ten years and a calving interval of one calf/year. This benchmarking should allow WCC managers to track their progress and the success of any implemented changes on the farm. In the WCCs, low conception rate and short longevity resulted in overall poor breeding performance. Currently, 91% of Malayan gaur cows produced only 4 calves/cow/natural lifespan. In general, management practices and the farm environment play integral roles in determining optimum calf production (Schuster et al. 2020). The declining trend of calves/cow/lifespan in the WCCs, over more than three decades, indicates a lack of a breeding management strategy, insufficient human resources and suboptimum animal husbandry practices.

The optimum body weights of heifers are important prior to their first breeding. *Bos taurus* beef heifers need to attain 60% to 65% of their expected mature body weight, before the first breeding (Patterson et al. 1992; Gasser 2013). In comparison, Nelore heifers, with favourable genetic merit for age at first calving were observed to reach puberty at 80% to 107% of the expected mature body weight. These heifers attained puberty at 18 months of age (Ferraz et al. 2018). In the Malayan gaur, mature females weigh approximately 500-700kg (Ogilvie 1952; Johnston et al. 1994; Mamat-Hamidi et al. 2012). Thus, the weight at first breeding of the Malayan gaur should be within the range 300 – 480kg.

Stress is ultimately a major cause of reproductive failure. A dominant territorial bull will suppress reproduction in other bulls. In the WCC enclosures, the design is such that it only limits physical contact between bulls. However, the olfactory and vision senses are not limited by the horizontal bars that separate them. For cows, delayed resumption of ovulation and estrus can be due to metabolic-related stressors which in turn can be due to insufficient pre-calving nutrition and inadequate management practices, including alleviating stressors. The recommended body condition score (BCS) for bovids should be in the region of 2.75-3.0 (Crowe 2008). In the Bornean Banteng (*Bos javanicus lowi*), improving the nutrition in a wild herd resulted in a three-fold increase in the number of birth (Zainal Zahari et al. in press). Stress reduces fertility in cattle by interfering with the

reproductive hormones due to high levels of cortisol in the blood (Kumar et al. 2012; Wrzecińska et al. 2021). There is considerable evidence that acute stressors reduce GnRH and LH pulse frequency and delay ovulation (Suzuki et al. 2001; Peterson et al. 2006; Huszenicza et al. 2005). Local infection of the uterus in post-partum cows delays uterine involution, causes inflammation of the endometrium, reduces conception rate and may affect follicle growth, decrease estradiol secretion, and delay interval to first ovulation (Williams et al. 2007; Sheldon et al. 2002, 2008; Dadin et al. 2021).

Reintroduction Programme

Without reintroduction, conservation breeding may be seen as unsuccessful (Ebenhard 1995). PERHILITAN embarked on reintroduction with a pilot programme in 2010, in which two gaur individuals (1:1) were released. Unfortunately, the pilot program was not successful because the gaur starved to death. Additional reintroduction was planned and executed in the following years. As of 2022, 26 (16:10) captive-born Malayan gaur individuals have been relocated into wild habitats (PERHILITAN, unpublished information). One female individual released in 2012 was sighted with a male calf in January 2015 (PERHILITAN, unpublished information). However, unpublished reports suggest quite high levels of mortality in Malayan gaur released into the wild, perhaps because all cases were 'hard releases' (Paloma et al, 2021).

Nonetheless, even if a species is never reintroduced, conservation breeding programs can supply zoos with animals to display, thereby limiting the need to gather them from the wild (Ralls & Ballou 2013). Captive Malayan gaur have been transferred to zoos in Malaysia, including Melaka Zoo, Taiping Zoo, and Zoo Negara (National Zoo). Other than zoos in Malaysia, captive Malayan gaur have also been transferred to Khao Kheow Open Zoo in Thailand. Captive breeding programs also have considerable educational value because they can be utilized to educate zoo visitors about the benefits of preserving biodiversity and to boost enthusiasm for conservation (Ralls & Ballou 2013). Most importantly, a captive breeding programme provides an insurance against the potential risk of total extinction in the wild which, in view of the small and very scattered remaining wild clusters of Malayan gaur (Payne et al, 2021) is not an impossible scenario.

Genetics and captive breeding

Although the analysis presented here argues that a variety of management issues account for the observed poor and declining performance of the captive herd, genetics and the risks posed by inbreeding must not be ignored. Genetic diversity in any population comes from three sources: recombination, migration, and mutation (Griffiths et al. 2000). Since mutation rates are less likely to result in genetic variation in small captive populations, the genetic diversity of these populations is maintained by maximizing the genetic potential of the founders and immigrants (Ballou 1984). In captive populations, genetic diversity will inevitably be lost with each new generation (Crow & Kimura 1970). Introducing new bloodlines into the captive Malayan gaur population should be considered a priority, even though improvements in management and husbandry are the prime need. This is critical to maintain a high level of genetic variation and to ensure that the population in captivity is viable for reintroduction into the wild. Nonetheless, obtaining a wild gaur is no easy task; it has been 20 years since the last wild-caught gaur was

brought into the conservation centre in Malaysia. For the improved genetic sustainability of the captive breeding programme, assisted reproductive technology (ART) can be considered by collecting the sperm of bull gaurs in the wild, without the need to bring the animals into captivity, and apply in vitro fertilization with egg cells from captive cows. In addition, routine semen collection and cryopreservation from all the captive bull gaurs should be initiated on a large scale.

CONCLUSION

This study has furnished current information on captive gaurs in Malaysia for their future conservation. The life-history patterns of captive Malayan gaur should be similar to other bovids, but this analysis shows significant under-performance and weaknesses. Although some individuals lived more than 20 years and produced many calves, there are also very many individuals who failed to survive their first year of life. Moving forward, perinatal management is crucial to avoid future death after birth, trauma, anoxia or weakness. The high mortality of perinatal calves would suggest a need to improve attention to health, particularly of the dam and calf. Similarly, adequate nutrition to the pregnant cows will help to ensure a healthy calf. Prophylactic measures including the use of anthelmintics and anticoccidial medications must be implemented routinely. There is a need to ensure the paddocks are always clean, not overcrowded, and with ample dry land at all times, especially during rainy periods. Routine veterinary examination of the cow and calf can identify potential health issues. Calves that are neglected by the dam can be hand-raised to at least 4 months of age. In summary, improving captive Malayan gaur calf survivability requires re-prioritization of the management system.

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