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BREEDING AND REPRODUCTIVE PERFORMANCE OF THE AFRICAN PENGUIN (*Spheniscus demersus*) AT UNDERWATER WORLD LANGKAWI (UWL) MALAYSIA

MOHD HAIRUL BIN MOHD SALLEH[1,2*], FARHAN BINTI RUSLIN[1] and SHUKOR BIN MD. NOR[1*]

[1]*School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi, Selangor*
[2]*Royal Malaysian Customs Department, Kompleks Kastam WPKL, Customs Call Centre, No. 22, Level 5, Block C, Jalan SS 6/3, SS 6, 47301 Petaling Jaya, Selangor, Malaysia*
[*]*E-mail: mhairul.salleh@customs.gov.my; shukor@pkrisc.cc.ukm.my*

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ABSTRACT

This paper provides a demographic analysis of six years information collected on an African penguin (*Sphenicus demersus*) colony of Underwater World Langkawi (UWL) at Langkawi Island, Kedah, Peninsular Malaysia. These information include reproduction, sex ratio, seasonality, egg-laying date interval and age range of breeding. From the period of 2006 to 2011, 27 chicks survived while 16 chicks died within six years. The sex ratio favoured the female with 1.8:1 in 2006 and 1.38:1 in 2011, although the gender of about 14 second-generation individuals was unknown. Eggs were laid in all months of the year, but a higher frequency was observed between August and January or between autumn and winter (in the southern area). The calculated interval of egg-laying dates for each egg production was 6.719 ± 4.18 months. The mean intervals of egg-laying dates for identified females were 9.239 ± 4.26 months and 5.196 ± 3.34 months for rear infants and non-rear offspring, respectively. The age at first female egg production ranged between six and twenty years and the males that are actively involved in brooding at the age between three and twenty years. The age of the mother at first weaning of the offspring ranged from six and twenty years (n=43), while the males had first paternity between the ages of three and twenty three years (n=43). Monogamous breeding in the first two years (2006 and 2007) of this study was due to imbalance sex ratio between male and female (2:1) and respectively 1:1 or 1:2 between male to females. The captive colony grew at an average rate of 1.172 per individual per year. In 2011, the calculated rate was 1.15, indicating that the rate remained almost constant. Infant mortality in the first two months was 32.5%. This information is beneficial to increase the effectiveness of the management and conservation of African penguins in captivity.

Key words: African penguin, *Sphenicus demersus*, breeding, mortality, conservation and management

INTRODUCTION

The Sphenisciformes (penguins) are one of the most highly derived clades of existing birds (Ksepka *et al.,* 2006). They are also one of the oldest, most aquatic, and arguably most mystifying groups of birds (Kooyman, 2002). Interestingly, the penguins had extensive morphological, behavioural and physiological adaptations of the typical avian condition. These characteristics have allowed them to have a mostly aquatic lifestyle and to live in the most inhospitable environment in the world. (Ksepka *et al.,* 2006). African penguins (*Spheniscus demersus*) are naturally endemic to the greater Benguela upwelling ecosystem in the southwest of Africa (Crafword *et al.,* 2011). *Spheniscus demersus* breeds are distributed from Central Namibia (Hollam's Bird Island) to South Africa's Eastern Cape Province (Bird Island) (Hockey *et al.,* 2005), and in South Africa, the breeds are located in two specific regions; the Eastern Cape Province and the Western Cape Province which are separated by 600 km (Crafword *et al.,* 2011).

Studies have shown a drastic decline in the world's African penguin population. There were probably 1.4 million adult African penguins on Dassen Island (Shannon & Crawford, 1999), which were decreased to 300,000 adults in the mid-1950s (Rand, 1963). The numbers continued to decline from around 222,000 adults in the late 1970s to

* To whom correspondence should be addressed.

194,000 and 179,000 at the end of the 1980s and the beginning of the 1990s, respectively (Crawford *et al.,* 1995). The drastic reduction in the population are caused by numerous integrated factors, mainly: 1) climate change, 2) food shortage, 3) loss of habitat and 4) human interference or disturbance. For instance, *S. demersus* is very sensitive to changes in heat (Randall, 1983). Thus in windless, hot and cloudless conditions, the African penguin parents abandon their clutches and chicks to cool their bodies and stop further dehydration immediately. These actions then lead to the predation of their chicks and eggs by the Kelp Gulls (*Larus dominicanus*). Hypothetically, if temperatures get warmer out of the adaptable range of African penguins, more desertification of the nests will occur, and the success of breeding will be lower and lead to further declines in their populations. This is just one example of how heat/temperature changes are affecting the population of African penguin, not to mention the other factors, such as food shortage and loss of habitat (Hairul & Shukor, 2017).

The state of conservation of *S. demersus*, or also known as the Jackass penguin for its donkey-like bray, was re-assessed by the International Union for the Conservation of Nature (IUCN) in 2010, and the status was reclassified from “vulnerable” to “endangered” (BirdLife International, 2012). The population of *S. demersus* is moving towards the wrong direction, even with all human understandings on the ecology, genetics and behaviours of the *S. demersus.* Therefore, the African penguin is in needs to be intensively conserved either for conservation or rehabilitation or for part of re-introduction programmes in *ex-situ* conservation centres. *Ex-situ* conservation programmes can eventually function as insurance against the reduction of *S. demersus* in the wild populations and self-perpetuating wild populations. Besides, *ex-situ* conservation programmes can also increase the level of public awareness on the survival of the African penguin and can be used for education programmes for future generations. *Ex-situ* conservation programmes can contribute to improve the efficiency of meta-population management and to support the ongoing rehabilitation efforts of the species. Apart from all the contributions listed, *ex-situ* conservation programmes are invaluable for the development of knowledge (e.g. re-introduction, release, chick-rearing, etc.) and the studies of the species itself, which includes diseases and parasites, nutrition and diet, growth rate and others (Hairul & Shukor, 2016).

This paper presents the six years demographic data of the African penguin colony bornt and maintained in Underwater World Langkawi (UWL), Langkawi Island, Kedah, Peninsular Malaysia. The data reflects the structure of the age and the reproductive parameters such as first egg production age, maternity and paternity, number of offsprings, breeding age description, the survival of infants within two months, sex ratio, breeding seasonality, and egg-laying interval. The monogamous impact of species studies has also been observed, and the long-term data description is essential to evaluate the effectiveness of captivity management and to reduce the risk of animals extinction in the wild.

MATERIALS AND METHODS

The aquarium was situated on Langkawi Island, Kedah (Figure 1). When the colony was first introduced to the UWL in 2006, it had consisted of ten males and seven females.

The penguins were kept and maintained in Enclosure 13 (Figure 2) with built-in pool, land space, quarantine and isolation area. This colony was supplied with fair amounts of mackerel fish, sardines, shrimps, white sardines and squids, although the diet ratio varied among the meals. The feed was done by hand, cast in the pool or deck in the morning and evening.

Data collection

In brief, from the years 2006 to 2011, there were 143 eggs generated from known breeding pairs, 11 surviving chicks and 16 dead chicks. For this colony, a total of 40 penguins with 15 males, 11 females and 14 unidentified sex penguins are presently preserved in the aquarium. Breeding pairs were unchanged for the last six years, but the pattern was not all the same for females in this captive colony.

Information about the breeding pairs of penguins obtained not only from direct behaviour observation (e.g. same pair seen together which every individual tagged with number) but also from the record of nesting (e.g. which pair occupied every nest from N1 to N8). For reproductive management study, data such as lay date, number of days incubated, sire and dam, sibling identification, and method of rearing were recorded in the egg logs. Each laid egg was marked with a sticker, and the dye remained on the egg from the first day of egg. The first eggs laid must be marked as necessary if the expected incubation dates are to be calculated. Besides, trends in success or failure can be identified by tracking the pair’s reproductive history. Recording of reproductive data for penguins can be done simply by using large rookery maps as described by Ellis-Joseph (1990).

We recorded the range of egg-laying dates as the number of months between egg productions. Egg-laying dates mean the date of the beginning of the

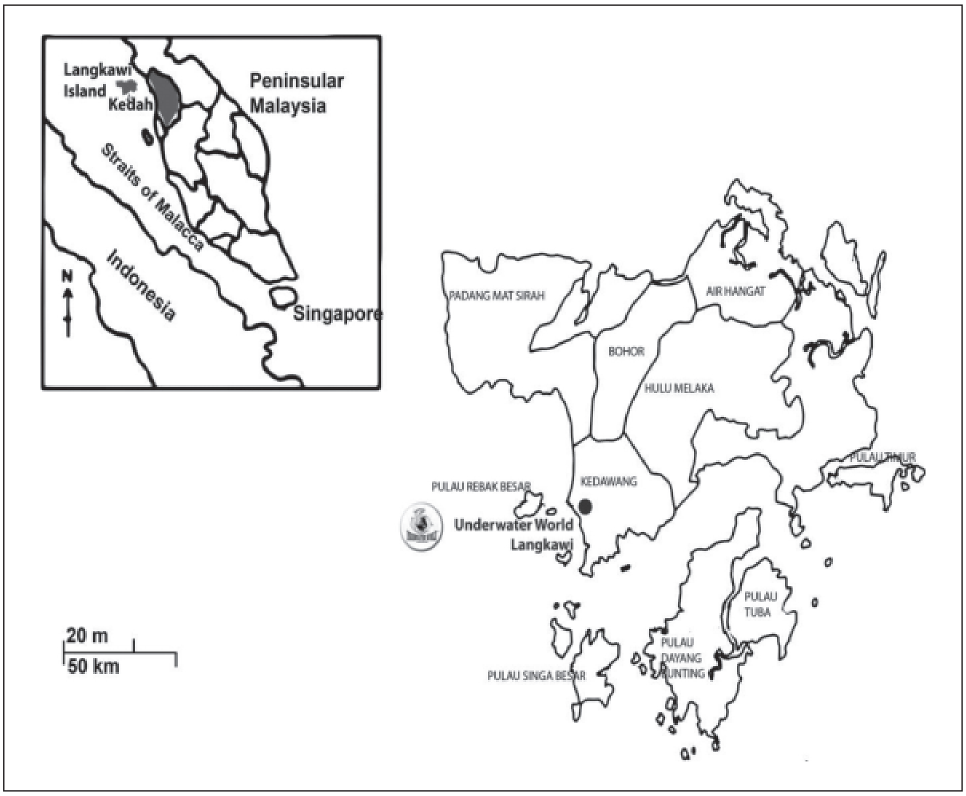

Fig. 1. Study site (Underwater World Langkawi) located at Langkawi Island, Malaysia.

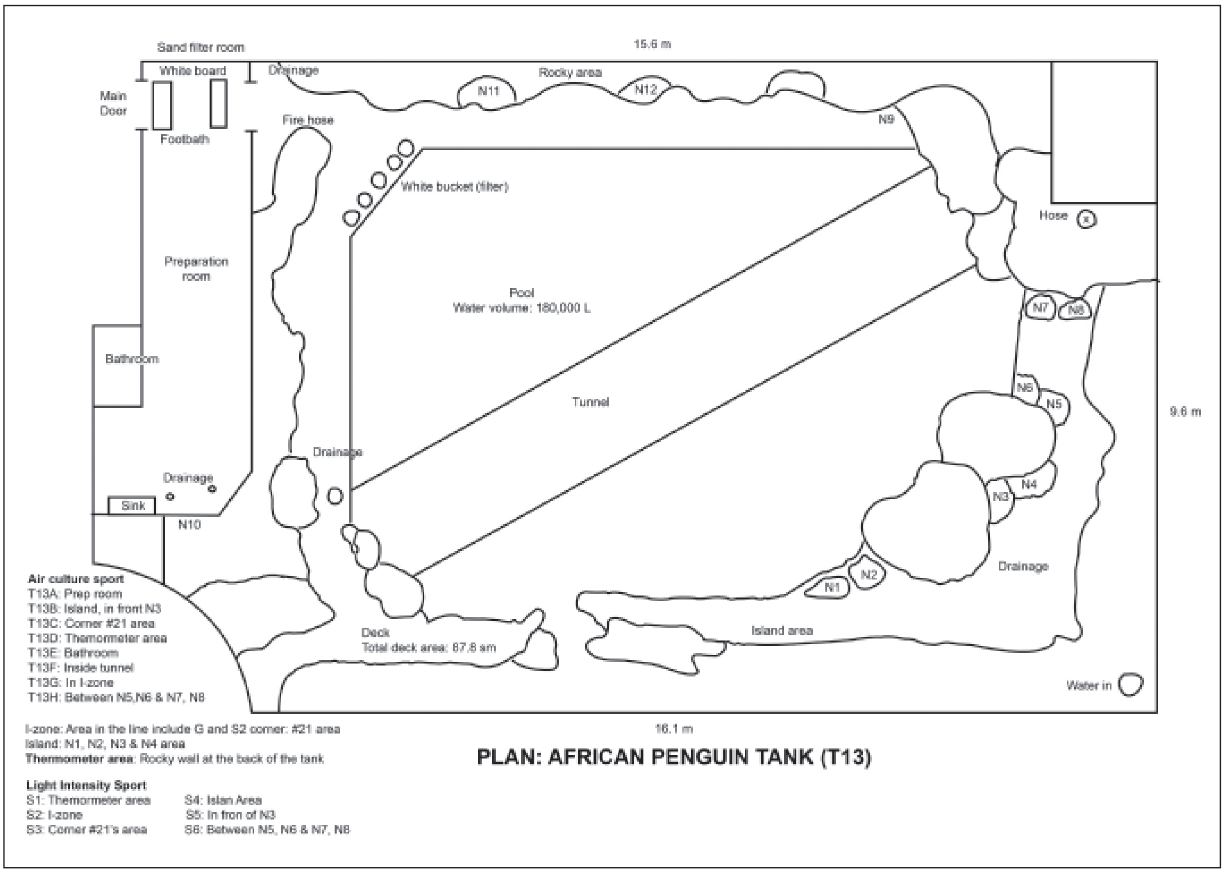

Fig. 2. Floor plan of Enclosure 13.

laying. Intervals were analysed using data collected from four females who had produced two eggs. Two or more hatched chicks are commonly observed in the species, and more than two chicks emerged at a time, as expected.

For reproductive seasonality, we examined the overall annual distribution of hatched chicks in the colony by counting all the eggs laid for all females (n=143), while the surviving chicks (43) were observed from January 2006 to December 2011.

Data analysis

The χ^2 test was used to compare the number of eggs laid from April to November, and from May to October. In addition, the same test was used to compare the total frequency of surviving chicks from parents between 8-23 years of age and 3 years of interval (i.e. from 2006-2008 and 2009-2012). The χ^2 test was also used to determine the difference in sex ratio between the surviving chick and the older cohort.

The Mann-Whitney test was performed to determine the differences between the median age of the parents who had raised only one chick and the age of the father who had raised more than one chick. Mann-Whitney test was also conducted to describe the differences between the female egg-laying dates interval after chick survival and the egg-laying dates interval during the absence of rearing infants.

P-value < 0.05 were considered to be significant for all tests performed. Normality testing using the Kolmogorov-Smirnov test was performed for parameters with sufficient sample size. Mean sample is shown by mean±SD. Descriptive statistics and tests were conducted in SPSS for Window at an alpha level of 0.05, and the results were reported as 1-tailed due to predicted direction of potential outcomes only were of interest in one direction (e.g. lower rates, younger ages, and longer intervals with an increasing number of chicks).

RESULTS

Chick

From the study, 27 chicks survived, and 16 died within six years of study (2006-2011). Of all 16 dead chicks, 31.25% of them died on the first three days (n=5), 56.25% of them died under the age of three months (n=9), and the remaining 12.5% of them died after the age of three months (n=2). Approximately 35% (n=14) of the sex of the individual was unidentified between the ages of one and six years. The sex ratio for identified surviving chicks (n=27) was 1.4 (female): 1 (male) from reproduction in the period from 2006 to 2008. There were no statistically significant differences in the sex ratio between the surviving chick and the older cohort (χ^2=0.14, P>0.05, df=1).

Adult

In 2006, the sex ratio was relatively higher for males aged between nine and twenty years (1:1.8) compared that in 2011 (1:1.167). The age of the adult male ranged from four to twenty five years (average=14.2, n=15) and the age for adult female ranged from six to twenty years (average=9.15, n=11). Changes in the calculated sex ratio was almost 1:1, suggesting a possible balance of breeding competition within the colony (Figure 3).

Pairing

The percentage of monogamous and non-monogamy pairs of African penguins was 28.57 and 71.43% respectively from 2006 to 2011. The pairs of the monogamous African penguin are recorded as follows; 10F/11M, 15F/4M, 13F/12M, 16F/17M, 6F/14M, 16F/7M, 13F/35M and 22F/17M. However, 13F had a different partner in 2010 and 16F in 2006. The highest reproductive rate was observed for pair 11M/10F with nine chicks (16.79%) followed by pair 12M/13F (n=15, 27%), pair 14M/6F (11.45%), pair 7M/16F (9.92%), and pair 3M/2F (6.87%).

Egg production has been observed for all 12 months of the studied years, but a high frequency has been observed from August to January (62.7%; Figure 4). Most of the females laid the first clutches between August and December, which ranges from 13 to 17 eggs per month. Approximately 42% of eggs were laid between January and June. Between February and July, 37% (n=53) of eggs were produced and the rest between August and April. The χ^2 test showed a statistically significant difference in between frequency of egg productions and hatched chicks between April to November and May to October (χ^2 =9.127, P=0.0025, df=1).

The brooding period was calculated from a total record of 45 eggs. The maximum and minimum duration of brooding were approximately 46 days and 34 days, respectively. The mean duration for the brooding period of the African penguin was 38.38±2.31 days. The incubation period for African penguin was approximately 38 days, by both the same male and female in the incubation task. The duration of incubation shifts depending on the availability of food at the time, but it usually takes about two and a half days.

Breeding success

The highest number of chicks survived was recorded in 2011, with about 83.33% of them (or five of the chicks) survived out of a total of six chicks. However, there was a high mortality rate recorded in 2010, with approximately 66.67% of the

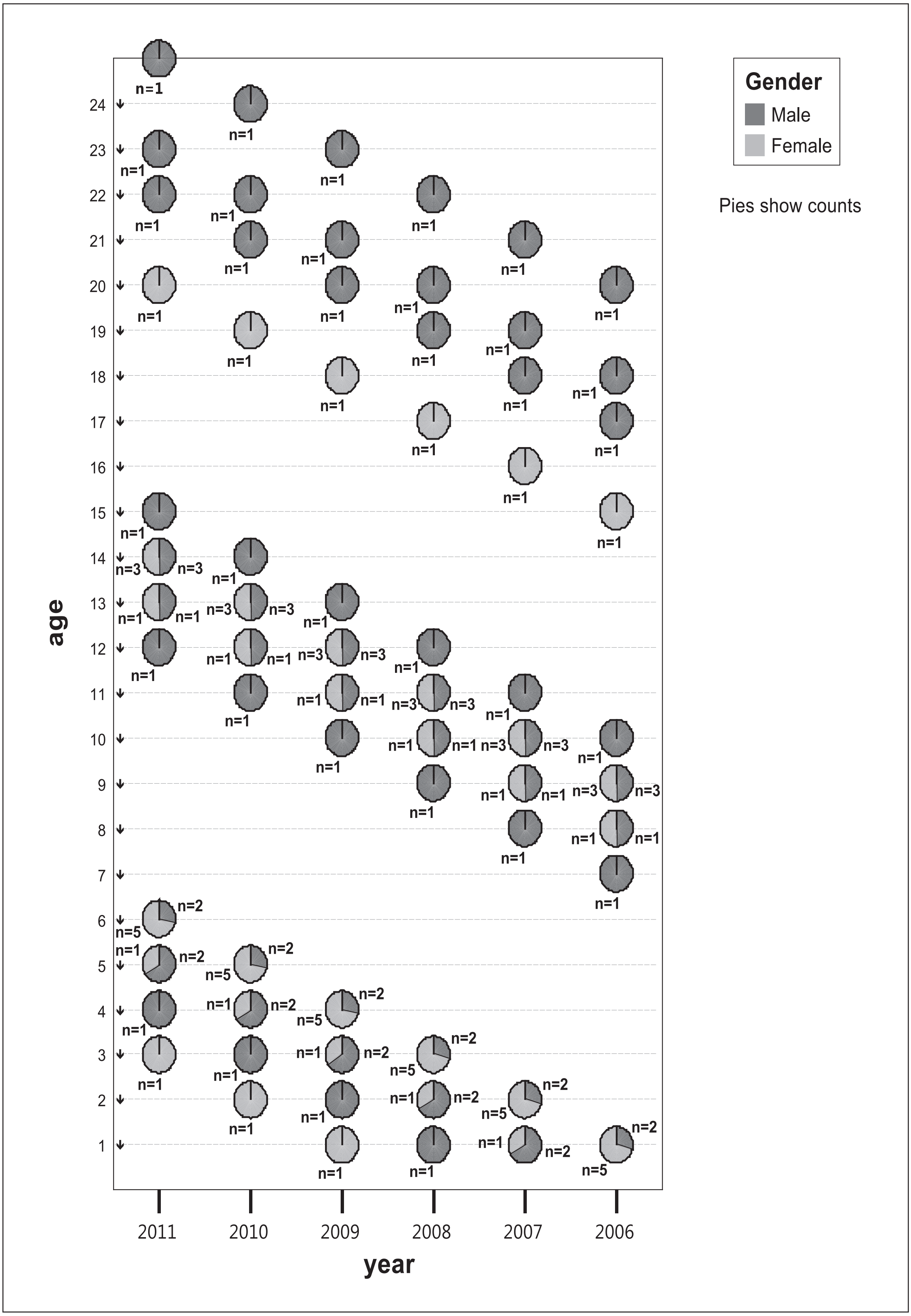

Fig. 3. The age structure of the African penguins from 2006-2011 (N=26).

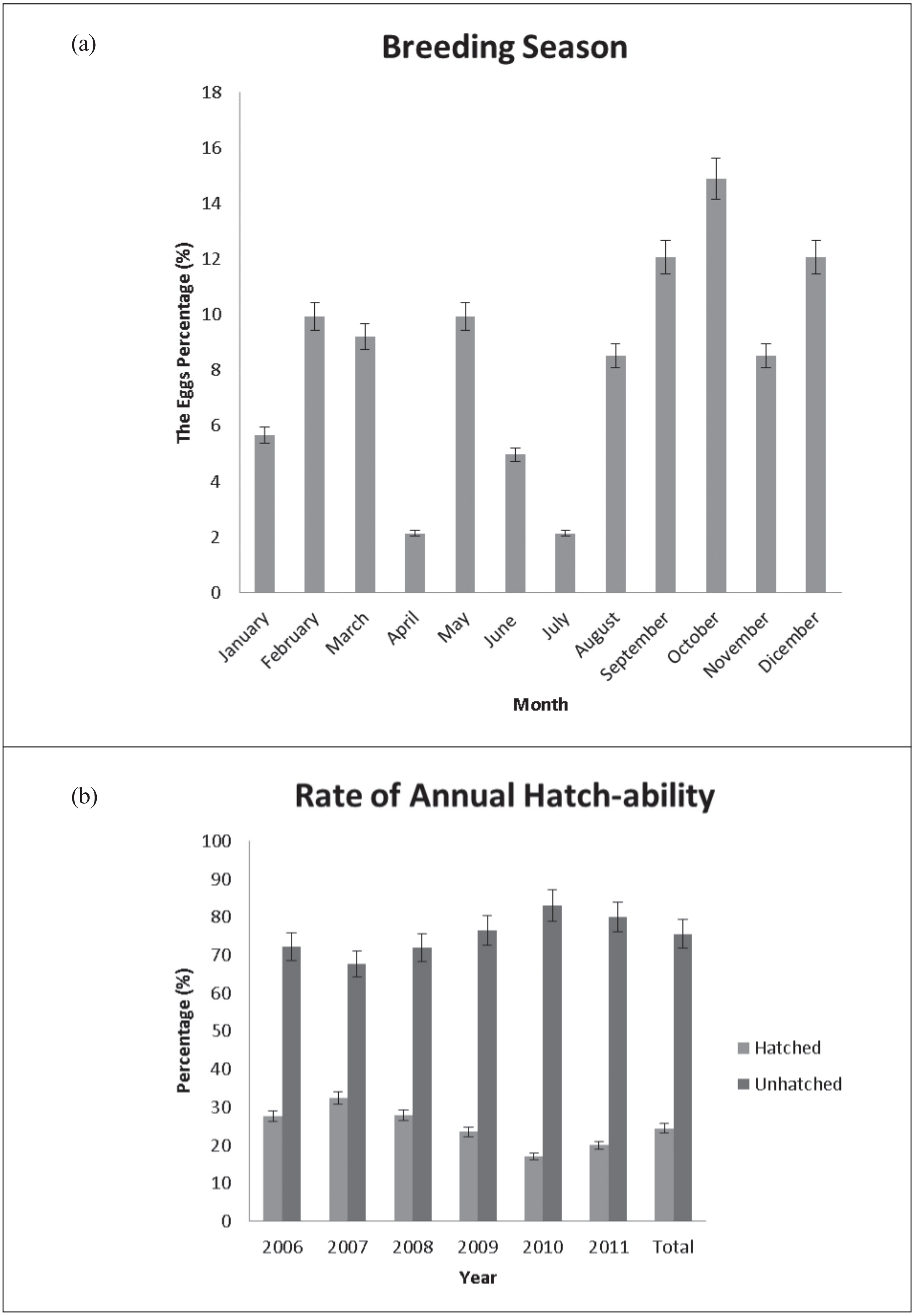

Fig. 4. (a) Rate of monthly egg production from 2006-2011 and (b) Hatching rate (%) of African penguin eggs at UWL between 2006 and 2011.

deaths (or four chicks) from a total of six chicks. There was a 50% chick survival rate recorded in the year 2009. In total, the highest chicks were produced at 25% in 2007. A total of 40 hatched chicks and 24 surviving chicks were recorded between 2006 and 2011, with 69.23% of surviving chicks reared between 2006 and 2008 (n=18) and 3.76% of chicks reared between 2009 and 2011 (n=8). The average mortality rate was 39.6%. The χ^2 test showed statistically significant differences between the two frequencies of surviving chicks from parents aged from 8 to 23 years, between 2006–2008 and 2009–2012 (excluding surviving chicks hatched at the age of 6 years and below in 2006) (χ^2 =3.846, P=0.0499, df=1, n=26).

Egg production

The youngest age of the first egg was six years old for females and three years old for males. The highest egg production was observed by pair 11M/10F with 24 eggs. The mean age range of males involved in nesting was 13.98±5.05. (Kolmogorov-Smirnov, K=0.136, P>0.05, n=40). Meanwhile, the mean age range for females producing eggs was 10.737±4.23 (Kolmogorov-Smirnov, K=0.791, P>0.05, n=40). Only two males (i.e. Ind 34 and 35) and two females (i.e. Ind 22 and Ind 27) out of a total of 12 chicks aged between three and six were actively involved in nesting and egg production in 2011, and only Ind 35 had three offspring by 2011.

Penguins' paternity and maternity in captivity

The youngest age of first maternity was six years and paternity had been observed in a male of three years (Ind 35). Of all paternity, ten years of father's age had the highest number of chicks (n=11), followed by twelve years (n=9), nine years (n=7) and thirteen years (n=5) as shown in Table 1 and Figure 5. Of all maternity recorded, nine years of mother's age had the highest number of chicks (n=8), followed by 10 years (n=7) and eleven years (n=5) as shown in Table 2. The mean age range for paternity was 12.45±4.554. (Kolmogorov-Smirnov, K=0.215, P>0.05, n=22) whereas the mean age range of maternity was 12.32±3.81 (Kolmogorov-Smirnov, K=0.799, P>0.05, n=22). The mean age range of the father with only one chick was 15.1±5.021 (n=10) and 10.25±2.701 (n=12) whereas for the father's age with more than one chick (Figure 6).

The Mann-Whitney test showed a statistically significant difference (P=0.036, n=22) in the age of the father, where are between only one chick (Md=13.5) and the age of the father with more than one chick (Md=10). For mothers, the mean age range for laid eggs and producing only one chick was 11.4±4.061 (n=10) and 13.08±3.579 (n=12) whereas for mother's age with more than one chick (Figure 7). The Mann-Whitney test showed no statistically significant difference (P=0.28, n=22) between mother's age of only one chick (Md=10.5) and mother's age of more than one chick (Md=12.5).

Interval of egg-laying dates

A total of 69 egg-laying intervals were analysed for ten females (Table 3 and Figure 8). The mean egg-laying interval for all females producing eggs was 6.719±4.18 (Kolmogorov-Smirnov, P=0.156). The mean interval of egg-laying for female rearing infants was 9.2388±4.2631 (Kolmogorov-Smirnov, P=0.884, range: 2.4-23.1, n=26) and 5.196±3.3448 (Kolmogorov-Smirnov, P=0.779, range: 1.8-13.6, n=43). The Mann-Whitney test showed a statistically significant difference (P=0.00, n=69) between the egg-laying data interval after offsprings survival and absence of infants rearing.

DISCUSSION

Age structure

The age structure is the relative number of individuals of each age in a population. It is also used in ecology to determine the overall age

Table 1. Frequency of hatched chick with established paternity

Freq of Ind.	Father's ID	Father's Age	Chick Hatched Per Individual	Cum. Freq	% Cum.
1	35	3	3	43	99.9
3	12,7,4	9	3,3,1	40	92.9
4	11,4,12,7	10	3,3,3,2	33	76.6
3	11,7,4	11	1,1,1	22	51
4	11,7,4,12	12	4,2,2,1	19	44
2	4,7	13	2,3	10	23.1
1	11	15	1	5	11.5
1	17	18	1	4	9.2
1	14	20	1	3	6.9
1	14	21	1	2	4.6
1	17	23	1	1	2.3

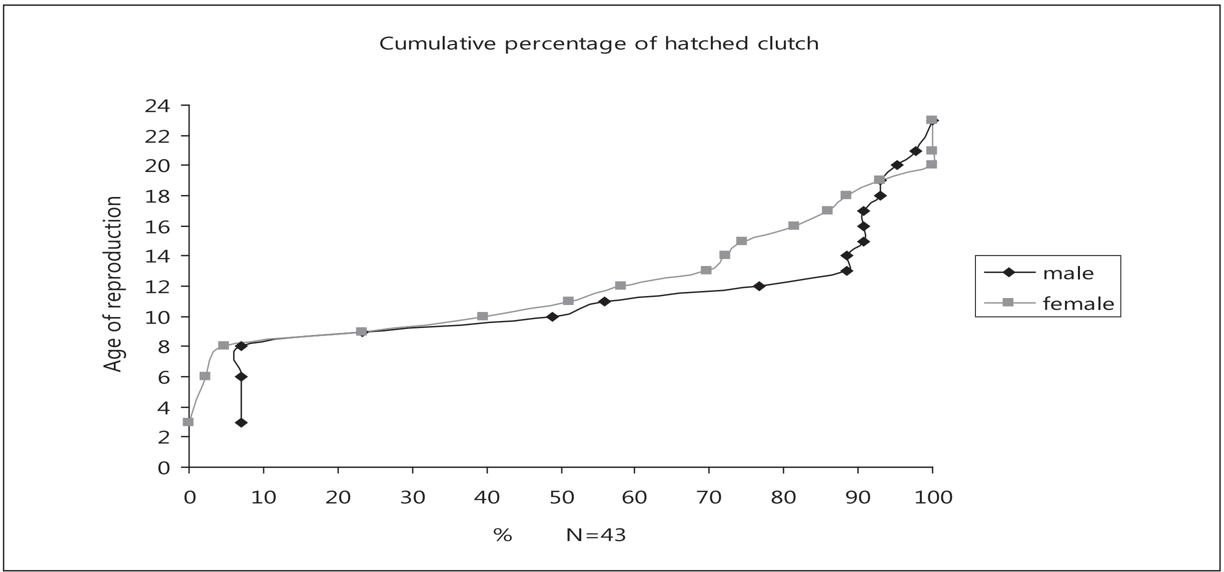

Fig. 5. Cumulative percentages of all hatched chicks produced with respect to age structure from 2006 to 20011 (N=43).

Table 2. Frequency of hatched chick with established maternity

Freq of Ind.	Mother's ID	Mother's Age	Hatched Chick Per Individual	$b_{xAge\text{-}specific\ birthrate}$	$m_{xAge\text{-}specific\ fecundiity}$	Cum. Freq	% Cum.
1	22	6	1	1	0.5	43	100
1	6	8	1	1	0.5	42	97.7
4	13,10,15,6	9	3, 3, 1, 1	2	1	41	95.4
3	13,15,10	10	3, 3, 1	3.5	1.17	33	76.8
2	10,15	11	4, 1	2.5	1.25	26	60.5
2	15,13	12	2, 1	1.5	0.75	21	48.9
2	13,15	13	3, 2	2.5	1.25	18	41.9
1	10	14	1	1	0.5	13	30.3
1	16	15	1	1	0.5	12	28
1	16	16	3	3	1.5	11	25.7
1	16	17	2	3	1	8	18.7
1	16	18	1	1	0.5	6	14
1	16	19	2	2	1	5	11.7
1	16	20	3	3	1.5	3	7.0

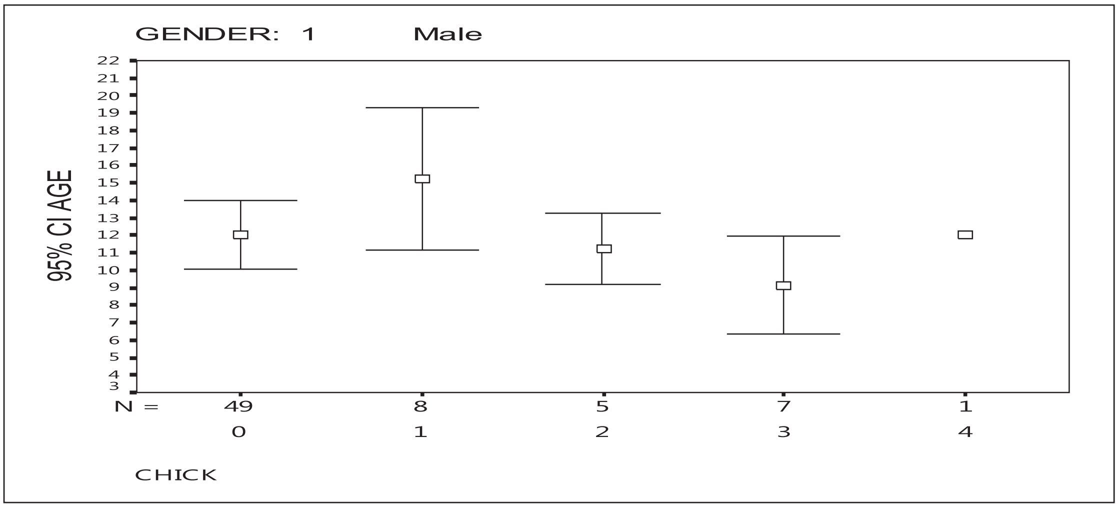

Fig. 6. A description of the father age with regard to the frequency of the hatched chick.

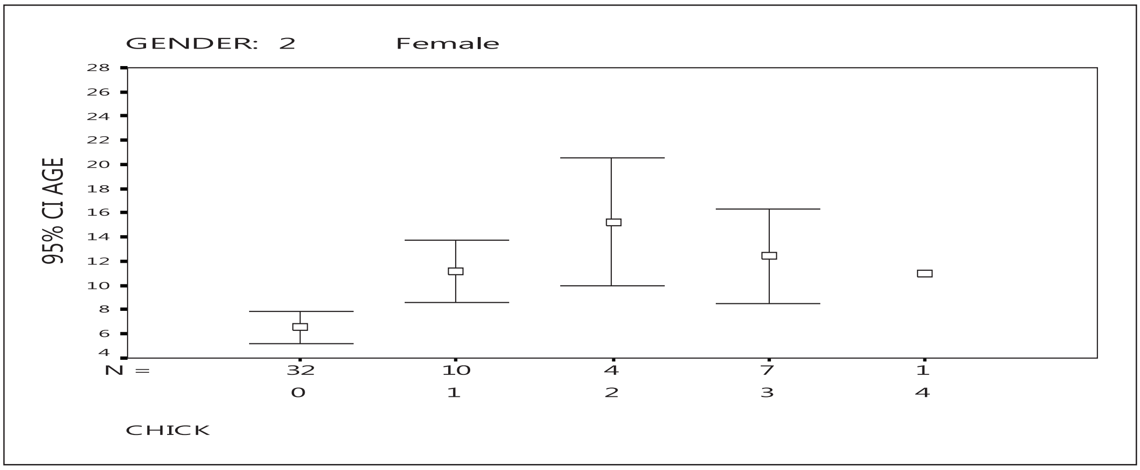

Fig. 7. A description of the mother age in relation to the frequency of the hatched chick.

Table 3. Interval of egg-laying dates in month

Mother's ID	Mean interval of egg-laying dates with surviving chick	Mean interval of egg-laying dates after production of unhatched eggs	Range of interval of egg-laying dates after egg production
13	7.75 (n=6)	4.24 (n=5)	1.9–13.69
16	10.23 (n=6)	2.30 (n=3)	2.0–11.26
6	6.36 (n=2)	6.45 (n=7)	2.66–11.46
15	8.22 (n=7)	3.11 (n=3)	2.07–12.55
10	9.57 (n=4)	4.17 (n=7)	2.31–13.16
2	–	4.79 (n=5)	2.46–7.36
27	–	5.00 (n=3)	2.06–10
22	–	3.58 (n=4)	1.82–6
18	23.16 (n=1)	10.74 (n=3)	8.13–23.16
19	–	5.58 (n=3)	4–12
	N=26	N=43	

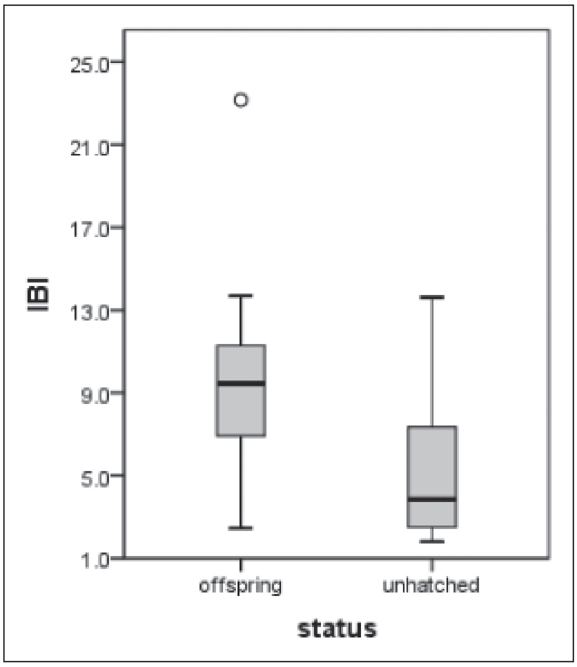

Fig. 8. The range of egg-laying intervals between female infants and unhatched eggs.

distribution of the population and to indicate the reproductive capacity and the likelihood of the continuation of the species (Cincotta & John, 2011). Figure 1 shows the age structure of the penguin population in Enclosure 13. All adults were able to produce eggs with their respective pairs, despite an irregular breeding pattern for six consecutive years, and this implies that the cohort is 100% fertile. The oldest male penguin in this group was penguin Ind 14 of the age of 25. While the oldest female penguin was penguin Ind 16 of the age of 20, the youngest females were Ind 35 and Ind 39 of the age of four (male) and three (female) respectively. For the group of unknown penguin age and gender, the age difference between them was only one year. Young penguins had a lower breeding success rate compared to the old ones. This can be associated with mature experience and maturity. However, the growth rate is expected to increase in the future, as the number of young penguins is higher than that of older penguins since the younger penguins have a longer life span than the older penguin thus it has higher chance to reproduce (Hairul & Shukor, 2017).

Monogamous effects have unproductive costs, which have been shown prominently in the absence of mating inability between some adult males and the females in the range of breeding age. From 2006–2008, the individual 1 M and 3 M were unpaired because of the absence of available females, and since then, both have not produced any surviving chicks. Currently, all unpaired females observed have not yet reached the current expected breeding age of this captive population.

Seasonality

The colony was observed to breed actively almost throughout the entire studied years. The nesting and breeding seasons in this colony were from April to November, with egg-laying activity peaked between October and November. The findings are almost the same as the colonies in Namibia, with peak nesting and breeding activities observed between November and December (Anton, 2012). A high number of clutches were also recorded between February and March. This resembles an egg-laying pattern of the wild population in Robben Island, South Africa (Crawford *et al.,* 1999).

Sexual maturity and age-specific parentage

The first age of breeding female was observed at the age of six years old, despite the loss of clutches. The first successful paternity of the Ind 35, was observed when the sexual maturity of the male in captivity was three years old. These show some similarity to the previous study reported by Crawford *et al.* (1999). The first breeding age recorded in Robben Island varied, with 36% of the birds studied had first successful breeding age at four years, and 18% of them were at the age between five and six years. However, the study did not include the gender profile.

Underwater World Langkawi presented a pattern of significant age-specific breeding success and also showed age-specific differences between males with just one chick and male with more than one chick. The data also showed that between eight and thirteen years of age, the male fathered 35 chicks (81%) out of 45 chicks between 2006 and 2011. Despite the observed success of breeding in male birds, the differences were not statistically significant, with 65% of chick reared by females between eight and thirteen years of age. Only eight breeding pairs were observed in the colony despite the expectation of eleven breeding pairs. This is due to a slightly skewed in sex ratio, which provides opportunities for three adult females, seven adult males and fourteen unidentified gender aged between one and five years to form breeding pairs when they were sexually mature (Hairul & Shukor, 2016).

Since male penguins in the current group are getting older, the probability of the male to sire more chicks will reduce. As a result, the growth of the group size in a couple of years (2012–2013) was expected to decrease before the age of the breeding males since the frequency of the same pairing of chicks was reduced over time-based from this study, on the difference between 3 years (i.e. 2006–2008). To change this situation, the introduction of female individuals into the captivity group within the breeding age could mediate population growth within two to three years (Hairul & Shukor, 2016).

Interval of egg-laying dates

In the wild population, the production interval of clutches was not widely observed due to difficulties in recognising the pairs in a wide range of homes. The breeding of UWL penguins took place between 1.8 and 4 months in the form of a female replacement brooder. A record from the Robben Island's African penguin provided details on a pair of breeders with first clutches at the beginning of February and a second egg clutch at the beginning of May (Crawford *et al.,* 1999). Later, the third clutches were also produced within 2 months (late June) that had been successfully hatched. Longer intervals in the production of the clutches were observed when the female cared for the chicks before fledgeling in the penguins. Double breeders Humboldt penguins (*Sphenuscus humboldti*) or the female penguin rearing two fledgelings at a time also lay eggs much later than the females, producing one first clutch of the year (Paredes *et al.,* 2002) when rearing activities were taking place.

Recommendations

In terms of food and feeding programmes, the UWL is recommended to change the penguin diet menu to the new variable. At present, majority of the penguin's diet is Mackerel where there is not much variety to be served. Hence, it is recommended for UWL to introduce a new feeding programme. Generally, it would be no problem to serve the same foods every day; even the foods are different from what the birds usually consumed in the wild because these natural food sources are too difficult and costly to find. However, what is important is to provide fresh and good quality food.

The use of several other aquatic species is encouraged to reduce the current facing problems which are easily cracked eggs and low hatchability problem. Hence, fresh foods with high calcium are demanding. Penguin's meals can be prepared by obtaining fresh live fish from the marine aquaculture activities around Langkawi. The provision of live fish could provide exciting new environments in feeding sessions can be held twice a day. In addition, the activity of giving live fish is similar to that in the wild as the wild penguins hunt their prey in their natural habitats to survive. With this, the penguins foraging behaviour can be maintained as in the wild.

In addition, the amount of food served should also be added since penguin's food requirements will increase with increasing age. Besides, there are several factors that influence the requirements of high numbers of food, such as breeding season and moulting process. Concerning the nest, the nest appears to be very limited and require a long struggle to get. Therefore, it is necessary to increase the number nest in the UWL as soon as possible, specifically in enclosure 13 with the rate of one pair of a nest. In addition, substrate materials to form nests should be provided all the time because these species normally breed throughout the whole year. The best and suitable material is proposed to reduce the problem of continuous widespread cracking eggs, such as nest supports materials or substrate capable in reducing this problem. The process of nest formation shall be recorded and monitored, which starts as early as a penguin collect materials and ends with the preparation of individual nest when the first eggs produced. Besides, the data on duration of chicks rearing should be recorded. These information are useful in research and development of UWL to improve their living environments and to troubleshoot when problems arise in the future.

The number of penguin populations in the UWL is increasing over time. Thus, gradually, the number of individuals whose gender has yet to be identified will increase. Therefore, UWL should identify the gender of the penguins in the population quickly. When the gender of each individual in the population is known, the sex ratio in the population will be known, and a more effective management plan can be planned and established.

CONCLUSIONS

Reproductive parameters could inform the health and status of African penguins in the captive colony with sufficient data. The difference between the egg-laying dates of the females during weaning was evident, and the egg production was much higher from May to October. The implication of the monogamous effect gives rise to the importance of breeding pairs to increase egg production and the survival of chicks. Long-term studies are essential to a good understanding of the demography of African penguins, with the intention to protect and manage this colony to thrive in captivity.

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