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Research Article

EFFECT OF INBREEDING ON MORTALITY OF CAPTIVE TIGER

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ABSTRACT: A study was carried out on the captive tigers of Nandankanan zoo, Odisha, India, to conclude any deleterious effect of inbreeding on mortality. A pedigree path analysis of 342 tigers was done to estimate the inbreeding coefficient of each tiger from the available pedigree information since the inception of zoological park in 1964. Percentage of animal with different range of inbreeding coefficient was classified based on their normal and white body coat colour. The correlation values between sex, colour and inbreeding coefficient with mortality were also estimated. The colour and inbreeding coefficient was found to be significantly ($p<0.05$) correlated with the mortality. The inbreeding was found to be significant ($p<0.05$) with white colour of tiger.

Key words: Inbreeding, Mortality, Captive tiger.

INTRODUCTION

Tiger is one of the species on the verge of extinction and its existence is threatened in its land of survival. In a certain period of time a species can get extinct if sufficient genetic diversity is not found in its population. In order to increase its number, breeding of tigers inside zoos is inevitable. The genetic variability is an important criterion to sustain the danger of extinction (Hedrick 1994). But for survival of tigers, small populations inside zoos are bred among themselves resulting inbreeding. The genetic diversity or variability is reduced with increase in inbreeding. Again loss of genetic variation due to inbreeding increases homozygosity in the population. Most of the deleterious traits are expressed in homozygous form in a population. Thus, inbreeding results in inbreeding depression which leads to decline in the phenotypic value of a trait (Wright 1977, Sinead *et al.* 2009).

The fitness traits are affected adversely due to inbreeding. However, some metric traits like birth weight, disease conditions, life span, etc are indirectly associated with fitness and are therefore, affected by increased level of inbreeding. Close inbreeding leads to reduction in fitness (Sarre and Georges 2009, Keller and Waller 2002, Rabon and Waddell 2010). Moreover, genetic drift is another consequence of close relative mating (Sarre and Georges 2009). An interesting finding with brother-sister, father-daughter and mother-son mating was birth of white tigers. But deformities and deficiencies begin to surface very soon in white tiger population e.g. cub mortality is higher in white tiger population (Warrick 2010, Xu *et al*. 2013). Therefore, the present study was conducted to estimate the inbreeding coefficient of each tiger with percentage of tiger population in each inbreeding range, to find the association of inbreeding with respective colour of tigers and at last, heterogeneity test of significance for sex, colour and inbreeding coefficient with respect to tiger's mortality was established.

MATERIALS AND METHODS

A total of 342 pedigree data of tiger maintained at studbook of Nandankanan Zoological Park,

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Bhubaneswar, Odisha from 1964 to 2015 were collected and used in this present research endeavor. The pertaining information of sire, dam, date of birth, date of death, sex, colour of tiger used in this investigation were recorded from the available records of the zoo. Pedigree chart of 342 tigers was constructed to calculate inbreeding coefficient (F) of each tiger using path analysis method (Falconer 1996).

Using the established correlation formula by Becker (1975), correlation between inbreeding coefficient with birth weight, age at first parturition, age at first mating, parity, number of cubs born in life time, number of cubs live up to weaning, age at death, litter size, number of white cubs born in life time, gestation period, sex ratio of cubs, average inter parturition period were calculated respectively.

Based on the inbreeding coefficient (F) values (0.000-0.049, 0.050 - 0.099, 0.100 - 0.149, 0.150 - 0.199, 0.200 - 0.249, 0.250 - 0.299 and 0.300 - 0.349) the entire population was divided into seven groups. Percentage of normal and white colored tigers in each group was estimated. Chi square test of heterogeneity (Snedecor and Cochran 1967) was applied to know the dependency of death on colour, sex and inbreeding coefficients as well as to find out the association of white colour and inbreeding coefficients at 5% level of significance.

RESULTS AND DISCUSSION

It was found that the inbreeding coefficient of all tigers ranges between 0-0.315. The entire inbreeding coefficient was divided into 7 groups ranging from 0.000 - 0.049, 0.050 - 0.099, 0.100 - 0.149, 0.150 - 0.199, 0.200 - 0.249, 0.250 - 0.299 and 0.300 - 0.349 respectively. The number of tiger born along with their percentage in these range of inbreeding coefficient was determined. The total number of normal and white tiger born along with their percentage was calculated (Table 1). Moreover, the relationship of inbreeding coefficient with colour, survivability, death due to different disease conditions and different reproductive traits of tigers were recorded. It was observed that the percentages of normal tigers (59.356 %) were higher as compared to that of white tigers (40.643 %). It was observed that in case of total number of tigers and normal orange colour tigers the percentage of born increases from 0.000 - 0.049 to 0.150 - 0.199 range of inbreeding coefficient then decreases sporadically while in case of white colour tigers the percentage of born increases from 0.000 - 0.049 to 0.200 - 0.249 range of inbreeding coefficient then decreases minutely.

The percentage of tiger death due to aged and disease condition was also calculated with respect to the inbreeding coefficient at each level. It was found that only 6.667 % of tigers were died due to increased age but remaining 93.333 % were died because of any disease condition. It was also found that the percentage of death due to any disease condition increases with the increase in the level of inbreeding coefficient (Fig. 1). It was determined that with the low range of inbreeding coefficient (0.000 - 0.099) the percentage of death due to any disease condition was low (12.585 %). But at higher range of inbreeding coefficient (0.200 - 0.299) the percentage of death increases to 43.197 % (Fig. 2). These indicate that the animals with higher inbreeding coefficient are more susceptible to any disease condition. The need for adequate levels of genetic diversity is a particular concern for endangered populations, primarily due to magnified effects of genetic drift and deleterious alleles as compared to larger populations (Hedrick and Kalinowski 2000). In natural environment, species that suffers from severe inbreeding faces an increased likelihood for extinction. However, in a captive environment these alleles are able to persist for much longer due to protection from outside threats (Lacy 1996). Therefore, it is equally important to maintain high genetic diversity in both captive and wild populations, not only for the salvation of a species, but also for the health of individuals. Based on the earlier data gained from

Table 1. Percentage of tigers with variable colour at different inbreeding coefficient level.

Sl. No.	Inbreeding Coefficient	Percentage of normal orange colour tiger with number	Percentage of white colour tiger with number	Percentage of total tiger with number
1	0.000- 0.049	14.778 (30)	10.079 (14)	12.865 (44)
2	0.050- 0.099	0.492 (01)	3.5997 (05)	1.754 (06)
3	0.100-0.149	11.822 (24)	0 (0)	7.017 (24)
4	0.150-0.199	27.093 (55)	31.654 (44)	28.947 (99)
5	0.200-0.249	16.256 (33)	32.374 (45)	22.807 (78)
6	0.250-0.299	21.674 (44)	22.302 (31)	21.929 (75)
7	0.300-0.349	7.881 (16)	0 (0)	4.678 (16)

Table 2. χ^2-Test of heterogeneity for colour with respect to inbreeding coefficient.

Inbreeding coefficient	Normal colour	White colour	χ^2-value
0.000-0.049	30	14	
0.050-0.099	1	5	
0.100-0.149	24	0	43.34797*
0.150-0.199	55	44	
0.200-0.249	33	45	
0.250-0.299	44	31	
0.300-0.349	16	0	

*p < 0.05

Table 3. χ^2-Test of heterogeneity for colour, sex and inbreeding coefficient with respect to mortality.

Condition	Features	Normal death	Death due to disease	χ^2 value
Colour	Normal	17	169	4.464554*
	White	4	125	
Sex	Male	7	147	2.178854
	Female	14	147	
Inbreeding coefficient	0.000-0.049	8	31	18.58505*
	0.050-0.099	0	6	
	0.100-0.149	3	21	
	0.150-0.199	5	94	
	0.200-0.249	0	60	
	0.250-0.299	4	67	
	0.300-0.299	1	15	

*p < 0.05

microsatellite analysis, it was apparent that among the white tigers and orange tigers sampled, there was no statistically significant difference in heterozygosity. Though it is known that early captive white tiger populations originated through inbreeding, (Thornton *et al.* 1967), it was evident from earlier that not all white tigers presently in captivity were significantly inbred. The white colour tiger, a product of homozygosity due to inbreeding, was susceptible to different maladies as reported earlier (Warrick 2010) which is also supported by the present finding (Table 2). Likewise, inbreeding had an associationship with white colour of tigers (Table 3) was confirmed the findings (Carney 2013).

Death of the tiger were significantly ($p < 0.05$) correlated with inbreeding. This is in agreement with previous findings that inbreeding affected various components of fitness traits in animal (Wright 1977). The dams with high inbreeding coefficient developed a good maternal behavior which result increased survival rate of the litter with reduced reproductive success (Dwyer 2008). In the present work, it was observed that litter size was positively correlated whereas age at death was negatively correlated with inbreeding coefficient. It is in agreement with the earlier study where maternal behavior of the dam increased because of the enhanced progesterone level which favours the survival of the offspring (Dwyer 2008). The maternal inbreeding of 119 zoo populations had a negative effect on fitness (Boakes 2006). The association between total inbreeding coefficient in dams with mortality at days 7 ($p < 0.05$), 30 ($p < 0.05$) and 90 (0.10) was found to be statistically significant indicating that it would decrease the mortality risk of the litter (Quilicot 2009). Similar findings were observed with reduced litter size in wolf (*Canis lupus*) (Laikre 1999), Mexican wolf (*Canis lupus baileyi*) (Fredrickson *et al*. 2007) and red wolves (*Canis rufus*) (Lockyear *et al*. 2009, Rabon and Waddell 2010). The reduction of litter size in the captive tiger of Nandankanan Zoo is comparable with the brown bear (Laikre 1996). A trend of lower litter size was visible in captive than free-ranging animals. Furthermore, with increased dam age, litter size was decreased in free-ranging populations (Lockyear *et al*. 2009).

However, in the present research work, from the studbook data it was not possible to make a comparison among different levels of inbreeding with survival at later stages of weaning. It may be proposed that the deleterious effects of inbreeding are expected to be less severe in species/populations which have a history of inbreeding. This suggests that the inbreeding effects for the tiger leads to its smaller litter size reduction as it is bred in captivity. Antagonistic report of reduced trend for litter size due to inbreeding was observed for the lynx (Laikre 1999). Since no significant correlation was found, it can be assumed

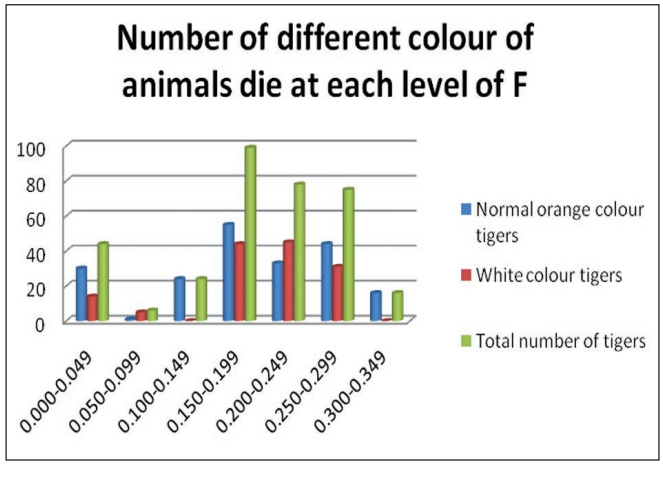

Fig. 1. Column diagram of number of different colour of animals died at each level of F.

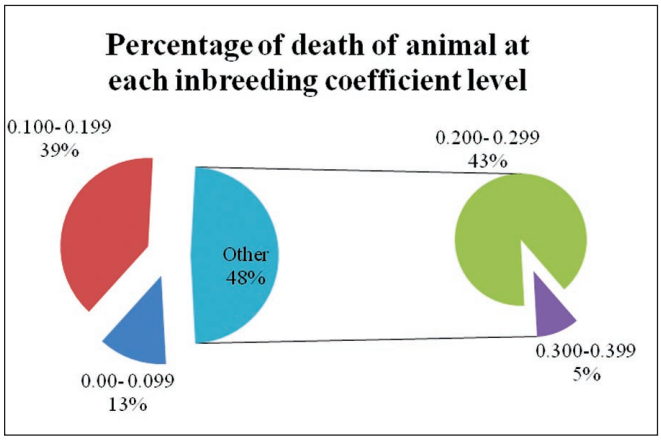

Fig. 2. Pie Chart depicting the percentage of animal died with increase in F.

that inbreeding in lynx does not have a large impact on litter size that leads to reduced in the population.

CONCLUSION

Inbreeding has adverse effect on survivable of tigers that may lead to its extinction. In order to save tigers, planned breeding should be made, with an utmost care to avoid brother-sister, father-daughter and mother-son mating. The studbook should be properly maintained in a zoo. The white coloration in tigers invites inbreeding as well as different maladies. So, temptation to produce more white tigers must be avoided. But inbred animal with better care and management now survive in captivity that would have died in wild condition. Although it is applicable to the inbred animals up to one years of age, thereafter inbreeding depression starts to play its role in the longevity of the young ones.

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