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A NOTE ON THE MINIMUM VIABLE POPULATION OF ORIENTAL PIED HORNBILLS IN PULAU UBIN

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ABSTRACT. **–** The population of Oriental Pied Hornbills *(Anthracoceros albirostris)* in Pulau Ubin, Singapore, was evaluated to find out the minimum number considered to be sustainable in the long term. One factor that was taken into consideration was the effective population size whereby genetic diversity does not diminish over generations. The small population of Oriental Pied Hornbills in Pulau Ubin, which has an area of only 10.2 sq km, is now about 50 individuals. The island is separated by a thin strip of sea from mainland Singapore and by another strip of sea from Johor, Malaysia. This may cause inbreeding. Release or exchange of some Oriental Pied Hornbills may be needed so as to ensure that the gene pool is sufficiently diverse. Signs of a weakened gene pool should also be looked out for, like albinism, deformities or lowered reproductive success. Further research into the topic of genetic diversity of Oriental Pied Hornbill will be needed to have a more accurate estimation of the minimum viable population needed to sustain genetic diversity and survive episodes of population depletion.

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KEY WORDS. **–** minimum viable population, Oriental Pied Hornbill, Singapore, Pulau Ubin.

INTRODUCTION

The term 'Minimum Viable Population' was first coined by M.E. Gilpin and M.E. Soulé in 1986 (Nunney & Campbell, 1993). The definition of the minimum viable population, which is commonly known as MVP, is the minimum number of individuals in that population needed to ensure that there is a 95% chance of survival of the population over the next 100 years.

The MVP can be calculated by using computer simulations, which are known as population viability analyses (PVA). The PVA can simulate what will happen in the given period in time, which is 100 years in this case. The Monte Carlo statistical method is used, simulating loss of alleles in the population according to the factors chosen in a random manner with a given probability. The same simulation is usually repeated more than a thousand times to make sure that it is as accurate as possible, and is not prone to error.

The concept of effective population size (N_e) was introduced by Sewall Wright (1931), who stated that the "Effective N" (N being the number of breeding individuals) was the size needed to prevent genetic drift. In several papers, the effective population size (N_e) has been used as the number of breeding adults. In this paper, Wright's definition of the Effective Population Size or N_e was used to study the number of breeding individuals needed to prevent genetic drift and the number of breeding individuals needed to prevent genetic depression among a population of Oriental Pied Hornbills.

A population does not experience any major genetic drift if the allele frequency in that population is relatively constant over many generations. Although mating is assumed to be random and some allele frequencies may randomly change, a big population with many breeding individuals will be largely unaffected, as these changes will gravitate around a certain steady state.

The effective population size (N_e) can be calculated. According to Nunney & Campbell (1993), many methods and approaches have been proposed by different authors to work out the effective population size. These formulae used to calculate the N_e take a few assumptions. Firstly, it is assumed that there is random mating. This means that mating preferences will not differ significantly from chance, and no factors affect preferential mating. Although this is usually not true in natural populations, it is a necessary assumption so that the effective population size will be easier to calculate. Secondly, there is no selection. Thirdly, the passing down of genes is completely by random chance.

Besides genetic drift, which happens over a long period of time, there may also be inbreeding depression, which happens over a short period and occurs in even smaller populations. If inbreeding occurs repeatedly, there will be a decrease in heterozygosity, this resulting in harmful recessive genes being expressed due to increased homozygosity (Lynch & Walsh, 1998)

In the case of the Oriental Pied Hornbill, the National Parks Board Singapore (Pulau Ubin Branch) (personal communication) has indicated that there are now approximately 50 Oriental Pied Hornbills in Pulau Ubin. Such a small number may be prone to inbreeding depression. This population is separated from other Oriental Pied Hornbills on mainland Singapore and in nearby Peninsular Malaysia by narrow sea channels. Of course, Oriental Pied Hornbills from Malaysia flying to Pulau Ubin is possible and should be taken in consideration. Nonetheless, the population of Oriental Pied Hornbills in Pulau Ubin might still be at risk.

There is a gap in the research here. How many Oriental Pied Hornbills in Pulau Ubin will be needed to prevent inbreeding depression, and make sure that genetic deterioration, as well as other factors like predation will not lead the population to extinction?

This study planned to answer two questions. Firstly was to find out the minimum viable population (MVP) of Oriental Pied Hornbills in Pulau Ubin. This will tell us whether the actual number is greater or less than the theoretical MVP. Secondly was to find out what measures can be taken to increase their population size.

METHODS

Firstly, the factors affecting the MVP were identified. The MVP as determined by each group of related factors was estimated. It was assumed that there is no interaction between the groups of factors. The MVP of Oriental Pied Hornbills in Pulau Ubin was taken to be the biggest of the various MVP estimates. In particular, the concept of effective population was used to estimate the MVP due to genetic factors. The factors affecting the effective population size were identified and examples given for some of the factors. Finally, ways of increasing the chances of the population in Pulau Ubin surviving in the long term were examined.

RESULTS

Factors affecting the minimum viable population (MVP). **–** According to Shaffer (1987), as cited by Nunney and Campbell (1993), there are four potential causes of extinction in populations that are small. They are: environmental stochasticity, natural catastrophes, demographic stochasticity and genetic stochasticity.

Environmental stochasticity refers to factors that are related to the environment, which include a shortage of food. There is not much information on the Oriental Pied Hornbills regarding this matter. Predation is also a consideration of the minimum viable population. In Pulau Ubin, there is no known predation of hornbills.

As for natural catastrophes, the minimum viable population is affected by natural events such as tree falls or heavy rain flooding nest holes, but not by more serious wholesale natural disasters. Demographic stochasticity is a group of factors causing the birth rate to be lower than the mortality rate, leading to negative population growth.

As for genetic stochasticity, it basically is regarding the allele frequency, and uses the concept of the effective population size (N_e). The MVP involving the genetic stochasticity and the N_e have different definitions, so they are not the same. If the population size is big, there will be little genetic drift and inbreeding.

Factors affecting effective population size (N_e). **–** The factors that will influence the effective population size are the amount of genetic drift and inbreeding depression. The number of breeding adults needed to prevent genetic drift is usually much bigger than the number of breeding individuals needed to prevent inbreeding depression.

Inbreeding depression causes reduced fitness. This is due to the recessive deleterious genes showing out due to reduced heterozygosity and increased monogamous genes. The effects can include albinism, not rare in wild birds. There are many diseases that can be inherited and the genes that pass on the disease are typically recessive, for example the iron storage disease. Iron is an important nutrient for all organisms, including birds (Beutler et al., 2001). Excessive iron is toxic for birds (Sheppard & Dierenfeld, 2002) and various species including mynas, birds of paradise and hornbills have been reported to have this disease. It is heritable and the gene for it is recessive (Zhou et al., 1998). Hornbills from Pulau Ubin could be sampled to find out the allele frequency of the defective gene in Pulau Ubin, as a proxy for other heritable conditions.

Minimum viable population estimate. **–** There are many estimates of the MVP due to environmental stochasticity, demographic stochasticity and natural catastrophies. One of them is an estimate of the MVP for the Kaka *Nestor meridionalis*, done using simulations (Leech et al., 2008). According to this study, the MVP of Kaka is approximately 258 for the risk of quasi-extinction to be low (<0.05) if predation is the only factor. Quasi-extinction is the population being below the critical number to survive. In this paper, the Kaka population is assumed to have gone below the quasi-extinction threshold when the number of adult females is below 25 at any time. When it is below that number, the population is subjected to inbreeding depression.

Predation is not an issue in Pulau Ubin as the Oriental Pied Hornbills hardly have any predators. Pythons and civet cats have been reported to prey on Oriental Pied Hornbills but there are no other likely predators than pythons in Pulau

Ubin. Hunting by man is not a factor affecting the population. Moreover, we can reasonably expect that the environmental, catastrophic and demographic factors are well controlled and that the MVP estimate from these factors would be less stringent than an MVP determined by genetic factors.

According to Franklin (1980), as cited by Nunney and Campbell (1993), the minimum number of breeding individuals needed to prevent short-term inbreeding depression is 50 breeding individuals. An effective population size above 50 will prevent serious short-term inbreeding depression, but will not maintain the genetic diversity. In order to prevent lost of genetic variation, an effective size of about 500 will be adequate. The MVP should be about five to ten times of effective population size to prevent genetic drift. So, the MVP should be about 2500 to 5000 individuals.

DISCUSSION

Pulau Ubin has only 50 hornbills, which might be sufficient to prevent short-term inbreeding depression but is far from meeting the MVP of 2500 to 5000. Will this pose a problem as well as an obstacle for the conservation of Oriental Pied Hornbills in Pulau Ubin?

When the MVP and effective population size were calculated, the migration rate was not considered as the population was assumed to be isolated. This may give an overestimation of the N_e and subsequently the MVP, as there may well be genetic exchange between populations on Pulau Ubin and in Peninsular Malaysia. This would greatly reduce the number of breeding Oriental Pied Hornbill adults in Pulau Ubin needed to prevent genetic drift and maintain a diverse gene pool.

A more detailed population viability analysis simulation should be done. Also, the hornbills should be monitored for signs of inbreeding such as albinism and lowered reproductive rate. The population could be increased to levels closer to the MVP by measures such as increasing the number of nest boxes, increasing the availability of food, or shifting birds between nearby populations.

In order to encourage genetic exchange between neighbouring populations, suitable habitat corridors should be maintained so as to prevent isolation. Industrialisation of neighbouring coastlines could be a factor reducing the chances of movement across narrow sea channels, for example Pulau Tekong, the next nearest and largest island to Pulau Ubin, can also be promoted as a sanctuary so that hornbills have larger areas of habitat in which to maintain a viable population.

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