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Survival and Causes of Death in the Sweden Population of White-Tailed Sea Eagle (*Haliacetus albicilla*), Golden Eagle, (*Aquila chrysaetus*) and Caspian Tern (*Hydroprogne caspia*)

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Abstract

The three species White-tailed Sea Eagle, Golden Eagle och Caspian Tern have different developments in Sweden. The population of the White-tailed Sea Eagle is increasing with at least 10% per year, the Golden Eagle has a doubtful small increasing population and the number of Caspian Tern breeding in the Baltic Sea is decreasing.

The analysis of the survival were calculated by North, et al. maximum likelihood method. All birds in the analysis were "found dead" and found between 1988 - 2017. The number of White-tailed Sea Eagles in the analysis were 548. The calculation of the survival show that the survival to breeding age 6+ for the White-tailed Sea Eagle was 44,5% ±2,3% (s.e.), next year 82,6% ± 2,4% (s.e.) and constant survival all other years was 84,2 ± 1,2% (s.e.).

Calculating the number of young to maintain a stable populationen for the White-tailed Sea Eagle with the estimated survival gives 0,66 young per pair and year. In the beginning decades of the 2000 the White-tailed Sea Eagle have a production of about 1,6 young per pair and year. With a production of 0,8 young per year and per female, the White-tail Sea Eagle would increase with 20% per year if breeding begin at 6+ and 12% if the breeding begin at 7+.

In the calculation of the survival of the Golden Eagle there were 135 individuals. The survival to the age of 5+ was 30,8%±4,5% (s.e.), next year 79,4% ± 6,5% (s.e.) and the years thereafter 86,0% ± 2,8% (s.e.). If the Golden Eagle begin to breed at the age of 6+ the survival correspond to 22,7% ± 4,2% (s.e.), 90,3% ± 5,5% (s.e.) and 84,1% ± 3,4% (s.e.). If these calculations of survival for the Golden Eagle the Golden Eagle must produce 1,14 young per pair if breeding at the age of 5+ and 1,56 young if the beginning of breeding is at age 6+ . The number of young per pair between 2010 - 2019 was 1,19 young per pair and year. With a production of 0,6 young per year and female the population of the Golden Eagle increase with 4,7% if the breeding age is 5+ but decrease with 2% if breeding begin at 6+ of age.

Depending of a small number of ring och found Caspian Terns (115 individuals) and with only 80 individuals in my calculations the results are very uncertain. The survival was estimated to the age of 3+ to 40,8% ± 5,7%, the fourth year 85,5% ± 6,1% and all other years 78,0% ± 4,0%. It is not likely that the birds have a higher survival the fourth year than later. If the calculation is made from the first year and later the constant survival is 81% witch is the mean of the other calculation. Using these proportions of survivals each pair must produce 1,15 young per year to maintain a stable population. The Sweden and Finland populations produced 0,8 young per pair. With a production of 0,4 young per female the population would decrease with 3% per year.

Keywords: White-Tailed Sea Eagle; Population; *Haliacetus albicilla*

Introduction

Changes in populations depend on their survival and reproduction. The longer the individuals are fertile the more young they will reproduce. However, in birds some individuals produce more young than others. But that is the whole reproduction in the populations that counts. The average of young which are ringed may therefore be used as a random sample of the whole population.

By a combination between an estimate of the number of ringed young and an estimate of the survival of the species it is possible to calculate the faith for the population, if it is increasing, stable or decreasing. In this paper I will estimate the possible future of the populations of three species in Sweden; White-tailed Sea Eagle (*Haliacetus albicilla*), Golden Eagle, (*Aquila chrysaetus*) and Caspian Tern (*Hydroprogne caspia*).

Materials and Methods

I got 570 individuals of White-tailed Sea Eagles ringed between 1976-2017, 143 individuals of 1Golden Eagles ringed between 1976 - 2016 and 112 individuals of Caspian Terns ring between 1968 - 2016 and reported found dead from the Swedish Bird Ringingcenter (Naturhistoriska Riksmuseet, Stockholm). All three species are long lived species; long lived record in Sweden for White-tailed Sea Eagle is 33 years 5 months (found dead), Golden Eagle 32 years (found dead) and Caspian Tern 30 years (ring number read on a living bird). https://www.nrm.se/download/18.1014476716d832a801b143d3/1570517237873/Åldersrekord%20Sverige%2020190924.pdf). Therefore it seems likely that the three bird species would have a similar life history.

In my study I have not used all the individuals depending on rather few finding of dead birds during 1976 to 1987. In these 12 years only 22 White-tailed Sea Eagles were found dead and only two birds were younger than five years. Thus 548 White-tailed Sea Eagles were used in my survival study.

For the Golden Eagle only eight individuals were found dead between 1976-1987 and therefore 135 individuals of Golden Eagles were used in this study and for the Caspian Tern 32 terns were found during the 20 years and no one was younger than three years so only 80 individuals could be used in the study.

In my matrices [1] a 0 year young bird represent a bird from ringing date and 365 days later, a 1 year old bird is 366-730 days and so on. Sometime a bird age is defined as 1K, 2K (K=calendar year) and so on where a bird borne one year is defined as 10 until 31/12 the same year and thereafter 1K. An 1K bird is then about 250 - 615 days and most like an 1 year bird in my study; 2K equal to 2 years old bird and so on.

Seven individuals of the Golden Eagles have been ringed as adults and defined to be between 1K+ and 7K+. I have defined these birds as 1 year old and so on in my matrices which maybe an under-estimation.

I order to investigate the possible developments for the three species I used the maximun likelihood method by North, et al. [1] for estimate the survival to the breeding age (s1), the year thereafter (s2) and later years (s). After the first years of living birds have a rather constant survival according to North, et al. [1].

The estimation of the numbers of females in a brood for sustain a stable population I used the formulas by Henny, et al. [2].

$$m = \frac{1-s}{s_1 s_2 \left(1-s+s_3\right)}$$

In the formula m is the number of female young in the brood for a stable population and when North & Morton estimate s1, s2 and s the s3 is identical with s in my use of the formula. The mortality is only estimated for females but I assume that identical mortality for both sexes.

To estimate the number of young per brood the estimated m must be multiplied by two.

In order to clarify if a population is increasing, stable or decreasing I used Henny, et al. (1990) formula

$$u = m \times s1 - 1 + s$$

where u > 0 show an increase och u < 0 a decrease of the populationen och m = averages number of females per brood och s1 = survival to the breeding age och s = constant survival.

Results

White-Tailed Sea Eagle

Mean age for the 570 White-tailed Sea Eagles found dead are 6,0 ± 0,75 (s.e) years. Dividing the White-tailed Sea Eagles into two groups; one found dead without naming the causes of mortality and a second part with named causes or probably causes, show that the first named group is 6,9 ± 0,4 (s.e) years (n=224) and the second 5,4 ± 0,3 (s.e) years (n=346). The differences of 1,5 years are statistically significant (t=3,14 P<0,001). My explanation for this result is the first group is “dead of natural causes” but the other often “dead by human activities” that more often hits young unskilled individuals.

The most known common mortalities are:
"killed by train" 143 ex
"killed by electric wire or wire" 18 + 43 ex
"killed in trafic" 18 ex
"poison" 12 ex (three individuals by unknown chemical)
"wounded/ "bad" + "common weaken" 41 ex + 8 ex (and "wounded but unknown if released"
4 ex).
"found by wind-poweraggregates" 14 ex
"killed by parasites/bacteria" 9 ex
"flying towards to solid object" 8 ex
"caught by raptor/owl including own species" 5 ex
"shoot" "found shoot" 4 ex
Other causes of death are more uncommon.

I supposed that the poisoned and the shoot birds are determined by conservators at the Naturhistoriska Riksmuseet in Stockholm in finding lead shots in the birds and in their gizzards.

The White-tailed Sea Eagle begin to breed at the age of 6K (Helander in e-mail). Thus, the survival of the eagles between 0 - 5 years old represent s1, 6 years old as s2 and older as s in my calculation by North, et al. [1]. The results from the maximum likelihood formula give:

s1 = 0,445 ±0,023(s.e.), s2 = 0,826 ±0,024(s.e.) resp. s = 0,842 ±0,012(s.e.)

Between 1995-2000 the White-tailed Eagle produced 1.65 young per year in the Baltic sea area. In Lapland the production was lower 1,26 young per brood (Helander 2003). With a production of 1,65 young per brood the population of White-tailed Sea Eagle would increase with 20,5% using the formula (2). However, many birds failed in their first breeding attempt. If the White-tailed Sea Eagle begin to breed at 7K the calculation of the survival gives:

s1 = 0,373 ±0,023(s.e.), s2 = 0,786 ±0,030(s.e.) resp. s = 0,861 ±0,013(s.e.).

With this estimate the White-tailed Sea Eagle would increase with 12,6% each year.

Golden Eagle

Mean age for the 143 dead found Golden Eagles are 3,6 ± 0,4 (s.e) years. The most known common mortalities are very alike the causes of the White-tailed Sea Eagle:
"killed by train" 20 ex
"killed by electric wire or wire" 21 + 18 ex
"killed in trafic" 8 ex
"poison" 2 ex
"injured/ "bad" + "common weaken" 15 ex + 1 ex (and "injured but unknown if released"
2 ex).
"found by wind-poweraggregates" 2 ex
"flying towards to a net" 2 ex
"collision by airplane" 1 ex
"shoot" "found shoot" 4 ex

Other causes of death are more uncommon. I have supposed that the Golden Eagle begin to breed at 5 years of age (5K) according to Gensbøl, et al. My estimates give following numbers:

(0-4 year) s1 = 0,308 ±0,045 (s.e), (5 year) s2 = 0,794 ±0,065 (s.e) and s= 0,860 ± 0,028(s.e).

With these survival the Golden Eagle would have 1,14 young for a stable population. If the Golden Eagle begin to breed at 6 years (6K) I found the following survival:

(0-5) s1 = 0,227±0,042 (s.e), 6 year (6K) s2= 0,903 ±0,055 (s.e) and s = 0,841 (0,034 (s.e).

With these estimates the Golden Eagle must produce 1,58 young per year for a stable population. Between 2010 - 2019 the Golden Eagle produce 2232 young in 1876 successful breeding attempts or 1,19 young per nest (Tjernberg in e-mail). Because the White-tailed Sea Eagle produce fewer young i Lapland (see above) and about 90% of the Swedish population of the Golden Eagle breed in the northern part of Sweden (>61 latitude) I got information from Gotland with about 40 breeding pairs. But in Gotland the production was equal as in the rest of Sweden, 1,20 young per pair (Hedgren in e-mail).

Thus if the Golden Eagle begin to breed at 5 years the population would increase with 4,8% each year but decrease with 2,1% if breeding start at 6 year.

Caspian Tern

Of the 112 Caspian Terns 51 individuals were shot or captured in their wintering area. All other were "found dead".

The only 80 Caspian Terns which were possible to use for estimating their survival gave following results when I supposed that the tern begin to breed at 3 years of age (3K).

(0-2 year) s1 = 0,408 ±0,057 (s.e), (3 year)s2 = 0, 855 ± 0,061(s.e) and s = 0,789 ± 0,040(s.e).

With the estimated number of young 0,8 per pair (Lötberg in e-mail) the population of Caspian Tern would decrease with about 3% per year. For a stable population the Caspian tern would produce 1,15 young per year.

Discussion

Only for the White-tailed Sea Eagle the number of dead birds are satisfactory for a more correct estimate. With only 143 individuals for the Golden Eagle and 80 birds for the Caspian Tern the estimations are more uncertain and the standard errors are larger.

However, my results are in agreement with the given information in Ottosson, et al. [3]. The authors suggest that the White-tailed Sea Eagles increase with about 10% in the first decade of 2000. The Golden Eagle may increase with 3% each, but this increase can be a result of the more careful inventory efforts. For the Swedish population of the Caspian Terns a decrease to about half the number has been seen since 1970th.

The reasons for the very remarkable development for the population of the White-tailed Sea Eagle depend on the prohibition of DDT and PCB in the 1960ies and the massive feeding of White-tailed Sea Eagles with poison-free meat from dead pigs. From about 40-50 pairs living in Sweden at 1960 nowadays the population is about 1000 pairs along the Baltic coast and at the larger lakes in middle of Sweden.

The increase of the Golden Eagle population is more uncertain. In my estimation the increase depends on that the Golden Eagle start breeding at least one year earlier then the White-tailed Sea Eagle. It is rather difficult to determine the exact age of young birds of the Golden Eagle by plumage. But the Golden Eagles have also other problems; In Gotland only 70% of started breedings are successful (25 of 36 attempts) (Hedgren in e-mail). The Golden Eagle is also chased by hunters and their breedings are destroyed by interferens and/or their nests and breeding-tree [4]. The Golden Eagle has also lover production of young compared with the White-tailed Sea Eagle 1,20 vs 1,60. In my estimations I found also a much lover survival to breeding age; 6 year 22,7% for the Golden Eagle and 44,5% for a 6 years White-tail Sea Eagle, but my results maybe an effect of my small numbers of Golden Eagles in the sample.

My estimation for the Caspian Tern indicate a faster loss of individuals in the Baltic population. The estimation of the number of young by 0,8 per pair can be an underestimation. It is quite difficult to count free-living young and witch hide in gras and weeds.

The Baltic population wintering in the River Niger´s delta in Mali but depending on clima change and disturbance in Mali [5]. The wintering area seemed to changed to the larger area round western Africa; results from satellite data (Lötberg i e-mail) with maybe a disadvantage for the terns. Ludwid, et al. [6] found that the Caspian Terns in Lake Ontario survived to 88% in their age of constant survival. If the Caspian Tern in the Baltic sea also survival in that degree (instead of about 81%) the population would increase by about 4% [7,8].

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