Minimum requirements for monitoring of the survival of vultures in Vulture Safe Zones and release areas

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10 January 2023

Introduction

Saving Asia's Vultures from Extinction (SAVE) has made recommendations for monitoring of the safety of Vulture Safe Zones and release areas. These involve (1) undercover surveys of pharmacies, (2) sampling of liver tissue from cattle carcasses for measurement of NSAID prevalence and concentrations and (3) monitoring of the survival rates and causes of death of vultures tagged with PTT satellite tags or GPS/GSM tags. This note concerns minimum requirements for method (3).

Procedure

SAVE recommends the tagging of at least 50 wild adult vultures and monitoring of their survival for one year or tagging of 25 vultures and monitoring of their survival for two years. I refer to this as a minimum of 50 vulture-years of monitoring. Fixes from the tags should be monitored at least daily and every effort should be made to recover carcasses of any birds that appear to have died to confirm death and establish its cause. Vultures should also be marked permanently with subcutaneous PIT tags and engraved alloy rings marked with a unique alphanumeric code. There should be monitoring of vulture feeding locations visually to read rings and/or with a PIT tag reader to read PIT tags. This allows the identification of birds which have been lost to follow-up after failure of their tracking tag or the tag harness.

The following calculations were used to define the minimum number of vulture-years of tag monitoring. Suppose that the mean annual survival probability of adult vultures in the study area is S and that the daily probability of survival (DSR), is constant. DSR is then given by

$$DSR = S^{(1/365.25)} \qquad \text{(Eq. 1).}$$

Consider a cohort of vultures tagged at time t_0. The probability Z of a tagged bird still being alive on a later day t_1 is given by

$$Z = \exp(\log_e(DSR)*(t_1 - t_0)) \qquad \text{(Eq. 2).}$$

By integrating Eq. 2 with respect to t_1 for t_0= 0, the expected mean number of days for which a tagged bird is alive and being monitored (exposure days = ED) during the period t_0 to t_1 can be obtained as

$$ED = (\exp(\log_e(DSR)*t_1) – 1)/ \log_e(DSR) \quad \text{(Eq. 3)}.$$

The expected mean number of deaths K observed per bird monitored for t_1 days is given by

$$K = 1- Z \quad \text{(Eq. 4)}.$$

The next step in the argument is to define possible values of S. Under the best possible (though unlikely) conditions, S=1 or very close to 1. Monitoring of tagged wild adult White-rumped Vultures in Nepal, where the population of this species has been increasing, found a value of S of 0.974 (Mallord et al. in prep). A review of values of S estimated for other stable or increasing populations of other Gyps species, suggests a minimum value of S = 0.90, with S = 0.95 being typical for a viable population (Mallord et al. in prep). Based upon this, I consider four values of S; 1, 0.95, 0.9 and 0.8. The last value is proposed as a case where population size would be decreasing rapidly because recruitment of young birds to the adult population could not possibly balance the annual death rate of existing adults, given that the annual mean number of fledged young per adult in healthy populations is typically around 0.25.

Suppose that the number of vultures tagged and monitored is T. I used equations 1-4 to generate expected values of K and ED for the four assumed values of S. From K and ED, I calculated the expected number of observed deaths (T*K) of tagged birds and the expected number of monitored exposure days (T*ED). I then calculated DSR as 1- (K/ED) and its exact binomial 95% confidence limits by the method of Clopper and Pearson (1934). By raising the confidence bounds of DSR to the power 365.25, I then calculated the expected 95% confidence interval for S derived from monitoring T birds for one year and two years. I performed these calculations for values of T from 10 to 100.

Results

Figure 1 shows the 95% Clopper-Pearson 95% confidence intervals for each value of S, plotted against T, for a monitoring period of one year after tagging. The curves are colour-coded to identify the assumed value of S. It is evident that the confidence intervals become narrower with increasing numbers of birds tagged (T). However, the effect of T on the breadth of the confidence intervals is much more marked between T=10 and T=50 than it is in the range T=50 to T=100. When T=50 or larger the identification of the true value of adult survival rate (S) as being at or above 0.9, rather than below 0.9 becomes more reliable. This can be seen by looking at where the blue, green, gold and red lower confidence bound curves, which represent values for S=0.8, 0.9, 0.95 and 1 respectively, intersect the vertical dotted black line, where T=50.

Another version of Figure 1 can be drawn, but is not shown, using the procedure described above, but with a two-year period of monitoring after tagging instead of a one-year period. When this is done, the diagram looks similar to Figure 1, but with values of T on the horizontal axis being half of those for the one-year version.

Conclusions

It is usual in field studies of tagged vultures for some tags or harnesses to fail, which causes that individual to be lost to follow-up. In such cases, it can often be recognised from details of the fix records, or searching the last fix location for a shed harness, that failure, rather than death, has occurred. The results for these individuals should be included in the survival analysis by right-censoring them at the assumed date of failure. Ideally, ring resightings or PIT tag records of the individual after tag or harness failure should be used to confirm that failure caused loss to follow-up.

Based on these results, it is suggested that tagging and monitoring 50 wild adult vultures for one year or 25 vultures for two years would provide an adequate monitoring programme and that the area could be considered safe with reasonable confidence if the estimated annual survival value for adults at the end of the monitoring period was 0.9 or greater. Of course, tagging a larger number than this would further increase the reliability of the conclusions drawn. It is most efficient to tag only adult vultures because the usual annual survival rates of immatures are lower and are less well documented than for adults in stable populations.

References

Clopper, C.J. & Pearson, E.S. (1934). The use of confidence or fiducial limits illustrated in the case of the binomial. *Biometrika* **26,** 404-413.

Mallord, J.W., Bhusal, K.P., Joshi, A.B. Karki, B., Chaudhary, I.P., Rana, D.B., Galligan, T.H., Bowden, C.G.R. & Green, R.E. (in preparation) Survival of wild and released White-rumped Vultures Gyps bengalensis, as revealed by GPS telemetry, its implications for conservation of vultures in Nepal.

Figure 1. Annual survival rate S of adult vultures, and its 95% confidence limits, estimated by monitoring tagged birds for one year. Rates are plotted against the number of birds initially fitted with tags T. The colour-coded thick horizontal lines each represent the true value of S (blue = 0.8, green = 0.9, gold = 0.95, red = 1). The two thin lines of the same colour represent the lower and upper 95% confidence limits for that value of S. Where the coloured curves intersect the vertical dashed line shows the expected outcomes for T = 50.