COMPARISON OF SURVEY METHODS FOR ESTIMATING AMUR TIGER ABUNDANCE

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INTRODUCTION

The success of conservation actions taken on behalf of endangered species can only be determined if trends in abundance are monitored over time. Therefore, Amur tiger conservation is predicated on accurately tracking their abundance. However, precise estimates of tiger numbers are difficult to achieve given the large home ranges, densely forested habitat, and elusive nature of tigers. Presently, Amur tiger numbers are monitored by annual track surveys on 16 monitoring units throughout their range in Russia. The minimum number of tigers present is calculated using a travel distance algorithm, along with an index of abundance derived from track data (Hayward et al., 2002; Miquelle et al., 2005). However, there is uncertainty associated with the minimum tiger estimates because they lack statistical bounds of error. With methodological innovations over the past few decades, a number of survey techniques conducive to monitoring tigers that do calculate statistical bounds of error have been developed. Therefore, our objective was to identify a more statistically robust method feasible under the biological and logistical constraints associated with sampling Amur tigers in Russia. We tested five candidate sampling methods using capture-recapture technology. These methods included 1 - camera trap (tigers identified by unique striping pattern), 2 - hair trap (tigers identified by microsatellite DNA from hair samples), 3 - opportunistic DNA (tigers identified by microsatellite DNA from hair and scat samples), 4 - scent-matching dogs (tigers identified by the unique odor signature of scat), and 5 - track ID (tigers identified from morphometric features of their tracks photographed in snow). We then compared the 5 candidate methods and the track survey method against each other to assess their relative effectiveness in estimating Amur tiger abundance.

MATERIALS AND METHODS

Our fieldwork was carried out in Sikhote-Alin Zapovednik from June 2007 through July 2008. We conducted 4 sampling sessions, each 3 months in duration, alternating between the 3 major river basins in the reserve (Serebryanka, Djigitoyka, Kolumbe). We implemented camera trap, hair snare, opportunistic DNA, and scent dog methods during each of the 4 sampling sessions. The track ID and track survey methods were only conducted during the single winter sampling session when snow was present. We divided our study area into a grid of 49 km^2 units to guide placement of sampling stations (camera traps, hair snares) and transect routes (opportunistic DNA, scent dogs, track ID). Given the average female home range size in the reserve of 390 km^2 (Goodrich et al., 2010), grid units were sufficiently small to guard against gaps in coverage that could lead to tigers with no opportunity of being sampled (Karanth, Nichols, 1998; Karanth et al., 2002). Sampling stations and transect routes were checked every two weeks. The track survey followed traditional survey routes established without consideration of any grid system, but covered the major drainages in all 3 sections of the reserve. The track survey was conducted twice, taking between 1 and 2 weeks each time.

We compared the 6 sampling methods using values and scores from a hierarchical rubric employing 3 broad criteria of performance: 1 - logistical constraints encompassing physical cultural, and political barriers to implementation; 2 - statistical precision, bias, and complexity; and 3 - the cost in money, time, and personnel of establishing and implementing the method. Under each heading of the primary criteria, we examined specific sub-criteria using values and scores calculated for each method (Table 1). We ranked the 6 methods from best to worst for each sub-criterion by comparing these values and scores (Table 2, 3). In cases where a method did not produce sufficient data to calculate one of the required rubric values, it was ranked below methods with sufficient data for calculation for that sub-criterion. Because we ranked all 6 methods using 21 sub-criteria of interest (126 ranks total), these data needed to be condensed for a meaningful comparison of methods. Therefore, we calculated 3 summary metrics from the sub-criteria ranks: 1 - mean rank for logistics, statistics, and cost associated with each method; 2 - mean rank overall for each method; and 3 - cumulative mean rank for all methods combined. Despite the importance of each individual sub-criterion, certain ones were more critical to a method's success than others. We weighted ranks for these 5 sub-criteria (difficulty of protocol, difficulty of permitting process, confidence interval (CI), capture probability, annual budget) to be twice as powerful in the calculation of mean ranks.

Results

Of the 6 methods, only 3 – camera traps, opportunistic DNA, and the track survey – garnered sufficient recaptures or samples to estimate abundance during each sampling session they were tested. Abundance estimation was possible in 3 out of 4 sampling sessions for scent dogs, 1 of 4 sampling sessions for hair snares, and 0 of 1 sampling session for track ID (Table 4). Overall, the track survey method amassed the largest sample sizes followed by camera traps, opportunistic DNA, and scent dogs. Hair snares and track ID methods produced the least samples and recaptures.

Mean ranks overall for individual methods compared against the cumulative mean rank for all methods combined indicate that track surveys were most useful followed by scent dogs and camera traps, all of which had mean ranks better than the cumulative mean rank for all methods combined. In contrast, opportunistic DNA, hair snare, and track ID methods all had mean ranks inferior to the overall mean rank for all methods (Fig. 1). Despite these results, mean ranks for logistics, statistics, and cost for each method indicate that high-performing methods overall may be critically deficient in one or more of these criteria. Whereas a perfect method would rank first for all 3 criteria, no method analyzed here did so (Fig. 2). Both the track survey and track ID methods, although performing well logistically and in terms of cost, were weak statistically. Similarly, camera traps and opportunistic DNA, although statistically superior, performed poorly in terms of logistics and cost. Scent dogs and hair snares were average in their performance across criteria.

Discussion

All 6 methods investigated in our study are capable of estimating tiger abundance. However, our comparison rubric shows that some methods are more appropriate than others for Amur tiger monitoring at present.

Currently, the track ID method is infeasible. This method produced insufficient samples to generate an abundance estimate. Snow proved too plastic a substrate for successful application of this method because it relies on substrate remaining consistent across the study area throughout sampling. Similarly, hair traps are infeasible due to insufficient sample sizes. Tigers were unresponsive to hair traps baited with scent lure that had elicited a cheek-rubbing response in captive Amur tigers. This resulted in very few hair samples being deposited on the traps.

The remaining methods can be feasible for Amur tiger monitoring under the right circumstances. Opportunistic DNA is very robust statistically, but the lack of a local lab capable of DNA analyses is problematic. In addition, during our study, scat collection was inconsistent between technicians. Methods relying on scat sample collection will be biased if there is high variability in effort between technicians. Scent dogs are fairly robust statistically and should be less expensive than DNA analysis. However, this method also relies on outside experts for analysis and is vulnerable to inconsistency in scat sample collection. Track surveys are inexpensive and easily implemented. However, it was one of the less precise methods compared. This limitation is significant since it introduces uncertainty into tiger estimates calculated from track surveys. Meanwhile, camera traps are statistically robust and allow for local scientific autonomy. Tiger biologists can set camera traps, collect data, and estimate abundance themselves without relying on experts outside the region. However, it is the most expensive method.

Greater precision in Amur tiger abundance estimates may be feasible through double sampling (Cochran, 1977; Thompson, 1992) by coupling extensive track surveys with a statistically rigorous capture-recapture approach such as camera trapping. Within the 16 established monitoring units, track surveys should continue on an annual basis. Camera trap surveys should rotate through individual units on a 5 – 10 year cycle. Relative abundance estimated from track counts can be calibrated against absolute abundance estimates from camera trapping. By combining the 2 methods, biologists can gather more information on tiger population trends than either method would generate alone, providing the most reliable knowledge from available resources.

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