An Experimentally Determined Persistence-Rate Correction Factor for Scat-Based Abundance Indices

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Abstract

*Indices or density estimators derived from counts of scat can be used as indirect measures of animal population density. An important issue in these studies is that scat decay rates vary across habitats and seasons. This is an often overlooked source of bias when using scat-based indices to make comparisons of relative abundance among sites or over time. I propose a simple method by which experimentally determined scat-persistence rates can be used as a correction factor in such indices. This measured persistence rate also serves as an important parameter in models that convert scat count data into population estimators. I test this method in a relative abundance survey of sambar deer (*Cervus unicolor*) for 6 sites across 2 national parks in northern Thailand. Using the correction factor changed the qualitative predictions of the abundance survey by altering the rank of the sites ordered by estimated sambar density. The ratio of corrected:uncorrected index values, which would stay constant across sites if there was no habitat-based variability in scat-persistence rates, changed by a factor of 2.7 when measured across sites and by 1.6 when measured across parks. This suggests that the application of persistence-rate correction factors could reduce the bias of scat-based index or estimator surveys by specifically accounting for decay rate variability.* (WILDLIFE SOCIETY BULLETIN 34(4):1216–1219; 2006)

Key words

bias, Cervus unicolor*, correction factor, pellet groups, population estimators, population indices, relative abundance, sambar deer, scat, spoor, Thailand.*

Scat counts have long been used to indirectly assess mammal density in lieu of directly sampling the animals themselves (Bennett et al. 1940). If scat abundance proportionally relates to actual mammal abundance, scat counts provide a valuable index of population size (White 1992). If the functional relationship between the abundance estimate and true population size is known, this index can be used to estimate population density (Krebs et al. 1987).

Scat-based indices and estimators have been shown to scale proportionally to known snowshoe hare (*Lepus americanus*; Krebs et al. 1987), deer (*Cervus nippon*; Marquez et al. 2001), and large carnivore (Stander 1998) density. Yet several studies comparing estimated deer population sizes from scat-based estimators to known populations in enclosures showed high variability in index-based estimates of deer abundance and relatively low correlations between the estimated and actual abundance values (Eberhardt and Van Etten 1956, Ryel 1959, Downing et al. 1965, Dzieciolowski 1976). Studies testing the relationships between deer abundance estimates calculated from scat-based estimators and other estimators (e.g., drive counts, line-transect samples) have showed weak relationships (Dasmann and Taber 1955, Fuller 1990) or relationships with substantial variation between years (Harris 1959) or habitats (White 1960).

An important source of variation in pellet numbers between locations in the above studies (and a potential partial explanation for the weakness of the relationships between pellet-based abundance estimators and actual population size) is that persistence of the scat pellets might vary between study sites or over time at the same location. There could be substantial spatial and temporal variation in the rates at which dung beetles, erosion, desiccation, and other factors cause scat to degrade or disappear. This variation could lead to fewer pellet piles being found at some sites than at others regardless of actual differences in animal density or behavior. Loss of scat due to natural degradation should minimally affect the usefulness of scat-based abundance indices, as long as the degradation rates are similar between study sites or periods. However, several studies have demonstrated important differences in scat decay rates depending on the habitat into which pellets were deposited (Low [1959], unpublished data, as cited by Neff 1968; Dzieciolowski 1976).

Marquez et al. (2001) suggest that a measure of persistence rate should be included as a parameter in the model used to convert raw scat counts into population estimators. Their method involves marking a sample of fresh pellets in the areas to be surveyed and measuring their persistence rates over the months preceding the scat survey. While this approach should improve the accuracy of scat-based estimators, it has several potential problems. First, determinations of whether scat is fresh can at times be problematic. Van Etten and Bennet (1965) show that, under certain habitat and weather conditions, pellet piles up to 2 years old can appear fresh. Furthermore, in some areas it may be difficult to locate a sufficiently large sample of fresh pellet piles to allow accurate determinations of decay rates.

I propose a simple study design to experimentally measure scat-persistence rates that can overcome the above sampling and logistical issues and should improve accuracy in scat-based indices and the density estimators derived from them. The method, exemplified here for deer, works as follows: 1)

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scat pellets known to be fresh are collected from areas of high animal use, 2) pellets are air-dried and mixed, 3) pellet piles are set out at random or systematic locations within the study area and marked with flagging, 4) concurrent with conducting the scat survey, the proportion of the experimental pellet piles still visible is measured to determine the scat-persistence rate, and 5) observed scat counts (uncorrected indices) are divided by the persistence rate to create corrected index values.

Scat surveys generally use 1 of 2 general methodologies: the "clearance plot" method, whereby plots or transects are cleared of existing scat and then, usually several months later, resampled for scats that have been deposited in the intervening time; and the "standing crop" method whereby plots are not cleared beforehand (Marquez et al. 2001). Applying a persistence-rate correction factor is especially important in the standing crop design because there is otherwise no way to determine the age of the observed pellet piles. But such correction factors also should be used in the clearance plot design to measure the rate at which any pellet piles deposited since plot clearance have disappeared. In this case experimental piles can be set out at the time of plot clearance and persistence measured during plot sampling, thus ensuring that factors promoting pellet-pile decay act concurrently on experimental and naturally occurring scat piles.

Study Area

I experimentally tested the persistence rates of sambar (*Cervus unicolor*) scat pellet piles across sites in monsoon forests of northern Thailand to assess whether use of a persistence-based correction factor alters the qualitative results of a scat-based relative-abundance survey. This work was part of an ongoing study on the effects of wildlife poaching on zoochorous tree seed dispersal in 4 national parks: Doi Inthanon, Doi Sutep-Pui, Nam Nao, and Khao Yai. Khao Yai National Park (2,172 km^2; 14°26′N, 101°22′E) was a large plateau, 700–900 m in elevation, with mixed deciduous forest on the steep slopes and evergreen seasonal or mixed evergreen–deciduous forest types throughout most of the area (Smitinand 1977). It received about 250 cm of rain annually, mostly from May to October; there was a pronounced dry season from December to April. Abundance of many large mammals was high in the central portion of Khao Yai (Lynam et al. 2000, 2003). Nam Nao (966 km^2; 16°44′N, 101°34′E) was a matrix of mixed evergreen–deciduous forest types with open, grassy, pine–dipterocarp woodland (Elliott 2001). All sampled plots in this park were in mixed evergreen forest. The understory vegetation in the mixed evergreen forest of both parks was fairly open with rattan palms (Arecaceae) and *Strobilanthes* spp. (Acanthaceae; especially in Khao Yai) common and much exposed leaf litter on the forest floor. There have not been any recent mammal-density estimates in Nam Nao.

Other pellet-forming ungulates in these parks included the common muntjac (*Muntiacus muntjak*), Fea's muntjac (*Muntiacus feae*; Nam Nao only), mouse deer (*Tragulus* spp.), and possibly the southern serow (*Naemorhedus sumatrensis*) and long-tailed goral (*Naemorhedus caudatus*; Lekagul and McNeely 1977, Srikosamatara and Hansel 2000). Serow and goral are unconfirmed in Nam Nao, and in Khao Yai they are rare and tend to reside in the hilly portion of the park (Srikosamatara and Hansel 2000), not close to the sites used in this study. Muntjac and mouse deer scat was easily distinguished from that of sambar by size.

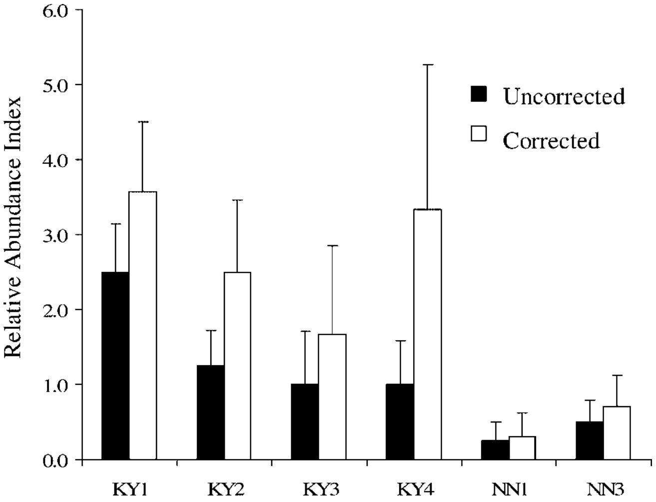

Figure 1. Sambar relative-abundance indices across 6 sites in Khao Yai (KY) and Nam Nao (NN) national parks, Thailand, in 2003, with and without scat-persistence-rate correction factor; standard error bars represent variation across transects within each site.

Methods

I haphazardly selected 4 0.5-ha plots in each park. Out of the 16 plots, only 6 showed evidence of sambar presence; the animals may be extirpated in Doi Sutep-Pui and Doi Inthanon, and only 2 of the sites in Nam Nao had sambar scat. Therefore, I used only the 6 plots (4 in Khao Yai [KY], 2 in Nam Nao [NN]) with sambar scat for the analyses below. Within these plots I randomly chose 4 50 × 4-m parallel belt transects in each plot, each $\geq$10 m apart. To limit variation in the number of scat pellet piles due to differences in habitat or presence of local food sources, I staggered transects so as to stay within forest cover (i.e., avoiding light gaps) and to avoid fruiting *Choerospondias axillaris* (Anacardiaceae) trees.

I cleared the transects of existing scat pellet piles at the beginning of the field season (mid-Jul) and sampled them for new pellet piles at the end of the season (mid-Oct). I conducted all surveys to reduce observer bias (Neff 1968).

I developed a plot-specific measure of scat-persistence rates. In early July I collected fresh sambar scat from the grassy lawn of the Lam Ta Khong campground in Khao Yai National Park, a site of very heavy sambar use. I dried pellets in the sun and then transported them to the study sites. On the same days that transects were cleared of existing pellet piles, I initiated the pile persistence-rate experiments. I placed 10 piles of 10 pellets each at randomly chosen locations within each plot and marked them with pin flags. At the end of the season, I determined whether piles were

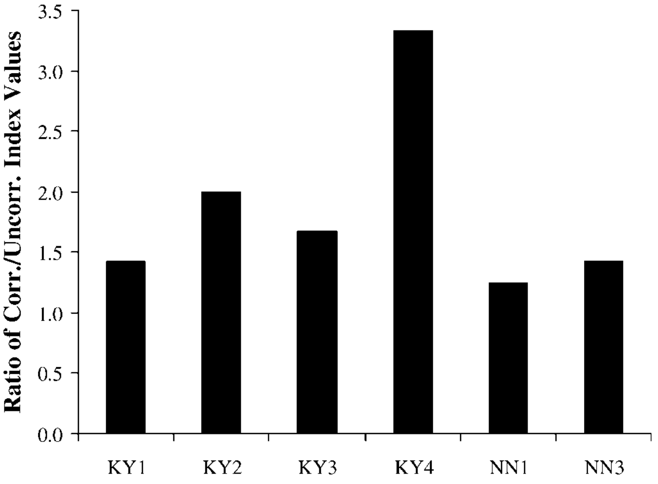

Figure 2. Ratios of corrected:uncorrected sambar abundance index values across 6 study sites in Khao Yai (KY) and Nam Nao (NN) national parks, Thailand.

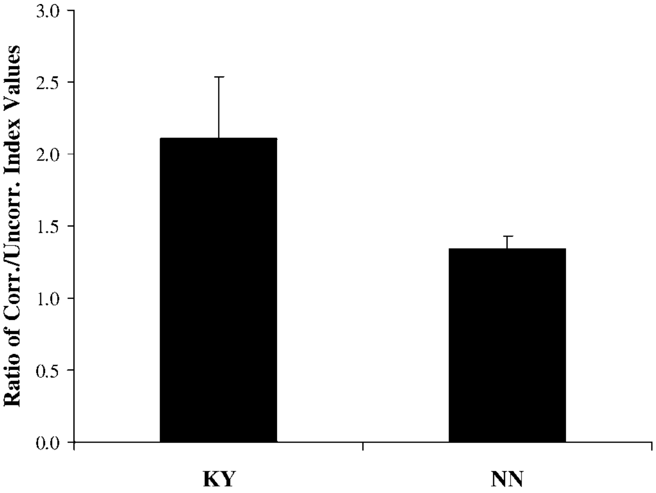

Figure 3. Ratios of corrected:uncorrected sambar abundance index values across Khao Yai (KY) and Nam Nao (NN) national parks, Thailand; standard error bars represent variation across sites within a park.

still visible. Piles were scored as either "visible" or "not visible," rather than by the proportion of original pellets remaining. The proportion of the 10 original piles still remaining at the end of the season constituted the persistence-rate correction factor.

The uncorrected sambar abundance index was the mean number of pellet piles across the 4 transects on a plot. The uncorrected index value divided by the plot-specific persistence-rate correction factor constituted the corrected index. If there was any loss of pellet piles at all, the corrected index value would be higher than the uncorrected value. But if scat-persistence rates were similar across sites, the ratio of corrected:uncorrected index values would remain relatively constant. I calculated these ratios for all 6 sites (treating the sites themselves as independent) and separately for the 2 parks (treating sites within the parks as replicates).

Results and Discussion

The rank of the 6 sites, ordered by relative sambar abundance, changed when the persistence-rate correction factor was applied. The rank order based on the uncorrected abundances was KY1 > KY2 > KY3 = KY4 > NN3 > NN1; the rank of sites using the corrected sambar abundance was KY1 > KY4 > KY2 > KY3 > NN3 > NN1 (Fig. 1). The ratio of corrected:uncorrected abundance values (Fig. 2) varied among sites by a factor of 2.7. The ratio of corrected:uncorrected abundance values between parks (Fig. 3) varied by a factor of 1.6. I speculate that the differences in scat persistence among sites and parks were due to variation in dung beetle abundance and local weather and habitat conditions; drier sites probably had higher persistence due to reduced direct impacts of precipitation on scat.

Many studies using indices seek to assess relative differences in population density between sites. The application of the persistence-rate correction factor in this study changed the qualitative ranking of sites, implying that differences in scat decay rates between environments could be an important source of bias in index measurements. This result is further supported by the observation of highly variable corrected:uncorrected index-value ratios across sites and parks. The persistence-rate correction factor proposed here should increase the accuracy of abundance indices, while serving as a necessary parameter in density estimator equations based on scat-count data.

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