Effects of habitat on visibility of elephants during aerial census

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Abstract

During a study of elephant biology in Zimbabwe a relatively simple opportunity arose to document the effects of habitat and topography on the aerial visibility of elephants. This involved relocating individually radiocollared elephants concurrent with aerial census of the population to which they belonged. Sightings of elephants were considered 'failed' when no elephants could be seen by aerial observers once the aircraft had been flown in a tight circle around the radiocollar signal location for some 8 minutes. These cases, which amounted to 15% of the sighting sample (n = 88), were all in steep, rocky hills covered by high-canopy woodland and incised by narrow, thickly wooded valleys. Such terrain did not cover enough of the study-population range to affect the accuracy of the census estimate in survey strata sampled by aerial transects. Nevertheless, the unique trial was useful in allowing localized failure rates of elephant visibility under theoretically ideal observation conditions to be appreciated by those seeking to improve routine census technique.

Résumé

Lors d'une étude portant sur la biologie de l'éléphant au Zimbabwe, nous avons eu la possibilité relativement simple de montrer les effets de l'habitat et de la topographie sur la visibilité des éléphants à partir d'un avion. Il s'agissait de localiser individuellement des éléphants équipés de colliers radio tout en recensant d'avion la population à laquelle ils appartenaient. On estimait que la vue des éléphants avait « échoué » lorsque les observateurs aériens n'avaient pas pu voir d'éléphants alors que l'avion avait effectué des cercles étroits pendant quelque huit minutes autour de l'endroit donné par la localisation radio. Ces cas, qui représentaient 15% de l'échantillon (n = 88), se produisirent tous dans des collines abruptes et rocailleuses, couvertes de forêts à haute canopée et coupées de vallées étroites et densément boisées. Ce genre de terrain ne couvrait pas de portions suffisantes de l'aire de répartition de la population pour affecter l'exactitude des estimations fournies lors de l'étude des strates échantillons par les recensements par transects aériens. Néanmoins, ce test unique s'est avéré utile puisqu'il permet à ceux qui cherchent à améliorer les techniques routinières de recensement d'apprécier les taux d'échecs localisés de la visibilité des éléphants, dans des conditions d'observations théoriquement idéales.

Mot clé supplémentaire : stratification

Introduction

Researchers agree that aerial counting of elephants in the savanna range is precise and cost efficient when sample counts are used (Craig 1993, Mbugua 1996). However, even sample aerial surveys underestimate true numbers of elephants because some animals within the sampling units are overlooked (Craig 1993). Therefore, it is beneficial to establish the degree to which observers conducting aerial census fail to see elephants. Unfortunately, opportunity to critically assess such visibility bias has been limited by expense, logistics and lack of adequate personnel to do the job. During a recent study of elephant biology in Zimbabwe, an opportunity arose to document the effect of different types of habitat on the visibility of elephants whose location was accurately known. This paper compares possible visibility bias of elephants in four different habitats of one census zone.

Study area and methods

The study took place in the Sebungwe region of Zimbabwe, a 15 000-km^2 semi-arid savanna of mainly undulating topography. Vegetative cover is dominated by *Brachystegia* and *Julbernadia* spp. (miombo) and *Colophospermum* (mopane) woodland, interspersed with numerous riparian fringes and occasional dense thickets. Isolated ranges of rocky hills protrude from the savanna. Land use is a mosiac of protected areas for wildlife and communal land for humans. In the latter, elephants still occupy habitats not yet transformed by agriculture. The elephant population in Sebungwe of approximately 12 000 animals is isolated from other populations in the country, making immigration and emigration of elephants impossible. Unnatural mortality, such as from poaching or problem animal control, is low. Aerial census of elephants has been conducted across the entire region annually for over 20 years.

Nineteen elephants, 12 cows and 7 bulls, were fitted with radio collars as part of a three-year study comparing the biology of elephants inside and outside protected areas (Hoare 1997). The success in visually locating these tagged animals from an aircraft was assessed when searching took place during the same times of day in the same months as the annual aerial census for the Sebungwe population. These times were from 0800 to 1100 h and from 1530 to 1700 h during the late dry-season months of August, September and October. Standard aerial tracking techniques were used (Kenward 1987) by a two-man team of pilot and observer. All collared animals were tracked on the same flight on each occasion (every 7 to 10 days) and the data set was compiled from two successive years, 1994 and 1995.

Each collared elephant had a different radio frequency. Having homed in on the signal from each radio transmitter, the aircraft was flown in a tight circle above the signal location until elephants were sighted. A string of data was recorded at each elephant fix: location coordinates, group size, group type, age classes in group, habitat occupied, and estimated distance to human settlement and to water. Sightings were assigned to four broad habitat categories commonly used in botanical studies of this part of the Zambezi Valley (Timberlake *et al.* 1993): miombo, mopane, thicket, riverine.

Sighting success was scored according to three categories: *succeed* meant all animals in the group were counted; *fail* meant that no elephants were seen; *partial*, which applied only to female groups, meant that one or two individual animals were seen but that the remainder of the family group (whose size was known from many previous observations) was obscured by vegetation. Failure of the sighting was admitted only when no elephants had been seen after 5 to 8 minutes. During this time the aircraft circled the area repeatedly, up to 10 times, in both directions and flew low over the signal location in an attempt to use engine noise to flush animals from their concealment.

Results

The overall scores in 88 attempts at census-concurrent sightings were: ‘succeed’ 82.9%, ‘partial’ 2.3%, and ‘fail’ 14.8% (table 1). Failures were greater among the collared females (85%) than among the males (15%).

Of the 11 failed sightings for cows, 9 (82%) were from elephants living in the same communal land study area—Omay. The remaining two failures for

Table 1. Census-time sightings of elephant groups containing a radiocollared animal in the Sebungwe region, Zimbabwe. Data are numbers of sightings and are separated into the four major habitat types and by sex of elephant

	Miombo			Mopane			Thicket			Riverine			Total		
	S	P	F	S	P	F	S	P	F	S	P	F	S	P	F
Cows	17	0	3	16	0	5	5	1	1	8	1	2	46	2	11
Bulls	3	0	0	7	0	0	3	0	0	14	0	2	27	0	2
Total	20	0	3	23	0	5	8	1	1	22	1	4	73	2	13

S = succeed, P = partial, F = fail

cows were from the protected area of Sijariara-Chete, which is nearest to Omay and has similar topography and vegetation. The only two failures for bulls were also in the Omay communal land. Of the 13 failures overall, 9 (69%) were in thickly wooded rocky hills and 4 (31%) in dense riparian fringes. Mean crude densities of elephants in the Sebungwe protected areas (1.15 per km^2) are consistently much higher than those in the contiguous communal lands (0.46 per km^2) (Hoare and du Toit 1999). But there was no significant difference between the failures of cow sightings in the two land categories ($x^2 = 1.77$; $df = 1$; $p < 0.05$).

In the areas where sighting failures occurred, there are steep hills strewn with large boulders and covered by high-canopy woodland. Elephants in this area often stand in shadow under canopy trees. The ground is uneven and the animals are the same colour as the rocks among which they may be standing. In addition, the numerous watercourses are narrow, often supporting a dense fringe of riverine vegetation. A combination of these factors can make elephants indiscernible from above. In several cases of failed sightings, the radiocollared animal was situated in the worst places for visibility, such as a steep and thickly wooded rocky gorge.

Interestingly, few failures occurred in thickets, which are botanically the densest of the habitat types. But they are mainly composed of multistemmed shrubs, which, while severely restricting visibility on the ground, are short enough to allow the backs of elephants to protrude above them. Thus the animals remain visible from the air. In areas where complete success was achieved in sighting the tagged cow and bull groups (Gokwe District—both inside and outside protected areas), the topography is flatter and includes more open-canopy miombo woodland on sandy plateaux and wider rivers with alluvial woodland on terraces. To an airborne observer, these vegetation types do not effectively conceal elephants.

Discussion

The study data confirm that habitat and topography combinations can account for the failure of aerial observers to see a proportion of the elephant population in certain areas. A 'localized' failure rate of 15% gives an indication of the proportion of elephant sightings that may be missed in the most difficult parts of this census zone, even under ideal observation conditions. Under less than ideal observation conditions, such as from a survey aircraft on a transect passing rapidly overhead concealed or partially concealed elephant groups, this shortfall could be higher. But in the Sebungwe, these conditions probably apply only to relatively small areas, and it is likely that elephant population estimates for all census subunits (strata) are within the calculated confidence limits, consistently 20–25% over many years of annual aerial census (DNP&WLM 1996).

The Sebungwe elephant population is one especially suited to census experimentation. It is geographically enclosed, has known low levels of mortality, occupies mosaics of land use and habitat, and has census data spanning many years. The population trend over the last 20 years is stable, although from year to year the estimates vary (Hoare 1997). The present experiment therefore supports the hypothesis that visibility bias may be contributing to the variable year-on-year population estimates, which are obtained from census with fairly consistent precision. In turn, visibility bias is probably influenced by other unquantifiable factors, such as the use of different observers and differences in vegetation condition between years.

The possible net effect on the elephant population is that the contiguous administrative subunits of elephant management, in this case districts, are not being provided with population estimates of uniform accuracy, because of the influences of habitat. Nevertheless, these districts are allocated equal proportions of their respective elephant populations by the wildlife authorities as offtake quota for hunting and problem animal control—about 1%.

Craig (1993) reviews the possibilities for prior allocation of sampling effort to survey strata and examines the pitfalls of using post-hoc correction factors on survey data. Prior allocation of sampling effort to census strata is usually based on prior knowledge of likely elephant density. Allocation of increased sampling effort in problem strata has been the traditional way to overcome the effects of terrain on visibility. In the Matusadona National Park, for example, adjacent to the Omay communal land, a smaller, slower aircraft is used, and block sample counts replace transect sample counts in the rough terrain of the Zambezi escarpment (Mackie 1995). In strata with blocks, sample blocks are each total counted for elephants, and these block strata typically have a higher sample intensity (20–30%) than transect strata (5–15%).

In areas where the transect sample count method crosses rugged terrain but has to be retained for logistical reasons, elephant census design should find a way to accommodate the association between habitat, topography and visibility bias. In this study, the numbers of individual elephants being missed during census in problem strata can be estimated using the proportion of failed sightings from the radiocollar relocations (14.8%). If one were to consider using a local correction factor, a possibility could be

corrected estimate	=	*C* (raw estimate)
where *C*	=	correction factor of 100 / (100 – 14.8)
	=	1.17

Theoretically, the use of such correction factors in other situations presents a dilemma because it has to make the assumptions 1) that sighting failure is independent of the group size of elephants and 2) that habitat conditions and the census technique are equal between years. Cases where a correction factor may be justified include a first-time census where habitats can be mapped but where there is no prior indication of elephant density.

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