Monitoring of sex and age ratios in ungulate populations of the Kruger National Park by ground survey

D.R. MASON

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Objectives, techniques and problems of monitoring ungulate population structure and trends using standardised ground surveys as an adjunct to aerial counts are described and discussed in the light of experience gained over the past seven years. Because of ambiguities inherent in the interpretation of juvenile survival rates from data on age class distributions and until the accuracy and repeatability of the aerial counts in Kruger National Park have been assessed, a complementary approach to population monitoring using ground and aerial surveys is advocated.

Key words: ungulate population monitoring, Kruger National Park, sex and age classifications.

D.R. Mason, Kruger National Park, Private Bag X402, Skukuza, 1350 Republic of South Africa.

Introduction

Trends in wildlife populations are determined by the relative rates of natality and immigration versus mortality and emigration and reflect the interplay of numerous, often variable, environmental factors. Movements of the larger herbivores across the Kruger National Park (KNP) boundaries are curtailed by fences and the limited crossing that does occur at breaks and gaps is generally insignificant as an influence on population dynamics. Reliable information on trends is central to the conservation and management of game populations, monitoring of which has largely depended on standardised aerial censusing as described by Viljoen (1989). These aerial surveys are conducted annually during the dry season and also provide some data on calf percentages and social structure for certain large herbivore populations, but not the more comprehensive data on sex and age composition that can be obtained from periodic sample counts on the ground. Moreover, apparent trends in population numbers based on aerial counts may be subject to counting variability between successive years. Field classifications of sex and age classes also have limitations, particularly in that they do not provide information on adult mortality, which is necessary for interpreting age ratios. Adult mortality rates may markedly influence estimates of juvenile mortality based on the proportions of juveniles and adults at different times, and increases or decreases in population size may occur without change in age ratios (Caughley 1974a). Ideally therefore, a combination of aerial and ground surveys should facilitate more reliable assessment of population trends by providing complementary data on population size and structure.

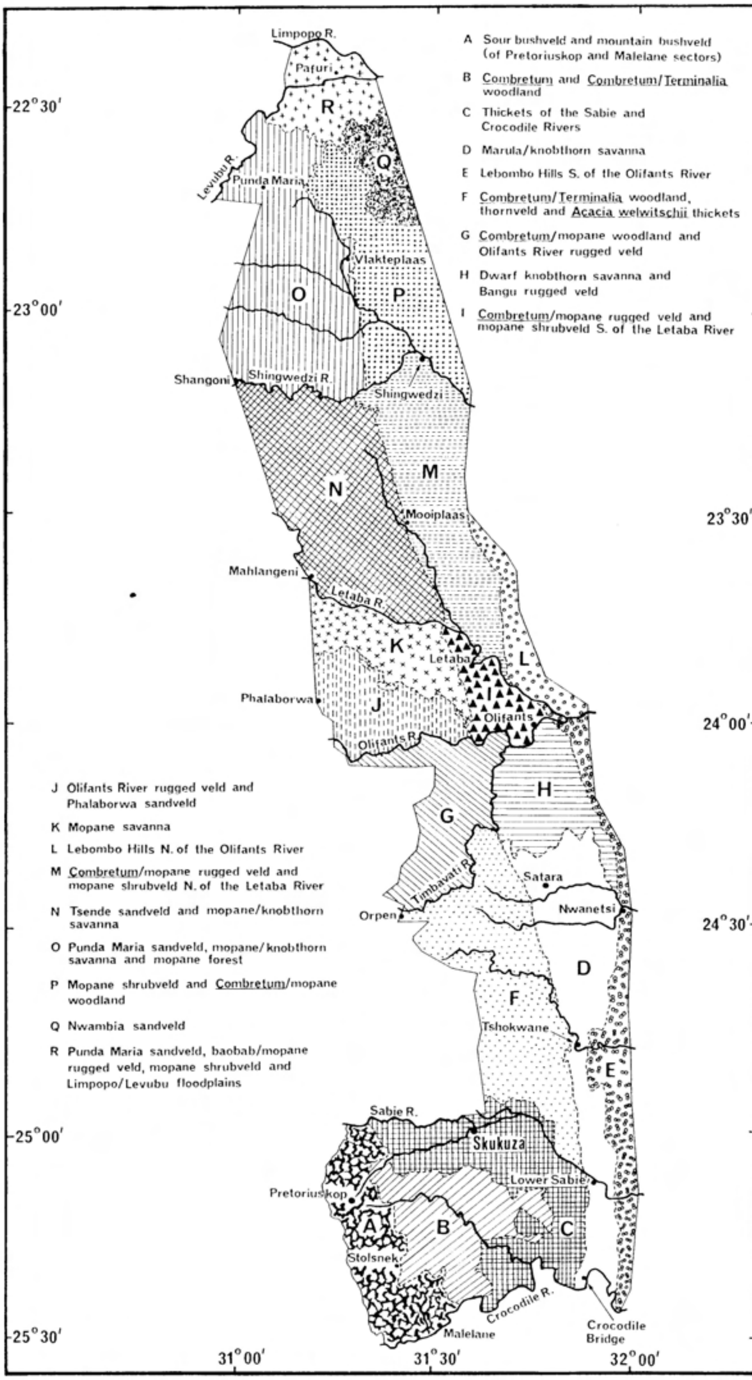

Fig.1. Sampling regions used for monitoring population structure of ungulates in the Kruger National Park.

Objectives

The project objectives are: to assess the usefulness of sex and age ratios as indicators of population trends of ungulates in the Kruger National Park; to investigate variance of these ratios in relation to sample size; to investigate correlations between these ratios and rainfall patterns.

Methods

Sex and age classifications of ungulates (excluding buffalo *Syncerus caffer* hippopotamus *Hippopotamus amphibius* and impala *Aepyceros melampus*) are conducted annually by vehicle throughout the KNP during August, September and October in 18 representative sampling regions (Fig. 1) delineated and simplified from the 35 landscape units described and mapped by Gertenbach (1983). Whereas social groupings among most ungulates in the KNP seldom comprise more than 25 individuals at the time of the surveys (late dry season), impala frequently occur in large herds comprising several sex and age classes. Sampling of impala population structure is therefore entrusted to a team of at least two observers in a vehicle, but is focussed in areas of high population density over a much shorter time period.

The size of the KNP (just over 19 400 km^2) and the intensive observation often necessary for counting and classifying animals entail daily survey periods averaging about 11 hours in a vehicle. During the three months of the survey, distances of up to 11 600 km are traversed each year, making every effort to count and classify all ungulates encountered to ensure representative samples of their population structure. Binoculars (8,5 x 44) and a zoom telescope (15-60 x 60) are used to assist counting and classification, and animals are regularly approached or followed away from roads except in the wilderness areas where off-road driving is not permitted. Special efforts are made to counteract undercounting bias where vegetative cover is dense or when members of a group are scattered while feeding or resting in shade. Whenever conditions are such that one or more individuals in the vicinity of a group might easily be overlooked, especially with animals like kudu, nyala, bushbuck and giraffe, observation time is prolonged; this policy is frequently vindicated as successively more members of a group are located, sometimes also by listening for sounds of movement and feeding from among the bushes.

Most ungulates are reasonably approachable by vehicle in most regions of the KNP because of protection and their habituation to tourist traffic on the extensive road network. Nevertheless, in the interest of sampling success and continuity, it is sometimes necessary to follow animals on foot, although the outcome of such efforts is always in the balance. Termitaria and trees are then used as vantage points where convenient. Moreover, climbing on to the roof of the vehicle to gain better visibility is frequently necessary. Limited foot traverses are also undertaken in certain areas inaccessible by vehicle to boost samples of certain ungulates, e.g. nyala in the ironwood *Androstachys johnsonii* thickets of the rugged lower Olifants River valley, although returns are usually small.

Generally the sequence of sampling coverage of the KNP is from south to north, commencing along the Crocodile River in early August and finishing up to the Limpopo River by late October. However, a rigid schedule of areas and dates is impracticable because of delaying factors such as vehicle problems or waterlogged tracks. Driving speed is adapted to habitat and visibility conditions and most routes are covered only once. When ferry trips are made through previously sampled areas, recording is confined to animals and groups of recognisably new identity on the basis of sex and age composition, individual idiosyncrasies and locality. Where mixed species groups are encountered, attention is focussed first on the rarer species such as tsessebe *Damaliscus lunatus*, leaving common species like zebra *Equus burchellii* until last. Since common species in the more open habitats are often visible from afar as widely scattered groups, sampling effort involving off-road driving is restricted to more economically practical distances while nevertheless striving to maintain the continuity that is necessary for a representative population sample.

In large concentrations of zebra, as many family groups and stallion herds as possible are counted and classified by observing which individuals associate together. To do this it is often necessary to drive the vehicle in among the herds and make intensive observations, discriminating between groups on the basis of distinctive stripe patterns as well as sex and age composition and behaviour.

Ungulates are sexed and classified wherever possible into three age classes: juveniles (birth-12 months), yearlings (12-24 months) and adults (older than 24 months). Knowledge of birth periods or peaks is useful for discriminating between age classes in seasonally breeding animals. Published and unpublished descriptions of criteria for sexing and ageing free-ranging ungulates, and especially diagrams or photographs of horn development and body growth, are used as field guides and include the following:

black rhinoceros *Diceros bicornis* (Hitchins 1970)

blue wildebeest *Connochaetes taurinus* (Talbot & Talbot 1963; zur Strassen 1969a; Attwell 1980)

bushbuck *Tragelaphus scriptus* (Simpson 1973)

eland *Taurotragus oryx* (Kerr & Roth 1970; Underwood 1975; Jeffery & Hanks 1981)

giraffe *Giraffa camelopardalis* (Hall-Martin 1975; Leuthold & Leuthold 1978)

grey duiker *Sylvicapra grimmia* (Riney & Child 1964; Wilson, Schmidt & Hanks 1984)

impala *Aepyceros melampus* (Child 1964; Roettcher & Hofmann 1970; Spinage 1971; Howells & Hanks 1975)

klipspringer *Oreotragus oreotragus* (Norton 1987)

kudu *Tragelaphus strepsiceros* (Simpson 1966; zur Strassen 1969b; Burdett 1983)

mountain reedbuck *Redunca fulvorufula* (Rowe-Rowe 1973)

nyala *Tragelaphus angasii* (Rowe-Rowe & Mentis 1972; Lobao Tello & Van Gelder 1975; Anderson 1986)

reedbuck *Redunca arundinum* (Jungius 1971; Jungius & Claussen 1975)

roan antelope *Hippotragus equinus* (Joubert 1976)

sable antelope *Hippotragus niger* (Grobler 1973; Estes & Estes 1974)

tsessebe *Damaliscus lunatus* (Huntley 1973)

warthog *Phacochoerus aethiopicus* (Mason 1984)

waterbuck *Kobus defassa ugandae*[2] (Spinage 1967, 1982)

white rhinoceros *Ceratotherium simum* (Hillman-Smith, Owen-Smith, Anderson, Hall-Martin & Selaladi 1986)

zebra *Equus burchellii antiquorum* and *Equus zebra zebra*[1] (Smuts 1974, 1976; Penzhorn 1982)

[1]*Equus zebra zebra*, the Cape mountain zebra, does not occur in KNP.

[2]*Kobus defassa ugandae*, the Uganda defassa waterbuck, does not occur in KNP where waterbuck are represented by *Kobus ellipsiprymnus*.

In certain ungulates and especially among females it is impracticable or difficult to distinguish between yearlings and adults on the basis of body size or other criteria. Yearling and adult females are not separated in impala, waterbuck, wildebeest, tsessebe, reedbuck, nyala and bushbuck because body size in these two age classes is closely similar or overlaps at the time of the survey; among males however, the yearling age class can usually be distinguished on the basis of horn development. Grey duiker, steenbok *Raphicerus campestris* and klipspringer apparently attain adult dimensions before 12 months of age and no yearling class is distinguised for either sex in these small antelopes.

For each group of ungulates classified, the total count of individuals is assigned a confidence level to allow for variation in accuracy due to vegetation density, distance from the observer, group size, and other circumstances. Counts which are considered to include most or all of the animals in a group rate a confidence level of 99-100 %. Reasonably accurate counts rate a confidence level of 95-99 %. Counts that are suspect (especially when visibility is poor and when animals run away or mill about in large herds) are assigned a confidence level of <95 % and discarded. In terms of numbers of individuals that cannot be classified or that might have been overlooked because of impeded visibility, approximate limits of accuracy for particular confidence ratings are not uniform for counts of different ungulates because of variation in their typical group size. Wider limits are accepted for larger groups, whereas it would be unlikely that undercounting bias involves more than one or two individuals for observations of ungulates that typically occur in small groups. Notwithstanding this element of subjectivity in the system of ranking counts according to confidence levels, sampling effort is constantly directed at obtaining counts of the highest confidence.

For ungulates where the total sample classified exceeds 100 individuals, the data on population composition are analysed according to sampling regions (Fig.1) or larger blocks demarcated by rivers. The proportions of breeding groups, bachelor groups, lone adult males and lone adult females are also determined, thereby providing an indication of social structure. Mean group sizes of all social units are calculated since they may be partly related to environmental conditions and population density.

Discussion

Bias in aerial censusing of wildlife populations has been the subject of many papers (e.g. Pennycuick & Western 1972; Caughley 1974b; Melton 1978a, 1978b; Norton-Griffiths 1978; Short & Bayliss 1985; Allen & Samuelson 1987; Pollock & Kendall 1987; Samuel, Garton, Schlegel & Carson 1987; Short & Hone 1988). Such counts are only justifiable if they are either reliable or at least repeatable (Brooks 1978). While some assessments of the accuracy of aerial counts have been made, for example in Zululand (Brooks *op. cit.*) and Australia (Short & Bayliss *op. cit.*; Short & Hone *op. cit.*), by calibration against more reliable ground counts, no correction factors for converting observed aerial counts to absolute population estimates have been determined for the Kruger National Park. However, it is accepted that the KNP aerial counts do not reflect the total populations (Joubert 1983), and although repeatability has not been critically evaluated, Viljoen (1989) considers that the data already collected do allow "feasible deductions" about population trends and the relative distribution of herbivores. These qualifications concerning the KNP aerial surveys nevertheless serve to justify the use of ground surveys to obtain supporting data on relative recruitment and survival rates among sex and age classes of ungulate populations that may substantiate conclusions about population trends. Certainly there is a need to establish the relationship between population growth and age proportions for particular populations, whence it may be found that age proportions can serve as a useful index of recruitment and of changes in population growth (Sinclair & Grimsdell 1978).

In ungulates with restricted birth seasons, population condition can be indexed by first year mortality, the estimation of which requires data on the reproductive output and mortality rate of adult females as well as the number of young aged about 12 months as a proportion of the adult female population (Grimsdell 1978). The ground population surveys in KNP slightly precede the bulk of births in most seasonally breeding ungulates, thus providing an indication of juvenile survival over the first 8-11 months from birth until shortly before the next pulse of recruitment. During the August-October sampling period, visibility is usually still good because of the predominantly dry conditions and many herbivores are still concentrated around water and riparian habitats. However, consideration should also be given to monitoring the production of juveniles shortly after the bulk of births of strictly seasonal breeders. In bontebok *Damaliscus dorcas dorcas*, Novellie (1986) demonstrated a significant positive correlation between rainfall over the 12 months preceding the mating season and the proportion of lambs surviving at the end of the lambing season; moreover there was evidence of a negative relationship between population density and the lambing percentage.

Among ungulates with less restricted seasonal birth periodicity, juvenile survival in kudu is closely correlated with rainfall during the period of pregnancy and lactation (Owen-Smith 1984) whereas in mountain zebra, Penzhorn (1985) found no correlation between the size of the foal crop and annual rainfall. As an important determinant of population dynamics, juvenile survival thus needs to be related to such factors as rainfall, population densities, predation and reproductive patterns. On a more basic level, reproductive performance in terms of ovulation and conception rates, might be related to regional soil differences via their influence on nutritional conditions.

Compared to the data span of over two decades for the bontebok lambing percentages used by Novellie (1986) to investigate rainfall effects, sex and age data from the ground surveys of KNP ungulates extend over a period of only seven years (1983-1989). Some data from a pilot study to test field techniques are also available for December 1982 and January 1983, but only for the southern half of KNP (Mason 1983). The KNP falls within the summer rainfall region where wet and dry cycles following one another at approximately 10-year intervals have been shown to exist (Tyson & Dyer 1975; Gertenbach 1980). While monitoring of the structural dynamics of ungulate populations over a full wet and dry cycle may be desirable to adequately elucidate relationships with rainfall, preliminary results suggest that low rainfall is associated with a low ratio of juveniles to mature females in certain drought-sensitive species. For example, rainfall during the 1982/83 season was 51 % below average and the severe drought conditions before and during the 1982 farrowing season (November, December) of warthogs in the KNP resulted in widespread deaths due to malnutrition and a sharp population decline. Poor juvenile survival was evident at the time of the August-October 1983 ground survey, when juveniles comprised only 12,3 % of a population sample of 187 warthogs classified and occurred in the ratio of 35,9 juveniles per 100 adult females. This was corroborated by the extreme scarcity of warthogs in the yearling age class (4,3 % of a sample of 348 warthogs) during August-October 1984, when juveniles were much better represented (52,3 % and 195,7 juveniles per 100 adult females). Subsequently, with improved rainfall during the 1983/84 and 1984/85 wet seasons, the population recovered.

Ungulate species in KNP often occur in habitats that vary widely in floristic composition, although habitat features selected or tolerated are inadequately documented. Many of the 35 landscapes classified by Gertenbach (1983) and even the 18 sampling regions adapted from them (Fig. 1) are too small or unimportant as habitats to be meaningful in comparisons of ungulate population structure and dynamics, especially for rarer species where sample sizes are seldom adequate, and for species that are comparatively mobile such as zebra, wildebeest and giraffe. Therefore population samples of the latter three species have been analysed according to only four sampling regions demarcated by the Sabie, Olifants and Shingwedzi rivers, while the 18 smaller sampling regions have been retained for the remaining species which have more restricted home ranges or distributions in the park. Further modification of this system may be necessary depending on the characteristics of each species and relative sampling success. A comparison of population traits in relation to the major west-east division of the KNP between predominantly granitic and basaltic soils may also be pertinent.

While certain of the rivers that cross the KNP may demarcate relatively discrete sub-populations of some ungulates, none are absolute barriers to game movements, especially in the dry season. Compared to the Sabie and Olifants rivers, the Shingwedzi River is even less of an impediment but conveniently sub-divides the long north-south axis of the northern half of the park, which may be useful for investigating spatial and temporal variations in ungulate population structure.

Experience of habits and characteristics of each ungulate species is obviously advantageous in sampling population structure, although sample sizes are inevitably small for the rarer species. Impala present special problems because they frequently occur in large breeding herds which, *vis-a-vis* bachelor herds, are more difficult and sometimes impossible to count and classify with reasonable accuracy, especially in thick cover. Moreover, such large herds require an inordinate amount of sampling time to avoid their under-representation in the population sample through an accumulation of incomplete and inaccurate counts. In view of the abundance and wide distribution of impala in KNP, sampling of their population composition subsequent to 1983 was delegated to at least two observers, thereby facilitating simultaneous counting of more than one sex and age class and gaining time to concentrate on other species.

The system of assigning confidence ratings to each count and classification provides a continual incentive to obtain quality samples and facilitates assessment of bias in the total population samples. Classification counts rated at the < 95 % confidence level have generally constituted a satisfactorily small percentage of total observations. Moreover, where cumulative sex and age composition is very similar for counts with confidence levels of 95-99 % or 99-100 %, such counts can be combined to provide maximum sample sizes for analysis. Confidence assessments are less satisfactory in thick cover, such as along the banks of the Levubu and Limpopo rivers, and the proportion of counts considered inaccurate is inevitably higher despite follow-up efforts on foot. Furthermore, with large milling aggregations of zebra, the system breaks down because the total numbers present and the proportion classified are difficult or impossible to assess accurately. However, as many family and stallion groups as can be distinguished are classified and counted on a more or less random basis, following or circuiting around and through the concentration by vehicle until a favourable spread of groups occurs. This is only practicable on a fairly limited scale and is very timeconsuming. Cryptic species including giraffe regularly require closer approach to accurately discern numbers present, especially when group members are strung out feeding along watercourses. Extensive manoeuvering and cross-country driving where terrain and vegetation allow, or stalking on foot, are crucial to the accuracy of the surveys.

Nevertheless large groups of any species are more difficult to count and classify than small groups so that at least slight under-representation of large groups is probably unavoidable, especially when animals spook and run. Sampling duplication arising from movements between adjacent sampling regions probably occurs on a minor scale with common, wide-ranging species where group size and composition are variable. However, this would not constitute a bias because of the random emphasis in sampling.

A scarcity of information on the contribution of yearling females to reproductive output of certain ungulates, and the variability thereof, may make juvenile survival rates based on ratio counts difficult to interpret. Under favourable conditions a high proportion of yearling females might rapidly attain a critical threshold of bodily size and development associated with sexual maturity, and subsequently contribute significantly to the calf crop and population trend. Unfortunately, at the time of the ground surveys it is impracticable to distinguish yearling and adult females of several species.

Since mature females comprise the basic nucleus of breeding groups, data analysis for all the more common ungulates will also consider the mean number of adult or adult plus yearling females associating together, in case this may reflect environmental circumstances and so provide an additional index of population trends. Patterns in mean size of breeding groups would otherwise be confounded by the inclusion of variable components of juveniles, yearling and adult males, and yearling females (if distinguishable).

The ground surveys of ungulate population structure have already provided valuable insights into population fluctuations and processes over the past seven years. Preliminary results have been the subject of unpublished reports but more comprehensive evaluation of patterns *vis-a-vis* the project objectives is still pending for each ungulate species. Finally, the data already accumulated on sex ratios, social units and typical group size and composition for the largely undisturbed ungulate populations of the KNP may provide useful guidelines for stocking or introducing viable breeding nuclei and balanced social elements of these ungulates elsewhere.

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