## 6.1.2 TOWARDS THE INTERPRETATION OF AERIAL SAMPLE CENSUS DATA FOR RHINOS

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### INTRODUCTION

Census of rhinos both from the air and the ground is notoriously difficult. They occur at relatively low densities, usually singly or in small numbers. Black rhinos (Diceros bicornis) in particular tend to be of retiring habits, associated with bush cover and to spend a large part of the day inactive or in shade and rarely contrast with background colour. All this leads to problems of visibility and wide confidence limits in census results (Goddard, 1967 & 1969, Norton Griffiths, 1978). Accuracy can be improved with method, but it is not always practical to carry out counts designed specifically for rhinos, and information often has to be used from more general counts.

As part of the IUCN/NYZS/WWF African rhino survey it was necessary to gather broad base-line data throughout Africa, on apporximate numbers, distribution and trends for conservation and management purposes. This prompted an examination of census methods in relation to rhinos, with the objectives of :-

a) assessing the validity of figures, and
b) improving interpretaton of existing data

The method most widely used in eastern and much of the rest of Africa, for collecting multi-purpose information from large areas is aerial systematic sampling (Norton-Griffiths 1978). It also gives the most variable and possibly inaccurate results for rhinos. The first approach was therefore to concentrate on this method. Tests of the aerial systematic sampling method over known populations have been made. Preliminary results are presented and compared with existing information as a basis for discussion and future refinement. The relative accuracy of a variety of methods is briefly reviewed as background.

### CENSUS METHODS FOR RHINOS

The degree of census accuracy and the method employed vary with objectives, resources, and size and type of area.

The most accurate way to find out the number of rhinos in an area is an in-depth study to recognise individuals and home ranges, (For example, Goddard 1969, Hitchins 1968, Owen Smith 1973)

A more rapid indication of population size and distribution can be obtained by counts. Methods include :-

| | | |
|---|---|---|
| Ground counts | total | direct sightings<br>indirect methods e.g. spoor, middens etc. |
| | sample | direct sightings, e.g. in blocks, tracks or transects |

| | | |
|---|---|---|
| Aerial counts | total | helicopter<br>fixed wing aircraft |
| | sample | helicopter sample blocks fixed wing - systematic transects<br>random "<br>blocks<br>stratifications of the above |

Aerial methods only are considered here.

AERIAL COUNTS FOR RHINOS

Some comparison of different aerial methods applied to black rhinos has been made, for example in Hluhluwe Game Reserve by Hitchins (pers. comm.), in Meru National Park, by Kenya Rangeland Ecological Monitoring Unit (KREMU) (Stelfox 1980) on a ranch in Laikipia (Elliot, Brown, pers. comm, Hillman), and in Selous Game Reserve (Borner & Mbano, pers. comm.)

In general these indicate that high intensity helipcopter counts are the most accurate for rhinos. These are followed for accuracy by high intensity total or sample fixed wing counts, low intensity sample fixed wing, then low intensity total fixed wing counts.

For example, in comparing census results with known black rhino populations the following results were obtained :-

| AREA | COUNT TYPE | AIRCRAFT | % ACCURACY | RANGE | n | SOURCE |
|---|---|---|---|---|---|---|
| Hluhluwe | Total | Helicopter | 41% | 9.8.70% | 12 | Hitchins |
| | Total | Fixed Wing | 12% | 4.9.22% | 18 | Hitchins |
| | Total | Helicopter | 82% | | 1 | Elliot |
| Laikipia | Total | Fixed Wing | 23% | | 1 | Hillman |
| | Sample High | Fixed Wing | 87% | 79-97% | 5 of 2 | Hillman |
| | Sample Low | Fixed Wing | 39% | 0-88% | 9 of 2 | Hillman |

The Hluhluwe area is larger and more heavily vegetated than the Laikipia ranch, hence the overall difference in accuracy. The sample count figures were based on different analyses of two different counts.

It has often been felt before that total counts were generally more accurate than sample counts (e.g. Stelfox 1980, Elliot pers comm.) and in some areas, such as Hluhluwe, sample counts are inapplicable because of terrain. Total counts can also be varied more to give greater accuracy if enough is known about the habitat and the distribution of the population. However, for the same amount of flying time the high intensity fixed wing sample counts in Laikipia gave considerably greater accurancy than a fixed wing total count.

The fairly obvious basic principle that is demonstrated by these results is that the more accurate the method, the more expensive it is of both money and time. These are not always available and it is rare that rhinos are the primary census target. The most cost-effective way to get maximum information from a very large area is by aerial sample counting. The standard method most widely applied in eastern Africa and a number of other areas is that of systematic aerial sampling (Norton Griffiths 1978). Hence a large amount of information exists which was gathered in a method not designed to be accurate for rhinos but which can give some indication of numbers.

Correction factors have been employed specifically for rhinos. Factors that Goddard (1969) used, for example, in a series of counts in Tsavo were based on test total counts on known populations on Ngorongoro. He corrected from 2 to 7 times under different circumstances. But what does one do when faced with a (hypothetical) figure of 2,000 rhinos for Selous G.R. for example? Does this mean there are 2,000 rhinos there, or 4,000 or 14,000? The answers could make quite a difference to national and even worldwide estimates of rhino populations.

My questions therefore were -

a) How accurate for rhinos was the available information? and,

b) How could it be corrected to make it more accurate?

SYSTEMATIC AERIAL SAMPLE COUNTS FOR RHINOS

In this preliminary exercise I have compared results from aerial systematic sample counts over known or relatively known populations, and included both existing work of others and tests specifically carried out by myself.

These were as follows :

| AREA | METHODS | SOURCE |
|---|---|---|
| Amboseli N.P. ecosystem | Series of 6-8% samples, bi-monthly over 85,000 $km^2$ | Western D. 1980 (in press) |
| Meru N.P. | Six 5.6-31% sample tests over 1,500 & 2,600 $km^2$ | Stelfox J.C. 1980 for KREMU |
| Nsefu N.P. (Luangwa) | 16% test sample over 80 $km^2$ analysed at diff. intensities | Douglas-Hamilton et al, 1979 |
| Ranch in Laikipia | Two 42% test samples over 52$km^2$ test samples over 52 $km^2$ analysed at diff. intensities | Hillman (this paper) |

Habitat types in relation to visibility in these areas are :

| | |
|---|---|
| Amboseli | Relatively open plains and *Acacia* savannah, with localised swamp vegetation and *Acacia* and *Phoenix* woodland. |
| Meru | Mixed open grassland and thicket savannah woodland and thicket and riverine woodland. |

| | |
|---|---|
| Nsefu | Some riverine deciduous woodland, open grass and Capparis plains and mixed mopane and Terminalia woodland with clearings. |
| Laikipia ranch | Grass plains, mixed thicket and grassland, riverine woodland. |

## Methods used for test counts in Nsefu & Laikipia

i) Nsefu

This was carried out at the time of a 3% sample count of the whole valley by the IUCN Elephant Survey (Douglas-Hamilton et al 1979)

The rhino population of Nsefu was reasonably known from the ground by some individual recognition and frequent use of the area (Carr pers. comm.) and was estimated at approximately 60 black rhinos. The standard method employed throughout the high intensity count was the same as during the main census i.e., 2 rear seat observers (animal counts), 1 front seat observer (habitat parameters), strip width of c. 150 m each side, height of 300 ft., parallel transects flown n/s, aircraft a Cessna 185, timing of mid to late p.m.

Counting was done at 16% intensity and analysed at 16%, at 8% and at 4% intensities taking a variety of combinations of transects, using Jolly's Method 2 (Norton Griffiths 1978) in an HP 97 calculator.

ii) Laikipia

Two sample counts (Hillman and Hamilton P.) and a total count (Hillman and Malpas) of the fenced area of the ranch were carried out.

The rhino population was well known from repeated high intensity counts, ground recognition and knowledge of introductions (Brown, Elliot, pers comm.) It was known to be 34 black rhino and 11 white (Ceratotherium simum simum).

Sample count methods were as outlined in Norton Griffiths (1978) but with only one rear seat observer (Hamilton). Strip width was 150m, height was 305 ft, parallel transects were flown 500m apart across the riverine catena, aircraft was a Piper PA12 and timing was late pm (A) and early am (B).

Sampling was done at 42% intensity and analysed at 42%, 21%, 11% and 3% intensities taking a variety of combinations of transects, using Jolly's method 2 in a Radio Shack TRS-80 desk computer. As a comparison, zebra (Equus burchelli), and buffalo (Synceros caffer), were analysed at the same series of intensities.

Percentage accuracy was taken as 100% less the percentage difference between the known population and the estimated population.

The counts were carried out in the dry season. A further series was planned at other seasons, but due to aircraft problems were not carried out. Considerably more work is needed and the results presented here are therefore preliminary.

RESULTS OF TEST COUNTS

Overall results at maximum sampling intensities are summarised in Tables 1 and 2.

More detailed results are presented elsewhere for Nsefu in Douglas-Hamilton et al (1979) and for Laikipia ranch in Hillman (1981, unpublished typescript).

The percentage accuracy of the population estimates from different intensities of sampling of known populations are compared in Fig 1 for black rhinos and in Fig. 2 for zebra and wildebeest. The figures for white rhinos were discarded since the population was too small and distribution too clumped for meaningful results. At sampling intensities greater than 15%, accuracy was better than 80% and ranges in accuracy varied no more than 10% either side of the mean for different counts. However, below that, accuracy drops off steeply and variation increases. A drop in accurancy is to be expected since it is inherent in the method and for buffalo the picture is found to be very similar with a steep decline, though with zebra the curve is shallower and the loss of accurancy less. Helicopter and fixed total counts of the Laikipia population are plotted on Fig. 1 for comparison. The helicopter count is of the same order of magnitude of accurancy as the high intensity sample count, but the fixed wing total count gives less accurate results for the same flying time as the high intensity sample counts.

Fig. 3 examines the degree of variation in the method when used on rhinos by considering the standard errors of rhino population estimates from a wide variety of sample counts using the same method in different areas. The standard errors as percentages of population estimates, vary at the lower and more commonly used sampling intensities from higher than 100% in one case, to as low as 20%. For a species considered to be extremely difficult to census by this method the latter is by no means an unreasonable result. It is however based on a large population size and a large area.

In determining correction factors, the magnitude of each estimate relative to the known population also needs consideration since this may vary both above and below the known. Figure 4 plots the mean and range of the estimates as percentages of the known. Except for Nsefu the mean of the estimates are all below the known. In the case of Nsefu it is suspected that the 'known' population estimate may have been less than the number actually there, since a larger proportion of sightings in the woodland were made than had been expected from the ground knowledge. In two cases with black rhinos the population estimates were over twice that of the known population.

DISCUSSION

i) Accuracy

At high intensities aerial sample counts in the cases examined gave very reasonable population estimates for black rhinos. For a given amount of resources and flying time a systematic sample count was found to be more cost effective than an attempted total count. It is, however, realised that the height and strip width controls necessary for sample counting are not always feasible in certain terrains. Both types of census were carried out in a standard form as if the area was unknown, to simulate the more usual kind of situation. It is also recognised that in a small enough area, if the habitat and habits of the population are well enough known and if searching is limited to optimum times of the day, accuracy of total counting may be improved.

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The region of 15% (12-20%) sample counts appeared to be the drop off point beyond which loss of accuracy & degree of variation were too high for accurate interpretation of a single count of a small population or very small area. Even greater variation at all intensities was found by KREMU (Stelfox, 1980) but this may have been exacerbated by the fact that the rhinos were at low density, particularly harrassed and that numbers declined between two census periods. These are not uncommon factors. However, the degree of accuracy and variation did not single out rhinos as particularly different from other species for which this is an acceptable method. The similarity of results for buffalo is probably due to their clumped distribution, which in a small count increases the variation enormously, and the above proviso could equally be applied to any of a number of species. Considerably more test cases under different conditions are obviously required and ideally should be done on larger populations and areas.

However, there are no large, sufficiently well-known populations in suitable areas, and other types of tests are also being carried out to assess methods (Borner and Mbano pers. comm.)

In a situation where the area censused is large and the total rhino population is also relatively large and well distributed, results such as those of Douglas-Hamilton in Selous in 1976 may be obtained where the average confidence limits were only 20% of the population and the repeatability of the two estimates reinforced the credibility of the results. These have also been backed up a further results of censuses in Selous by Borner and Mbano (pers. comm.). However, the most commonly encountered situation these days is of small populations. Most information comes from counts in the region of 3-5% and therefore extreme caution has obviously to be applied in considering information from any one count of a small population. The work by Western indicated that while variation between individual counts may be high, combination of a series of counts may bring the figures to accurately interpretable levels and correction factors may be applied. Very large areas or large populations may yield reasonably interpretable information from single counts, but it is not known which way each of the above factors may influence the accuracy.

In interpreting the data from any one area habitat factors influencing visibility can be considered. Sample counts of large areas are generally carried out from early morning through to late morning and again in the latter part of the afternoon. Much of the counting time may not therefore be optimum sighting time for rhinos. The test count in Nsefu was designed to simulate this, those in Laikipia were at more optimum times, although the morning count timed as a trade-off between visibility conditions and rhino activity patterns may have been slightly late and certainly yielded lower results than the evening count. Little can be drawn from so low a sample however. If the raw data from counts is available, better interpretation may be possible by stratifying data for time of day.

ii) Correction factors

Correction factors that have been applied to rhino census figures elsewhere included those of Goddard (1969) which varied from 2x to 7x, but were based on, and applied to, somewhat different methods. Western (1982) combined a series of estimates over seven years of censuses and compared these with the populations known to have been present at the time. He obtained a mean estimate of 57% of the known populations and therefore corrected by 1.8x. Kremu corrected their rhino population estimates for the rangelands of Kenya by a factor of 2x on the basis of test counts in Meru. This provided a figure in close agreement with the figure of less than 1,500 for the rhino population of Kenya which was derived by the Kenya Rhino Action Group by combining information from detailed censuses where available. and estimates from Wardens, Researchers and other knowledgeable individuals for each area.

The results obtained here indicate that correction factors in the region of 1.5-2x are not unreasonable and at times may even be conservative. However there is so much variation at low numbers that they should not be applied to single estimates from small populations, but may be feasible for large areas/populations and combined estimates. They also indicate that we do not have enough information at present to draw any definite conclusions about the magnitude of correction factors and that each area must also be considered separately. Refinements to correction factors may be made by detailed examinations of original data. Statistically larger samples and more work under different conditions are needed to reach more than the preliminary conclusions which are presented here for discussion and a basis for further investigation.

CONCLUSIONS

1. High intensity systematic aerial sample counts may give a reasonably acceptable degree of accuracy for rhinos and may be more cost effective under certain circumstances than total counts.

2. A rapid drop in accuracy and substantial increase in variation was found to occur below 12-20% sampling intensity, but rhinos were not the only species for which this occurred.

3. Little reliance can be placed on single estimates from low intensity samples, unless in combination with other background information, but combined results or those from large areas or large populations may provide reasonable information especially if other factors specific to each area are considered.

4. Correction factors can improve the accuracy of the estimates but we do not have sufficient information to derive factors for wide application. These should be considered separately for each area and refinements may be possible from detailed data. Very large correction factors are not found to be necessary for broad based information, but factors in the region of 1.5-2x are not unreasonable.

5. More work is still needed under different conditions.

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| SPECIES |  | COUNT | POP. EST. ± S.E. | KNOWN POP. |
|---|---|---|---|---|
| Laikipia ranch |  |  |  |  |
| Black rhino | A | 33 | 10 | 34 |
| Black rhino | B | 27 | 11 | 34 |
| White rhino | A | 23 | 10 | 11 |
| White rhino | B | 3 | 3 | 11 |
| Zebra | A | 269 | 83 | c 320 |
| Zebra | B | 177 | 46 | " |
| Buffalo | A | 339 | 122 | c 460 |
| Buffalo | B | 544 | 182 | " |
| Nsefu |  |  |  |  |
| Black rhino |  | 60 | 29 | 60+ |

Table 1 Results of morning (A) and afternoon (B) sample counts at 42% intensity on Laikipia ranch and a single 16% sample at Nsefu.

| SPECIES | SAMPLE | n | POP EST. | % ACCURACY (Combined) | % of KNOWN (Combined) |
|---|---|---|---|---|---|
| <u>Laikipia ranch</u> | | | | | |
| Black rhinos | 42% | 2 | 30(27-33) | 88(79-97) | 88(79-97) |
| | 21% | 3 | 33(27-39) | 87(79-97) | 97(79-115) |
| | 11% | 5 | 35(0-67) | 44(0-88) | 22(0-168) |
| | 3% | 5 | 58(29-68) | 30(0-85) | 58(0-226) |
| White rhinos | 42% | 2 | 13(3-23) | 18(9-27) | 118(27-209) |
| | 21% | 2 | 10(0-19) | 14(0-27) | 86(0-172) |
| | 15% | 2 | 14(0-27) | 0 | 122(0-245) |
| | 11% | 4 | 11(0-26) | 7(0-27) | 102(0-236) |
| | 3% | 8 | 16(0-68) | 0 | 229(0-618) |
| Zebra | 42% | 2 | 223(177-269) | 69(53-84) | |
| | 21% | 1 | 158 | 49 | |
| | 11% | 4 | 269(114-538) | 50(32-74) | |
| | 3% | 3 | 339(84-728) | 39(26-64) | |
| Buffalo | 42% | 2 | 442(339-544) | 75(74-75) | |
| | 21% | 3 | 420(175-574) | 67(38-89) | |
| | 11% | 4 | 418(132-1018) | 40(21-78) | |
| | 3% | 4 | 239(0-931) | 2(0-5) | |
| <u>Nsefu</u> | | | | | |
| Black rhinos | 16% | 1 | 60 | 91 | |
| | 8% | 2 | 63(12-112) | 14(5-22) | |
| <u>Amboseli</u> | | | | | |
| Black rhinos | 6-8% | ±30 | Actual figures | 57 Western 1981 | |
| <u>Meru</u> | | | | | |
| Black rhinos | 18% | 1 | 16 | 28 | |
| | 17.8/6% | 1 | 34 | 60 | |
| | 9% | 1 | 44 | 77% | |
| | 31% | 1 | 0 | 0 | |
| | 5.6% | 1 | 0 | 0 | |
| | 5% | 1 | 0 | 0 | |

<u>Table 2</u> Percentage accuracy of estimates of known populations at differing sampling intensities. Ranges are shown in parenthesis.

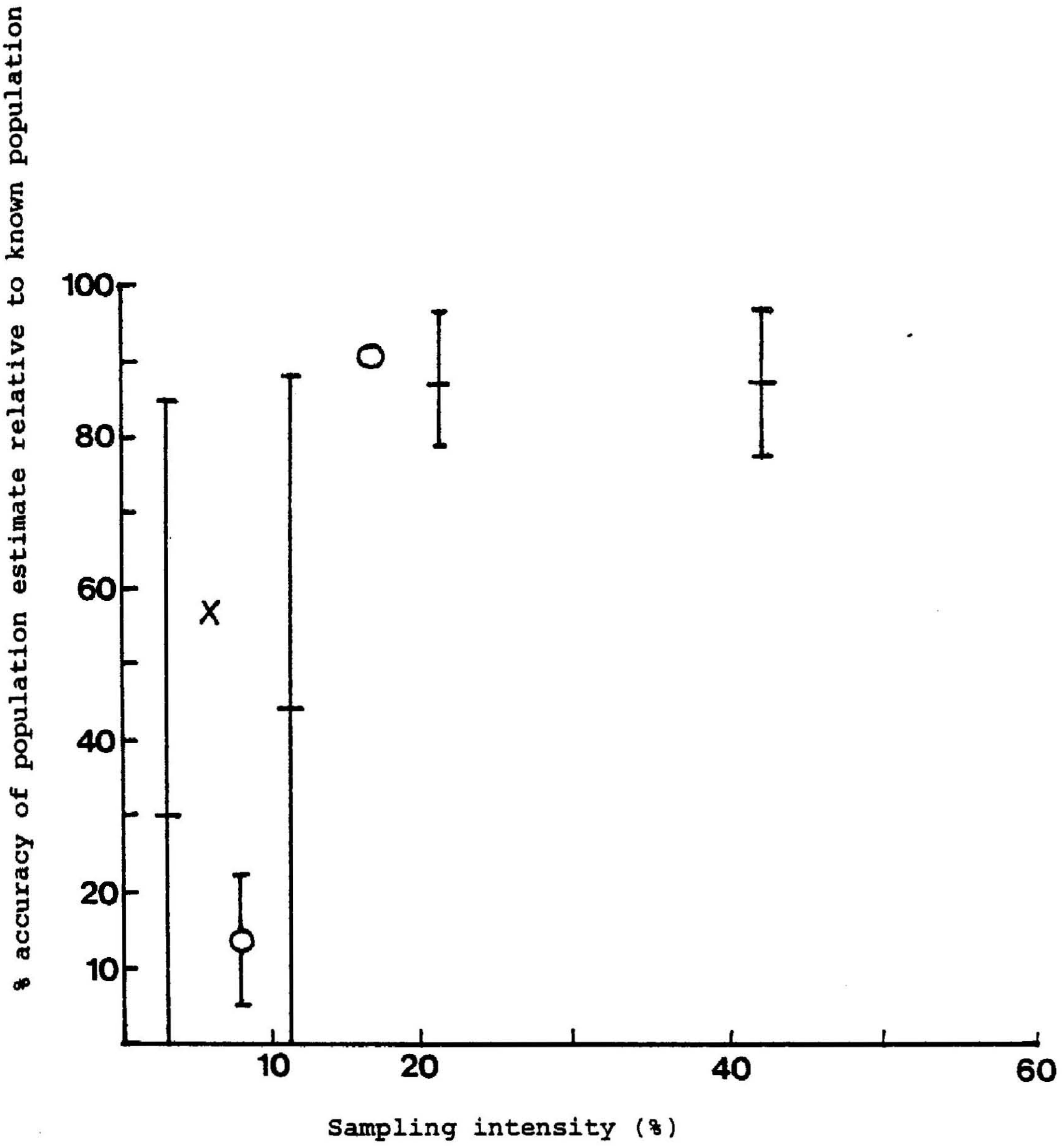


Fig.1 PERCENTAGE ACCURACY OF AERIAL SAMPLE COUNTS OF BLACK RHINO AT VARYING INTENSITIES

(- = Ranch in Laikipia, O = Nsefu National Park, X = Amboseli ecosystem)

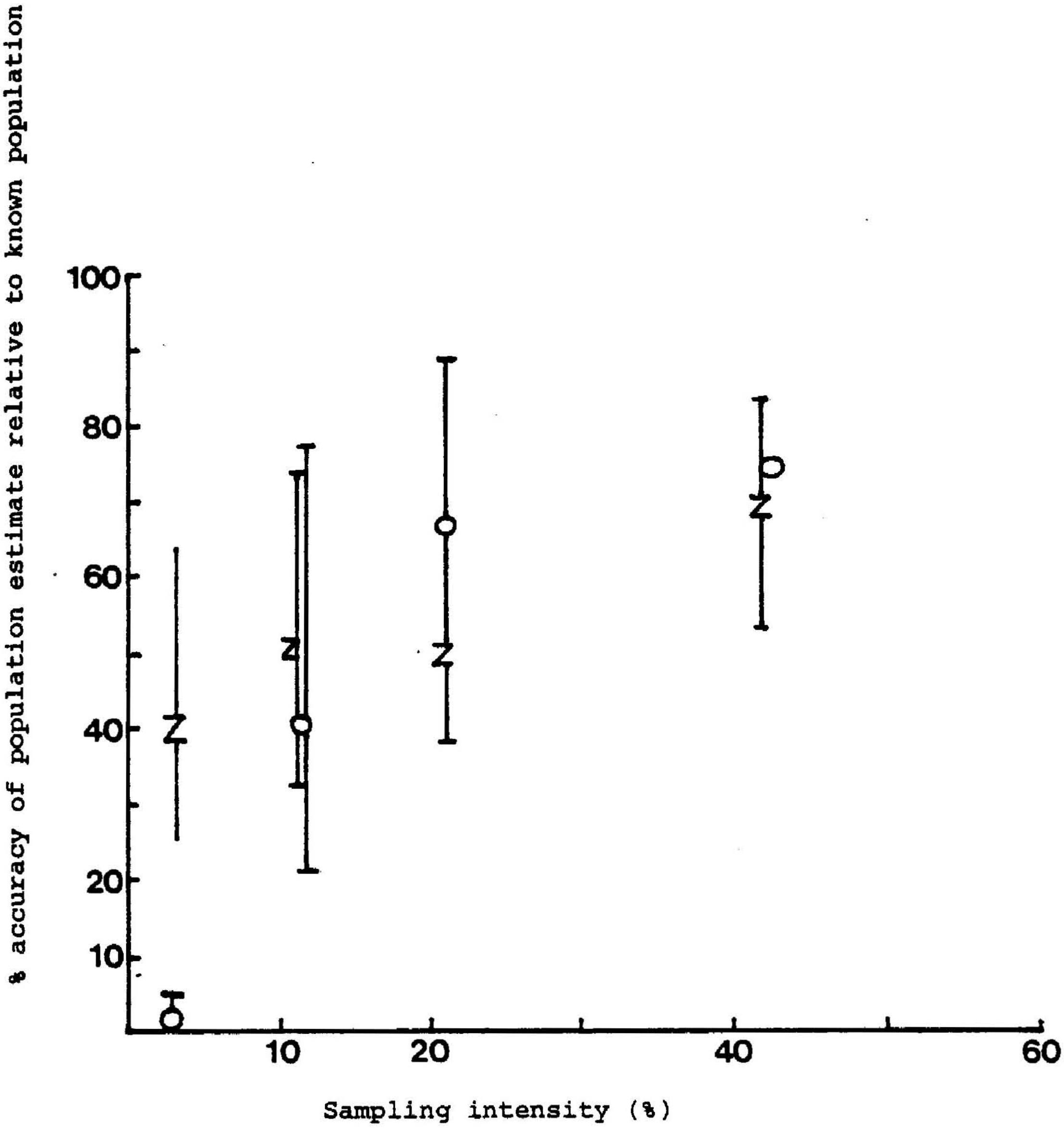


Fig. 2 PERCENTAGE ACCURACY OF AERIAL SAMPLE COUNTS OF ZEBRA AND BUFFALO AT VARYING INTENSITIES ( Z = Zebra, O = Buffalo)

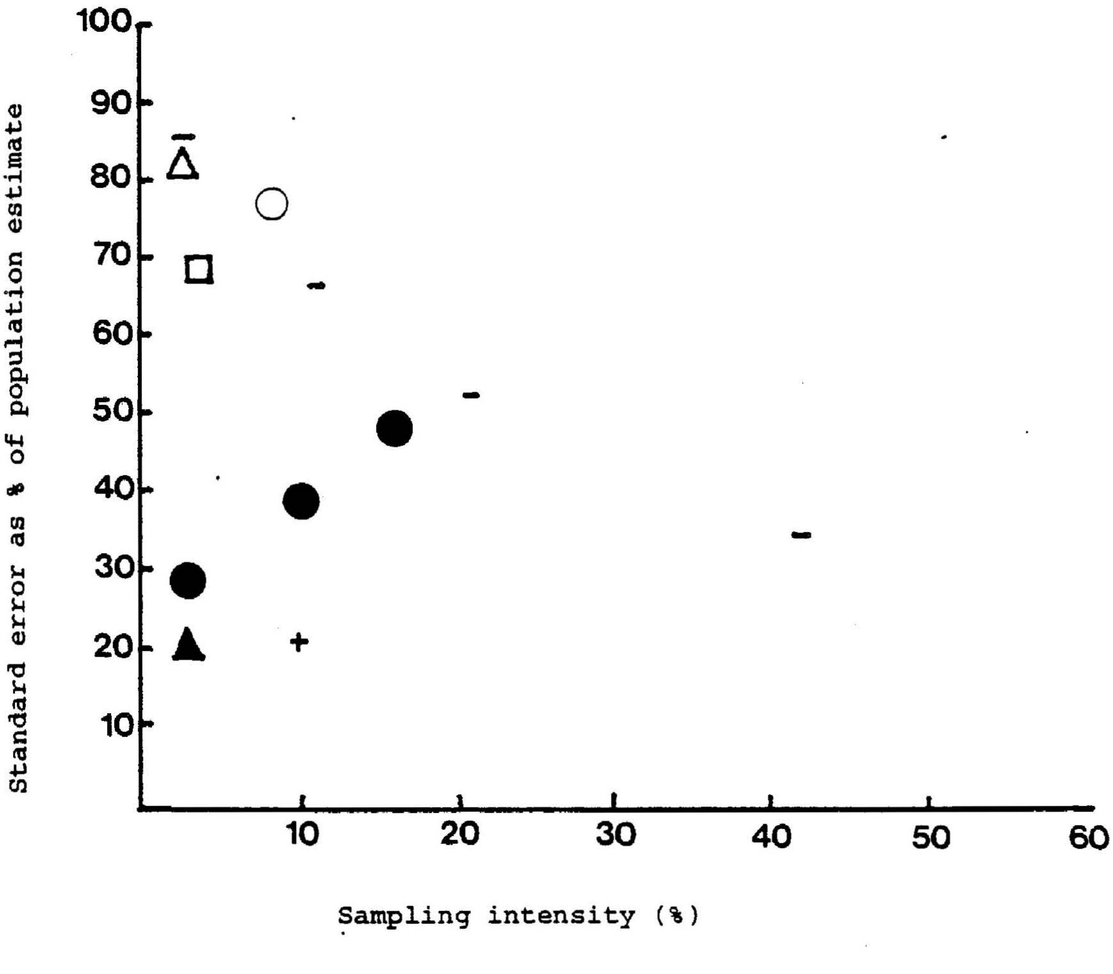


Fig.3 PROPORTIONATE STANDARD ERRORS IN POPULATION ESTIMATES OF BLACK RHINOS FROM A VARIETY OF AERIAL SAMPLE COUNTS AT DIFFERENT INTENSITIES

- = Ranch in Laikipia (1980, Hillman, this paper)
O = Meru N.P. (1976. Douglas-Hamilton et al)
Tsavo ecosystem (1978, Douglas-Hamilton et al)
Kenya rangelands (1979/80, KREMU)
O = Nsefu N.P. (1979, Douglas-Hamilton et al)
S = Serengeti N.P. (1987, Douglas-Hamilton)
Selous G.R. (1976, Douglas-Hamilton)
+ = Rufuji basin (1980, Ecosytems)

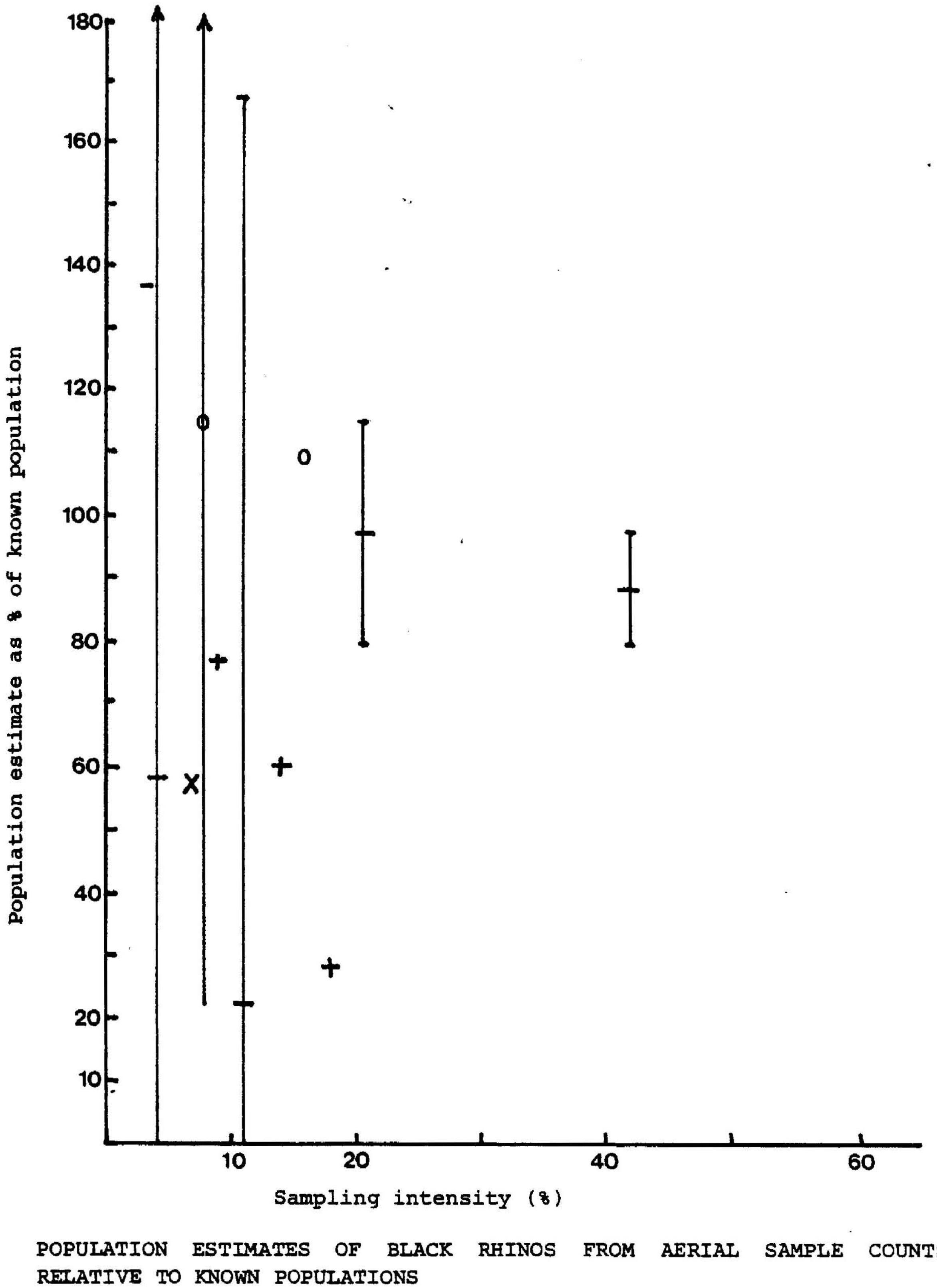


Fig.4 POPULATION ESTIMATES OF BLACK RHINOS FROM AERIAL SAMPLE COUNTS RELATIVE TO KNOWN POPULATIONS

- = Ranch in Laikipia
O = Nsefu N.P.
X = Amboseli ecosystem
+ = Meru N.P.