SEX-IDENTIFICATION TECHNIQUE AND SEX-RATIO IN TIGER : DOUBTS AND CLARIFICATIONS

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Introduction

A review of literature on parameters for sex-identification from pugmarks of a Tiger is given in Sagar and Singh (1991). A simple technique is also described there to distinguish the sex of Tiger from an understanding of the difference between the length and breadth of a "biological quadrangle" into which the squarish-pug of male or rectangular-pug of female would fit-in.

Paranjpe *et al.* (1993) have provided an "intuitive method" to identify the sex of Tiger from pugmarks. They have also applied a "Bhattacharya technique" for the same purpose. As a prelude to these Paranjpe *et al.* (1993) are critical of certain points which they presumed are weaknesses of the sex-identification technique described in Sagar and Singh (1991).

In this paper it is intended to : (1) clarify the doubts regarding the technique described in Sagar and Singh (1991), (2) examine the applicability of the intuitive method to data from Similipal, (3) discuss the intelligibility of the Bhattacharya technique to common field-foresters, and (4) discuss the sex ratio in Tiger in the light of the comments and data contained in Paranjpe *et al.* (1993).

Clarification of doubts

1. (a) *Wildlife techniques on known animals* : It is a well known fact that protracted captivity tends to change the behaviour and the finer aspects of morphometrics in animals. The changes can be sudden or gradual depending on captive-prone-accidents and experiences, or the housing and rearing conditions, respectively. Some very common examples are the deflaying of toes in soft-pawed animals and deformity in the hooves of ungulates due to floor conditions. Captive animals also tend to be heavy, the effect of which on pawed animals need to be carefully quantified. Therefore, testing an observation from the wild on captive animals cannot always be an 'acid test'.

Nevertheless, it will be worthwhile to test the departure of the technique developed in the wild from animals of known sex and without any perceivable deformity under zoo conditions.

(b) *Application of 1.5 cm-rule elsewhere* : (i) The 1.5cm rule holds good for Tigers with pugmark length (PML) equal to or more than 11.0 cm, which is the size for adult Tigers. For younger Tigers the difference between PML and PMB (the breadth of the pug) will obviously be less, as will be evident

from the ready reckoner, regression equations and the figure on page 26 in Sagar and Singh (1991). Therefore, for younger animals it is recommended to use the ready reckoner (Table 1) or the regression equations with ± SEE reproduced below.

Male : PMB = 0.940 (PML) - 0.138 cm;
SEE ± 0.503 cm
Female : PMB = 0.724 (PML) + 1.467 cm;
SEE ± 0.589 cm

(ii) Regarding the utility of this rule to other Tiger populations there should be no doubt because the technique itself has emerged just to resolve the traditional controversy of whether to accept a pugmark-shape as squarish or rectangular, there being hardly any instance of a perfect squarish-dimension in the biological world of Tiger pugmarks. That is, in a 'biological square' the length and breadth may not be equal, yet into such a square the male pugmark fits. As per the technique under discussion the extent of permissible difference between the length and breadth measurements have been determined to qualify a biological square for male pugmarks.

(c) *Sex discrimination from breadth alone - not possible* : Paranjpe *et al.* (1993) have suggested that because of strong correlation between the length and breadth measurements (Sagar and Singh, 1991) length is virtually known and that sex-discrimination could be based just on breadth. This is not correct. Because of strong correlation, by using the regression equations we can certainly know the other dimension if one is known. But in such cases, from a single PML value we can have two separate values of PMB, one for the male, the other for the female. Conversely, for each PMB value we can obtain PML values for male and female separately by using the following regressions.

Male : PML = 0.839 (PMB) + 2.744 cm;
SEE = ± 0.474 cm
Female : PML = 0.874 (PMB) + 3.431 cm;
SEE = ± 0.647 cm

After obtaining male and female PML values for the same PMB value, we have to compare it with the actual field measurement. If the latter matches the male-PML the animal is a male, and if it matches the female-PML the animal is a female.

Therefore, we need both the PML and PMB values in order to determine whether the quadrangle described over a pugmark tracing conforms to a biological square or a rectangle which is the basis for sex discrimination. Breadth alone can not accomplish the job. Moreover, the measurements have to be of the hind pugmark and not the front pugmark. The front pugs are broader in order to support the heavier build of the body in the front and also provide a broad paw for attack on prey.

(d) *What is the expected sex-ratio* : By using the regressions which are the bases for the so-called 1.5 cm-rule and the ready reckoner, we have found the following proportions of male : female : cub for Similipal Tiger Reserve.

Year 1989 : 1: (2.55) : (1.05);
1990 : 1: (2.31) : (0.95);
1991 : 1: (2.04) : (0.91);
1992 : 1: (2.04) : (0.91).

The sex ratio is approximately 1 male : 2+ females. This is indeed substantially different from the 1 : 1 ratio pleaded by

Table 1

*Ready reckoner on hind pugmark lengths (PML) and corresponding breadths (PMB) to identify the sex of Tiger. All measurements are in cm.**

A			B		
Standard PML	PMB		Standard PMB	PML	
	Male	Female		Male	Female
9.0	8.3	8.0	8.0	9.5	10.4
9.2	8.5	8.1	8.2	9.6	10.6
9.5	8.6	8.3	8.5	9.9	10.9
9.7	9.0	8.5	8.7	10.0	11.0
10.0	9.3	8.7	9.0	10.3	11.3
10.2	9.5	8.9	9.2	10.5	11.5
10.5	9.7	9.1	9.5	10.7	11.7
10.7	9.9	9.2	9.7	10.9	11.9
11.0	10.2	9.4	10.0	11.1	12.2
11.2	10.4	9.6	10.2	11.3	12.3
11.5	10.7	9.8	10.5	11.6	12.6
1	10.9	9.9	10.7	11.7	12.8
12.0	11.1	10.2	11.0	12.0	13.0
12.2	11.3	10.3	11.2	12.1	13.2
12.5	11.6	10.5	11.5	12.4	13.5
12.7	11.8	10.7	11.7	12.6	13.7
13.0	12.1	10.9	12.0	12.8	14.0
13.2	12.3	11.0	12.2	13.0	14.1
13.5	12.6	11.2	12.5	13.2	14.4
13.7	12.7	11.4	12.7	13.4	14.5
14.0	13.0	11.6	13.0	13.7	14.8
14.2	13.2	11.7	13.2	13.8	15.0
14.5	13.5	12.0	13.5	14.1	15.2
14.7	13.7	12.1	13.7	14.2	15.4
15.0	14.0	12.3	14.0	14.5	15.7
15.2	14.2	12.5	14.2	14.7	15.9
15.5	14.4	12.7	14.5	14.9	-
15.7	14.6	12.8	14.7	15.1	-
16.0	14.9	13.1	15.0	15.3	-
16.2	15.1	13.2	15.2	15.5	-
16.5	15.4	13.4	15.5	15.7	-
16.7	15.6	13.6	15.7	16.0	-
17.0	15.8	13.8	16.0	16.2	-

* In order to use this table follow the following example. Suppose we have got a field measurement of hind pug PML x PMB = 13.1 x 11.0cm. If we want to take the PML as base then in column (1) 13.1 is between 13.0 and 13.2. The corresponding PMB for these two are 10.9 and 11.0 for females, and is close to our field data. Therefore, the animal is a female. Alternately, for the same field data we can use the PMB value 11.0cm and see that the observed PML value of 13.1cm is closer to 13.0cm PML table-value for female, but away from the table-value for male, i.e., 12.0cm. Therefore, the pugmark is that of a female.

Paranjpe *et al.* (1993) A more complete discussion on sex ratio follows in a separate section which should clarify the reason for the difference in observations. It has got nothing to do with the technique of 1.5 cm-rule, but may be due to the selection of census areas.

(e) *Indication of errors in the 1.5 cm-rule* : Firstly, by saying the technique as 1.5 cm-rule we are limiting the sex-discrimination to the adults only which have PML longer than 11.0 cm. In its full context the regressions with the standard errors of estimate indicate the level of errors.

(f) *Date for 1.5cm-rule* : As mentioned under methods (Sagar and Singh, 1991) the data were drawn from the 1989 - census to make initial inferences. Later, this hypothesis of 1.5cm difference for adults was tested over combined data from 1989 and 1990 census and the full text of regressions were deduced from n=42 for male and 101 for female. In subsequent years the deduced technique has been used directly.

2. *Application of the "intuitive method"* : From the "intuitive method" it is inferred that (Paranjpe *et al*, 1993) if the breadth of a tiger pugmark is equal to or more than 12.0 cm then it is that of a male. Other pugmarks are those of females.

Form the census figures for four consecutive years from 1989 through 1992 I have used 346 breadth measurements which have been recorded for males and females. The mean is 10.9 cm and standard deviation (s) is ± 1.2 cm. According to our records the data are for 111 males and 235 females. On applying the intuitive method of sex discrimination from breadth alone the proportions changed to (111-74+33) male : (235-33+74) female, or 70 male : 276 female, or 1 male : 3.9 female. In the above, because of the limitations set under intuitive method, 74 males were interpreted as females and 33 females as males. The sex ratio, therefore, changed from 1 : 1.2 to 1:3.9 male : female. This is different from the 1:1 ratio expected by Paranjpe *et al.* (1993). Besides, by applying the limits imposed under the intuitive method the ratio is bound to shift in favour of the females. Occurrence of this phenomenon is explained below.

In any natural population of tiger the number of young males may be equal to the number of young females but it is always greater than adult males. Therefore, by maintaining the 12.0 cm limit for the breadth of male pugmarks, we are putting all young males, all young females and all older females - who all have pug-widths less than 12.0 cm under one category, i.e. females. Therefore, the number of females is artificially increased.

Therefore, as discussed above, sex-discrimination cannot be done only from the breadth measurements, and the sex ratio is bound to distort under the present limitations given under the intuitive method. The latter distortion will, contrary to the belief of Paranjpe *et al.* (1993) further favour the female numbers.

The above problem arises because the intuitive method ignores young males and large females i.e. males with PMB less than 12.0 cm and females with PMB greater than 11.9 cm. Data from Similipal indicate that about 12% of total females have PML larger than 14.0 cm or PMB larger than 11.6 cm (Sagar and Singh, 1993).

Although I do not insist for the test of their intuitive technique on captive animals (see Section 1 a) or animals of known sex, if

is not clear how have Paranjpe *et al.* (1993) been able to observe sexual dimorphic characters of all the 75 wild tigers. Is sighting of tigers in their study area so easy ?

3. *Intelligibility of the modified-Bhattacharya technique to common biologists* : The Bhattacharya (1967) technique itself, as stated in Paranjpe *et al.* (1993) appears simple and intelligible to biologists in its original purpose of determining the age structure of fishes in a catch. I am at ease because, in the past, totally unaware of the Bhattacharya technique and with hardly any statistical background, I have, in a similar manner, determined the rates of growth in the wild for *Gavialis gengeticus* (Singh, 1978) and *Chamaeleo zeylanicus* (Singh, 1986). In these works I have, (a) by dot-plotting compared the snout-vent lengths on the date (month) of capture of a wild specimen with the measurement known for the month of hatching, (b) searched for stratified curves representing separate classes of growing year, and (c) allowed for probable growth ranges.

With the above background I must confess that the modified or extended version of the Bhattacharya technique is becoming difficult in portions to understand, hindering therefore, to appreciate the full merits of the applications in determining the sex of Tiger from pugmark widths. This is not withstanding the fact that the use of the breadth alone as the basis and the categorical denial that a male pug-width cannot be smaller than 12.0cm are difficult to accept.

From my own experience as a research biologist and as an instructor of wildlife techniques for foresters, I have realised that knowledge of basic statistical principles is essential for proper presentation of data, quantifying relationships and even testing their 'global' nature. However, this knowledge should at no time tend to burden a biologist or forester with too much of superscripts and underscripts to simpler alphabetic or numeric denotations to such an extent that the fieldman tends to forget the fundamental biological principles. If a technique is meant for application in the field it has to be intelligible to the user. Wildlife biologists will always look forward to a proper amalgamated languages that incorporates biological thoughts and statistical principles and is intelligible to common field biologists.

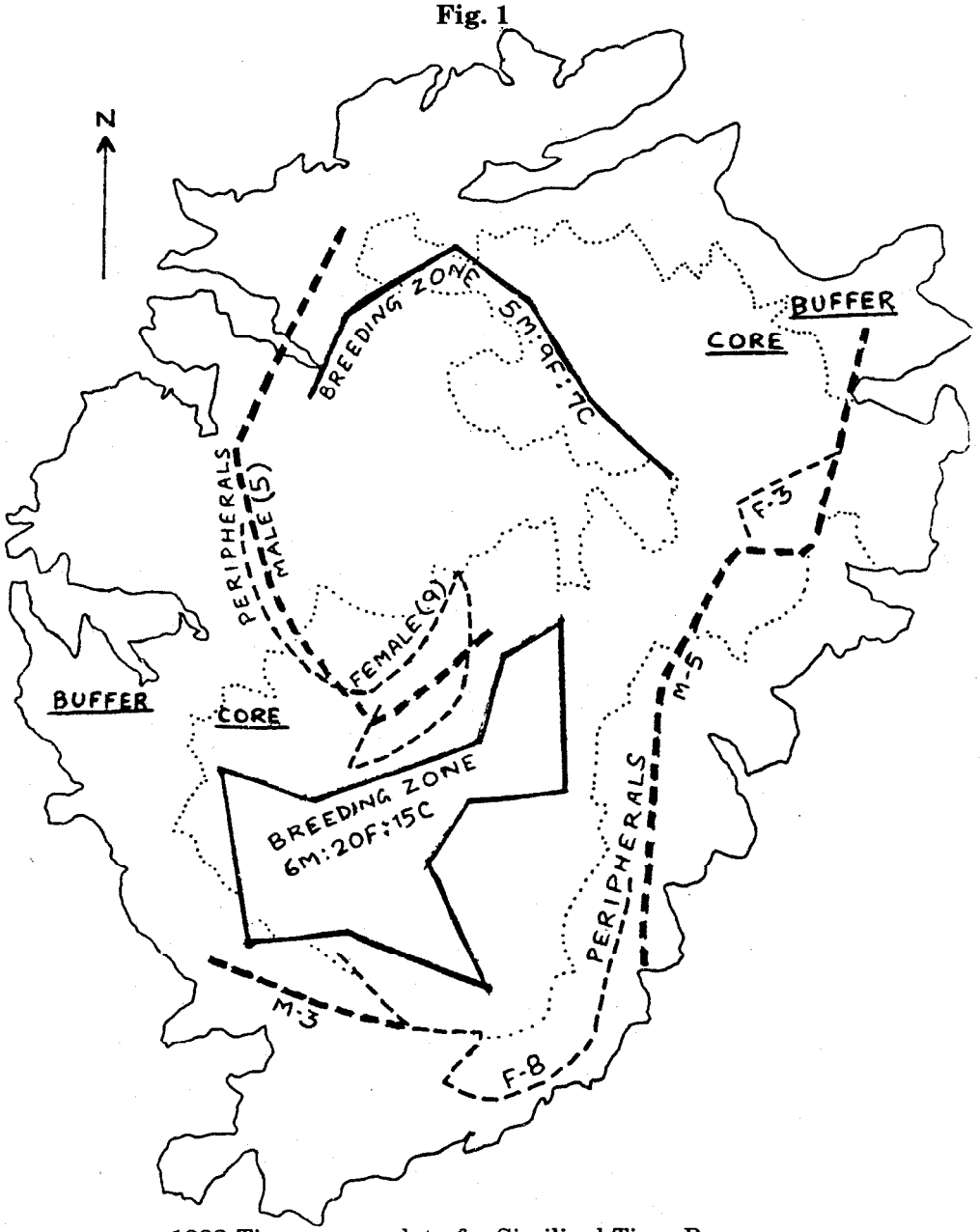
4. *Sex-ratio in Tiger* : In a species with litter size greater to one, the male : female ratio at birth is expected to be 1 : 1. In later stages this ratio will remain unchanged or tilt in favour of a particular sex, whichever way it is advantageous to the population that is responsible for new recruitments and species survival.

(a) *Equal Sex-ratio at birth* : Saharia (1979) has stated a sex ratio of 66 M : 80F or 1M : 1.22F at birth for Tigers born at the National Zoo, Delhi. It is further mentioned that 49% of the cubs born reach adulthood in captivity to produce a final sex ratio of 20M : 29F or 1M : 1.45F. The first part of this data is significant to highlight an approximately 1 : 1 sex ratio at birth.

Schallar (1969) has also suggested that the sex-ratio at birth is about equal. Sankhala (1978) suggested that the sex ratio at birth favours 10-20% for female Tigers which is covered under the data in Saharia (1979).

(b) *Ratio favouring adult females* : Kurup

Fig. 1



1992-Tiger census data for Similipal Tiger Reserve.

The map demonstrates one breeding zone in the south and one breeding zone in the north. The male : female : cub in the breeding zones is 11 : 29 : 22, outside which there are peripheral animals in the proportion 13 : 20 : nil. The sex ratios are 1: 2.6 and 1 : 1.5 in the breeding zone and the periphery, respectively. The proportion of male tigers increase to the periphery.

(1982) is of the opinion that the adult sex ratio is much in favour of females due to differential mortality rates adversely affecting the male population, and quotes Schallar (1969) who "found a ratio of four Tigress per Tiger at Kanha". Hicks (1910) estimated a ratio of three females to one male in these times. Assuming an equal opportunity of bait acceptance for male and female, baiting results have indicated 1M:4F by Sinha (1979). Data from Chitwan, Nepal shows that the population of sub adult male:female were 13.9% : 11.1% or 1.2M : 1.0F but if changed to 25%M : 50%F of 1M : 2F for the adults (McDougal, 1979). This observation indicates a shift in the sex ratio favouring adult female Tigers. Tamang (1979) describes 50-100 km^2 size for territories of male Tigers and 10-30 km^2 for females. Considering the adult sex ratio favouring females, Tamang's observation indicates 2-3 female territories within each male territory. The converse can also be deduced from territories to a sex ratio favouring females. Leyhausen *et al.* (1990) have concluded that the size of territory is large in males and small in females in order to contain as many females in breeding condition as possible in a male territory. Panwar (1979) has recorded 1M : 2-4F for breeding populations occupying the inner zones of a prime habitat in Kanha. As stated in Section 1(d) above the Tiger sex ratio for Similipal during 1989-1992 is 1M : 2+F, yet different in different zones (Fig.1).

(c) *Ratio favouring adult males* : Anwar (1979) has stated the sex ratio of Tiger in Bangladesh as 3M : 1F, but the reason for this distortion could not be explained. Sawarkar (1979) has recorded during the years 1972-1978 in Melghat 19 (±8) Males : 15 (±8) Females : 12 (±6) unidentified sex : 7(±6) Cubs. Considering the definitely known animals, the sex ratio is 19M : 15F or 1.2M : 1.0F. Because of large values of standard deviations for 19 males and 15 females it is obvious that detections of Tigers in the census areas were widely fluctuating in the early years of Project Tiger. The reason for this may have been the habitat condition, or the developing stage for the finer aspects of the census technique or some other local factors, or a combination of several factors. Nevertheless, the ratio of 1.2M : 1.0F is not much different from 34M : 41F (or 1 : 1.2) stated or 1 : 1 Expected by Paranjpe *et al.* (1993) for the same area. Panwar (1979) has stated 1-3M : 1F outside the breeding area and 5M : 2F in the most peripheral area of Kanha.

(d) *Sex ratio and natural selection* : In order to explain the observed sex ratios of Tiger in different areas by different authors we may recollect some known facts from Tiger's biology and general evolutionary considerations.

(i) Other than freaks in behaviour, the female Tiger is almost entirely responsible for upbringing of the cubs for 2-3 years from birth, after which time the cubs become 'fit' to be able to lead independent, solitary life, the normal characteristic of a Tiger. During this period the male has almost no role toward the female or the cub. Instead, he may have during this period sired the cubs of several other females.

(ii) To continue the race of a population where the male has virtually no reproductive role other than for successful mating, the ecological cost of maintaining such males would adversely affect the population as a whole if the male is not used by more than one female every season. Therefore, a single male should be used to participate with a number of females for reproduction during any single breeding season. This is also

observed from higher proportion of females in the inner or breeding zone in Kanha (Panwar, 1979) and Similipal (Fig. 1).

(iii) Compared to any female, since a male Tiger has more numbers of breeding participation within any particular period, the likelihood of "inbreeding depression" (Frankel and Soule, 1981) in the long run can be reduced from a population only if the male is kept out of breeding activity early in its life time. That tends to indicate that as and where opportunities exist younger males should replace the older males in any defined male territory. Studies to indicate that the older males are usually in the peripheries of prime forest habitat, i.e., away from the main breeding population (Panwar, 1979) (Fig. 1).

(iv) During 1990 census in Similipal we noticed the putrifying carcase of a male with 12.6 x 12.0 cm pugmark which could be traced back to 1989 census data from the same area. Expectedly, during the census we recorded another young male with 11.7 x 10.8 cm pug from the same area. This observation not only clarifies that young males tend to replace the older ones but also highlights the speed at which the replacement takes place, irrespective of the reason of death of the older animal.

(v) In a parallel note, an older mother may leave her territory to a tenacious daughter from an earlier litter (Sahu and Sharma, 1993).

(e) *Discussion on sex-ratio* : From the above and the earlier sections it is clear that, the sex ratio for tiger may be 1:1 at birth, but because of innate differential mortality in male cubs and the genetic and ecological cost considerations against adult males the ratio will favour females in the prime "breeding territories". Individuals of either sex, younger or older, who are out of the major breeding performance within the population, hold on to peripheral territories and therefore, the sum total sex ratio may be different, again.

It is obvious that even where the census beats and census routes are fixed or "standardised" for repetition year after year the objective has been to ascertain the minimum numbers of Tiger in a definite area and their 'trend' over the years. With this, certain areas may remain unscanned, and/or the areas covered under census may be governed by biases like "manpower-constraints" and "area-accessibility". While the approach is excellent to know the trend of numbers, sex ratio may be different depending on the extent of inclusion of "pre-breeding" or "post-breeding" Tigers.

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SUMMARY

The hind pugmarks of female Tiger fit into a rectangle while that of a male Tiger fit into a "biological square" whose length and width may not be equal. For adult females with pugmark longer than 11.0cm the length-width difference is more than 1.5cm. A ready reckoner has been provided to compare length-breadth dimensions and ascertain the sex of Tiger from hind pugmarks. The idea of using the breadth alone for sex-identification has been dismissed because of limitations. The sex ratio of tiger at birth is 1:1. It changes in favour of reproducing females because genetic-depression and ecological cost do not favour natural selection in maintaining males longer or in large numbers in a closed population. The census figures from different Tiger populations may present different sex ratios because of local factors and also the extent of inclusion of "pre-breading" or "post breading" Tigers which remain peripheral to the main breeding population. It is urged that wildlife techniques should ideally emerge from the wild because of distorted behaviour as well as morphometrics known to occur with animals under protracted captivity. It is further urged that application of statistical principles to biological thoughts should be in a language intelligible to field biologists.

बाघों में नर-मादा पहचानने कि विधि और लिंग अनुपातः संदेह और स्पष्टीकरण

एल०ए०के० सिंह

सारांश

बाघिन के पिछले पैरों के पद चिह्न आयत में ठीक बैठते हैं जबकि नर बाघ के चिह्न "जैवकीय वर्ग" में बनते हैं जिसकी लम्बाई और चौड़ाई बराबर ही हों यह जरूरी नहीं । प्रौढ़ बाघिनों के पद चिह्नों की लम्बाई 11.0 से०मी० से अधिक रहे तो लम्बाई-चौड़ाई का अन्तर 1.5 से०मी० से अधिक होता है । पिछले पैरों के चिह्नों की लम्बाई-चौड़ाई की तुलना करने और उनसे बाघ का लिंग ज्ञात करने के लिए एक तैयार गणक बनाया गया है । चौड़ाई मात्र से लिंग की पहचान करने वाला विचार उसकी सीमाओं को देखते हुए छोड़ दिया गया है । जन्म के समय बाघ का लिंग अनुपात 1:1 होता है । यह पुनरूद्धपादक मादाओं के पक्ष में परिवर्तित होता है क्योंकि आनुवंशिक मंदता और पारिस्थिकीय लागत नर को अधिक समय तक या अधिक संख्या में बनाए रखने के प्राकृतिक वरण वर्तमान बन्द संख्या के कारण अनुकूल नहीं है । विभिन्न बाघ जमाओं की गणना के आंकड़ो से भिन्न-भिन्न लिंग आंकड़े स्थानीय कारकों तथा "पूर्व प्रजनन" और "उत्तर प्रजनन" बाघों को सम्मिलित करने की सीमा के कारण मिल सकते हैं जो प्रधान प्रजनन केन्द्रों की परिधि पर ही रहते हैं । इस बात पर जोर दिया जाता है कि वन्य प्राणी प्रविधियों को जंगली दशाओं से ही प्राप्त करना आदर्श रहेगा । क्योंकि लम्बे समय तक बन्दी अवस्था में रखे जाने से उनका व्यवहार विस्थापित होना और देह व्यापार-मात्रिकी बदना ज्ञात ही है। इस बात पर जोर दिया जाता है कि जैविकीय विचारों के साथ सांख्यिकीय सिद्धान्तों को ऐसी भाषा में प्रयुक्त किया जाना चाहिए जो क्षेत्र में काम करते जीव-विज्ञानियों की समझ में आ सकें ।

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