Methods of abundance estimation

- Why count?
  - Concern about conservation
    - Lion / tiger
  - Assessment of resource base
    - Timber/ NTFP
  - Assessment of threat to humans
    - Blackbuck count- farmers
    - Elephant count-villagers
- Estimating population and its growth
- Estimate age – sex composition
- Compare population with carrying capacity

- Standard methods
  - Capture- recapture
  - Nearest neighbor
  - Line transect

- Non- standard methods
  - Waterhole census
  - Dung pile count
  - Bird count based on calls
  - Pugmarks method

Estimation of Tiger Population using Pugmarks

A.P.Gore

S.A.Paranjpe

- Pugmark - a single tiger paw print as a tracing / photograph taken from fixed height

- Pugmark Track Set –
  a series of paw prints from the same individual

Traditional method

- Locate pugmarks
- Trace them onto paper
- Record time and place
- Visual comparison
- Eliminate repeats
- What is left is the count

- Criticism
  - No validation
  - No oscillation in count
  - Very low count of cubs
  - Subjective
  - Identifiability - questionable

How to improve?

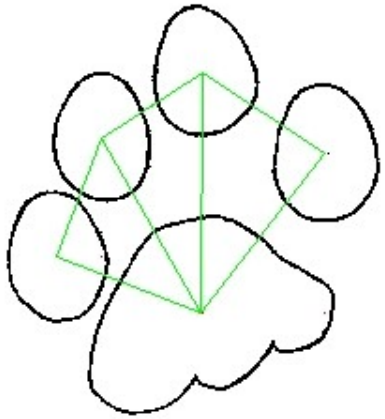
Quantify shape and size

- Pad
  - 1. Area
  - 2. Major axis
  - 3. Minor axis
- Pug
  - 4. Length
  - 5. Width
- Distance
  - 6. Toe 1 centre to Toe 2 centre
  - 7. Toe 2 centre to Toe 3 centre
  - 8. Toe 3 centre to Toe 4 centre
  - 9. Pad centre to Toe 1 centre
  - 10. Pad centre to Toe 2 centre
  - 11. Pad centre to Toe 3 centre
  - 12. Pad centre to Toe 4 centre

SigmaScan Pro - frd 1 data

File Edit View Image Macro Worksheet Measurements Mode Tools Window Help

Pick parameters - of distances between centres of pad & toes using the previously measured centre X/Y's



	A Area	B CMBin x	C CMBin y	D Maj Len	E Min Len	F Angle	G Perim
14							
15	78	121	244	82.637764	0	0	181.681
16							
17							
18	94	133	212	107.04205	0	0	232.735
19							
20							
21	129	160	195	128.00391	0	4.01E-015	259.656
22							
23							
24	86	193	216	107.61505	0	1.03E-015	227.504
25							
26							
27	64	95	197	67.416615	0	2.39E-015	148.710
28							
29							
30	55	134	148	64.350602	0	1.86E-015	139.823
31							
32							
33	66	193	152	77.935871	0	8.39E-017	168.450
34							

Data Statistics

A.P.Gore S.A.Paranjpe

For Help, press F1 NUM

Start SigmaScan P... 10:31

How to use measurements?

- **Establish objective criteria**

- **Factors possibly affecting a pugmark print**
  - **Substrate**
  - **Operator**
  - **Sex of animal**
  - **Locality**
  - **Inter-individual variation**
  - **Intra-individual variation**

Experiments

- **Substrate-** same animal different substrates : Coimbatore
  - 3 substrates- fine soil, wet mud, sand
  - Two animals only
  - ANOVA for each variable
  - Most variables show no effect

- **Operators-** same trail different operators: Melghat
  - Single trail
  - 6 operators
  - 3 prints each
  - ANOVA for each variable
  - Most varibles show no effect

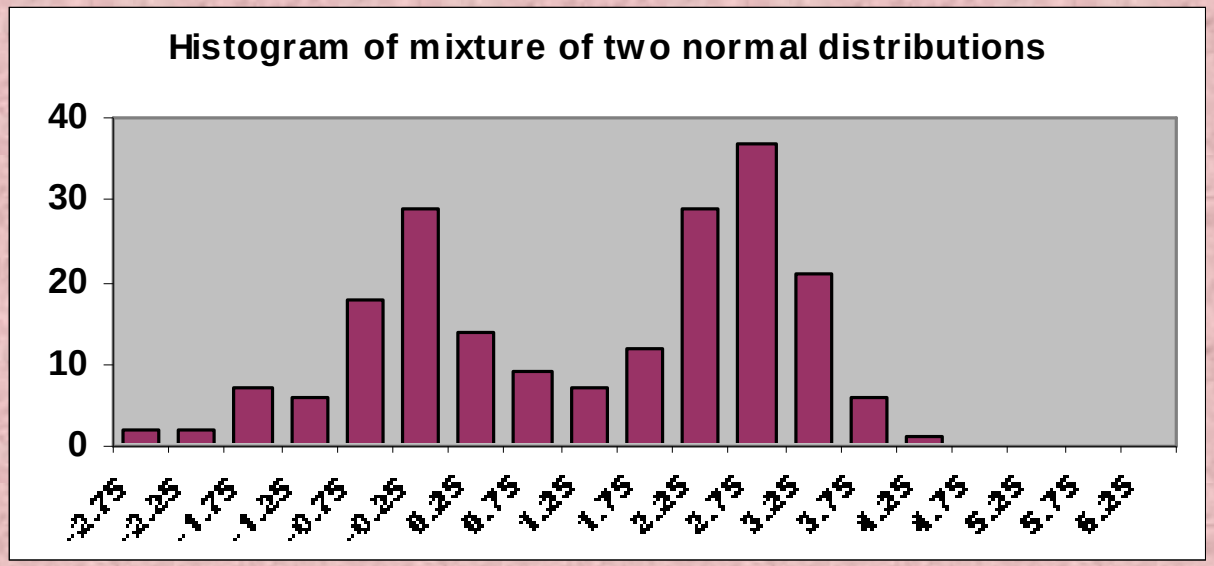
- Sex- Pune, Coimbatore
  - 5 animals- 2 males, 3 females
  - Several prints on each (total 100)
- Logistic regression : P= prob(a given animal is a female)
  - 3 measurements significant
    - Pad center- Toe 1 center distance(X_1)
    - Pad center- Toe 2 center distance (X_2)
    - Toe 1 center- Toe 4 center distance (X_3)
    - $\ln(p/(1-p)) = 56.06 - 2.76X_1 - 3.56X_2 - 1.1X_3$

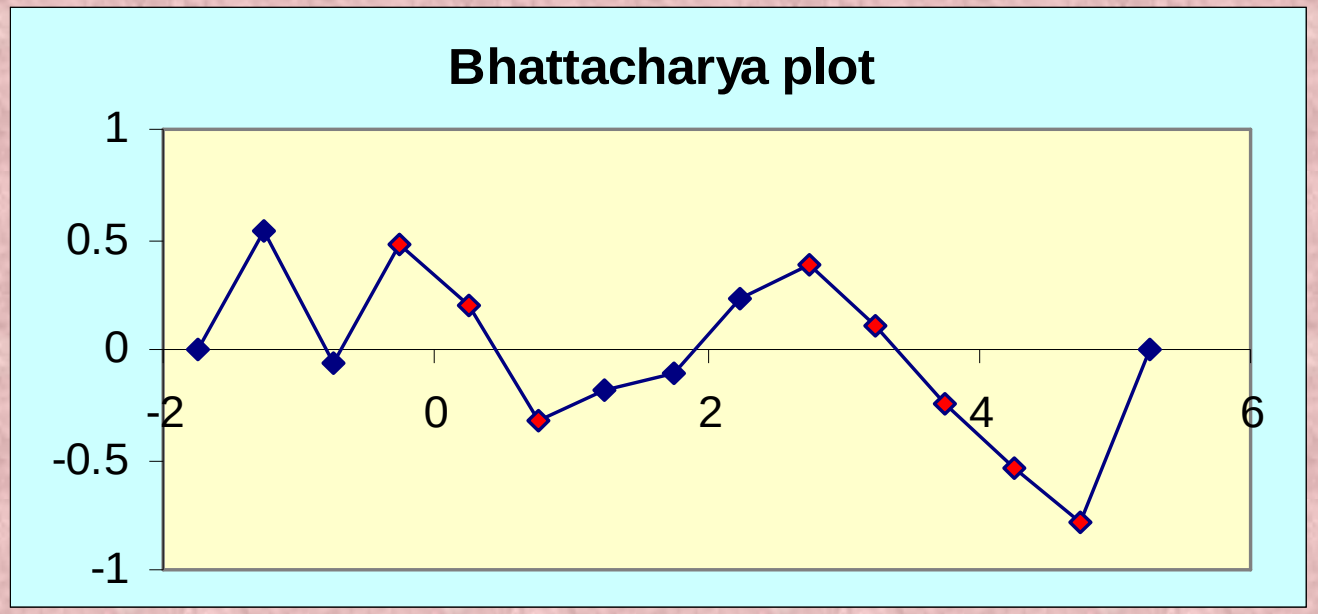
Sex identification using logistic regression

Decision	Known sex		Total
	M	F	
M($p<0.25$)	23	7	30
F($p>0.75$)	1	59	60
Ambiguous	6	1	7
Total	30	67	97

Sex discrimination using Bhattacharya method

- Mixture of normal distributions : to be separated
- For a single normal distribution
- $Y = \ln (f(x+\Delta)/ f(x)) = - [2 \Delta(x+ \Delta/2) - 2 \Delta \mu] / 2 \sigma^2$
- Slope of a line = $- \Delta/\sigma^2$ intercept = $\Delta \mu / \sigma^2$
- Mixture of distributions gives multiple falling lines
- Plot y Vs $x+ \Delta/2$. Gives sequence of straight lines with negative slope- each line one component


Histogram of mixture of two normal distributions
40
30
20
10
0
-2.75
-2.25
-1.75
-1.25
-0.75
-0.25
0.25
0.75
1.25
1.75
2.25
2.75
3.25
3.75
4.25
4.75
5.25
5.75
6.25


Bhattacharya plot
1
0.5
0
-0.5
-1
-2
0
2
4
6

- Bhattacharya method:
  - Male – squarish print
  - Female – rectangular
  - (Length – breadth) (of the covering frame)
  - Near 0 – male , > 0 female
  - Histogram of Breadth bimodal
  - Separate components by Bhattacharya method
  - Component with smaller mean breadth- females
    - With larger mean breadth – males

Results:

$\mu_1 = 10.26$, $\mu_2 = 12.75$

estimated proportion of females= 40/75 ≈ 0.53

Simplified rule adopted by foresters: (L-B) >2.5cm - female

- Locality - field data from project tiger: Melghat and Kanha
  - 90 prints each
  - Half data used for calibration
  - Discriminant analysis
  - Half data used for validation
  - Initially 10 variables used
  - Variables tested for redundancy
  - Two variables adequate
    - Toe1C- Toe2C distance
    - Toe1C- Toe3C distance

Classification of 90 tiger pugmark tracings from two populations

True Population	Classification Using 10 variables		Classification Using 2 variables	
	I	II	I	II
I	44	1	40	5
II	8	37	4	41

Does this help in estimating Tiger number?

- No.
- All analysis so far – macro level only
- Key question-
  - How many distinct tigers in a set of n pugmark tracings?
- An intuitive approach:
  - Compare known intra individual variation with observed inter pugmark variation.
  - How to assess intra individual variation?
  - Analyze multiple tracings from the same trail.

An intuitive algorithm

- $\underline{X}_1, \underline{X}_2, \ldots, \underline{X}_n$: n vectors (n pugmarks) of order p
- $\underline{X}_i$ Follows normal distribution
  - with mean vector $\underline{\mu}_i$
  - Var- cov matrix Σ (assumed to be known)
- Number of distinct tigers k (unknown)
- Step 1 - H_0 : k = 1 (only one tiger)
- $T_n = \text{sum}[(X_i - \text{Xbar})' \Sigma^{-1} (X_i - \text{Xbar})]$
- Reject H_0 if T large .Then try k=2

An intuitive algorithm(cont.)

- H_0 : k=2
- Omit one vector $\underline{X}_i$ which causes max reduction in T_n
- Check if $T_{n-1}(i) = \text{sum}[(X_i - \text{Xbar})' \Sigma^{-1} (X_i - \text{Xbar})]$ is small
- If yes, two tigers. Otherwise continue omitting.
- Process terminates when homogeneous subgroups identified
- Each subgroup – one tiger
- confidence statement?
- Not available in standard literature.
- Recent algorithm developed by Chatterjee and Samanta(1999)
  - Not tested

Foresters' current approach
Discriminant Analysis

- Establish the parameters fit for consideration to facilitate individual identity
- Multiple Group Discriminant Analysis done using SPSS Systat (unitwise)
- Canonical Scores Plot from data generated by tracings/ digital photographs in SPSS Sigma ScanPro
- Number of distinct pugmarks ascertained unitwise
- If all tracks from each foot are grouped into 2 groups (eg. A & B) : then these sets are from 2 different tigers
- Equal mixing (overlap) may indicate a single animal
- 75% to 80% correct grouping is acceptable

Camera trap method

- Major criticism about pugmark method
  - Identifiability
- Alternative suggested : Camera trap
- Tiger walks on footpaths
- Two cameras placed on two sides of road opposite to each other
- Activated as a laser beam is cut by any object
- Tiger picture from both sides

- Claim : stripes on the back of tiger carry signature
- Treat photograph as capturing and marking a tiger
- Use capture-recapture model to estimate number
  - Objections:
    - Identifiability
    - Cost effetiveness
    - Feasibility
    - Proper sampling of forest
- Controversy: which method is better
  - Camera trap or pugmark?

Comparison
Camera trap Vs Pugmark

•**Identity**	
Based on picture	based on pugmark
Ocular comparison	numerical comparison
•**Intra individual variability**	
Not measurable	measurable
•**Cost**	
Expensive	inexpensive
Equipment intensive	labor intensive
•**Suitability**	
Not suited for low density	low density –no limitation
Unsuitable for rugged terrain	unsuitable for swamps

Comparison
Camera trap Vs Pugmark(cont.)

Sampling	
Will see only a small fraction	virtually every individual seen. Can build a directory. Individual life history can b accumulated.
Territoriality is a problem	no problem
Confidence interval	
Can be given	cannot be given