# REPORT ON THE QUANTITATIVE ANALYSIS OF LEOPARD (*Panthera pardus*) TRACKS

Summary of the original paper

H. Rüther, T. Stuart* and C.T. Stuart

*To whom correspondence should be addressed: African Arabian Wildlife Research Centre, POBox 6, Loxton 6985, South Africa. E-mail: candm@stuartonnature.com.

## INTRODUCTION

A population survey of the leopard (*Panthera pardus*) was undertaken in the Cedarberg Wilderness, Western Cape province, South Africa, from October 1990 to May 1991. The objective was to find an inexpensive, accurate and readily repeatable method to monitor the numbers of leopard in the area over a longer period of time. In September 1991, we undertook a survey of the leopard population in the western Soutpansberg in Limpopo Province of South Africa.

Much work using tracks to identify individual cats has been undertaken in India on tigers (*Panthera tigris*), with less extensive work on other species. Seidensticker, Sunquist and McDougal (1985) used tracks to distinguish male from female leopards in the Sauraha area in Nepal. Fitzhugh and Gorenzel (1985), and Smallwood and Fitzhugh (1993), have investigated the use of tracks for mountain lion (*Felis concolor)* in California (USA).

The Cedarberg and Soutpansberg work have provided the data for a feasibility study on the use of tracks for the identification of individual leopards during censusing programmes.

## MATERIAL AND METHODS:

### Study areas:

The Cedarberg Wilderness Area, encompasses 651 $km^2$ (65 100 ha) between Citrusdal and Clanwilliam.

The Soutpansberg mountain range is located in the northern Limpopo Province, South Africa. This study was undertaken on Lesheba Wilderness, which lies in the west of the mountains.

### Control Animals:

A control series using tracks of captive leopards was analysed: two adult females in Tygerberg Zoo, and seven adult animals (two females, five males) at Chipangali Wildlife Orphanage.

### Recording and Data Acquisition Methods:

The following methods were employed for this study:
1 - manual tracing onto perspex,
2 - single-image photography with scale placed next to track and

3 - stereo photography with reference frame placed over track.

Manual Tracing:

A sheet of perspex 21 cm x 30 cm was placed over the track. With a felt-pen the outline of the track was traced, looking vertically onto the sheet at all points. Locality, date, time and estimate of when the track was made was recorded.

Eighteen tracks were traced in the Cedarberg Wilderness Area.

This was used to draw eight tracks of two captive females at Tygerberg Zoo. The left front track of both females was drawn on dry, damp and muddy ground, and each track was drawn by two of the authors (TS and CTS).

Photographic Recording:

A 35 mm SLR-camera loaded with 400 ASA monochrome film was used to photograph tracks with a scale placed next to the photo or a portable aluminium frame of cubic shape with known dimensions. Films were developed to produce maximum contrast in prints. Fifteen leopard tracks were recorded in Lesheba Wilderness.

In the control study 31 tracks of seven leopards at Chipangali were photographed. The control-series of track recordings of known animals was made to investigate:

1. difference in size and shape of same paw's imprint on different substrates

2. symmetry between right and left tracks of one individual

3. deviations in tracings of one paw executed by two observers.

4. significance of the differences in the paw measurements between individuals

5. feasibility of track measurements as a tool to differentiate individuals even if tracks found on different substrates.

## DATA ANALYSIS METHODS:

Data analysis was based on geometric interpretation of data digitised from traced paw imprints or single photos.

### Digitizing of traced imprints

The different recording methods made it necessary to employ two different techniques in preparation of data for digitising.

The track-tracings were duplicated from the perspex onto paper by means of a photocopier. Black-and-white negatives were mounted in slide frames and projected onto paper on which track-outlines were traced with pencil. In the photographic approach reference points had to be transferred together with the paw tracing to provide a scale.

The sheets with tracing were affixed to a Summagraphics digitizing board and digitized. In

the digitising process the five components of each track, one pad and four toes, are converted into separate x/y data arrays and recorded in ASCII file format.

**Evaluation of track-parameters from digitised outlines**

Once pug-mark outlines are available in digitised form track parameters can be evaluated using algorithms. The following parameters were derived from the digitised data:

- distances between toe centres and pad centre
- distances between the edges of each toe and the pad edge
- distances between successive toe centres
- distances between edges of successive toes
- distance between the centres of the extreme toes
- distances between the indentations at the back of the main pad and the centre of the main pad
- distance between the indentations at the back of the main pad
- 'length' and 'width' of each toe and of the main pad
- toe areas, pad area and area of the pentagon formed by the centre points of toes and pad
- angles between the four lines joining the pad centre and the toe centres.

Thirty-seven parameters were thus available.

## STATISTICAL ANALYSIS

For statistical analysis the 37 parameters (12 for cluster analysis) derived from digitised traces on perspex and single photographs were used. The following analysis methods were employed:

1 - correlation coefficients between data sets
2 - similarity transformation
3 - cluster analysis.

**1 - Correlation coefficients:**

Not only the correlation coefficients between the full set of 37 parameters were determined but the parameters were grouped into distances, areas and angles. The correlation coefficients failed to reveal a significant pattern and in some cases low correlations were obtained for tracks from the same individual while high correlations occurred between different animals.

**2 - Similarity transformation:**

In a different model the hypothesis was tested, that imprints from the same animal would retain a geometrically similar shape. To test this the five centre points of paw and toes of each imprint were transformed into the corresponding points of all other imprints by means of a least-squares similarity transformation. This model provides a measure of comparison in form of the variance. The variance is an indication of the average remaining discrepancy between the five points of two paws after the transformation (shift, rotation and scale) has been applied. One would expect small variances for similar imprints and vice versa. No significant pattern emerged and large variances were found to occur in the transformations of imprints of the same individual, while some tracks from different animals resulted in small variances.

**3 - Cluster analyses:**

The results of the cluster analysis can be represented in a dendrogram, the construction of which is based on the following principles: (Anderberg 1973, Späth 1980)

parameter groups allocated to subbranches of the same branch are more similar than those allocated to different branches

the more unique a cluster is, the later in the tree it is joined to other clusters.

Inspection of the dendrogram of the control group shows that the attempt to cluster the data was not satisfactory in spite of the ideal conditions in which paw imprints could be acquired in this environment. To draw any conclusion from the cluster analysis of paw imprints of the field group would therefore be mere speculation.

## DISCUSSION OF DATA ACQUISITION AND ANALYSIS METHODS

The present investigation was carried out to contribute to resolving a controversy which appears to exist in the work done on track identification of tigers in India. The tracks can be evaluated by subjectively studying and comparing their appearance and recording atypical characteristics. Together with recorded date and locality then can lead to the conclusion that a certain number of animals is most probably involved. This method has also been used by the authors in the current study and was found to be very useful.

**Data acquisition:**

Difficulties were encountered with optimum light conditions for the photography. Direct sunlight at a low angle - i.e. early morning and late afternoon sun - provided the clearest track outlines, but caused hard, confusing shadows to be cast by the reference-frame.

The necessity of having to trace the tracks from the negative onto paper before digitizing can introduce errors. In order to minimize these, only one person did the tracing under conditions as uniform as possible.

Two photographs of the same track were only taken to provide stereoscopic images for photogrammetry. Considerably more information than from single track photographs or tracings can be obtained from image pairs. The reader is referred to the "Manual of Non-Topographic Photogrammetry" (1989) for the details.

**Data analysis:**

It is unlikely that parameters beyond the selected ones would contribute further information, in fact, the 37 chosen parameters do already duplicate information. It is of course possible to introduce further analysis methods, but the authors believe, that the chosen techniques are sufficiently comprehensive to identify any significant variation in data sets. None of the investigated analysis techniques - correlation coefficients, similarity transformation or cluster analysis, was able to differentiate with an acceptable degree of probability between different individuals or to group together imprints of the same animal.

## CONCLUSION

1 - subjectively studying and comparing the appearance and recording atypical characteristics

of tracks can lead to the conclusion that a certain number of animals is most probably involved.

2 - hand-tracings of tracks, even if done by the same person, have serious short-comings and photographic methods are preferable.

3 - in spite of the careful optimisation of track recording and analysis methods - no evidence emerged in favour of the principle of track measurements as a tool to differentiate between individual leopards.

4 - Photogrammatic analysis of tracks may be more promising and still needs to be evaluated.

This text only provides a summary of the original paper. This and list of references is available from Chris and Tilde Stuart, E-mail: candm@stuartonnature.com.