# INFLUENCE OF TOURISTS' PRESENCE ON CHEETAH BEHAVIOR IN THE MASAI-MARA NATIONAL RESERVE

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## I.     Introduction

Cheetahs are considered "Vulnerable" by the IUCN and are listed in CITES Appendix I (Nowell & Jackson 1996). One of the largest natural populations lives in Kenya (Marker 2002). However, even on protected land the cheetah is increasingly affected by anthropogenic factors including poaching and disturbance by tourists (Burney 1980). The Masai-Mara National Reserve, home to the members of this family of felines, is one of the most-visited parks in the world, with the number of visitors growing each year. In recent years, the negative impact of tourism on rare species—the cheetah, in particular—has been widely discussed. Various studies have demonstrated that factors of tourism such as the number of cars, their location (on or off the road) and distance from animals, their speed and manner of approach, the noise of tourists, and more have a substantial influence on cheetah behavior (Burney 1980; Karanja 2003; Henry 1980; Caro 1994; Rönn 2002 and others). However, up to this point the question as to which of the factors listed is most disturbing has remained open. The purpose of this work was to assess the simultaneous effect on cheetah behavior of several aspects of the presence of tourists.

## II. Materials and Methods

**1. Study area.** The work was conducted at Masai-Mara National Reserve (1510 km$^2$) and adjacent area (2054 km$^2$) as a part of Cheetah Conservation Project launched by Kenya Wildlife Service (KWS, Kenya) with the support of Ecco Travel/Base Camp, IFAW, Narok and Trans Mara County Councils (Ngoru et.al. 2001; Ngoru & Mulama 2002).

**2. The time of data collection and equipment.** Observations were made within 160 days in a period between September 2001 and July 2002. Binoculars «Steiner» 7x50 and «Panda» 10x50, rangefinder were used.

**3. Methods of data collection.** We traveled by car in search of the animals, scanning the terrain in various directions from elevated areas using binoculars. Each cheetah was identified by individual patterns of the rings and spots on its tail and the spots on its front and hind legs. Visual observation of the cheetahs was conducted, and instantaneous time recording (Martin & Bateson 1993) method has been used with filling up forms at three minute intervals during two hours observation set. While observing a group, a focal individual has been chosen for recording behavior. Each sample point included the following information: 1) the behavior of the focal animal; 2) the behavior of tourists (noisy or not); 3) the total number of cars; 4) the distance between the cars and the cheetah in 4 categories (1 - less than 5 meters, 2 - between 6 and 15 meters, 3 - between 16 and 30 meters, 4 - more than 30 meters); 5) the number of cars off the road.

An ethogram was created based on preliminary observations of cheetah behavior, including various patterns of locomotion and stationary behavior. Hunting behavior was also recorded, including the stalking, chasing, catching, and killing of prey. The following precautions were taken in order to minimize the effect of the researchers' influence on observed cheetahs: silence was observed and a significant distance was maintained from moving animals (Burney 1980)— farther than the tourists.

**4. Data collected.** A total of 110.65 hours of cheetah observations were made, from which: 69.5 hours in absence of tourists and 41.15 in presence of tourists. In all, 2,213 sample point were recorded, from which 1,390 (62.8%) in absence of tourists, and 823 (37%) in their presence.

**5. Statistical data processing.** Microsoft Excel 2003 was used to prepare a database. The following statistical data processing methods were applied to assess the influence of tourists on cheetah behavior: 1) the least-squares method, which

was used to build a mathematical model of the influence and also to estimate this model's coefficients; 2) Microsoft Excel 2003's built-in method for creating a trendline, which was used to compare the influence of simple- and complex factors of the presence of tourists on cheetah behavior.

To calculate the effect of tourists on cheetah activity, a table was compiled of all the data from the observations (except behavior), and two additional binary variables were entered: 1) whether the animal was active or inactive; 2) whether the subject's behavior had changed or not.

An animal was considered active when standing, moving, taking some sort of any action, including auto grooming while sitting or lying down. An animal was considered inactive when lying down with its head on the ground or raised; or when sitting. Behavior was considered to be changed if there was a shift in the type of behavior pattern from one sample point to the next. The values for activity and behavior changes in the absence of tourists were considered the baseline.

The data we collected on cheetah activity and behavior changes is only expressed with the numbers 1 and 0, so it cannot be verified with the normal curve test. This can be explained by the fact that a normal curve is continuous, whereas the observation results are expressed discretely. In this case, therefore, standard statistical methods that assume the data has a normal curve can only be applied after a series of modifications. At the same time, the method of least-squares may be correctly applied to data with any probability distribution, because its results do not depend on the type of distribution (Gmourman 1997).

We used a linear model as the basis for computing the effect of the presence of tourists on cheetah behavior. This model was chosen under the hypothesis that environmental factors associated with the appearance of tourists close to cheetahs have a linear effect on behavior, e.g. the effect on cheetah behavior is directly proportional to the rate of external influence. Such a characterization is the simplest of all possible, and every investigation of unknown patterns should begin with it. Should it subsequently be clear that a linear model does not satisfactorily

describe the pattern being investigated, then a more appropriate model should be looked for. But if it does describe the pattern satisfactorily, then the linear model should be retained. A similar approach is widely employed in modern non-equilibrium thermodynamics to describe any effect on an object. While doing this, the mechanism of the effect is not being studied; rather it is critical to study only how a certain object responds to an external influence (Prigozhin, Kondepudi 2002).

In the first stage, only the number of cars was considered a factor for changing cheetah behavior. This relationship can be described with the following formula:

$$A = k_0 A^0 + k_1 Nm \qquad (1)$$

where,

A is the cheetah activity in the presence of tourists (per minute);
$A^o$ is the cheetah activity in the absence of tourists (per minute);
Nm is the number of cars with tourists;
$k_0$ is a coefficient that characterizes the contribution of "baseline" cheetah activity to their activity in the presence of tourists;
$k_1$ is a coefficient that characterizes the influence of tourists on cheetah activity.

The least-squares method was applied to the data to estimate the values of the coefficients. That is, the coefficients were found such that S—the sum of the squares of the differences between the observed values of cheetah activity and the same values estimated by using the formula 1 —was minimized (Bronstein, Semendyaev 1980).

$$S = \sum_{i=1}^{n} (k_0 A_i^0 + k_1 Nm_i - A_i)^2 \qquad (2)$$

where:

S is the sum of the squared deviations of the computed values from the observed values
i is the number of observation by an order
n is the total number of observations

After the standard transformation (Bronstein, Semendyaev 1980), we arrive at a system of two linear equations with two unknowns. After solving this system, we get computed values for the coefficients $k_1$ and $k_2$. However, direct use of the

data about cheetah activity and the number of cars with tourists is not productive, because these values have different scales. Consequently, no conclusion about the importance of a particular factor on changing cheetah activity could be drawn from the magnitude of the corresponding coefficient. This is related to the fact that the coefficient magnitude would depend not only on how important the factor is, but also on its absolute size (the greater the factor's absolute size, the smaller the corresponding coefficient must be). Consequently, it would not be possible to compare the computed coefficients with each other. To eliminate this condition and to bring all the data to a uniform scale, we first normalized each row of data. That is, each row of observation data was divided by the maximum value in that row, constraining the magnitudes to the interval from 0 to 1. These values were then multiplied by 100 to get percentages (%). Following normalization, the coefficients obtained by the least-squares method directly reflected a factor's level of influence on overall cheetah activity. Therefore, the coefficients could then be compared to ascertain the most significant factors.

In order to assess the significance of various factors of the presence of tourists, we applied the least-squares method in matrix form (Gmourman 1997), based on Gauss's theorem (Bronstein, Semendyaev 1980). This method is a standard statistical procedure and makes it possible to not only estimate the unknown coefficients, but also the reliability of these estimates ($\Delta_k$).

We estimated the contribution of the following factors to a change in cheetah behavior: the baseline activity of the animals, the total number of tourist cars, the number off road cars, the number of cars with noisy tourists, and the distance between the cars and the cheetahs. To do this, all observation data was separated into 15 minute intervals from 8:00 to 19:15. For each interval, the average value of each factor was estimated. That is, for each factor, all of the values were added together, and then the sum was divided by the total number of cars observed during the given 15 minutes.

Having made the assumption that distance effects cheetah activity contrariwise to the rest of the factors (the greater the distance, the smaller the effect), the effect of the inverse of the distance was studied, rather than directly studying the distance. To do this, the inverse was computed for the each distance. These values were then summed, and the resulting number was divided by the total number of cars that were recorded for each 15-minute interval. Thus, we receive the average inverse distance. According to our chosen linear model, we have this formula:

$$A = k_0 A^0 + k_{Nm} Nm + k_{Vd} Vd + k_{Sh} Sh + k_{L^{-1}} L^{-1} \quad (3)$$

where:
A is the cheetah activity in the presence of tourists (per minute);
$A^o$ is the baseline cheetah activity (per minute);
Nm is the number of cars with tourists (%);
Vd is the fraction of cars off the road (%);
Sh is the fraction of cars with noisy tourists (%);
$L^{-1}$ is the average inverse distance of the cars with tourists from a cheetah (%);
$k_0$ is a coefficient that characterizes the contribution of baseline cheetah activity to their activity in the presence of tourists;
$k_{Nm}$ is a coefficient of the effect the number of cars on cheetah activity (%);
$k_{Vd}$ is a coefficient of the effect of cars off road (%);
$k_{Sh}$ is a coefficient of the effect of tourists' noise (%);
$k_{L^{-1}}$ is a coefficient of the effect of distance between cars and cheetahs (%).

In the matrix method of least squares, a so-called structure matrix is first constructed whose rows represent sets of observable quantities of factors that influence the value that is being investigated (in our case, the cheetah activity). The total number of rows corresponds to the number of observations. Following (Gmourman 1997), we designate the structure matrix A.

$$\mathbf{A} = \begin{bmatrix} A_1^0 & Nm_1 & Vd_1 & Sh_1 & L_1^{-1} \\ A_2^0 & Nm_2 & Vd_2 & Sh_2 & L_2^{-1} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_n^0 & Nm_n & Vd_n & Sh_n & L_n^{-1} \end{bmatrix} \quad (4)$$

where:
A is the structure matrix;
n is the number of 15-minute intervals.

Then we create a column vector that contains the observed quantities Y.

$$\mathbf{Y} = \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_n \end{bmatrix} \quad (5)$$

The unknown coefficients are column vector k.

$$\mathbf{k} = \begin{bmatrix} k_0 \\ k_{Nm} \\ k_{Vd} \\ k_{Sh} \\ k_{L^{-1}} \end{bmatrix} \quad (6)$$

The unknown vector k is found by the Gauss-Markov theorem (Gmourman 1997) using the following matrix expression:

$$\mathbf{k} = (\mathbf{A^T A})^{-1} \mathbf{A^T Y} \quad (7)$$

where T signifies the transposition of a matrix (i.e. the matrix that results from swapping rows for columns), and -1 signifies the inverse of a matrix.

To estimate the accuracy of the results, we calculated the sum of the squared deviations of the observation results from the theoretical calculations:

$$R = \sum_{i=1}^{n} \left( A_{практ} - A_{теор.} \right)^2 \quad (8)$$

Then we find the variance ($\sigma^2$) of the collected data according to the formula:

$$\sigma^2 = \frac{R}{n-p} \quad (9)$$

where p is the number of parameters being calculated—5, in our case.

It is well-known that the estimated values for the variance obtained by the coefficient formula (7) are equal to the product of $\sigma^2$ and the diagonal elements of the matrix $(\mathbf{A^T} \mathbf{A})^{-1}$. The root mean-square deviations from the coefficients are found by taking the square root of the corresponding variance. Then the accuracy of the obtained values is estimated. This is done by using formula (10) to compute

a confidence interval which contains the unknown coefficients with 95% probability.

$$\Delta_k = \frac{\sigma_k}{\sqrt{n}} t_{0.05,\, n-p-1} \quad (10)$$

where:

$\sigma_k$ is the root mean-square deviation for coefficient k;

$\Delta k$ is the possible deviation of the true value of the coefficient k from its calculated value;

$t_{0.05,\, n-p-1}$ is the Student's coefficient for n-p-1 degrees of freedom with 0.05 probability (found with a table).

Thus, with 95% probability, the true value of the unknown coefficients will lie in the interval from $k - \Delta_k$ to $k + \Delta_k$.

The data about behavior changes was processed using this same methodical model. The same factors were estimated as when assessing the effect of tourists on activity. But rather than $A^o$, $iA^o$ was used, which characterizes the change in cheetah behavior in a 15-minute time slice without tourists present. Additionally, A was replaced by iA, which characterizes the change in cheetah behavior in the presence of tourists. The appropriate structure matrix iA and column vector iY were constructed in a fashion similar to (4) and (5). This data was used to calculate the column vector of coefficients ik, which contains coefficients that characterize the factors' level of influence on changes in cheetah behavior. The meaning of these coefficients is analogous to (3), but in this case $ik_o$ characterizes the contribution of baseline changes in behavior.

To better detail the effect of the presence of tourists on cheetah behavior, the joint effect of several factors on changes in animal behavior was also assessed. We applied linear regression (Gmurman 1997) to this end. We only applied this procedure to the variable of changes in behavior in the presence of tourists. To do this, we computed factor pairs by multiplying the following factors with each other: the number of cars and the inverse of the distance to the cheetahs (NmL), the number of cars and the fraction of noisy tourists (NmSh), the inverse of the distance to the cheetahs and the fraction of noisy tourists (LSh), the number of cars

and the fraction of cars off the road (NmVd), the inverse of the distance to the cheetahs and the fraction of cars off the road (LVd). Then an assessment was made of the relationship between changes in cheetah behavior and these complex factors, as well as its relationship simply to the number of cars and the inverse of the distance to the cheetahs. So-called trendlines were constructed, and mathematical equations that describe these lines were obtained. This calculation was performed using Excel's built-in tool. We get the values of $R^2$, which are the squares of the linear correlation, at the same time as the equations of lines. They let us judge how well the calculated trendlines describe the actual relationship between the numbers—the closer $R^2$ is to 1, the stronger the relationship between the two values.

## III. Results

### 3.1 Activity and changes in cheetah behavior

In the course of a day, the number of tourist cars varied, as did the behavior of the tourists in the presence of cheetahs. To use the data that characterizes the cheetah activity and changes in behavior in the presence of tourists, we employed the following model, based on formula (3). The results of this calculation are presented in Fig. 1 and 2.
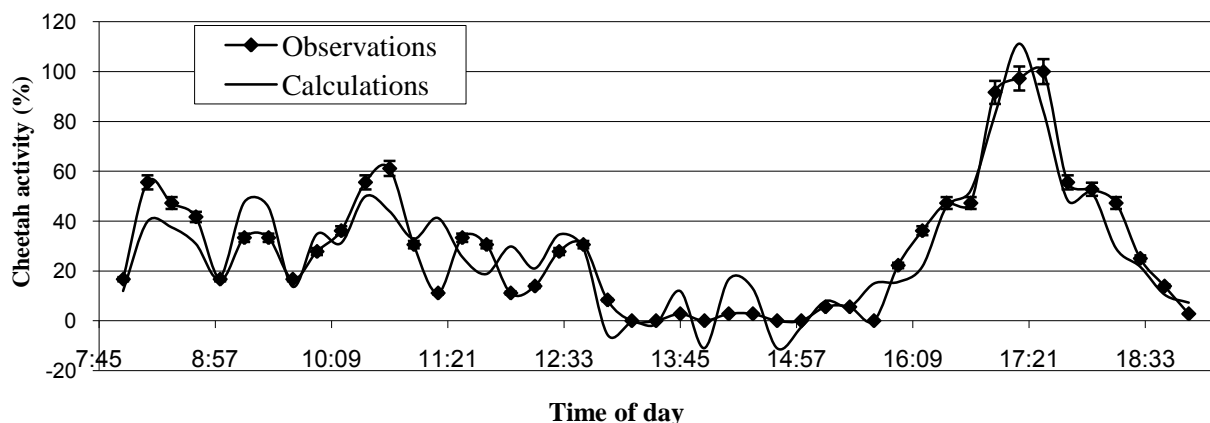


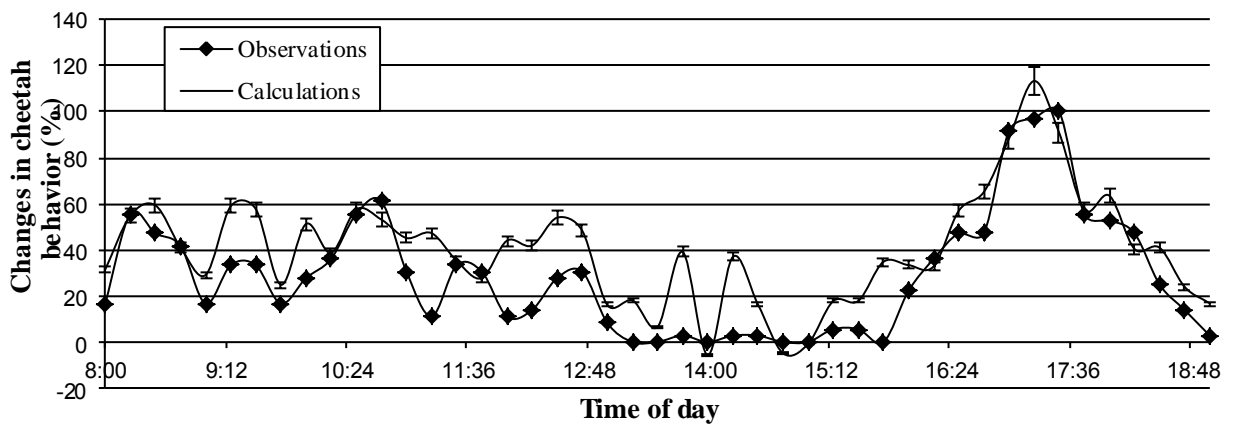Figure 1 – The effect of the presence of tourists on cheetah activity

Figure 2 – The effect of the presence of tourists on changes in cheetah behavior

It is clear from the figures that the model sufficiently describes cheetah behavior in the presence of tourists (agreement between the calculation with the observation data), although it is not entirely adequate. The coefficient values obtained using this model can be used to assess the contribution of each independent variable (baseline activity and changes in behavior, factors of the presence of tourists) to the value of two dependent variables (activity and changed behavior of cheetahs). Although the time corresponding to peaks in cheetah activity practically always agrees with the calculated time, the magnitudes of these peaks are quite different from one another. This can probably be explained by the fact that other factors, not accounted for in the proposed model, have an effect on cheetah behavior, and, most likely, are not related to tourists.

A comparison of the dynamics of the baseline cheetah behavior with the behavior in the presence of tourists testifies to the substantial effect that tourists have both on animal activity and on the frequency with which they change their behavior (Fig. 3 and Fig.4).
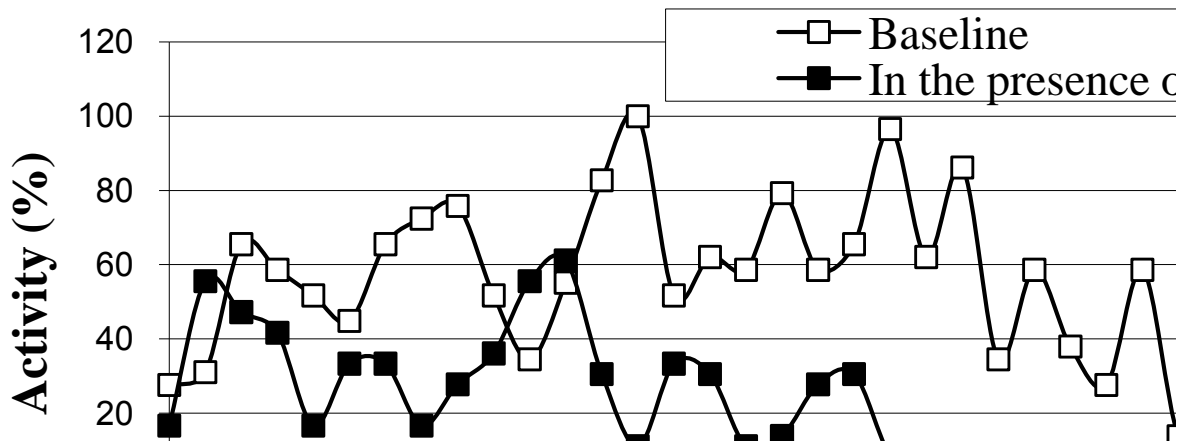
Figure 3 – The change in activity of cheetahs affected by tourists
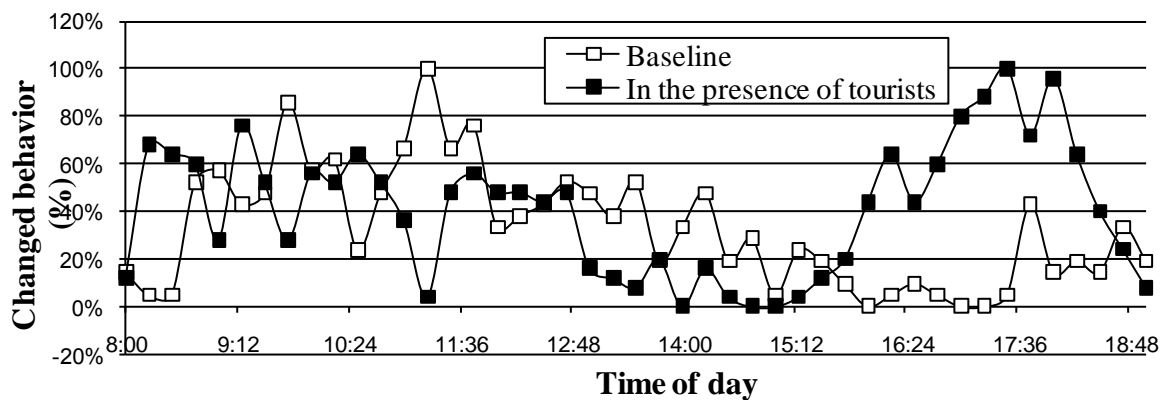


Figure 4 – The change in behavior of cheetahs affected by tourists

We assessed the effect of tourist groups on the activity and behavior changes of cheetahs, according to the contribution of factors of the presence of tourist groups close to the cheetahs, specifically: the number of tourist cars, their distance from the cheetahs and their position relative to the road, and also the number of noisy groups. The contribution of each factor was examined independently as well as in various combinations.

**3.2 The effect of independent factors of tourist presence on cheetah behavior**

1) <u>The number of tourist cars</u>. The calculated values for the coefficients $k_0$ and $k_1$ for two types of data—the maximum number of cars and their total number—are presented in Table 1.

Table 1 – The effect of the presence of tourist cars on cheetah activity

|  | For the total number of cars | For the maximum number of cars |
|---|---|---|
| $K_0$ | 0.31 | 0.10 |
| $K_1$ | 1.17 | 0.73 |

where $k_0$ is a coefficient that characterizes the contribution of baseline cheetah activity to their activity in the presence of tourists;

$k_1$ is a coefficient that characterizes the influence of tourists on cheetah activity.

It can be seen from Table 1 that, in both cases, the coefficient describing the effect of cars on cheetah activity is significantly greater than the coefficient defining the effect of baseline cheetah activity. We can conclude from this that the presence of cars with tourists is a substantial factor that changes cheetah behavior; the dynamics of their activity completely changed in the presence of tourist cars. Additionally, the total number of cars had the most pronounced effect on animal activity.
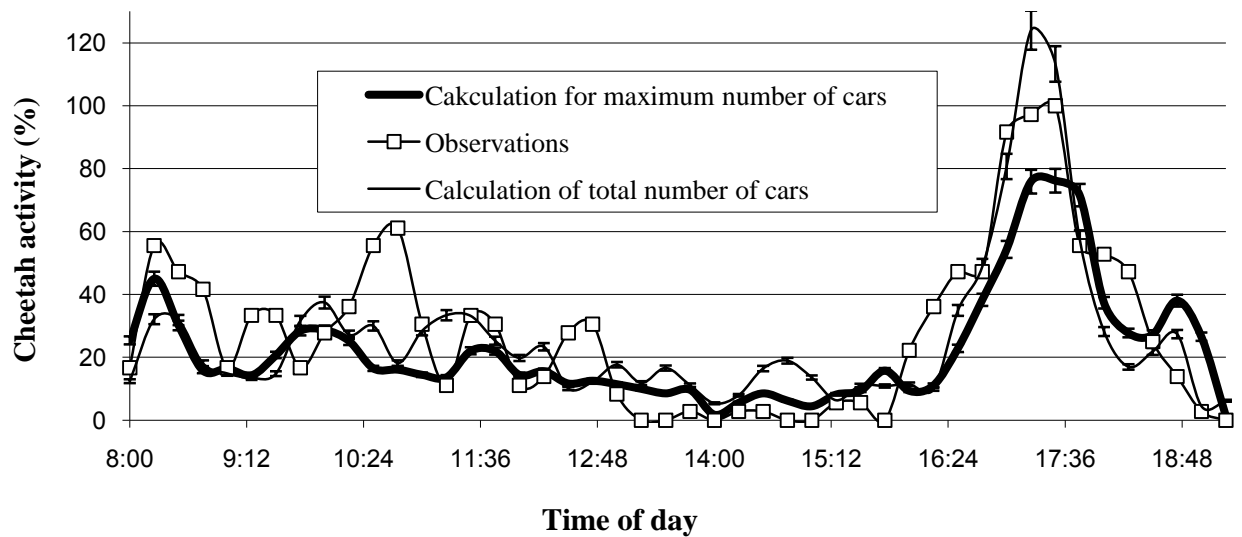


Figure 5 – The relationship between cheetah activity and the number of tourist cars

The results of the calculations using the model based on formula (1) for various sets of coefficients as well as the observation data presented in this diagram demonstrate that the hypothesis about the effect of the total number of cars on cheetah activity is supported by our observations. Furthermore, cheetah activity changed by 75% compared to the baseline, and the share of baseline

cheetah activity was no more than 25% of cheetah activity in the presence of tourists: 1.17/0.31≈4 (Table 1).

It can be seen from Fig. 5 that the mathematical model we have built describes the observation results quite well, particularly in the period of the greatest number of tourists, i.e. the morning and the second half of the day. Furthermore, the plot corresponding to the total number of cars lies somewhat closer to the observation data. This is indicated by the small size of S (the sum of the calculated errors from the actual values), which characterizes the proximity of the calculated values to the observed results. The smaller it is, the better the model describes the observations (S=1.16 for the total number of cars, S=1.31 for the maximum number of cars). Thus, we can say that the total number of cars is a more significant factor than their maximum number, although the differences are not very substantial.

2) The distance of tourist cars from cheetahs. In Fig. 6, the effect of distance of tourist cars on cheetah activity and behavior changes is shown. The average of these parameters without tourists present is also shown. It is clear from the figure that for cheetahs the critical distance at which cars with tourists had the greatest impact on cheetah behavior (indicated by the solid arrow) is around 7 meters (6-8m), Reducing the distance further begins to have the opposite effect—if cars come closer, both the activity and the changes in behavior are substantially reduced.
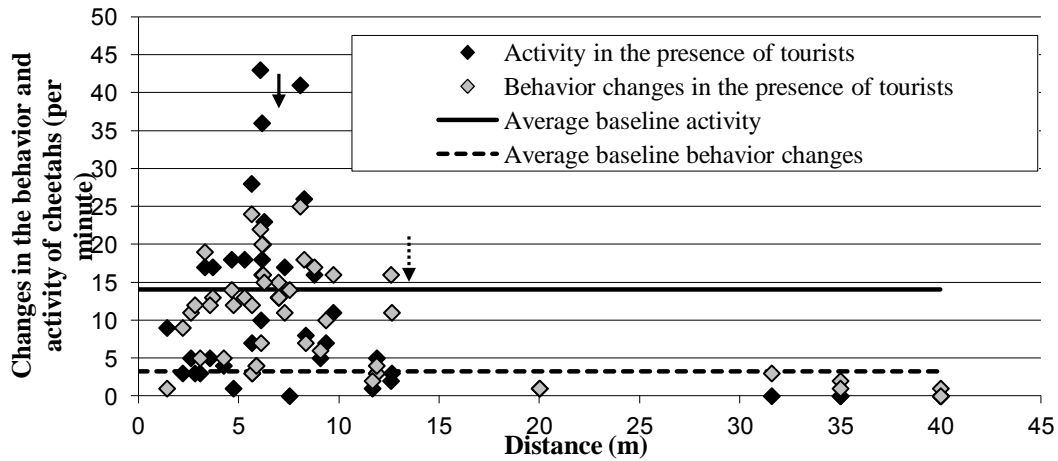
Figure 6 – The effect of distance of tourist cars from the cheetah on cheetah activity and behavior changes

From this we can conclude that under no circumstances should tourists approach closer than 8 m. At distances greater than about 13 m, both the animal activity and behavior changes become less than the average values of these parameters without tourists. That is, cars at a distance greater than 13 m have a weak influence on cheetahs. Consequently, this distance, which does not disturb the cheetahs, may be termed safe (indicated by the dotted arrow).

Thus, distance of tourist cars from the cheetahs was the second most significant factor affecting cheetah activity and behavior changes.

3) The position of tourist cars relative to the road and the noisy behavior of tourists in a group. According to our observations, tourists in cars were noisy 47.63% (n=392) of the time—nearly half. However, as follows from Table 2 and Table 3, the values of the coefficients $k_{Sh}$ and $k_{Vd}$ are so small in absolute terms that statistically they can be treated as zero. This is evidence that, by itself, the position of cars off the road and the noisy behavior of tourists has little effect on cheetah activity and behavior changes.

Table 2 – Factors affecting cheetah activity

| $k_0$ | $k_{Nm}$ | $k_{Vd}$ | $k_{Sh}$ | $k_{L^{-1}}$ |
|---|---|---|---|---|
| -0.187±0.049 | 1.05±0.06 | -0.075±0.062 | -0.113±0.062 | 0.168±0.062 |

Table 3 – Factors affecting changes in cheetah behavior

| $ik_0$ | $k_{Nm}$ | $k_{Vd}$ | $k_{Sh}$ | $k_{L^{-1}}$ |
|---|---|---|---|---|
| -0.171±0.043 | 0.864±0.058 | -0.088±0.059 | -0.013±0.062 | 0.47±0.062 |

where $k_0$ is a coefficient that characterizes the contribution of baseline cheetah activity to their activity in the presence of tourists;

$ik_0$ is a coefficient that characterizes the contribution of baseline changes in cheetah behavior to their changes in behavior in the presence of tourists;

$k_{Nm}$ is the coefficient of the effect of the number of cars;

$k_{Vd}$ is the coefficient of the effect of cars off the road;

$k_{Sh}$ is the coefficient of the effect of tourist noise;

$k_{L^{-1}}$ is the coefficient of the effect of the distance between cars and cheetahs.


In both cases, the coefficient $k_{Nm}$ is the greatest, substantially greater in absolute terms than every other coefficient as well as $k_{L^{-1}}$ , as can be seen in Table 2 and Table 3. We can conclude from this that the main factors affecting cheetah activity and changes in their behavior are the number of cars near the animals and the distance between car and cheetah. In the case of the effect on activity, the value of the latter factor is quite smaller than the effect on behavior changes. In the case of affecting changes in cheetah behavior, the coefficient accounting for the distance differs from $k_{Nm}$ less than half.

The result of the calculation demonstrates that our estimates are quite accurate, because the error values for the most significant coefficients ($k_{Nm}$, $k_{L^{-1}}$ ) in absolute terms are less than the coefficients themselves and the relative error is 4.5% and 29%, respectively (Table 3). Considering that the proposed model only accounts for the influence of tourists and does not account for the most other factors (e.g. weather conditions, the time of year, the population's gender and age composition, and individual peculiarities of the animals), an error of 29% does not seem too large. This value indicates that the presence of tourists is a very serious factor affecting cheetah behavior. That the accuracy of the remaining coefficients

is considerably worse can easily be explained by their much smaller significance and their proximity to zero.

## 3.3 The effect of combinations of factors of tourist presence on cheetah behavior

From the data presented in Table 4, it can be seen that the effect of complex factors on changes in cheetah behavior are significantly stronger than that of the simple factors. Being especially close to 1, the value of $R^2$ for the product of the fraction of noisy tourist groups and the number of cars indicates that, more than the others, the particular combination of these two factors affected changes in cheetah behavior.

Table 4 – The effect of complex and simple factors of the presence of tourists on changes in cheetah behavior

| Factor | L | Nm | NmL | NmSh | LSh | LVd | NmVd |
|--------|------|------|------|------|------|------|------|
| $R^2$  | 0.02 | 0.47 | 0.53 | 0.81 | 0.72 | 0.31 | 0.27 |

where L is the distance; Nm is the number of cars; Sh is the number of cars with noisy tourists; Vd is the position of cars off the road; NmL is the number of cars and the distance; NmSh is the number of cars and the number of cars with tourists; LSh is the distance and the number of cars with noisy tourists; LVd is the distance and the position of cars off the road; NmVd is the number of cars and the position of cars off the road; $R^2$ is the square of the coefficient of linear correlation.

Many cars with quiet tourists affect cheetah behavior in approximately the same way as a few cars with noisy passengers. The value of $R^2$ was obtained by analyzing the graphs of the relationship between the changes in cheetah behavior and the single- and complex factors (Fig. 7 and 8). Similar reasoning can be put forward for the rest of the factor pairs that were studied: the number of cars and the inverse of the distance; the inverse of the distance and the fraction of cars with noisy tourists; the number of cars and the fraction of cars off the road; the inverse of the distance and the fraction of cars off the road (Table 4). In every case, any one of the complex factors had a more substantial effect than any one of the "pure" factors.
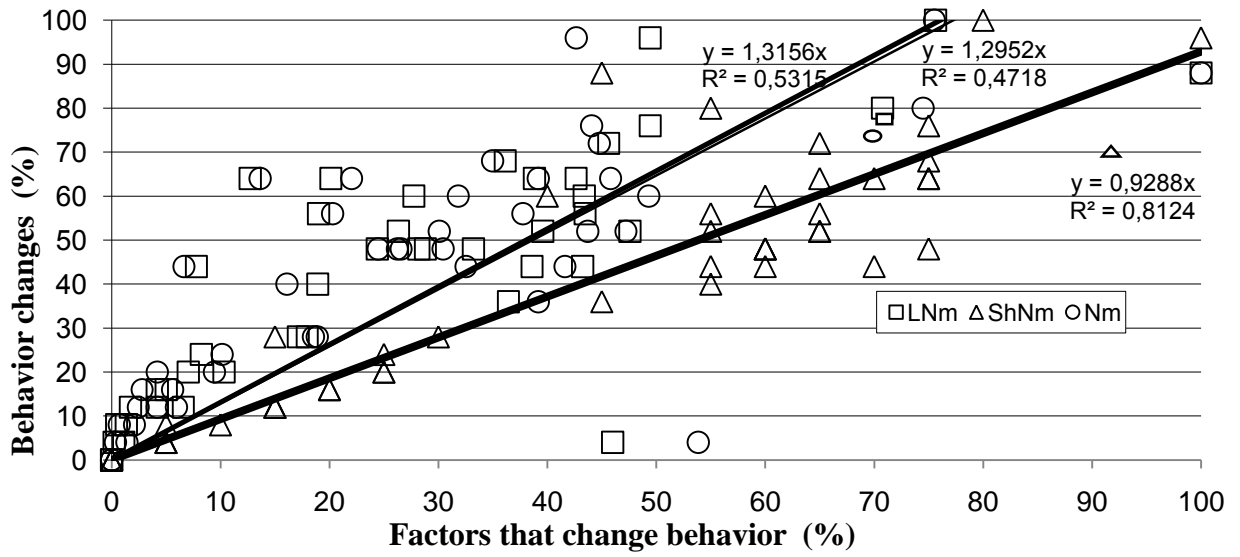
Figure 7 – The relationship between changes in cheetah behavior and factors related to the number of tourist cars
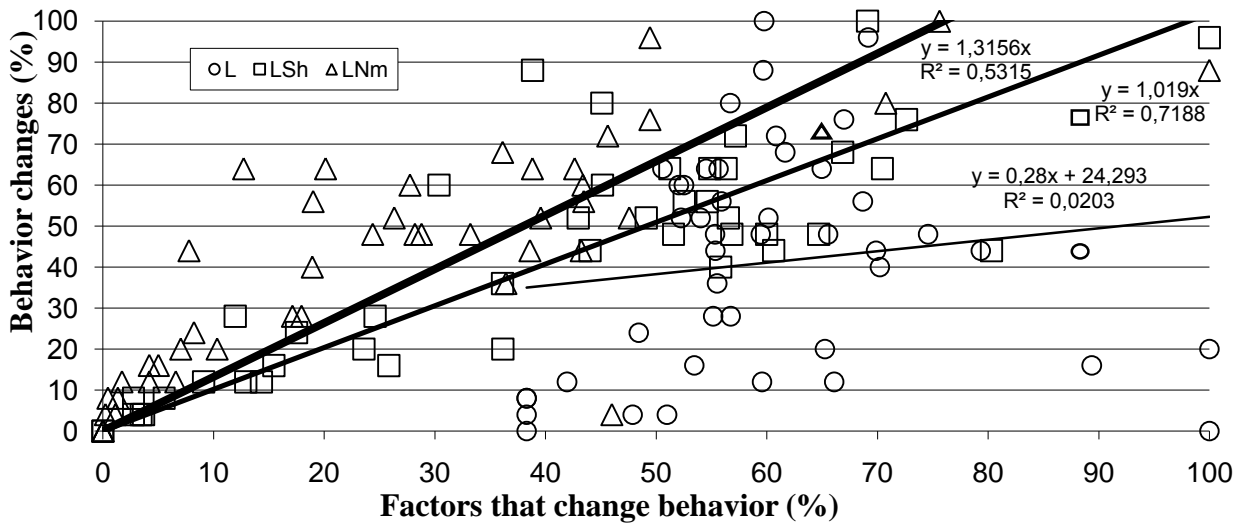


Figure 8 – The relationship between changes in cheetah behavior and factors related to the distance from tourist cars

As the same time, the factor of cars being off the road does not have a substantial effect on animal behavior, even in combination with other factors, and is not absolutely independent. It strongly correlates to the distance between car and cheetah. Altogether, we can conclude that out of the complex factors, the

combination of the number of cars and the number of cars with noisy tourists has the most pronounced effect on cheetah behavior. Knowing the combination of the total number of cars and those with noisy tourists, 8 times out of 10 we can predict whether or not cheetah behavior will change.

The shortcoming of our model is that we treat the effect of distance as linear, whereas it is more accurately described by a peaked curve (Fig. 6). Exploration of a more accurate relationship between cheetah behavior and distance is an important goal for future investigations.

## 3.4 The effect of the presence of tourists on cheetah hunting behavior

From September 2001 to July 2002, we observed hunting behavior 36 times (Fig. 9). Cheetah hunting activity was distributed more or less equally during daylight hours (Table 5).
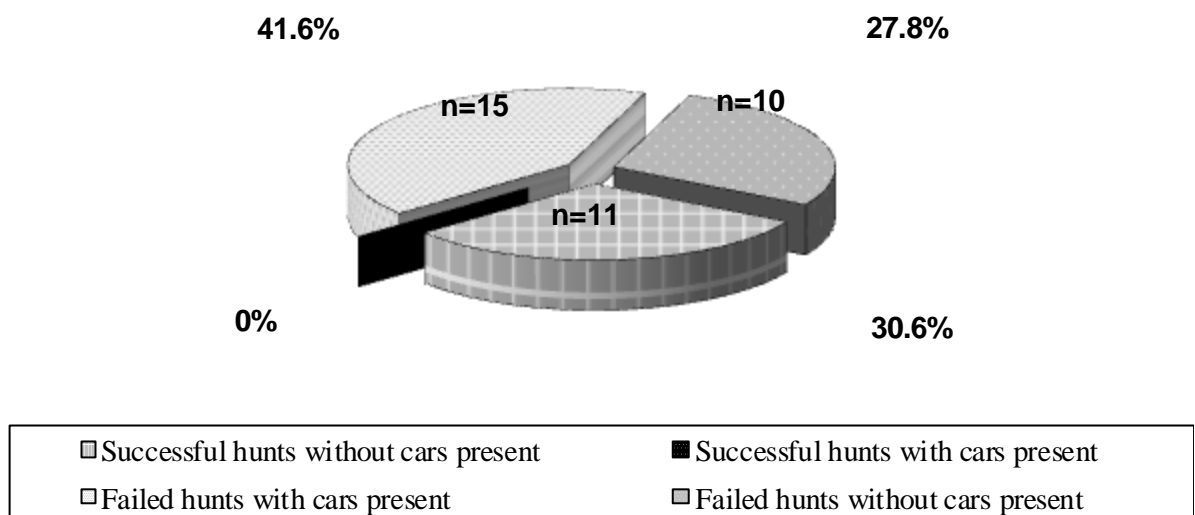


Figure 9 – The relationship between hunting success and the presence of tourists

Table 5 – The distribution of successful and failed hunts by time of day

| Successes without tourists | | Failures without tourists | | Failures in the presence of tourists | |
|---|---|---|---|---|---|
| 7.45 | 17.00 | 8.43 | 14.45 | 9.00 | 17.09 |
| 10.46 | 17.15 | 9.45 | 16.20 | 9.22 | 17.10 |
| 11.00 | 18.15 | 10.15 | | 10.30 | 17.11 |
| 11.30 | | 11.20 | | 12.00 | 17.20 |
| 13.00 | | 12.22 | | 12.45 | 17.21 |
| 16.20 | | 12.47 | | 16.04 | 17.21 |
| 16.30 | | 12.50 | | 16.40 | 18.15 |
| 17.00 | | 14.23 | | 17.08 | |
| **Total: 11** | | **Total: 10** | | **Total: 15** | |

During the day, the number of cars simultaneously close to a cheetah increased and had reached 21 cars by 13:00 and 23 cars at 17:23. However, most often between 2 and 5 tourist cars were simultaneously close to a cheetah (Fig. 10).
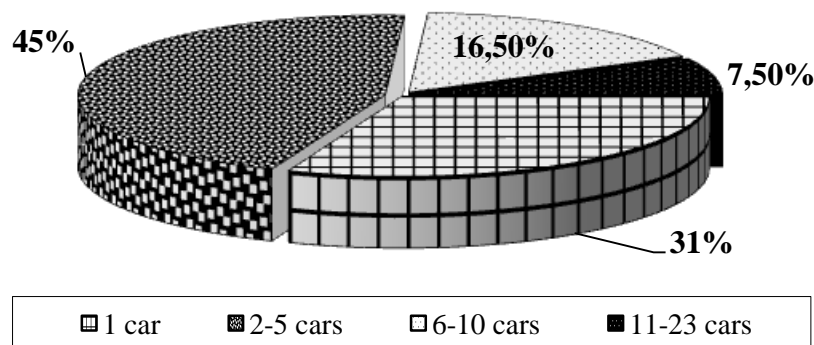


Figure 10 – The number of tourist cars simultaneously close to a cheetah

During the day, we observed the maximum number of tourists close to cheetahs in the morning hours with a peak between 11:00 and 12:30, and in late afternoon from 17:00 to 17:30. The fewest were observed from 13:00 to 14:45 (Table 6). In the period from 15:45 to 17:50 (hours of cheetah hunting activity), 16-17 cars (Fig. 11) replaced one another around a single animal. During the tourists' lunch break (from 12:30 to 16:00), 16.6% (n=6) of the hunts were recorded, only one of which was successful.

Table 6 – The number of tourist cars around a cheetah during the day

| Time | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Maximum number of cars in 3 minutes** | 10 | 13 | 15 | 21 | 21 | 5 | 2 | 16 | 17 | 23 | 9 | 4 |
| **Average number of cars in 3 minutes** | 3.5 | 5 | 4.5 | 7 | 6 | 2.5 | 1 | 2 | 3 | 3.7 | 3 | 3 |

## IV. Discussion

Because the first observations on a natural reserve of cheetah behavior in the presence of tourists were made in the 1970s, a comparison of our results with the results obtained by Burney (1980) seems interesting. There are tourists' guides who are responsible for tourist behavior on the safari, and it is not possible to examine their behavior apart from the behavior of the groups, and the impact these tourists have on the environment in general, and wild animals in particular.

Just like 20 years ago, in the course of the day, the largest number of tourist groups close to cheetahs were observed in the early morning and late afternoon. The fewest were observed in the middle of the day. This is evidence that during lunchtime information spreads quickly between tourists and guides. On the same day or the next morning, drivers most often come out to the place where a cheetah had been seen the previous day. During the course of our observations, these were usually the resident females with cubs and adolescents. By sharing the location of a cheetah with other drivers in the park, the guides attracted an unmanageable number of vehicles.

The number of tourist groups in different areas of the natural reserve varied widely: the most, 23 we observed near the Keekorok and Simba Lodges. Near the Serena and Voyager Lodges, on average, 5 cars were close to a cheetah, while not far from Governor's Camp there were only one or two cars. This is explained by the fact that the resident drivers of these lodges and campsites have followed the Masai-Mara National Reserve's regulations. Most often as it was shown by Karanja (2003), once tourists spot a cheetah, they violate the rules on practically more than in half of cases, including following moving animals and driving off road.

Although according to our calculations the presence of cars off of the road did not substantially affect cheetah behavior (Table 2 and 3), such misbehavior could be fatal for animals hiding in a tall grass. Several times we have witnessed that, in searching for cheetahs, the cars that leave the road nearly run over a family of cheetahs—a female lying in the grass with her cubs.

The violation of regulations by non-resident drivers can be explained by the desire of tourists to see as many places and animals as possible in a short period of time and by the poor monitoring of regulation violations. At the same time, resident drivers have demonstrated good knowledge of the cheetahs that inhabit areas belonging to their campsite. They named the lion prides, hyena clans that were most often encountered along tourist routes and they have also given names to cheetahs. Information about the encounters with these predators regularly was recorded in special drivers' record books which drivers gladly demonstrated to us alone with their photographs of cheetahs. These made it possible to tell how well particular animals could be identified. The accuracy with which cheetahs were identified, in contrast to the resident lion and hyena groups, unfortunately, was not high. Sometimes the drivers would mistake an animal's gender, and different individuals of both sexes were given the same name. Thus, in 1989, the female named Queen was known to use cars as an observation point, making her a popular tourist attraction. It was always easy to find her near the lodges mentioned above, and she did not fear cars. During our discussion with the resident drivers, they confidently used this name to refer to 3 animals—2 different females and one male—because they were focused only an animal's ability to jump on the roof or the bonnet of a car and did not pay attention to its sex or individual color patterns of the tail.

If in the 1980s the mid-morning and the last hour of daylight were characterized by fewer visitors (Burney 1980), then in 2001-2002 the situation fundamentally changed with respect to mid-morning. In fact, the number of cars that we simultaneously recorded gradually increased, beginning at 8:00 and by

10:50 there as much as were 21 cars (Table 6). Tourist activity did not slacken by the end of daylight—even after dark several cars remained near the cheetahs.

If tourists noticed a cheetah ready to hunt, they often began to drive the game in the cheetah's direction with their cars, making the hunt impossible. In such cases, the cheetah preferred to escape from the moving cars and wait until the cars stopped. Generally, after a few failed attempts at hunting in the presence of tourists, the cheetahs refused to hunt. All successfully completed hunts took place in the absence of visitors.

According to Burney (1980), the percentage of successful hunts 30 years ago was higher in the presence of tourists. Based on this, Burney even hypothesized that in certain situations the presence of visitors may have a positive effect on the outcome of hunting. However, in the 1980s there were at most 1-3 cars (Fig. 12) near the cheetahs. A concentration of more than 6 vehicles around cheetahs hunting in the natural reserve was an extraordinarily rare phenomenon. In 17 months, Burney only observed this twice (Burney 1980), which was 0.5% of cases. In 8 months, we observed more than 6 cars simultaneously near cheetahs in 20% of cases. The increased flow of tourists over two decades has increased the proportion of cars near animals (Fig. 12).
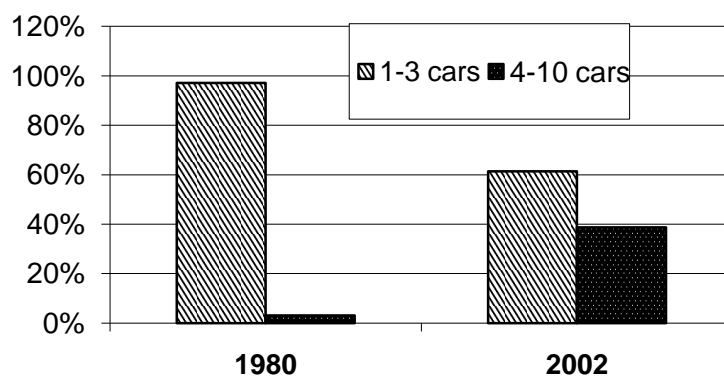


Figure 12 – The number of cars simultaneously recorded near a cheetah
Burney's data (1980) and our data (2002)

As far back as the mid-1970s it was shown that a concentration of more than 6 cars around cheetahs sharply reduced their hunting activity. Based on observations at the Amboseli National Park in Kenya, Henry showed that cheetahs actively avoid cars; in the presence of tourists they stop hunting and altogether exhibit a shift of activity to the darker time of a day night—before the sunrise and after the sunset (Henry 1975). It is well-known that sometimes cheetahs hunt at dusk and in darkness (from 18:30 to 19:50) or eat previously killed prey in darkness (Burney 1980). We managed to observe two hunts at dusk, around 18:15 (Table 5). One of them was concluded successfully, but the female, who had a cub, surrendered her prey to a different female with three cubs.

The fact that cheetahs in the reserve have hunted at the hottest time of day when there were no cars in the park, may be an indication of the disturbance caused to cheetahs by the presence of visitors, which provokes the animals to hunt when people are not around. The distance of our car from a hunting animal in the presence of tourists was always greater than the distance of the tourists' cars—and was more than 20 m from the animal. Therefore, we assume that the car of observer did not disturb the hunting animal.

At the end of the 1970s, Burney (1980) concluded that the effect of cheetah tourism in the Masai-Mara National Reserve was minimal, but he warned that sharp growth in the number of visitors could create problems for the wildlife. Since that time the park's attendance has grown by more than 2.5 times (Karanja 2003), and the behavior of tourists has begun to substantially impact the cheetahs.

The results of our research demonstrate that the presence of tourists near cheetahs completely changed the animals' daily activity, including the frequency of behavior patterns changes (Fig. 3, 4). Therefore, it can be considered a factor of the cheetahs' disturbance. The number of cars and their distance from the animals (Fig. 5, 6) had the most pronounced effect. This result agrees with the opinion of a number of authors (Henry 1980; Caro 1994; Rönn 2002). Other authors have stated that in places frequently visited by tourists, the animals may not only become

accustomed to cars, but benefit from using them as observation points or hiding places (Burney 1980; King 1998). However, this opinion is based on observing how cheetahs responded to the researchers' own cars.

An analysis of the relationship between the changes in cheetah behavior to the distance from a car reveals a distinct manifestation of the so-called "surrounding effect" (Fig. 6). At a distance of about 7 m, the effect on cheetah behavior is at a maximum; a reduction in the distance leads to a reduction in activity as well as changes in the animal's behavior. Relative to the "surrounding effect", the opinions of researchers are diametrically opposed. Thus, King affirms that being surrounded by cars does not have a negative effect on the behavior of this predator, citing the fact that in the presence of tourists cheetahs simply lie down and do not appear agitated (King 1998). The opposite opinion is based on observations of a cessation of cheetahs' activity while being surrounded by minibuses with noisy tourists (Henry 1980; Rönn 2002); or, conversely, in a frequently changed poses (Burney 1980); in interrupted hunting, abandonment of prey (Burney 1980; Rönn 2002), and even infanticide (Grieser 1996). In certain instances, aggressive tourist behavior may result in the loss of a cheetah's prey or even a threat to its life by attracting predators. S. Durant observed, for example, how a cheetah litter was split up by tourist cars.  As a result, one of the cubs was lost (Ray et al. 2005).

In our view, the behavior of cheetahs who lie down when surrounded by cars (sometimes closing their eyes) and do not show any sign of visible activity, is a manifestation of apathy (stress immobility) as a reaction to the stress induced by tourists. Our results agree with those obtained by Rönn (2002), according to which the more cars that surround cheetahs or the shorter the distance becomes, the more often cheetahs lay down; though the animals began to move again when the distance closed to less than 5 m.

## V. Conclusion

The immediate presence of tourist cars in the Masai-Mara National Reserve causes cheetahs to all but completely change their current activity. The level of this effect is determined by three parameters: the distance, the number of cars, and the noise of tourists. Additionally, they have the strongest effect on cheetah behavior in paired combinations. Knowing the combination of the total number of cars and those with noisy tourists, 8 times out of 10 it can be predicted whether or not cheetah behavior will change. To avoid the negative effect of tourists on cheetahs, it is necessary to strengthen regulatory compliance monitoring in the presence of wild animals.

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