POSSIBLE ALTERNATION OF REST-ACTIVITY CYCLE AND VIGILANCE BEHAVIOR IN PERIPHERAL MALE STUMPTAILED MACAQUES (MACACA ARCTOIDES) IN EXTERIOR CAPTIVITY: A PRELIMINARY REPORT

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SUMMARY

Social structures emerge in primate groups mainly as a response to environmental pressures. Social structure impacts significantly on predator detection, food gathering and reproduction, and it is also an indicator of social condition and age and sex categories within the group. Differentiated activities which depend on social status, sex and age have been described in established social groups of primates. Dominance patterns influence the behavior of some species. It seems that the night-time spatial arrangement of members of a primate group is an anti-predation strategy, either by increasing detection and defensive capabilities in the case of large sleeping groups, or by emphasizing inconspicuousness in the case of more solitary sleepers. The persistence of social organization during rest-activity cycles in primate groups allows for the prediction that individuals in a group having the same monitoring needs may alternate their rest-activity condition to assure vigilance. In this study, we examined the rest and activity conditions of two peripheral individuals in an established social group of *M. arctoides.* Each subject was videorecorded twice for two continous periods of 24 hours each, totaling a videorecording of 96 hours. The rest and activity conditions observed in both subjects were grouped in the four possible conditions:

Condition 1. Subject A resting, subject B resting;
Condition 2. Subject A resting, subject B active;
Condition 3. Subject A active, subject B resting;
Condition 4. Subject A active, subject B active.

These were compared with a concordance test. Results revealed that peripheral males alternated their rest-activity cycles. That is, while one subject was resting, the other remained active. The possibility that rest-activity alternation is an adaptation to maintain constant vigilance is discussed.

Key words: Primates, alert, behavior, *macaca arctoides*.

RESUMEN

En grupos de primates, la estructura social emerge como respuesta a las presiones del ambiente, la cual tiene un impacto importante sobre la detección de los depredadores, la ganancia en el alimento y la reproducción. A su vez, estas actividades se ven favorecidas por variables como las categorías de sexo y edad, lo que sugiere que en grupos socialmente establecidos de primates las actividades individuales dependen de la jerarquía social, el sexo y la edad. Lo anterior indica que el dominio es un factor que afecta la conducta. Con respecto a la noche, en especies diurnas, los arreglos y la distribución nocturnos de los miembros es una estrategia de antidepredación, que incrementa la identificación de los depredadores y la posibilidad de defensa en grupos extensos. El reconocimiento de una organización social en primates sugiere que durante el ciclo de reposo-actividad hay funciones asociadas con la vigilancia y que ésta probablemente se alterna entre sujetos. En este estudio examinamos las condiciones conductuales de reposo-actividad de dos machos adultos periféricos de un grupo socialmente establecido de macacos cola de muñón (*M. Arctoides*). Cada sujeto fue monitoreado durante dos periodos continuos de 24 horas, para alcanzar un total de 96 horas de registro. Las condiciones de reposo-actividad de ambos sujetos se agruparon en cuatro condiciones:

Condición 1. Sujeto A reposo, sujeto B reposo;
Condición 2. Sujeto A reposo, sujeto B activo;
Condición 3. Sujeto A activo, sujeto B reposo;
Condición 4. Sujeto A activo, sujeto B activo.

Los valores obtenidos fueron comparados mediante una prueba de concordancia. Los resultados revelaron que los dos machos periféricos alternaron su ciclo de reposo-actividad. Esto es, cuando el sujeto A reposa, el sujeto B está activo. Los resultados se discuten en el sentido de que la alternancia de reposo-actividad es una adaptación natural, cuya función es cuidar al grupo de posibles ataques externos.

Palabras clave: Primates, alerta, conducta, *macaca arctoides*.

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INTRODUCTION

Social structures emerge in primate groups mainly as a response to environmental pressures (capuchin monkeys: Robinson, 1981; vervet monkeys: Cheney and Seyfarth, 1981; and mangabeys: Waser, 1985). Social structure impacts significantly on predator detection, food gathering and reproduction (Janson, 1990), and it is also an indicator of social satatus, and age and sex categories within the group (Jolly, 1985).

Differentiated activities dependent on social status, sex and age have been described in established social groups of primates (Smuts et al., 1987; Silk, 1987). Dominance patterns influence the behavior of some species. A series of studies carried out by Bernstein and collaborators with capuchin *(Cebus albifrons)*, (Bernstein, 1964, 1966a and b) and rhesus *(Macaca mulata)* monkeys (Bernstein and Sharpe, 1966; Bernstein et al., 1970) suggests that the role of the alpha male is to control intra-group disturbances and group response to external challenges. In gorilla *(Gorilla gorilla gorilla)* groups, however, males cooperate to protect females and youngsters and the dominant male guides the group and decides the direction and timing of group movements (Nishida and Hiraiwa-Hasegawa, 1987). In primate groups where the male is dominant, such as cercopithecines and cebids, these usually show higher levels of vigilance behavior than females (Gautier-Hion, 1980; Cheney and Seyfarth, 1981; Boinski, 1988; Van Schaik and Van Noordwik, 1989; Baldellou and Henzi, 1992; Rose and Fedigan, 1995). Likewise, the dominant male in vervet monkeys *(Cercopithecus aethiops)* and capuchin monkeys *(Cebus albifrons)* typically displays a hogher vigilance behavior (De Ruiter, 1986; Baldellou and Henzi, 1992; Rose and Fedigan, 1995).

There are four main hypotheses to account for vigilance behavior in vertebrate groups. The first posits predator detection function (Alexander, 1974; Dimond and Lazarus, 1974; van Schaik et al., 1983; Terborg and Janson, 1986; Cords, 1990; Lima, 1990; Burger and Gochfeld, 1992; Catterall et al., 1992). The second suggests that adult males keep watch to protect their offspring (Baldellou and Henzi, 1992; Rose and Fedigan, 1995; Gould et al., 1996). The third explanation is that individuals of both sexes keep watch to protect their territories (Baldellou and Henzi, 1992; Rose and Fedigan, 1995). Finally, the fourth suggests that individuals watch other members in their own group to prevent their proximity or contact with dominant members (Keverne et al., 1978; Caine, 1984; Caine and Marra, 1988; Maestripieri, 1993); this is called social monitoring (Caine and Marra, 1998; Baldellou and Henzi, 1992).

Grouping relations and systems are not only specific for activity periods; they can also be expressed during nocturnal and resting periods and present variations based on sex and age differences (Ramakrishnan, 2001). As there is a significant loss of attentiveness during rest (Bert, 1970), group activities are modified and adapted to meet impending needs. Primate activity periods are not exclusively diurnal, they extend to 24 hours; however, in diurnal primates activity periods are longer during daytime (Anderson, 1984).

It seems that the night-time spatial arrangement of members of a primate group entails an anti-predation strategy, either by increasing detection and defensive capabilities in the case of large sleeping groups, or by emphasizing inconspicuousness in the case of more solitary sleepers (Anderson, 2000).

Sleeping site selection has been considered important in sleep-related behavioral assays. Protection against predators is a factor influencing the selection process in different primate species. Anderson (1984) mentioned that the dominant male selects the sleeping site and, in some cases, adult males occupy the highest locations throughout the night to monitor the surroundings. When reaching adulthood, rhesus monkey males *(Macaca mulatta)* move towards the periphery of the group, both during the day and at night (Kawai et al., 1968; Neville, 1968ab; Vessey, 1973).

Studies have shown that dominant members of a group sleep together and occupy the centre of the huddle in order to protect themselves from predation, which may affect also both the quantity and quality of sleep (Anderson, 2000).

The persistence of a social organization during rest-activity cycles in primate groups allows the prediction that individuals in a group that have the same monitoring needs may alternate their rest-activity condition to assure vigilance. In this study, we examined the rest and activity conditions of two peripheral individuals in an established social group of *M. arctoides.*

METHOD

Subjects

Two peripheral adult males were selected from a group of nine stumptailed macaques *(M. arctoides)* that included both males and females. Animals were kept at the Department of Ethology of the National Institute of Psychiatry. Both peripheral subjects, Tomas (TO) and Francisco (FR), were individually recorded twice for two continous periods of 24 hours each, totaling a videorecording of 96 hours. Details of origin and establishment of the colony were published by Estrada and Estrada (1981), Díaz (1985), López-Luján et al. (1989) and Muñoz-Delgado et al. (2004).

Videorecording background

A closed television circuit, TOPICA-PELCO-SONY b/w, high sensitivity, was used for the videorecordings. The recording camera was placed in an area called the observatory, which is isolated from the rest of the laboratory by a matt glass screen with an access door. The monitor and remote control of the camera were located inside the laboratory, thus allowing researchers to videorecord macaques without the presence of persons. This arrangement originates no alterations in the behavioral response of the actors. Details of the equipment are given in Muñoz-Delgado et al. (1995).

PROCEDURE

Reliability of recorded behaviors

Subject behavior was sampled using the focal technique (Martin and Bateson, 1986). In a previous study, the interobserver concordance was determined with the participation of three unbiased observers. They employed a VHS videocassette recorder, a monitor and two 6-hour video-cassettes. A 12-hour period of nocturnal rest of an adult female macaque (*M. arctoides*) was recorded. The observers were previously trained in the free observation method to assay the behavior of a group of stumptailed macaques. A set of behavioral traits was selected to allow the identification of each of the subjects within the group. Subsequently, they were instructed to distinguish the rest-activity behaviors to be set apart from the videorecordings (table 1). Once they were trained, the observers wrote down the frequency and duration of the selected behaviors, recording the exact moment when the particular behavior took place. These recordings were done in sessions lasting two and a half hours, during four months. At the end of this period, and based on the results (concordance index <0.50), behaviors were redefined based on precise operational concepts describing these behaviors. Atemporal behaviors were eliminated.

Once the operational definitions were obtained, the observers made a second assessment from the original videocassette in sessions lasting two and a half hours, twice a week. In this case, a minute by minute behavior assessment was carried out. There were four options of behavior, and if the subject remained a minimum of 30 seconds in one of them, this behavior was recorded. The behavior options were the following:

Behavior 1, rest with myoclonia, was determined as the prevailing behavior; it was manifested only once.

Behavior 2, rest without myoclonia, the subject had to remain 30 seconds or more.

Behavior 3, at least two transition behaviors occurring within a one minute interval were required.

Behavior 4, the animal was to be active for more than 30 seconds.

TABLE 1. Registered Behavior

Off
0. When the desired subject is not visible in the videorecording (10).
Rest
(1). Rest with myoclonous Observed subject is in a deep resting condition; main feature is one or various myoclonouses.
(2). Rest without myoclonous Observed subject is at rest mainly characterized by head nodding, muscular atony or immobility.
Activity
(3). Transition (with at least two pauses per minute) Observed subject is at rest, which probably produce somnolence characterized by yawning, head nodding, muscular atony, slow eye-blink, slow eye movements or mastication.
(4). Wakefulness Observed subject is active.

Results were analyzed with two statistical tests: Kappa de Cohen, which provides an interobserver index, and an interclass correlation coefficient of the time prior to analysis (Siegel and Castellan, 1988; Snedecor and Cochran, 1971). In the first analysis, which consisted of a 12-hour recording and was based on the behaviors defined, no interobserver reliability index was found, due to a distortion of the concepts. In the second recording, and after collecting data from a 6-hour observation period, significant concordance and reliability indexes were obtained with the following outcomes: For behavior (0), alpha was 0.943; for behavior (1), alpha equaled 0.785; for behavior (2), alpha value was 0.857; for behavior (3), alpha was 0.59, and for behavior (4), it was 0.859. This indicates that significant reliability indexes were found among the observers assaying rest-activity behaviors in stumptailed macaques (Adame et al., 2000).

Behavioral recording of peripheral males

Once the reliability index for the behaviors under study was obtained, the behavior of two peripheral subjects was observed during 48 hours for each subject, giving a total of 96 hours, with continuous 24-hours videorecordings. Forty eight hours of the total 96 hours of registration implied both subjects, as these subjects grouped together to pass the night. Of the remaining 48 hours, which were considered daytime period (0700 to 1900), 50% of the time also implied both subjects due to the closeness of their rest and contact activities. The remaining time was used by the animals in feeding, which meant competition and in consequence distance, and other activities. However, the total time recorded (96 hours), which included night-day, was considered for the analyses. Behavioral conditions were obtained

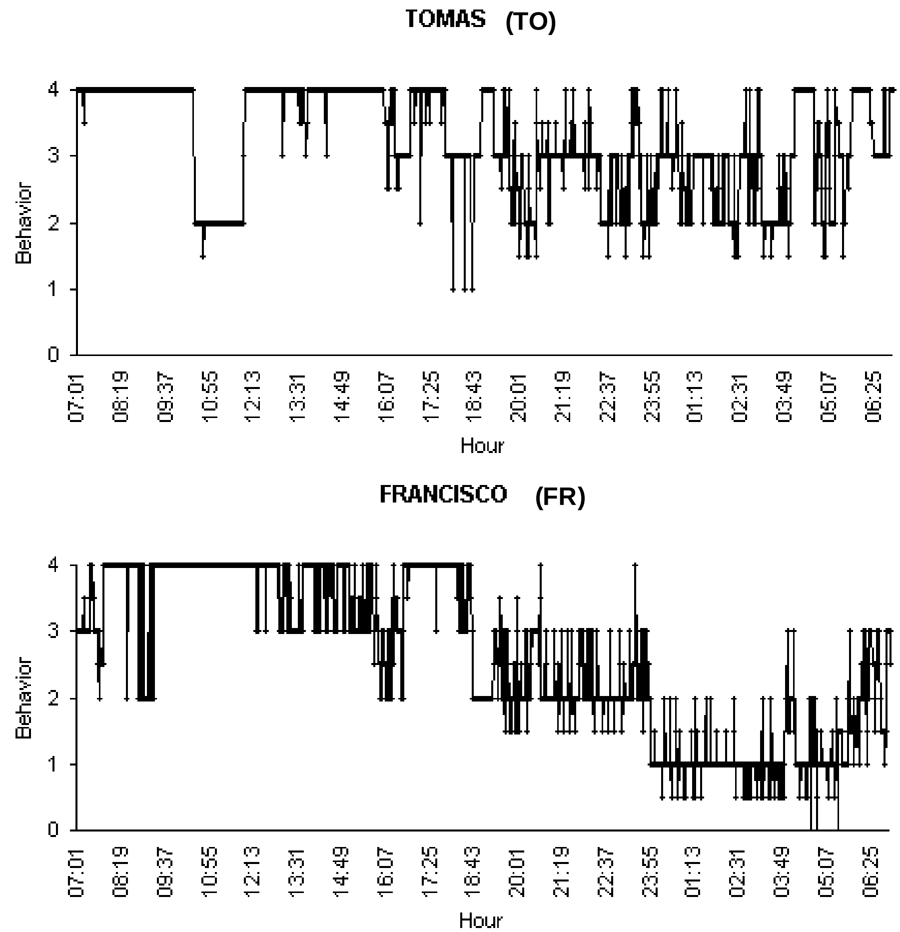

Fig. 1. Diagram of behaviors exhibited by TO and FR minute by minute from 07:01 to 07:00 hours, (48h/2=24h cycle): 1. Rest with myoclonia. 2. Rest without myoclonous. 3. Transition. 4. Wakefulness subject. See table 1.

minute-by-minute and classified from 0 to 4 (table 1), as described by Adame et al., 2000. Behaviors were categorized in two conditions: rest and activity (table 1).

Data analysis

One-minute intervals where both subjects could be observed in the videotape were selected, and the four conditions were reclassified into two: the first incorporating conditions 1 and 2, and the second including conditions 3 and 4. The subjects were in the two defined conditions, in accordance with the following options:

1. FR: condition 1; TO: condition 1.
2. FR: condition 1; TO: condition 2.
3. FR: condition 2; TO: condition 1.
4. FR: condition 2; TO: condition 2.

The Kappa Cohen test was performed (Snedecor and Cochran, 1971).

RESULTS

Figure 1 shows the presentation of behaviors 1 to 4 (table 1) throughout the 48h/2=24h for each subject (TO and FR), minute to minute. Afterwards, behaviors (1) and (2) grouped in state 1 and behavior (3) and (4) in state 2, in order to obtain Kappa's value. Kappa's values varied between –1 and +1. Alpha equal to 0 meant that values in the table were equivalent to random values. A value of 1 indicated perfect concordance. The analysis revealed an alpha of 0.23 for the behavioral conditions associated with rest-activity cycles of the subjects FR and TO. That is, while FR was in a resting condition, TO was active, and vice versa. Separate analysis of diurnal (06:00 to 17:59 hours) and nocturnal (18:00 to 06:00) periods did not reveal any significant deviation from the pattern obtained through the 96-hour period (alpha = 0.24 for daytime hours; and alpha = 0.17 for night-time hours).

DISCUSSION

The major finding, which to the best of our knowledge has not been previously described in the literature, is the behavioral alternation of rest-activity conditions between individuals. The described alternation appears to reflect a relationship between individual rest-activity profiles and social conditions. At night, the two male subjects stayed in sites as far away from the group as possible, remaining in contact or huddling; this may enhance the regulation of the rest-activity conditions allowing a continuous alertness throughout the night.

Some primates display group activity during short periods at night (Muñoz-Delgado et al., 1995, 1997; Ramakrishnan, 2001); consequently, the two peripheral males may alternate behavioral conditions to avoid harassment or attacks by other members of the group, as was proposed in the fourth hypothesis (Caine and Marra, 1988; Baldellou and Henzi, 1992). Our results, however, may reflect the function of predator detection, recalling Anderson's proposal (1984) that males occupy the highest locations while in sleeping positions to monitor the vicinity.

Since it is rather difficult to carry out this type of behavioral observations, we propose the necessity of combining this approach, which provides the type of activity a subject is undertaking, with a recently introduced technique in primate studies, namely, actigraphy (Kappeler and Erkert, 2003; Muñoz-Delgado et al. 2004ab). The latter registers the motor activity of a subject and, based on one-minute recordings, it is possible to deduce gross sleep-wakefulness stages.

The present finding and its implications indicate that more comprehensive studies should be carried out in other primate species from a similar perspective.

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