Behavioral Rhythms in the Nilgiri Langur, *Presbytis johnii*

ROBERT H. HORWICH
Institute of Micro-ontogenetic Ethology and Macro-cosmological Ecology

ABSTRACT. Eighteen complete daily profiles of 16 behaviors were compiled for three troops of Nilgiri langurs from Periyar Sanctuary in South India. Daily behavioral peaks from these profiles were tested for their associations with each other. Daily rhythms of feeding and resting showed four to eight peaks per day. When all observation days were lumped, however, a bimodal curve resulted as noted by most authors who have studied activity rhythms. The major daily behavioral associations were as follows: (1) feeding occurred during high rates of movement although not during major movement periods; (2) measures of troop movement were interrelated and occurred when troop members were dispersed; (3) movement was related to such active behaviors as whooping displays, coughing, juvenile whining, urinating, and scratching; (4) the above active behaviors showed some positive associations with each other; (5) play, grooming, and scratching showed positive associations with each other; and (6) rest periods were primarily periods of close social contact when grooming occurred and juveniles were with their mothers.

INTRODUCTION

Far from being a random series of events, an animal's day is composed of a complex sequence of events which form an orderly temporal arrangement based on the functional association of behaviors. Although daily activity rhythms in primates have usually been described in terms of a bimodal distribution: an early morning peak and a late afternoon peak, this is not how a primate troop orders its daily life. Data are usually collected on a number of troops or on a large number of days and lumped to produce what results in a gross daily curve. STRUHSAKER (1975) noted this in his study of *Colobus badius*. In this study I describe the daily patterning of behaviors in the Nilgiri langur, *Presbytis johnii*, using the troop as the basic organizational unit. When this is done and a specific troop is followed throughout a complete day, the resulting activity pattern is quite different from the typical bimodal daily rhythm ordinarily described. By breaking the day into shorter intervals, I looked for temporal associations between behaviors in order to understand the interrelationship of behaviors. These associations lead to the interpretation of functions and motivations of some of the behaviors.

METHODS

Observations were made on three troops of Nilgiri langurs, *Presbytis johnii*, which inhabit a forested peninsula in Periyar Sanctuary, South India (TANAKA, 1965; HORWICH, 1972) for a total of 600 contact hr during two two-month stays in April–May 1968 and January–February 1974. For three days each during 1968 and 1974, three troops were observed continuously from dawn to dusk. During these 18 days, quantitative records for 16 troop behaviors were recorded. Each troop was observed the afternoon before the observation day until after dark to determine the sleeping place and to ensure the easy location of the troop the next morning before sunrise. Observations were made by scanning all troop members

in sight at 5 min intervals. Each troop member excepting infants was recorded in one of three general behavioral categories: (1) feeding, (2) resting, and (3) moving. Additionally, a number of other behaviors were recorded whenever seen during the 5 min scan period. These behaviors included frequency of whines, number of location changes, whether infants were off their mothers, whether infants climbed on females (other than on the ventrum), the number of juveniles or infants playing, both socially (wrestling or chasing) or alone (locomotory), the number of animals seen grooming, frequency of whooping displays (HORWICH, 1976), frequency of coughs, frequency of scratches, frequency of urinations, whether juveniles were on their mothers, and the number of aggressive interactions. Additionally, during 1968, troop locations and general dispersals were recorded on maps of the area during 15–30 min intervals. Thus, later measurements gave values of troop dispersals as well as travel rates during the day. Temperature and relative humidity were also recorded at 15–30 min intervals.

These behavior quantifications (for each 5 min interval) were then lumped in the case of frequencies or were averaged to determine a value for each 15 min interval. Then a mean value for all 15 min intervals for each day was determined. Any values for 15 min intervals above the mean were defined as peak periods for that particular behavior and day. Then for each day any two behaviors were broken down on a 2×2 contingency table as to whether 15 min peak periods coincided or occurred alone, or if non-peak periods coincided. Chi-square tests for association were then performed on this data for each dyad of behaviors for each day to determine if there were statistically significant associations of peaks.

RESULTS AND DISCUSSION

INDIVIDUAL DAILY RHYTHMS VERSUS LUMPED DAILY TRENDS

The general daily activity of each troop consists of a frequent alternation between feeding and resting during the day, with a number of moving periods to change feeding locations. Each troop during a day may go through four to eight feeding periods which alternate with the rest periods. Figure 1 shows examples of the feeding, resting, and moving peaks that occur during individual days. When the data from many days are lumped or averaged, the general trend is one of a bimodal activity curve with a large feeding peak between 6 and 9 A.M. and a second major peak from 4 to 7 in the afternoon. Figure 2 shows an example of lumping data for three days from each of three troops and a total lumping of nine days for all three troops. Figure 2 totals exhibit the reduction of peaks to a bimodal trend so often seen in the literature. Again it should be stressed that this is the trend and not what any one troop does as its daily routine.

Figures 3 and 4 show a number of other behaviors as they occur in lumped form during the daily cycle. Many of these behaviors may occur infrequently during any one day and lumping days is the most adequate form of representation. Movements seem to occur throughout the day although the number of moves indicates a trimodal pattern at 7 A.M., noon, and 3–7 P.M. There seems to be a greater emphasis on movement in the late afternoon. This is sometimes exemplified by relatively long and active trips late in the day as though they are heading to a sleeping area. This is indeed the case, as troops did have particular resting areas (HORWICH, 1972) and showed a tendency to be in certain areas during certain times of day. For example, Troop 3 showed the tendency to remain in the same place at night for 22 days of observation from April 13 to May 12. During those days the troop rested in the same place except for four days, three of which were in another common area.

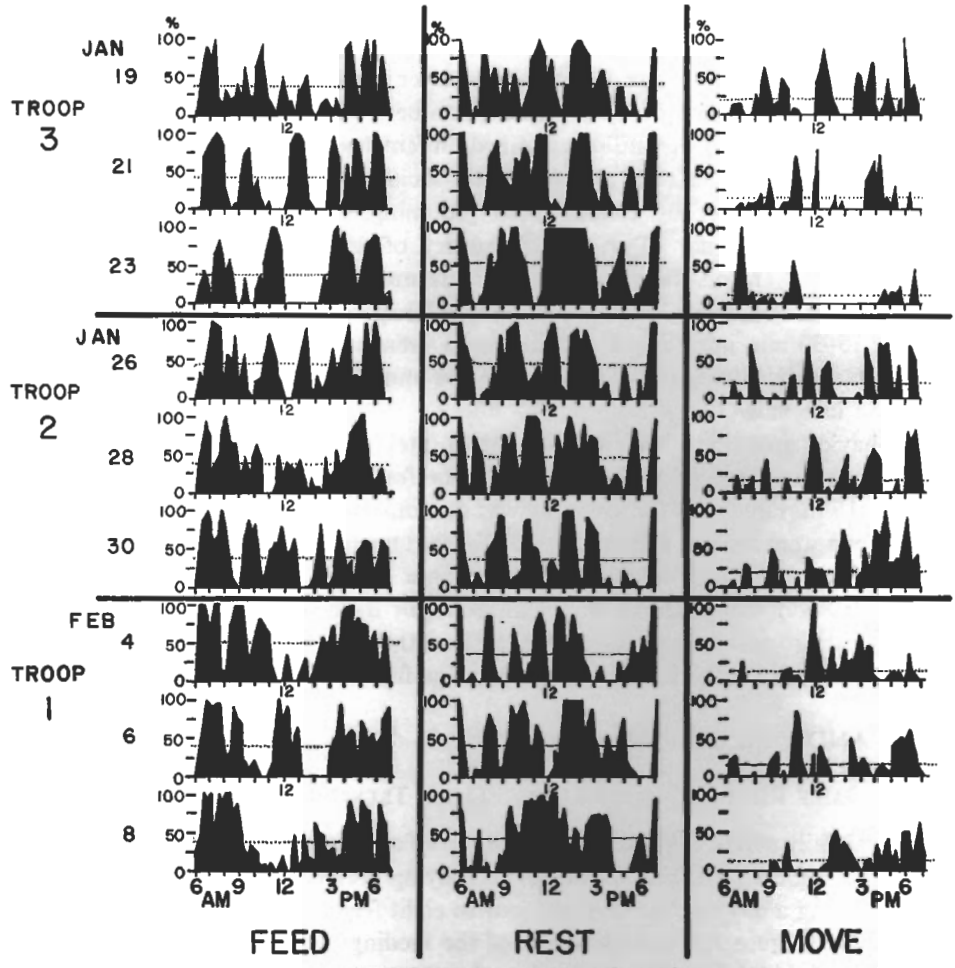


Fig. 1. The percentage of troop members feeding, resting, and moving as a function of time of day for each observation day in 1974. .....: the mean percentages above which are considered peaks.

I divided the map of Troop 3's territory into 110-ft square blocks and then compared all 22 observation days to the troop travels on April 13. April 13 was chosen because it was a day when the troop was continuously monitored and a route within the core area was travelled. For each day I calculated how many 110-ft blocks were deviated from the chosen day at any particular hour in the day. Figure 5 shows the results that the greatest amount of conformity during the day was at night when the place of sleep was extremely constant. There was also a decrease in deviation during the long afternoon rest period with a low point at 3 P.M. Troop dispersals (Fig. 5) also occurred at the highest rates early and late in the day.

Other patterns which are regular are when infants and juveniles are on their mothers (Fig. 4). This shows a trend going gradually up to a high level from 10 A.M. to 3 P.M. and then receding again. Grooming (Fig. 4) seems to be done mainly between 8–12 A.M. and again from 1–4 P.M. Although the data of 1974 and 1968 differ some probably due to seasonal differences and the 1974 data seem more restricted, in both years it seems as though the period between 9–12 A.M. is the most important grooming time. Play (Fig. 4) in 1974 showed

a general bimodality with most play occurring between 8–11 A.M. and 4–7 P.M. In 1968 there was an extra peak early in the morning at 7 A.M.

Whooping occurs as a bimodal peak (HORWICH, 1976), although most of it occurs in the morning between 6–11 A.M. (Fig. 3). Coughs (Fig. 3) seem to show a loose bimodality between 6–10 A.M. and 2–7 P.M. although 1974 data do not show it well. Rates of movement (Fig. 3) show a steady decrease from 7 A.M. until 1 P.M. after which a steady increase occurs until a half hour before sundown. Aggressive behaviors were too few to give any impressions but the few that occurred were often between 2–4 P.M.

BEHAVIORAL ASSOCIATIONS

The use of daily behavioral profiles in looking for behavioral associations was very effective and agreed strongly with my intuitive feelings during the field observations. Some additional associations occurred which were not expected. Generally this method of analysis examines and exhibits the biological processes of the individual or troop on a daily basis (HORWICH, 1976). In contrast, lumping of the data gives additional general trends and probabilities of occurrence of behaviors.

Table 1 shows a synthesis of the statistically significant behavioral associations based on the χ^2 tests. I have subsequently arranged the behaviors according to the natural groupings of the positive and negative associations in order to show overall relationships more clearly.

Feeding

The outlined boxes in Table 1 show the basic overall relationships. Box 1 shows that feeding is positively related only to movement rate and negatively associated with the main measures of troop movement. This means that although feeding is not associated with the major move periods it usually takes place at a higher rate of movement. Feeding is additionally negatively associated with rest periods and their related behaviors.

Movement

Box 2 shows the expected positive relationship of all measures of troop movement including rate of movement. Box 3 indicates an association of movement measures with certain vocalizations and active events, specifically coughs, whines, urinations, and scratching. Coughs were usually given by the male as he paused during moves. Whines were usually given by juveniles who were no longer carried during troop movements and would often follow their mothers closely, continually whining and grimacing. This became particularly pronounced when a long gap between trees had to be crossed and the juvenile showed anxiety about crossing, often hesitating for long periods before attempting the jump. The mother, on occasion, waited on the other side and less frequently, especially with particularly long jumps, retrieved her juvenile and carried it across.

Active Behaviors

Box 4 shows the positive relationship between a number of active behaviors including the three vocalizations, along with scratching and urination. This is in contrast with the general negative association between these active behaviors and the rest periods with the juveniles on their mothers. Whooping displays described in another paper (HORWICH, 1976), are a very puzzling behavior. They are loud and easily heard and although data were specifically taken on them, no conclusion on their function was forth coming. One function which was hy-

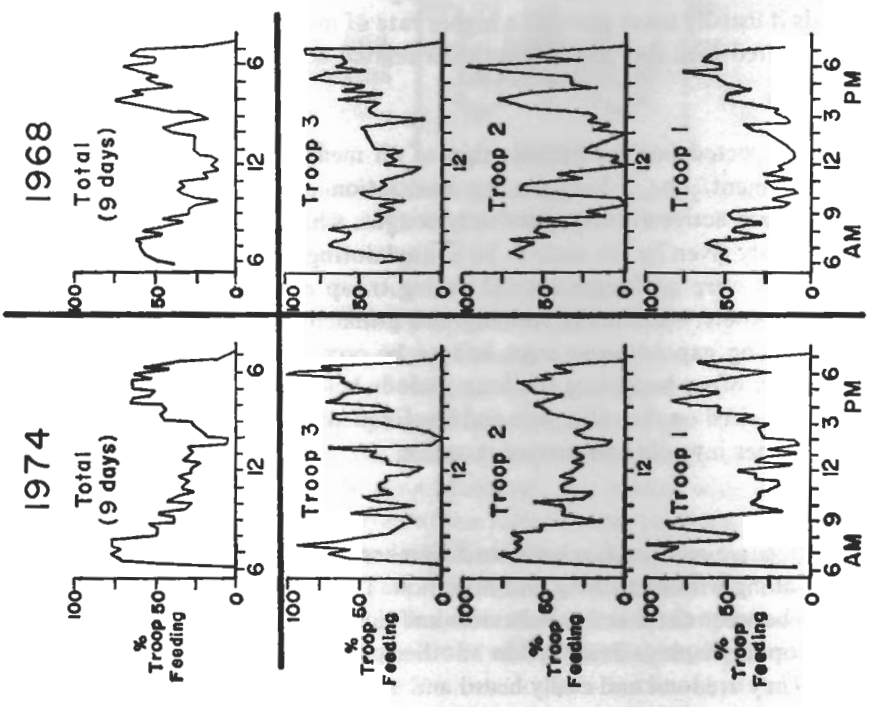


Fig. 2. The percentage of troop members feeding as a function of time of day for all three troops during 1968 and 1974. Each troop graph represents three full days of observation. The totals include all three troops for each of the years.

Fig. 3. Lumped frequencies for all observation days for all three troops as a function of time of day. Graphs show totaled frequencies of moves, coughs, whoops, and whines for 1968 and 1974. The average rate of movement is exhibited per half hour units in 1968.

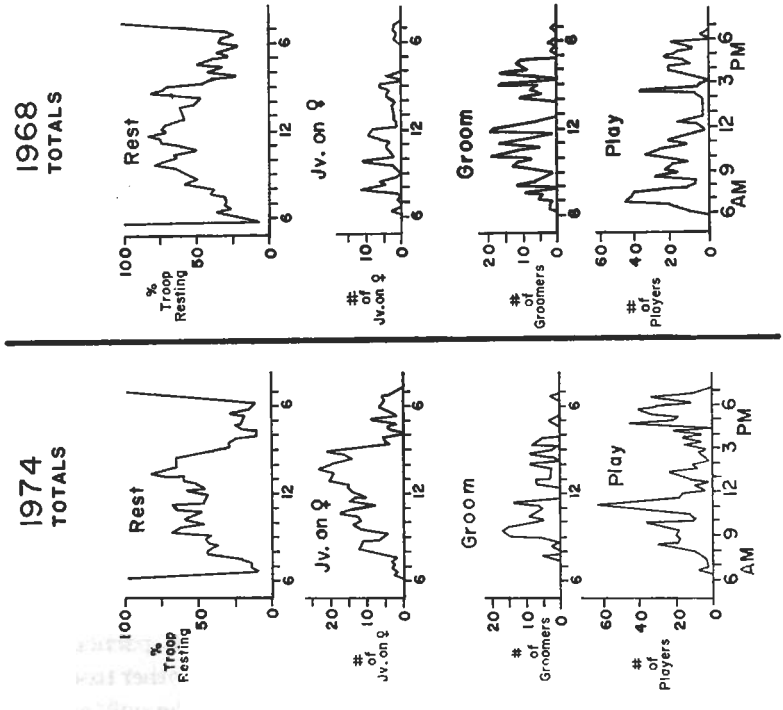


Fig. 4. Averaged percentage of troop members resting as a function of time of day for all observation days for all three troops. Additional graphs show lumped frequencies of juveniles on their mothers, groomers, and players for all observation days as a function of time of day.

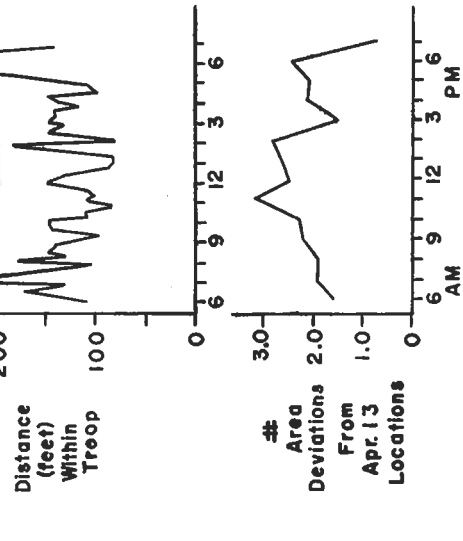
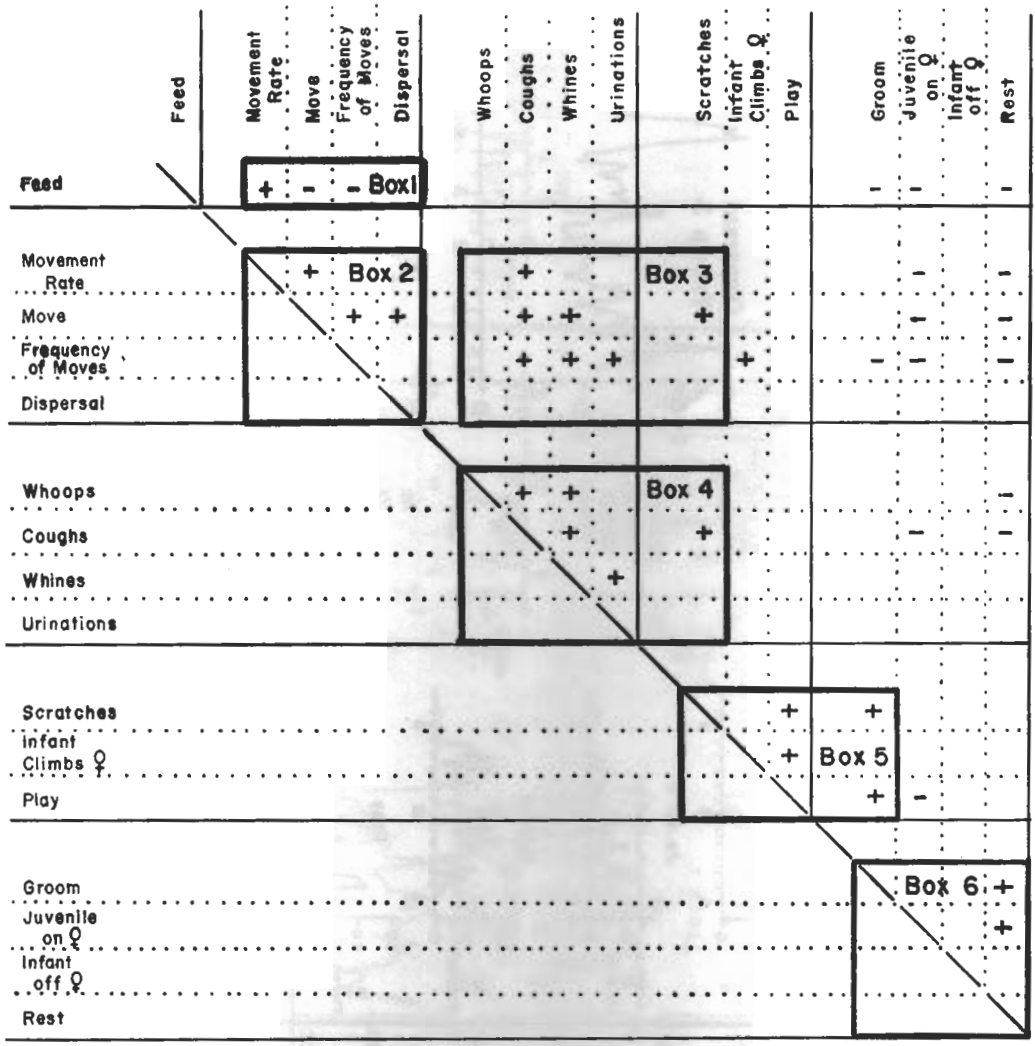


Fig. 5. Average distance between troop members on the extreme troop peripheries as a function of time of day for all observations on Troop 3 in 1974 (upper graph). The number of area deviations from the pathway pursued on April 13, 1968, as a function of time of day (lower graph).

Table 1. χ^2 table of associations of behaviors.



+: positive association; −: negative association.

pothesized and is strengthened by the association of whooping with whining is the use of the whoop display to maintain dominance within the troop. The whoop display involves an active locomotion and crashing through the branches (HORWICH, 1976). During it, juveniles and infants begin to cry and run to their mothers, indicating a fright response even though they had heard whooping a number of times each day. A similar behavior was observed in two species of colobus monkeys in captivity. When the males gave their roaring vocal display young juveniles and infants screamed and ran to their mothers. One particular female *Colobus polykomos*, began to submissively present to the male and to no other troop member although I had never seen him touch or threaten her. The roaring was the only action I had seen in which the young female gave cries and grimaces in regard to the male.

The association of whooping with coughs gives some support to another function of

whooping. Although whooping is not directly associated with troop movements, its association with coughs may indicate some relationship with troop movement or changes. Coughing seems to function in locating the male during movement and may actually affect the direction of movement although the male may not lead the moves. Whooping may rather forecast the change from one major activity such as resting, feeding, or moving, to another and it may serve to thus coordinate troop activities. Thus it may often precede moves although my data were not taken in a manner to determine this. However, this function may also be the reason whoops are sometimes given temporally close to inter-troop aggressive interactions although they are not used in a direct aggressive display. In one instance, I observed a whoop display given following an aggressive interaction between two troop males. One male displayed and then the troop headed toward the center of their territory away from the boundary dispute. On another occasion when a male had wandered an extensive distance from the troop and gave a whoop display, two females from his troop immediately ran in his direction.

Social Relationships

Box 5 shows the positive association of social activities some of which are associated with rest periods. These include play, grooming, scratching, and infants climbing on their mother which is an infantile play form. There is some evidence that these behaviors are related to a transition between rest and move periods. Grooming, for example, often occurred at the end of a long rest period. As some still rested, others would get up to move, encounter a troop member, and begin a grooming bout until one of the groomers moved away to feed or continue on a troop change of location. This trend is also suggested by the accumulated data of grooming for all three troops which shows most of the grooming occurred at the beginning and end of the main resting times and rarely occurred in the middle of the day (Fig. 4).

Scratches also show the possibility of this transition period. They are associated with movement and coughs which seem to function in communicating moves. On the other hand they are associated with play and grooming which are social contact behaviors and might stimulate the scratching. The relationship of social grooming and scratching may be in their common function in maintenance of body fur. Of course social grooming has a much stronger motivation linked to troop sociality and it is done primarily during the relaxed rest periods.

Rest Periods

Box 6 shows that rest is primarily only associated with certain social behaviors, grooming, and juveniles' clinging to their mothers. This again indicates the relationship of grooming and contact behavior to infantile needs which has been mentioned and expanded in another paper (HORWICH & WURMAN, 1978).

How Data Collection Methods Mask Daily Rhythms

Although there are many descriptions of activity rhythms of primate troop behavior in the field, these are usually as an extra bit of information as a part of a larger study (HORWICH, 1976). There have been a few detailed studies of activity patterns in nature (CLUTTON-BROCK, 1974), and I have found fewer still which consider the different methods of data lumping and how the resulting biological conclusions differ. I have found only two studies which show data differently, in which daily patterns as well as lumped general patterns in

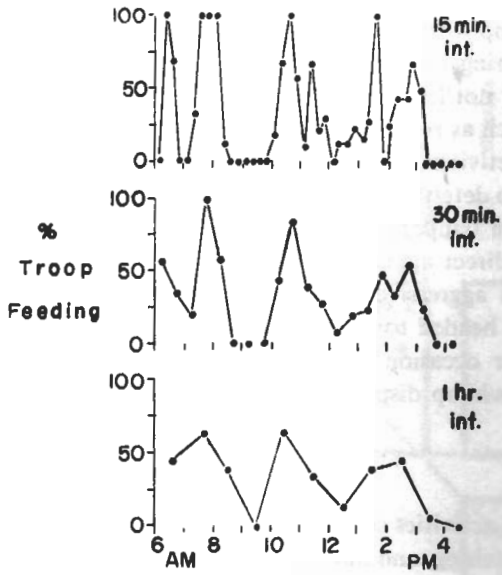


Fig. 6. The percentage of troop members feeding at 15 min, 30 min, and hourly intervals as calculated from 5 min observation periods in a troop of three yellow handed titi monkeys (constructed from KINZEY et al., 1977).

activity are shown. CLUTTON-BROCK (1974) noted that in *Colobus badius*, two to four bouts of feeding activity usually occurred on each day at the Kanyawara site. On the majority of days three peaks occurred. On some days the morning and evening periods extended to midday and only two bouts were present while on other days several distinct bouts occurred in the midday. At Gombe the dry season data were quite regular so that lumped data showed clear three peaks. However, during the wet season, the data look like the typical bimodal curves of lumped data of general primate activity. CLUTTON-BROCK (1974) however, notes that inspection of individual days of feeding activity suggests that a lack of a midday peak in feeding was not due to the absence of discrete feeding bouts at midday nor to a decrease in the amount of feeding activity at this time but rather to greater variability in the timing of midday feeding bouts. One major difference in the collection of that data and mine is that CLUTTON-BROCK lumped the data into half hour blocks and I used 15 min blocks of time. This can make considerable difference. I have earlier shown graphical differences when single days are compared with lumped data.

In another study of a family of three yellow handed titi monkeys (*Callicebus torquatus torquatus*) (KINZEY et al., 1977) a general trend of three peaks of feeding was found with peaks in early morning, late morning, and early afternoon. Although there is no mention of a difference in individual daily rhythms, they do show one complete day sample in which they recorded resting, feeding, and locomoting for each of the troop members every 5 min from 6 A.M. to 4 P.M. When these data are converted to daily graphs with 15 min intervals as I have done with langurs, the daily troop profile shows five or six feeding peaks (Fig. 6). A comparison with this data to the data lumped per half hour and hour again shows a masking of the additional feeding periods as with langurs and colobus.

In conclusion, both continuous collection of daily activity and an attempt at exhibiting smaller daily periodic units results in a more sensitive representation of the daily activity rhythms of an individual or troop on a daily basis. Examination of these more delicate cycles opens up a method of examining the associations and motivations of the behaviors.

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Author's Address: ROBERT H. HORWICH, *Institute of Micro-ontogenetic Ethology and Macro-cosmological Ecology, Route 1, Box 96, Gays Mills, Wisconsin 54631, U. S. A.*