

ASSESSING THREE METHODS TO ESTIMATE DAILY ACTIVITY PATTERNS IN RADIO-TRACKED MONGOOSÉS

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Abstract: We assessed 3 methods of estimating daily activity patterns in the Egyptian mongoose (*Herpestes ichneumon*): net activity time (M1), percentage of localizations with activity (M2), and distance traveled (M3). The 3 methods gave similar results ($r_s > 0.89$, $P < 0.0001$). With M1 and M2 7 days of tracking were necessary for obtaining a consistent activity pattern ($r_s = 0.91$), whereas 15 days were required for M3 ($r_s = 0.80$).

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Radio telemetry has been successfully applied to the study of circadian activity in animals. Nevertheless, it is difficult to obtain quantitative estimates of circadian activity, and it is not known how many days of sampling are necessary to produce consistent results in different species and seasons. The methods used to estimate circadian activity in wild animals with radio telemetry (all representing the results in definite time intervals) are: (1) those that measure net activity time (e.g., Erlinge 1980, Loughlin 1980, Ikeda et al. 1983), (2) those that measure the percentage of localizations coinciding with activity (Ables 1969, Garshelis and Pelton 1980, Haroldson and Fritzell 1984), and (3) those that measure distances covered (Ables 1969, Andelt and Gipson 1979, Haroldson and Fritzell 1984, Artois 1985). We compared results using these 3 methods in the study of activity of a small carnivore—the Egyptian mongoose—in southwestern Spain, including determining the sample size (i.e., no. tracking days) necessary to produce a consistent pattern of circadian activity for this species.

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STUDY AREA AND METHODS

We equipped 6 mongooses with radio collars containing tip switches (Wildlife Materials Inc., Carbondale, Ill.) from October 1985 to April 1986 in the Doñana Biological Reserve, Doñana National Park, southwestern Spain (approx 37°N,

6°30'W). Tip switches triggered a slow ($\bar{x} = 45$ bips/min [bpm]) and a fast ($\bar{x} = 90$ bpm) pulsing transmission mode depending on the collar position (see Garshelis et al. [1982] for a description of tip switches).

For 3 individuals (2 ad and 1 young F, as revealed by their body mass and dentition) we conducted 15 24-hour periods of intensive tracking on foot at close range (between 30 and 100 m) without disturbing their behavior (Palomares 1990). Throughout the tracking periods, we kept the portable receiver (AVM, Livermore, Calif.) continuously connected and noted the number of minutes during daylight that the animals were active; i.e., the animal was making some movement that frequently switched the pulse rate. These telemetric observations were usually complemented by direct visual observations. At night we only recorded the transmitter signal for 1 minute every hour. During the whole period, the position of the mongooses, as determined by direct observation, was noted every 0.5 hour during the day and every hour at night.

After confirming that the species in the area was strictly diurnal (Palomares and Delibes In Press), we limited tracking exclusively to the daytime periods; tracking for 13 diurnal periods was undertaken. From 28 tracking periods (15 of 24 hr and 13 of 14 hr) we obtained the following information: percentage of actual time with activity from 0600 to 2000 hours Greenwich Mean Time (GMT) (M1); percentage of localizations when the animal was active every ½ hour from 0600 to 2000 hours and every hour at other times (M2); and percentage of the total daily distance traveled in each 0.5-hour interval between 0600 and 2000 hours and in each 1-hour interval at other times (M3). Distance traveled was measured as the shortest distance between 2 consecutive locations. To avoid the error com-

monly associated with triangulation in radio-tracking studies (Tester and Siniff 1965, Mills and Knowlton 1989), we confirmed an animal's location by direct visual observation. Spearman rank correlation coefficients (r_s) were used for comparisons.

We used 2 approaches to establish the necessary sampling effort required to produce a consistent pattern of circadian activity. First, we estimated the minimum sample size (i.e., no. tracking days) needed to obtain an activity pattern figure significantly correlated to that obtained from all data. To do this, we compared the results obtained from accumulating the sampling days successively with the final result for 28 tracking periods. This was done independently for each of the 3 methods. Second, considering that M1 is a direct measure of activity time, M2 is a sampling of the same universe, and M3 is an indirect estimator because it measures distance instead of time, we established the minimum sample size (i.e., no. tracking days) with M2 and M3 methods needed to obtain an activity pattern estimate similar to that obtained with M1. To do this we compared the cumulative results obtained from M2 and M3 with the final result from M1. To make r_s more sensitive to variations within the period of activity, we limited the comparisons to the animals' active periods (0800–1800 hr). Seasonal variation in the activity patterns of mongooses is small in the study area (Palomares 1990), and all tracking days were performed during the rainy season of the year. So we assumed daily variation in activity during the study period was aleatory, and results were not influenced by the cumulative sequence employed.

RESULTS

The 3 methods gave the same overall results (Fig. 1), with maximum activity around 1330 hours, beginning and end of activity at about 0800 and 1800 hours, respectively, and a long period of nighttime rest. The value of r_s in comparing the results of M1 and M3 was 0.93, comparing M1 and M2 was 0.98, and comparing M2 and M3 was 0.89 (all P 's < 0.0001). Considering only the period of activity, some variation was detected with M3: there appeared an activity maximum after 1100 hours and a relative minimum after 1230 hours that were not detected by the other methods.

When we compared cumulative with final results for every method, r_s increased with the

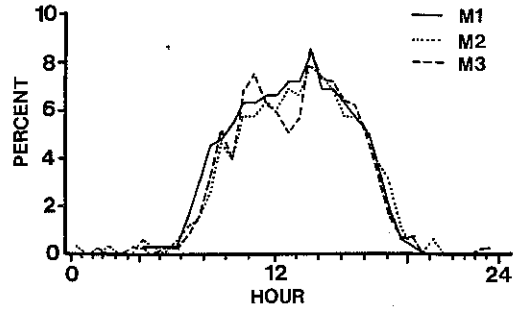


Fig. 1. Overall daily activity pattern of 3 mongooses estimated with 3 different methods from October 1985 to April 1986, Doñana National Park, southwestern Spain. All methods represent the relative percentages in 0.5-hour intervals from 0600 to 1900 hours GMT and 1-hour intervals for the remainder. M1 = net activity time; M2 = number of localizations with activity; M3 = distance traveled. M1 is represented from 0600 to 1900 hours only.

number of sampling days (Fig. 2a). With M1 and M2 the results became consistent on the seventh day, with values of r_s above 0.91, although on the third day they were already significantly correlated with the final results. With M3 however, 15 days of sampling were needed to obtain consistent r_s values; 8 days were necessary for the result to be significantly correlated with the final result.

When we compared the cumulative results of M2 and M3 with the final result of M1, M2 gave results more similar to those from M1, becoming consistent ($r_s > 0.9$) on the seventh day and becoming significantly correlated from the third day (Fig. 2b). For M3, by contrast, only after the eighth day were the results significantly correlated with the final results of M1; results were consistent after 8 days, but r_s was only about 0.7–0.8 (Fig. 2b).

DISCUSSION

Our results indicate that any of the 3 methods can be used to estimate accurately general patterns of daily activity. However, M1 is difficult and too expensive to apply, and unless automatic sensor-recorders of activity (e.g., Lancia and Dodge 1977) are available, the other 2 methods are simpler to apply and therefore are most often used. Of these last 2 methods, M2 is more sensitive than M3 in showing the circadian time of activity in the period when mongooses were active. Garshelis et al. (1982) also detected this greater sensitivity of M2 when studying black bears (*Ursus americanus*), although they lacked data on actual time of activity.

The variation we observed between M3 com-

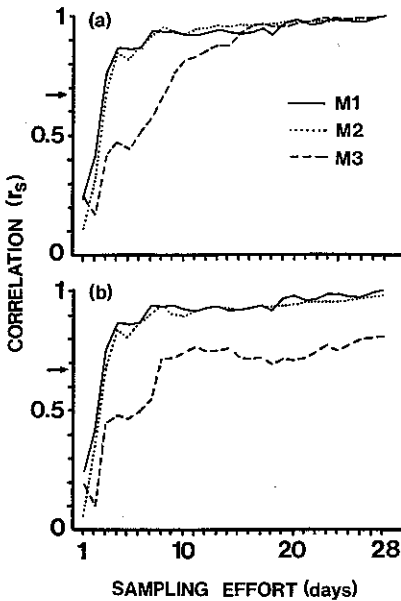


Fig. 2. (a) Correlations between the results obtained from accumulating the sampling days and the final result after 28 tracking periods for each method, and (b) correlations between the results obtained from accumulating the sampling days in M2 and M3 methods and the final result of M1. In the last case, M1 is also drawn for comparison. The arrow shows statistical significance at $P < 0.01$. (See Fig. 1 for description of methods.)

pared to M1 and M2 might have been caused because each method measures something different. For example, mongooses were active around noon, as M1 and M2 showed, but they devoted much time to eating, which involved smaller distances moved and caused M3 to dip in the middle of the day (Fig. 1).

In our study, cumulative results of all methods rapidly became consistent and statistically related to the final pattern of daily activity. Thus, few days of sampling were needed to estimate accurately daily activity in this species during the sampling season. However, M2 more closely reflected the actual measure of activity time, M1, than did the indirect estimator, M3. So if the primary interest is to determine activity time accurately, irrespective of whether activity is devoted to traveling or some other action, then the use of motion sensors would save time and money.

Our observations could probably be generalized to other carnivores, as suggested by Garshelis et al. (1982). Nevertheless, species with greater daily or seasonal variability in their patterns of activity (Ables 1969, Garshelis et al. 1982) might need longer periods of sampling

distributed throughout the year. Therefore, we recommend determining an adequate sampling effort for each species under study.

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