Locomotion and Activity Phasing of Six Carnivores and a Monkey

Comparative laboratory studies of mammalian activity have been hampered by the lack of a common measure, i.e., of a quantitative technique equally suitable for, say, a tiny rodent and a bobcat. While running in an activity wheel probably is the best technique for small mammals, it had not been applied to animals larger than the rat. Recently, however, PACKER[1] found that Tasmanian devils, *Sarcophilus harrisii*, will run wheels, while I have found that a wide range of confined cat- and dog-sized mammals readily do so. In essence a suitably large wheel simply provides an endless straight track along which animals can tread unhindered at their chosen gaits. The first comparative findings for influences of light on locomotion and activity phasing of medium-sized mammals are presented here briefly.

The animals studied were 1 female each of the bobcat (*Lynx rufus*), domestic cat (*Felis catus*), red fox (*Vulpes fulva*), cacomistle (*Bassariscus astutus*), tayra (*Tayra barbara*), and grison (*Grison vittatus*), and a male pig-tail macaque (*Macaca nemestrina*). Experimental procedures, including lighting, programming, recording, etc., were the same as for small mammals[2,3]. The activity wheel was 122 cm in diameter. The light cycle generally consisted of 12 h of bright light (up to 3200 lux), 10 h of dim light (up to 10 lux), and one transitional hour each of simulated dusk and dawn[2]. Times of daily feeding of zoo diets[4] were selected to minimize interference with activity. Study periods ranged up to 70 days.

The bobcat and domestic cat were arrhythmic, with most of the activity occurring at night. The customary gait was a 'deliberate' walk but galloping occurred regularly, particularly during twilights. Activity was in bouts of 10 to 30 min separated by much longer periods of rest. The red fox was nocturnal, at first, but sporadic daytime activity occurred late in the study. Activity was bout-like. For the most part the animal trotted, with frequent short periods of galloping. The cacomistle was strictly nocturnal. It trotted more or less continuously all night but galloped occasionally, especially during twilights. On the basis of amount of activity per unit time, all 4 animals were most active during twilights.

The 3 tropical animals were diurnal and tended to nap during midday. The monkey was most active during dawn and the post-dawn hours. It alternately walked on all fours and performed various acrobatics. The grison's activity was essentially bimodal, since it never missed its midday siesta. The tayra often was active more or less continuously but sometimes napped during midday. Both the grison and tayra walked most of the time. They were active very little or not at all during twilights.

Light intensity during the activity period influenced the arrhythmic and nocturnal animals much more than the diurnal ones. Thus, the speed, average length of running sessions, and amount of activity per unit time for the cats, fox, and cacomistle depended upon the light level during the night. On the other hand, the diurnal animals paid little note to temporary changes in the daytime light intensity-even a drop to total darkness. Like the small mammals of earlier studies[2,3], all 7 animals showed strong tendencies to tread unidirectionally for long periods.

Laboratory studies of the influences of light on activity phasing have the crucial advantage over field studies that all other environmental variables can be kept constant. Thus, the light regime is the chief external factor influencing activity phasing. If this regime fairly approximates natural light conditions, the phasing probably gives a good indication of the genetically determined state of adaptation of the visual system (the eye and all nerve connections). For example, if the animal is nocturnal in the laboratory, its visual system probably is adapted best for dim-light vision.

In the past, the chief behavioral guide for interpreting the anatomy of the visual system has been the activity phasing in the field[5]. But this phasing often is not a reliable index; it is an expression of complex interactions of the organism with many habitat factors, including light, predator pressure, food availability, latitude, and season. In this connection, mammals are highly adaptable and often can adopt habits for which their visual systems are not best suited. Indeed, studies of the vertebrate eye suggest that diurnality and nocturnality can appear and disappear over relatively short periods, evolutionarily speaking, as mutations and selection pressures direct[5].

Since only one representative of each species was tested, conclusions based upon these tests are only tentative. The activity phasing of 4 species, the bobcat, red fox, cacomistle, and monkey did not differ significantly from that presumed from field observations[6]. Reports for tayras conflict. Some workers report them to be primarily nocturnal[7], others chiefly or solely diurnal[8,9]. Our diurnal finding may help to resolve the conflict; tayras may be diurnal where unmolested but tend to become nocturnal where disturbed by man. It may be significant in this regard that the tayras that were diurnal[8,9] either were relatively undisturbed island inhabitants or tame animals in semi-captive conditions, with no fear of man.

The grison is said to be chiefly diurnal[10] but nocturnal activity also has been reported[11]. Since our animal responded like the tayra in most tests, and since both are tropical mustelids (weasel family) with many similarities, the same comments likely apply to the visual systems and activity phasing of both. The findings for the domestic cat suggest that a few thousand years of domestication have not altered a basically arrhythmic ancestral type.

Except for the domestic cat, there exists little or no direct knowledge of the retinal histology of the animals studied[6]. Until both the activity phasing in the laboratory and the detailed histology of the retinal cells and their interconnections (degree of summation, etc.) are at hand for a diverse representation of mammals, it would be

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premature to draw conclusions regarding relationships between the 2 lines of evidence.

The differences in the distribution of activity during activity periods probably correlate most closely with hunting and feeding habits in the field. One might expect a tendency toward continuous activity by animals subsisting on very small prey and plant materials, and toward bout-like activity by animals that take fairly large prey. The behavior of our animals fits roughly into this pattern. The tendency of the tropical diurnal species to nap during midday lends weight to the applicability of some aspects of laboratory findings to field behavior. The grison, in particular, has been reported to take shelter during midday heat[9]. The fact that a siesta also is taken in constant moderate temperatures in the laboratory suggests that the field habit is not solely a response to high temperatures.

The avid treading of wheels by cat- and dog-sized mammals suggests a new approach to their care and exhibition in zoos. Firstly, a suitably large wheel may offer a more desirable or efficient outlet for activity than the conventional zoo enclosure. Secondly, exhibits of mammals walking, trotting, galloping, performing acrobatics, and competing for the use of wheels probably would interest observers more than ones of their lying prone, sleeping, or occasionally pacing to and fro. The same approach also might succeed with larger mammals. A detailed report of these studies will appear elsewhere[6,12].

Zusammenfassung. Die Lokomotion sowie die phasische Aktivität sechs mittelgrosser Carnivoren und eines Makaken wurde am Laufrad untersucht. Die Laufaktivität nachtaktiver Tiere war stark durch die Lichtintensität beeinflusst, nicht aber die der diurnalen Tiere. Bei künstlichem Zwielicht waren erstere sehr aktiv, letztere wenig oder überhaupt nicht. Die Bedeutung dieser Ergebnisse für die phasische Aktivität im Freiland und den damit zusammenhängenden Grad der Adaptation des Auges wird diskutiert.

J. L. Kavanau

Department of Zoology, University of California, Los Angeles (California 90024, USA), 9 March 1970.

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The Culture of Goldfish Cells (*Carassius auratus*) at High Temperatures

It is known that if amphibian and reptilian tissues are selected from donor species ranging into tropical latitudes, growth and differentiation are possible in vitro at and sometimes above 37 °C[1,2]. Less is known regarding the upper limits for fish cell cultivation, although successful, short-term, primary cultures of goldfish cells at 37 °C have been recorded[3]. The growth rate of the FHM (fathead minnow) cell line[4] is maximal at 34 °C, cell death occurring at 38 °C. As the highest incipient lethal temperature of the goldfish, *Carassius auratus*, is regarded as being approximately 40 °C[5], the probability of culturing goldfish cells at 37 °C seemed high.

Material and methods: Primary cultures from a variety of adult organs of *Carassius* were prepared from aseptically minced tissues treated with 0.25% trypsin for 15 min at approximately 25 °C. After washing with serum-enriched medium, the explants were incubated at 31.5 °C on collagen films inside small Petri dishes maintained in an atmosphere of 5% CO_2 in air. The most effective medium used was Eagle's minimum essential medium supplemented with 20% young (3–6 month) calf serum and 0.1% lactalbumin hydrolysate. Antibiotics routinely used included sodium penicillin G (40 IU/ml), streptomycin sulphate (50 µg/ml) and amphotericin B (Fungizone) (2.5 µg/ml). Successive subcultures were carried out in flat McCartney bottles. Cell samples were transferred to other temperatures as required.

Results and discussion. Good primary outgrowths were obtained within 3–6 days from heart, spleen, ovary, testis and kidney. The most successful line[6] has been one derived from testis cells. At present this has been serially cultivated for 28 passages, occupying 140 days, with a period of 177 days' storage in liquid nitrogen at – 196 °C[7] between passages 17 and 18.

Cells have been maintained for 6 passages and 31 days at 37.5 °C without obvious morphological changes and with no apparent mitotic inhibition. Only preliminary experiments involving quantitative comparisons of growth rates have so far been carried out. Over a 3-day period, cells plated in similar numbers and densities showed overall population increases of 47% at 31.5 °C, 105% at 35 °C and 92% at 37.5 °C. Standardized cover-slip cultures incubated for 24 h at 31.5 °C, 35 °C, 37.5 °C and 39 °C showed normal cells and mitoses (Figures 1–3). The incidence of fragmented nuclei was possibly higher at 37.5 °C and above but the frequency of this condition has not yet been analyzed. In cultures incubated for 24 h at 41.5 °C, although a few relatively normal cells were still present (Figure 4), changes associated with cell death were generally apparent. Only a few mitoses, all obviously abnormal, could be found. The limit of heat tolerance of *Carassius* cells in vitro appears to be quite closely correlated with that of the fish in vivo[5].

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