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Case report

Social modulation of the daily activity rhythm in a solitary subterranean rodent, the tuco-tuco (*Ctenomys* sp)☆,☆

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ABSTRACT

South American subterranean rodents are mainly described as solitary and mutual synchronization was never observed among individuals maintained together in laboratory. We report that a single birth event was capable of disrupting the robust nocturnal activity rhythm of singly housed tuco-tucos from north-west Argentina. "Around-the-clock activity" was displayed by 8 out of 13 animals whose cages were closer to the newborn pups. However, experimental exposure to a pup vocalization did not produce a similar effect on the rhythms of adult animals. Our results indicate an effect of social interaction in the expression of biological rhythms even in solitary animals.

1. Introduction

Social modulation of circadian rhythms [1–3] has been reported in several species, such as birds [4–6], rodents [7–12], bats [13], primates [14–16] and invertebrates [17–20]. For a review, see [2,21]. Although several examples involve social animals, social modulation of activity rhythms could be particularly relevant in solitary species, such as hamsters [11,12], since encounters for reproduction and/or the need of intraspecific avoidance during non-breeding seasons require timing and synchronization among individuals. This synchronization could be mediated by non-photic social cues, such as pheromones, sound and sight of conspecifics.

Tuco-tucos (genus *Ctenomys*) are herbivorous subterranean rodents endemic to South America. The genus is very speciose, with circa 60 described species, and can be found in a great variety of habitats [22]. Despite evidence of sociality in some species (*C. sociabilis* [23], most tuco-tucos are deemed strictly solitary [24]. Among non-social species, reports of more than one animal found together are rare and restricted to mating couples or females with young [25,26]. In this context, we report that a single birth event unexpectedly disrupted the robust nocturnal wheel-running activity rhythm of a group of 13 singly housed tuco-tucos (*Ctenomys sp*) captured in La Rioja province in Argentina. This peculiar response of the other captive animals, which lasted one entire day on average for females and longer for males, revealed that circadian rhythms can be modulated by social cues, in this solitary subterranean rodent. An experiment was performed to test if this social modulation was intermediated by acoustic cues using playbacks of a pup vocalization.

2. Study species and ethical aspects

The animals used in this study were captured in the province of La Rioja, Argentina, in the locality of Anillaco (28° 48´ S; 66° 56´ W; 1445 m). The population of *Ctenomys* found in the area is called the Anillaco tuco-tuco however, species determination has not been completed yet. Morphological, molecular and genetic analysis for this purpose are ongoing.

During the time of this case report, tuco tucos were caught year-

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round for various experiments using PVC tube traps placed at fresh surface mounds inside natural burrows. Capture technics and laboratory experimentation protocols were approved and authorized by the Legal Technical Board (Oficina de Técnica Legal) of the Environmental Department of La Rioja (Secretaria de Ambiente, Ministerio de Producción y Desarrollo Local), Argentina (permission no 062-08). Every procedure followed the guidelines of the American Society of Mammalogists for animal care and handling [27].

3. Case report: effect of a birth event on activity rhythms

In the animal facility (410×300 cm), 13 adult animals (10 females and 3 males) were kept individually in acrylic cages (53×27 cm and 29 cm high) equipped with wire mesh lids and stainless steel running wheels. Cages were distanced from each other by 9 cm and animals were kept in 12 h light:12 h dark cycles (LD12:12) and 23 ± 2 °C. Food (fresh vegetables, seeds and rabbit pellets) was offered daily at random times. Because tuco-tucos obtain water from food, water was not provided. Wheel-running activity data was continuously recorded with the ArChron Data Acquisition System (Simonetta System, *Universidad Nacional de Quilmes, Buenos Aires*) at 5-minute intervals. Graphical output (actograms) and rhythm analysis were carried out using the *El Temps* software (A. Díez-Noguera, *Universitat de Barcelona*, 1999).

Under light/dark cycles, all tuco-tucos displayed very robust 24 h rhythms, with wheel-running activity concentrated in the dark phase (Fig. 1A). An unusual event of rhythm disruption was registered in several individuals: On October 22th 2008, one of the females (captured in July of the same year) gave birth to two pups in the animal facility. The female abandoned the pups, which wandered around the cage for two days until perishing. This event caused an unusual response in several other animals present in the room: out of 13 animals, seven females ran during the whole day and night (animals # 9, 19, 21, 23, 27, 29 and 24, the female with pups), displaying "around-the-clock" activity for one entire day. One male (# 10) also displayed this continuous 24 h activity but then totally interrupted activity for three continuous days. Two other males displayed long-term arrythmicity that lasted for at least 14 days (# 20 and 26) and rhythmicity was then restored without an observable phase shift (data

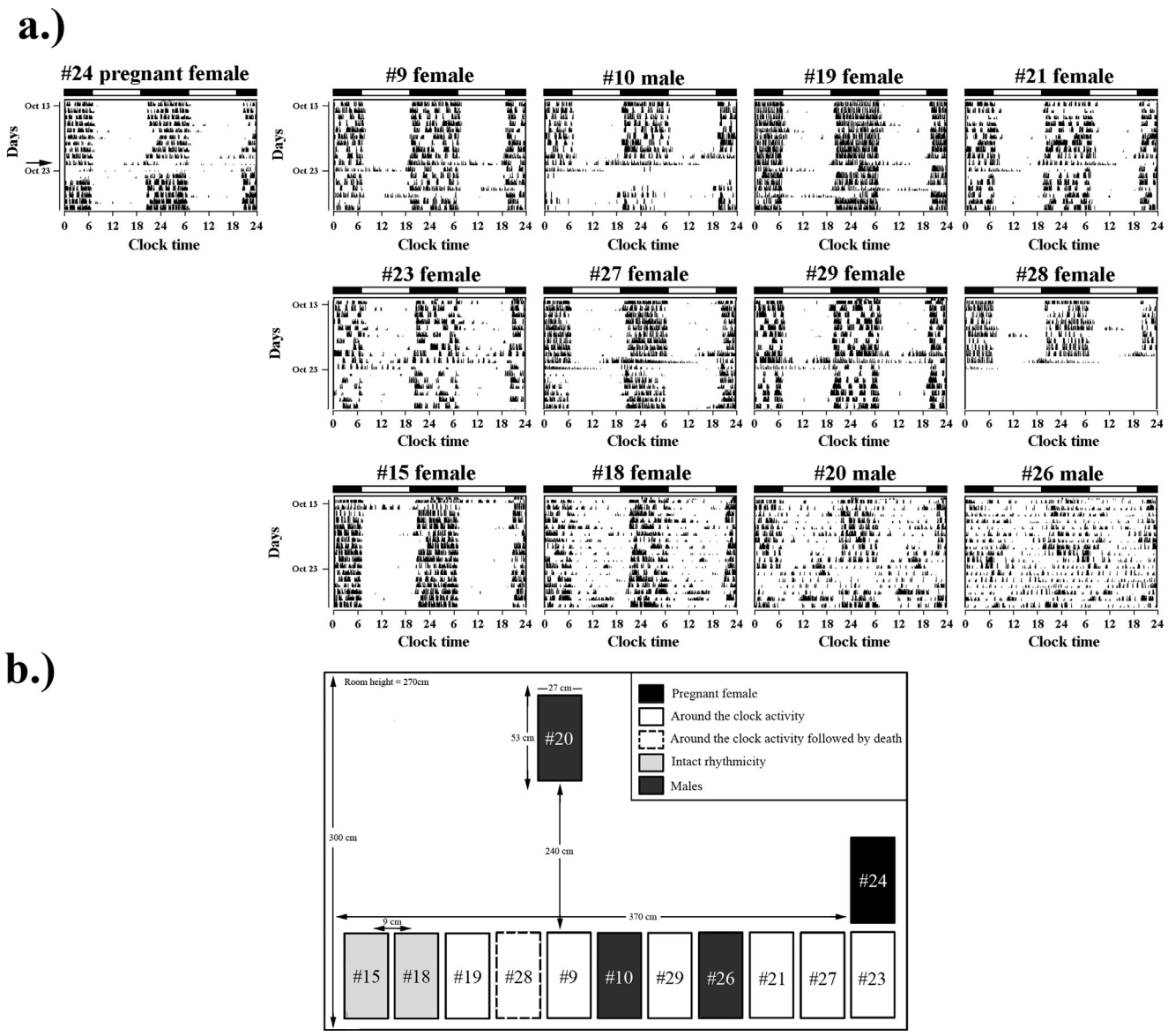

Fig. 1. Daily activity rhythms and spatial distribution of 13 individuals. A) Wheel-running activity rhythms depicted in double-plotted actograms. Each line represents two consecutive days and black marks denote activity. Black and white bars denote times of darkness and light, respectively, of an LD 12:12 cycle. On October 22, animal # 24 gave birth to two pups (shown with an arrow). B. Distribution of the animals within the animal facility. Animals # 15 and # 18 were farther away from the mom/pups and did not show any change in their rhythmic pattern.