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Seasonal changes in chronic social interactions and physiological states in female rat-like hamsters (*Tscheskia triton*)

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Abstract

We examined the behavioral characteristics and physiological states related to solitary lifestyle and dominant–subordinate relationships in female rat-like hamsters (*Tscheskia triton*), formerly known as *Cricetulus triton*. Wild adult hamsters were captured and caged singly in the laboratory during the non-breeding and breeding seasons. The experimental hamsters were subjected to 5 min staged dyadic encounters every day for 28 consecutive days by pairing two unfamiliar and weight matched females in a neutral arena. Aggressive behavior, defense and flank marking were quantified everyday within the first week and once each week during the last 3 weeks. Animals were then autopsied and their physiological and reproductive state assessed. Our results suggested that dominant–subordinate relationships could be established especially in non-breeding conditions, where the dominant displayed higher aggression and flank marking, and lower defense than its opponent. The breeding females followed this pattern except there was no difference in aggressive behavior, between the partners. The repeated encounters did not appear to reduce aggression or lead to amiable behavior or bonding. At the end of the experiment breeding females exhibited higher levels of serum estradiol, progesterone and corticosterone than non-breeding females. Both dominant and subordinate females in non-breeding condition had atrophied ovaries and uteri, whereas both dominant and subordinate females in breeding condition had hypertrophied ovaries and uteri. Non-breeding females possessed heavier and thicker flank glands than breeding females did. Dominant females displayed longer or thicker flank glands than subordinate did. Thus, our data suggest that the behavioral traits observed in our experiment support the solitary lifestyle of adult female rat-like hamsters and physiological state show some differences between social ranks or in both seasons.

Keywords: Dominant–subordinate relationships; Social rank; Physiology; Endocrine

1. Introduction

Some seasonally breeding rodents exhibit conspicuous seasonal shifts in behavior [16,19,23,24,48,57]. For example, many vole species are solitary when breeding and show high aggression, but are communal during the non-breeding season and show low aggression [48]. In contrast, in some solitary rodents such as the Syrian hamster (*Mesocricetus auratus*), males show elevated aggression when in non-breeding condition, while long photoperiod induces their gonad enlargement and gonad hormone production, and synchronously inhibits aggression [5,23,28]. In wild-captured, solitary adult rat-like hamsters (*Tscheskia triton*), both males and females remain highly aggressive during the non-breeding season [57]. These findings suggest that for some species there may be some correlations between traits of behavioral interactions and lifestyles. On the other hand, various studies have demonstrated that dominant–subordinate relationships are established quickly and maintained stably in many solitary male rodents [6,15,25], whereas the relationships in females are poorly known, especially in their non-breeding condition. Some limited studies have suggested that during the breeding season solitary females could not establish a stable social rank largely due to their reproductive status [18].

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Photoperiod is viewed as the most important proximate factor used by seasonally breeding rodents to mediate physiological regulation, such as the hypothalamic–pituitary–adrenal (HPA) axis and hypothalamic–pituitary–gonad (HPG) axis and endocrine status [4,8,43]. Those physiological changes can affect animals' behaviors, which then change seasonally with photoperiod [4,8,16,23,24,39,40,43].

Some studies have also demonstrated that there is a correlation between social rank or behaviors and the concentrations of some hormones [22,38]. For example, several authors have found that the level of testosterone was positively correlated with male dominance [20,42,47,58]. Further estradiol alone increase aggression and progesterone alone did not effect female aggression [1,17,36,47], while estradiol and progesterone together initially inhibited and later activated aggression [10,35]. With respect to the correlation between social dominance and blood glucocorticoid level, the traditional hypothesis is that the losers suffer more stress in social interaction, thus the level of glucocorticoid of subordinate individuals is higher than dominants. However, recent studies have shown that blood glucocorticoid level is not correlated with social dominance or is mainly altered in dominants [3,11,34].

Rat-like hamster (*T. triton*) is a solitary, non-monogamous species mainly inhabiting the farmland of North China, formerly known as *C. triton*. It breeds seasonally from late March to early September [50,56]. We have previously demonstrated that males are born with a pair of flank glands and a midventral gland, display high recruitment and are dispersal-prone; females are philopatric and have no stable mating association [51,55,56,59]. Males have high aggression during both the breeding and non-breeding seasons, and females are more aggressive during the non-breeding season [57]. There was also a correlation between social status, reproductive condition and flank gland marking in males [58]. Chronic exposure to predator odor could suppress aggression [52,53]. Our field capture observations suggest that individual adult male and females often live in two adjacent burrows and maintain a close social association (author's unpublished observations). Thus far, the social relationships and related physiological conditions of same sex adults, especially females remain unclear.

This study aimed (1) to examine whether female rat-like hamsters can establish stable dominant–subordinate relationships during the non-breeding and breeding seasons; (2) to determine the display of behaviors in the chronic social interaction encounter; (3) to investigate whether there are differences in physiological states of reproductive organs, and serum hormone levels between social ranks or the two seasons. We hypothesized that persistent undiminished aggression reflects the wild rat-like hamsters' solitary lifestyle, and physiological status should show some differences between social ranks or in both seasons.

2. Materials and methods

2.1. Animals and housing conditions

We captured rat-like hamsters using live-traps made of wire mesh in the farmland around Beijing during the non-breeding season (October, 2003) and breeding season (April, 2004). The hamsters were maintained in a reversed light:dark regime of 14 h:10 h (breeding condition, lights on at 1700 h) or 10 h:14 h (non-breeding condition, lights on at 2100 h) at approximately 20 °C for 4 weeks prior to the behavior tests. The subjects were housed individually in plastic cages (40 × 25 × 15 cm). Food and water were provided *ad libitum*. Wood shaving bedding material (softwood fibers) was changed weekly. Female rat-like hamsters weighing more than 80 g were assumed to be adults [50]. Females with perforate vaginas and showing regular estrous cycles were classified as potential breeders.

2.2. Social encounter

Twenty non-breeding (mean body weight ± S.D. = 121.83 ± 5.95 g) and 28 breeding adult females (mean body weight ± S.D. = 127.24 ± 3.40 g) were utilized in the behavioral tests. Two body weight matched (within 10% difference) breeding or non-breeding females were assigned to a pair. All behavior tests were conducted in an observation room under dim, red illumination during the first 2 h of the hamsters' dark cycle. The staged dyadic encounters took place in a clear Plexiglass box (length × width × height = 60 cm × 40 cm × 100 cm), in which two screens were placed parallel with the lateral wall to reduce the intensity of aggression and give losers a place to avoid being attacked. The arena was partitioned as two equal compartments using a removable opaque partition, and an individual from each pair was placed in one half of the arena. Following a 3-min acclimatization period, the opaque partition was removed and the hamsters were allowed to interact for 5 min. Behaviors were recorded by digital video. The interactions between the same pairs were repeated once per day for 4 consecutive weeks. Behavior was recorded everyday during the first week and on the seventh day of the last 3 weeks. The arena was thoroughly cleaned between trials with both water and 75% ethanol.

All behaviors within 5 min were cataloged using the following definitions and quantified by their duration using the software OBSERVER V 5.0 (Noldus, NL). Behavior was defined as follows [15,17,29,45,57,58]: *aggressive behavior*: biting, chasing, and sideways postures; *defense*: fleeing, cowering, threatening, lying on their back on the ground and upright postures; *flank marking*: arching back and rubbing toward the wall; *locomotion*: moving and exploring the environment; *amiable behavior*: mutual grooming, sitting or lying together. Females from each pair were recorded as either a winner or a loser by quantitatively comparing their attack-score in every daily encounter bout. The individual with the higher attack-score was considered the winner. After 28 days, the female in each pair displaying more wins than losses was defined as dominant and its opponent as the subordinate.

2.3. Physiological assay and hormone determination

Body weights were recorded once each week. On the 29th day, all animals were sacrificed. Blood samples were collected, centrifuged at 4000 rpm for 30 min, and serum aliquots were stored in polypropylene micro-centrifuge tubes at −80 °C until