



Different ovarian responses to potential mates underlie species-specific breeding strategies in common marmoset and Goeldi's monkey

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ABSTRACT

Callitrichids are cooperative breeders, characterized by obligate twinning, extensive paternal care, and monopolization of reproduction by the dominant female. This is the case in the common marmoset, and in common marmoset groups of more than one adult female, subordinate females are typically acyclic consistent with infertility. However, one callitrichid, Goeldi's monkey, gives birth to singletons and exhibits low paternal care. Given these reproductive traits of Goeldi's monkey, we hypothesized that there would not be suppression of ovarian activity. To test this hypothesis, we applied non-invasive endocrine methods in a step-wise experiment with laboratory groups of both species. In each species, six pairs of sisters were studied alone, in visual contact with an unrelated male and in a polygynous trio with the male, and urine samples were collected for determination of oestrogen titres reflecting ovarian activity. Common marmoset sister pairs exhibited a marked difference in social status: during the study 5 of 6 dominant females conceived but only 1 of 6 subordinate females; the remaining 5 subordinates were acyclic at the end of the study, and instances of ovulation typically resulted in aggression. Goeldi's monkey sister pairs showed no status differences: in all pairs, however, both sisters exhibited a temporary cessation of ovarian cyclicity on trio formation, followed by ovulation and conception. We conclude that these marked differences in ovarian responses reflect the differences in inter-female competition for paternal caregiving resources. In common marmosets with high inter-female competition, suppression of ovulation functions to reduce aggression received by subordinate females; in Goeldi's monkey with low competition, temporary cessation of ovulation could facilitate female choice.

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Introduction

Callitrichid monkeys have a highly specialized system of cooperative singular breeding with obligate twinning (Ah-King and Tullberg, 2000), extensive paternal care that starts within a few days of the birth of offspring (Garber, 1997; Goldizen, 1987), and strong monopolization of reproduction by the dominant breeding female (French, 1997). However, there is one callitrichid, Goeldi's monkey (*Callimico goeldii*), which gives birth to a singleton instead of twins (Martin, 1992) and exhibits delayed and low levels of paternal care (Heltne et al., 1973; Jurke and Pryce, 1994; Schradin and Anzenberger, 2001). In the common marmoset (*Callithrix jacchus*), in captive social groups of more than one adult female, the socially subordinate females are typically acyclic with low ovarian endocrine activity consistent with infertility (Abbott et al., 1981). In captive extended families with adult daughters, about 50% of these daughters are acyclic (Saltzman et al., 1997a,b,c). In their natural habitat, there are common marmoset groups with two simultaneously breeding females; genetic studies

suggest that these females are closely related, i.e. mother–daughter pairs or sister–sister pairs (Nievergelt et al., 2000). In captive Goeldi's monkey, adult daughters exhibit typical ovarian cyclicity in their natal family, even though they do not mate/reproduce in the family group (Dettling, 2002; Dettling and Pryce, 1999). In groups containing unrelated adult females, there are reports that both females exhibit ovarian activity, although one or both females can also exhibit periods of acyclicity, and conception or reproduction by more than one female can lead to aggression and loss of group stability (Carroll, 1988; Carroll et al., 1990; Pryce et al., 2002).

It is possible that the psychoneuroendocrine trait of ovarian acyclicity has evolved as a mechanism via which subordinate females can avoid aggression from dominant females, in species in which inter-female aggression would otherwise be high due to inter-female competition for paternal investment. If this is the case, then ovarian acyclicity in subordinate females would be expected to be more pronounced in the common marmoset than in Goeldi's monkey. To test this hypothesis, we applied non-invasive reproductive endocrinology methods in laboratory groups of common marmosets and Goeldi's monkeys. We based the study on sister–sister pairs because kin selection would predict that, relative to two unrelated females, there might be less competition for resources, particularly the

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resource of mate exclusivity, between sisters. Therefore, sister–sister pairs should provide a social situation that is sensitive to detecting inter-species differences in reproductive endocrinology supporting differences in reproductive strategies.

In each species, therefore, we experimentally induced three successive conditions in order to simulate the process of leaving the natal family and establishing a new breeding group. The conditions were as follows: females kept as sister pair (“Sister”), sister pair with restricted contact with an unrelated male (“Encounter”), and sister pair kept together with the unrelated male in a polygynous trio constellation (“Trio”). From six such trios per species and across each condition, we collected regular urine samples from females for determination of oestrogen metabolites that would provide accurate information on the status of each female’s ovarian activity. We then analyzed the relationship between social condition, ovarian activity

and social and reproductive outcome, specifically aggression and conception, in order to determine whether ovarian activity predicted social outcome, and whether ovarian activity and social outcome differed, as predicted by our central hypothesis, between these two callitrichid species.

Materials and methods

Study animals and housing conditions

We studied 12 captive-bred females of each of the species common marmoset and Goeldi’s monkey, between June 2003 and April 2005. All females were of adult body size and weight, at least 20 months of age and therefore of reproductive age (common marmoset: Abbott and Hearn, 1978; Goeldi’s monkey: Detting and Pryce, 1999). The study animals were maintained in the primate station of the Anthropological Institute, University of Zurich. They were kept in indoor cages of 4 m³ for common marmosets and of 6.1 m³ for Goeldi’s monkeys, equipped with natural branches, a sleeping box, and

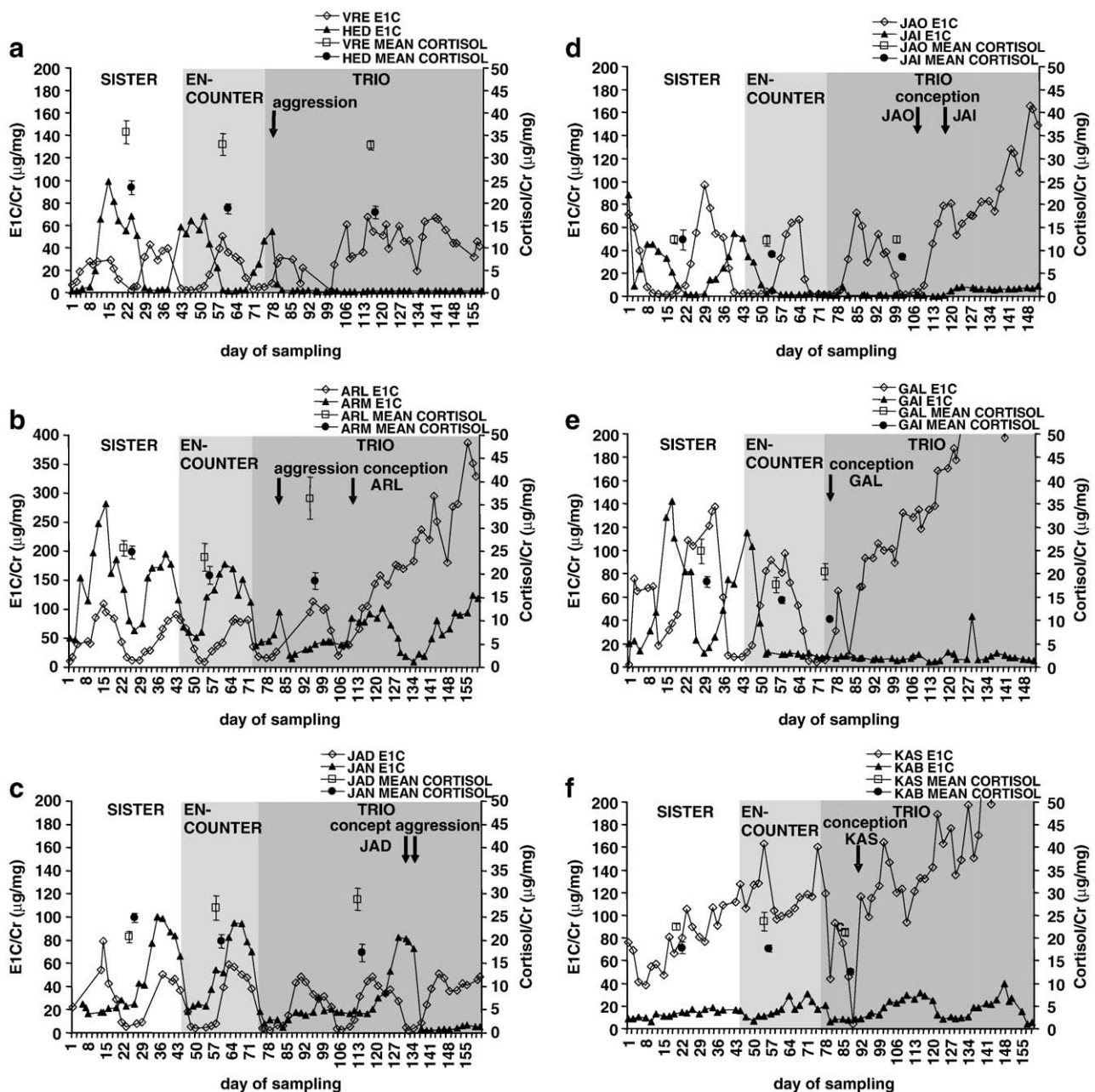


Fig. 1. (a–f) Urinary E1C profiles and mean ($\pm$ SEM) urinary cortisol values across the study period in common marmoset groups. Day of conception, estimated retrospectively, and day of first observed event of severe aggression that led to intervention and separation of the subordinate female, are indicated by an arrow. Mean cortisol concentrations during condition Trio are calculated using pre-conception samples only.

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