Body weight increase in expectant males and helpers of cotton-top tamarin (Saguinus oedipus): A sympton of the Couvade syndrome?

Susana María Sánchez Rodríguez, Fernando Peláez del Hierro, Ana María Fidalgo de las Heras,
Ana Morcillo Pimentel and José Manuel Caperos Montalbán
Universidad Autónoma de Madrid

In the cooperative breeding system of cotton-top tamarin (TCB; Saguinus oedipus) «expectant» males gain weight during the last months of pregnancy of their partners as a way to cope with energy costs of reproduction. This phenomenon was described only in humans as a symptom of «Couvade syndrome». As after infants' birth, TCB male and female helpers lose weight, the same as fathers do, it might be expected that previously, they also gain weight. In 8 groups of TCB, we explored body weight changes of the three categories of individuals, in periods of six months, under three different reproductive conditions: control (no pregnancy and without offspring), pregnancy (pregnancy and without offspring), and raising (with offspring). We found that across pregnancy, TCBs increase their weight in the last trimester of that period while across breeding TCBs reduce their weight in the first trimester. Expectant males and also helpers could be preparing during pregnancy in relation to the weight losses they experience when raising their young.

Aumento de peso corporal en machos expectantes y cooperantes de tití de cabeza blanca (Saguinus oedipus):¿un síntoma del Síndrome de Couvade? En el sistema de crianza cooperativa del tití de cabeza blanca (TCB; Saguinus oedipus) los machos «expectantes» aumentan de peso durante los últimos meses de la preñez de sus parejas como una forma de enfrentarse a los costos energéticos de la reproducción. Este fenómeno se había descrito únicamente en humanos como un síntoma del «síndrome Couvade». Puesto que los cooperantes macho y hembra de TCB asumen costos reproductivos, cabría esperar que previamente también ellos aumentaran de peso. Hemos explorado en 8 grupos de TCB el cambio de peso de las tres categorías de individuos, en períodos de seis meses en tres condiciones reproductoras diferentes: control (sin preñez y sin crías), preñez (preñez y sin crías) y crianza (con crías). Hemos encontrado que durante la preñez los tamarines aumentan de peso en el último trimestre de ese período, mientras que en la crianza reducen su peso en el primer trimestre. Los machos expectantes y también los cooperantes podrían prepararse durante la preñez en relación a las pérdidas de peso que experimentan durante la crianza.

In the cooperative breeding system of callitrichids monkeys the sole reproductive female of a group normally gives birth to dizygotic twins weighing 16 to 20% of mother's body weight (Tardif, Harrison, & Simek, 1993). Apart from the reproductive male, other members of the group, known as helpers or alloparents, provide care in rearing the young. In the cotton top tamarin (*Saguinus oedipus*) the gestation period has been estimated to be about six months (M= 184 days, Ziegler, Bridson, Snowdon, & Eman, 1987). Although offspring's independent locomotion begins after the first month of life (Cleveland & Snowdon, 1984), in the wild they are carried practically 100% of the time until their seventh week (Savage, Giraldo, Soto, & Snowdon, 1996). Weaning does not begin until week eight (Joyce & Snowdon, 2007), although mothers could become pregnant again 27.3 ± 4.1 days post-partum (Ziegler, Widowski, Larson, & Snowdon, 1990), and breeding periods in captivity frequently occur simultaneously with a new pregnancy.

Previous studies have found that cotton-top tamarin fathers and adult helpers lose weight after infants' birth, which has been related with the costs of carrying the infants, even in captivity (Achenbach & Snowdon, 2002; Sánchez, Peláez, Gil-Bürman, & Kaumanns, 1999; Sánchez, Peláez, Morcillo, & Gil-Bürman, 2005). It has been pointed out that the infant-carrying behavior of fathers and helpers may contribute to the improvement of the mothers' physical condition after birth (Sánchez et al.,1999), being critical for offspring survival (*Saguinus sps*.: Garber, 1997; Heymann, 2000).

More recently it has been found that expectant males of cotton-top tamarins and common marmosets (*Callithrix jacchus*) showed a significant weight increase during the last months of their mate's pregnancy whereas control males did not, which has been interpreted as fathers possibly preparing for the energetic cost of

fatherhood (Ziegler, Prudom, Schultz-Darken, Kurian, & Snowdon, 2006). Only in men it has been described such male sympathetic pregnancy symptom, and it has been referred as the «couvade syndrome» (Klein, 1991), that includes weight gain and other somatic symptoms. In the present study we retrospectively analyze body weight changes of reproductive individuals and adult helpers in family groups of cotton-top tamarins under three different female reproductive conditions: control (reproductive female was not pregnant and no dependent offspring), pregnancy (reproductive female was pregnant and no dependent offspring) and breeding (with dependent offspring). Our goal was to evaluate the described pre-birth weight increase in relation to the subsequent body weight losses after infants' birth, but considering the cooperative system as a whole and not as an isolate reproductive pair. Ziegler et al. (2006) speculated that the mid-pregnancy rise of glucocorticoids in pregnant females may stimulate a glucocorticoid response in expectant male tamarins (see also Ziegler, Washabaugh, & Snowdon, 2004). However, other factors such as behavioral communication, and feeding or resting behavior should be explored in order to clarify the basis of this weight increase. Our hypothesis is that if the weight gain of expectant males is related with the energetic costs of parenthood, it should be expected helpers (alloparents) also prepare for the body weight loss after infant births.

Method

Subjects

All the studied animals belong to the cotton-top tamarin colony at the Autonoma University of Madrid (UAM; Spain) and were housed in large indoor/outdoor enclosures. Animals are fed three times at day: porridge twice a day, between 8:00 a.m. and 8:30 a.m. and between 10:30 a.m. and 11:00 a.m., and a mixture of fruits, nuts, pellets, vegetables, bread, sunflower seeds and meal worms between 13:30 p.m. and 14:00 p.m. In our colony feeding schedules are routinely strictly controlled in order to avoid body-weight fluctuation caused by a variation in food supply. Porridge is weighed and food pieces cut in same weight units and a fixed number of each component is provided daily for each animal (for more details on colony husbandry and management see Sánchez et al., 1999, 2005).

Subjects of this study were adult individuals ≥24 months old (mean age 72 mo; range 24-131 mo) from eight different family groups (total group size excluding infants ranged from 2 to 10 individuals). A total of 13 different adult males and 5 different adult females were weighed during the study, and some of them have contributed to the sample under different occasions: 1) control condition: $n_{RM(reproductive\ males)}= 9$, $n_{MH(male\ helpers)}= 11$, $n_{FH(female\ helpers)}= 4$; 2) pregnancy condition: $n_{RM}= 6$, $n_{MH}= 7$, $n_{FH}= 4$; and 3) breeding condition:, $n_{RM}= 9$, $n_{MH}= 10$, $n_{FH}= 8$.

Procedure

Data were collected from January 2000 to January 2007. All individuals are routinely weighed on a scale (±1 g; Sartorius Universal Type 46100), at least in 3 different sessions per week, with a non-invasive procedure. Weighing sessions occurred in the morning before feeding, between 7:30 a.m. and 8:00 a.m (for details on weight procedure see Sánchez et al., 1999, 2005).

Weights have been retrospectively selected during three six months periods under different female reproductive conditions: 1) *control condition*: no sign of pregnancy was found in the reproductive female (next birth was at least 6 months after the end of this period), and no dependent offspring (age< 6 months) was present in the group, 2) *pregnancy condition*: the reproductive female was pregnant (six months prior to reproductive female's delivery), and no dependent offspring (age<6 months) was present ; and 3) *breeding condition*: during the 6 months after infants' birth (at least one offspring was alive at the end of this period).

Study design consisted of repeated measures across the months of each reproductive condition, but samples were independent among conditions. Since the data were collected over a long time, some individuals were weighed under different conditions and also some individuals were weighed under a same condition but at different times. However, because size, sex, and age composition of the groups changed along the seven years of data pool, and individuals' age and reproductive condition changed too, tamarins have been considered different within and between reproductive conditions (see above).

Data analysis

To standardize the individual's weight change among conditions, and among category of individuals, we calculated the *per cent change in monthly mean weight* relative to the first month's weight in the control and pregnancy conditions, and to the pre-birth weight in the breeding condition (monthly mean weight of the month prior to birth) (Sánchez et al., 1999, 2005). We have then expressed this difference as a percentage relative to the first month's weight which was considered 100%. Standardizing the weight change permits comparisons among different age classes and among species (Ziegler et al., 2006).

Two-way ANOVA was performed under each condition of our study (control, pregnancy, breeding) to test differences in the percent change in monthly mean weight among categories of individuals (reproductive males, male helpers, female helpers) as the first factor and across months as the second factor. When differences were found we used the Tukey post-hoc test for multiple comparisons to determine where the differences occurred. All tests were two-tailed, and we have considered that difference was significant when p<.05.

Results

When comparing the percent change of monthly mean weight of the different categories of individuals during the control condition no significant effect was found for category ($F_{2,21}= 1.35$, p= .27), nor for month ($F_{5,105}= .47$, p= .79), nor for the interaction of category with month ($F_{10,105}= .61$, p= .79).

During pregnancy condition the analysis did not show difference for the categories ($F_{2,14}= .002$, p= .99), however we have found a significant effect of the month ($F_{5,70}= 6.05$, p< .001), tamarins weighed more in months 6, 5, 4, and 3 than in the first one, and more in months 5 and 4 than in the second one. Increase in weight in months four to six of the pregnancy period was 3.3% (N= 17; SD= 4.1%). The interaction category × month was not significant ($F_{10,70}= .13$, p= .99) (Figure 1). Then we have compared the same categories of individuals across months four to six of the pregnancy period, but no significant effect of category

($F_{2,14}$= 0.14, p= .98), nor month ($F_{2,28}$= .96, p= .39), have been found, and neither the interaction category × month was significant ($F_{4,28}$= 0.33, p= .85).

During breeding condition no effect of category has been found ($F_{2,24}$= 1.61, p= .22), however difference was significant across months ($F_{6,144}$= 12.53, p< .001). The animals weighed less in months 1, 2, 3 and 5, than in the pre-birth, less in months 1, 2 and 3 than in month four, less in month 3 than in the sixth, and less in month 2 and 3 than in month 6. Tamarins decrease a mean value of 4.8% (N= 27; SD= 3.7%) in months one to three. No significant differences were observed for category, and its interaction with month factor ($F_{12,144}$= 1.30, p= .22) (Figure 1). From the pre-birth to the third month of the breeding period, although no significant effect of category has been found ($F_{2,24}$= 2.60, p<.09) male helpers show a trend to reduce their weight more than fathers, and female helpers; on the other hand a significant effect has been found across months (F $_{3,72}$= 22.56, p<.01), and weights were lower in the first, second and third month after infants' birth than in the pre-birth. Finally, an interactive trend between both factors ($F_{6,72}$= 1.93, p= .08), suggest difference among category of individuals across the first three months of breeding (Figure 1).

Discussion

It has been reported that captive expectant cotton-top tamarin males increase their weight up to 3% during last months their mate's pregnancy, and similar results were also found for reproductive common marmoset males (Ziegler et al., 2006). In biparental species, the evolutionary process might have provided males with mechanisms to perform their role in parental care (Daly, 1979), which could be in accordance with the suggestion of Ziegler et al. (2006) about the physiological responsiveness to the pregnancy of its mates (see also Ziegler et al., 2004). In men such male sympathetic pregnancy phenomena has been referred as the «*couvade syndrome*» (Klein, 1991, see also Storey, Walsh, Quinton, & Wynne-Edwards, 2000), which includes weight gain and other somatic symptoms. Ziegler et al. (2006) have considered that the observed weight increase of expectant males previous to the birth might function as a preparation for the energetic costs of fatherhood. However in the cooperative breeding system of the cotton-top tamarin, not only fathers, but also adult male helpers and adult female helpers (alloparents) experience body weight losses after infants' birth (Achenbach & Snowdon, 2004; Sánchez et al., 1999, 2005), that have been considered a cost related with their contribution to infant carrying (Sánchez et al., 1999). Therefore, we expected that adult male helpers and adult female helpers would increase their weight previously to infants' birth as expectant males do. Our results show no significant difference among expectant males, male helpers, and female helpers, and all they increase a 3.3% their weight during the last trimester of the pregnancy of the reproductive female, a similar amount to that described by Ziegler et al. (2006) for expectant males.

Ziegler et al. (2006) speculated that the glucocorticoid response in expectant male tamarins (see also Ziegler et al., 2004) might be related with increase in weight. Also some hormonal changes related to infants' birth have been described in adult male helpers of cotton-top tamarin (Ziegler, Wegner, & Snowdon, 1996). However, the subjacent mechanisms to body weight increase are still unknown, and some other factors, such as behavioral communication, feeding, and resting behavior, should be explored in order to clarify the basis of this weight increase around mid-pregnancy. Food supply is well controlled in our colony, and the same amount of energy is provided daily for each individual. However, we can not discard changes in the energy balance, by
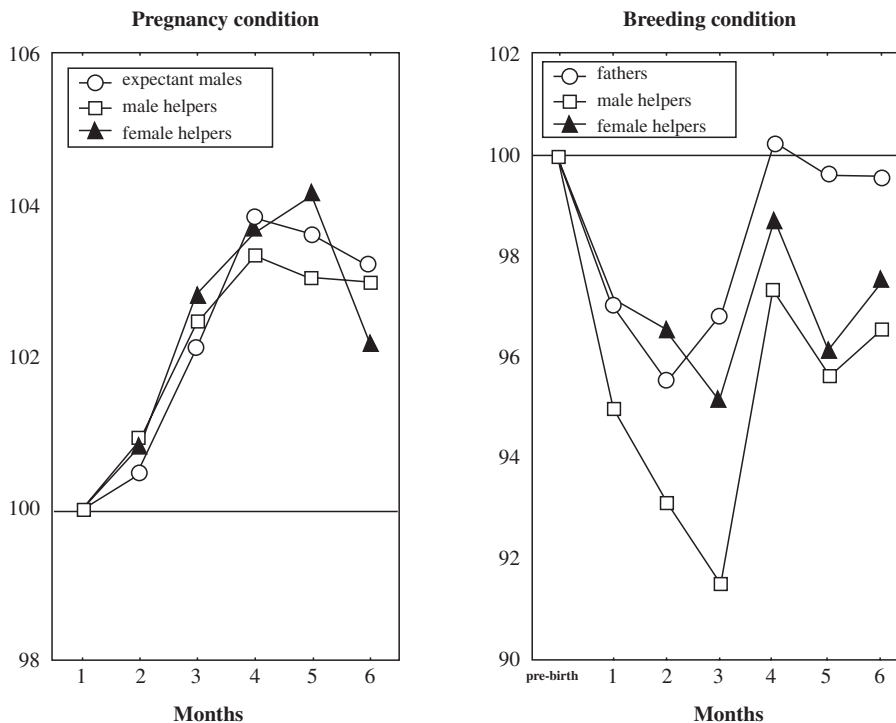

Figure 1. Percent change in body weight of the reproductive male, adult male helpers and adult female helpers under pregnancy and breeding condition

some alteration in food intake or energy expenditure (e.g. changes in activity) during pregnancy, in expectant males and in alloparents. In humans is well known that changes in weight are highly dependent on diet, but also on energetic expenditure related with physical activity (i.e., Amigo, Fernández, Rodríguez, & Rodríguez, 2005; Vera, 1998). In other primates in which fathers also have high energetic expenditure during female lactation (*Varecia rubra*), expectant males travel less, and feed and rest more, during their mate's gestation as the pregnant females do (Vasey, 2005). In cooperative breeding system in which helpers (alloparents) also have an increased energetic demand related with infant rearing, similar behaviours could be favoured through the evolution.

When comparing the percent change in body weight among fathers, male helpers and female helpers, during the months under the pregnancy condition we found a significant effect of months but not of the category. In relation to the pre-birth weight, tamarins lost weight especially during the first trimester, to a mean value of 4.8%. Although previous studies show a relation of body weight losses with infant carrying (Achenbach & Snowdon, 2004; Sánchez et al., 1999, 2005), neither can we discard an effect of changes in feeding or in the activity of tamarins. During the first trimester under the breeding condition, male helpers show a tendency to lose more weight than fathers and female helpers. The contribution of male helpers has been proposed as of especially relevance (Goldizen, 1987), and some studies indicate that the number of male helpers in the groups is a factor related with increase in infants' survival (Garber, 1997; Heymann, 2000). Also, individual roles in infant care varied greatly in function of the groups' composition, and family members compensated for these

variations by adjusting their own individual behavior (Washabaugh, Snowdon, & Ziegler, 2002).

In summary, our results support the functional hypothesis of Ziegler et al. (2006) that increase in body weight of expectant cotton-top tamarin males could be preparing them for the body weight losses that they experience after infants' birth, but also that male helpers and female helpers do it. Ziegler et al. (2006) suggested that such increase could relay on a special communicative system physiologically mediated between the mother and the expectant male. However, neither they nor we could discard the effect of some other factors in this weigh increase, such as changes in feeding or resting; and the same could be argued in relation to alloparents in a cooperative breeding system. Callitrichid primates seem to be a promising model for comparative studies.

Acknowledgments

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