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Pregnancy weight gain: marmoset and tamarin dads show it too

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Paternal behaviour is critical for the survival of offspring in many monogamous species. Common marmoset (*Callithrix jacchus*) and cotton-top tamarin (*Saguinus oedipus*) fathers spend as much or more time caring for infants than mothers. Expectant males of both species showed significant increases in weight across the pregnancy whereas control males did not (five consecutive months for marmoset males and six months for cotton-top tamarin males). Expectant fathers might be preparing for the energetic cost of fatherhood by gaining weight during their mate's pregnancy.

Keywords: weight gain; paternal care; couvade; primates

1. INTRODUCTION

Although most male mammals lack physical changes associated with female gestation, males in biparental species would be more likely to show these changes. Several biparental New World monkeys demonstrate changes in reproductive hormones associated with parenting. Male Goeldi's monkeys (*Callimico goeldii*) and cotton-top tamarins (*Saguinus oedipus*) have elevated prolactin in the late pregnancy of their mates (Ziegler & Snowdon 2000; Schradin *et al.* 2003), common marmoset fathers (*Callithrix jacchus*) have increased prolactin levels while carrying young infants (Dixson & George 1982; Mota & Sousa 2000), and expectant male cotton-top tamarins show changes in testosterone, dihydrotestosterone and oestradiol during their mate's late pregnancy (Ziegler *et al.* 2004). Men have shown hormonal changes during their mate's pregnancy. Expectant human fathers have higher cortisol and testosterone levels prior to the birth of their infant than after birth (Storey *et al.* 2000; Berg & Wynne-Edwards 2001). Between 11 and 65% of men across cultures have some symptoms of pregnancy (Masoni *et al.* 1994).

Physical changes, such as male weight gain, may be incidental to the hormonal changes occurring to prepare males for their role in infant care and may be a part of an evolutionary process that is occurring in biparental species (Daly 1979). Selection affects biparental males by diverting their reproductive effort into parental investment (Emlen & Oring 1977). Additionally, the extensive energetic investment made

by these fathers in caring for their young offspring may require larger energy reserves.

We examined body weights of expectant male common marmoset and cotton-top tamarin fathers over their mate's gestation to test the hypothesis that these fathers would gain weight before the birth of their offspring.

2. MATERIAL AND METHODS

We obtained a monthly weight measurement of marmosets and tamarins under three conditions: (i) males during their mate's gestation (14 marmosets, 11 tamarins), (ii) pregnant mates of most of these males (9 marmosets, 11 tamarins) and (iii) control males (6 marmosets, 7 tamarins) for a total of 29 common marmosets and 29 cotton top tamarins. The monkeys were weighed prior to the onset of pregnancy and weights were selected retrospectively by weeks from gestation. Gestation length is five months for the common marmoset (Hearn & Lunn 1975) and six months for the cotton-top tamarin (Ziegler *et al.* 1987). In both marmosets and tamarins, no individual contributed to both the control and the expectant categories.

Marmoset monkeys were housed socially at the National Primate Research Center, University of Wisconsin-Madison. During the study, males were living either as the breeding male of a family or with a mate. Control males were paired with a female which was not pregnant and no offspring were present. All males were between the ages of 1.75 and 11 years (mean \pm s.d. : 4.6 ± 3.0).

Tamarin monkeys were socially housed at the Department of Psychology University of Wisconsin-Madison as the breeding male of a family. Control males were paired with a non-pregnant mate. All males were between the ages of 3 and 12.75 years (8.6 ± 3.4).

No changes in diet quantity or quality occurred during the gestational period. Water was available *ad libitum* for both species. Marmosets were fed once daily between 12.30–14.30 h. Tamarins were fed one main meal between 12.00 and 13.00 h with an early morning and late afternoon snack.

Weights were obtained for marmosets in the morning prior to feeding by removing the marmoset from its cage in its metal nest box and placing the box on a scale (Sartorius, Model BP12000-S, $d=0.1$ g). The weight of the box was subtracted from the total weight leaving the monkey's weight in grams. Tamarins were weighed in their home cages by luring them individually onto a scale (Sartorius, Model LC 1600, $d=0.01$ g) with a treat and then recording their weight. This was repeated five times and the average weight was logged each month.

Statistical analysis. There were no differences between the expectant and control groups in weight during the first month for marmosets ($t=0.12$, $p=0.9$) and tamarins ($t=0.15$, $p=0.9$). *t*-tests were performed between months on the weight of each monkey's monthly weight to examine whether they increased their weight consistently from the first month. A Bonferroni correction was used due to multiple analyses. We calculated the percent change in weight from months to standardize the change in weight over gestational months. The second or third month was missed for four male marmosets, two male tamarins, three female marmosets and one female tamarin. The average of the month preceding and following that month was used for the missed month. Male and female percent change in weight by month was analysed with repeated measures Friedmans two-way ANOVA. Wilcoxon signed ranks tests were used for *post hoc* analyses.

3. RESULTS

The mean weight of marmoset expectant fathers was 410 ± 8 g (mean \pm s.e.m., $n=14$) for the first month of gestation and had increased to 424 ± 11 g by the fifth month. Month five was significantly higher than month one ($t=4.0$, $p=0.001$) and month two ($t=3.9$, $p=0.01$). No other months were significantly different from each other. There was no weight difference in month one between marmoset control and expectant males (406 ± 24 , $t=0.2$, $p=0.9$). Control males showed no differences in weight across the gestational months (for all *t*-tests, $p>0.05$). Expectant marmoset males showed significant weight change across the five gestational months (2.4–20.4% increase, $F=17.2$,

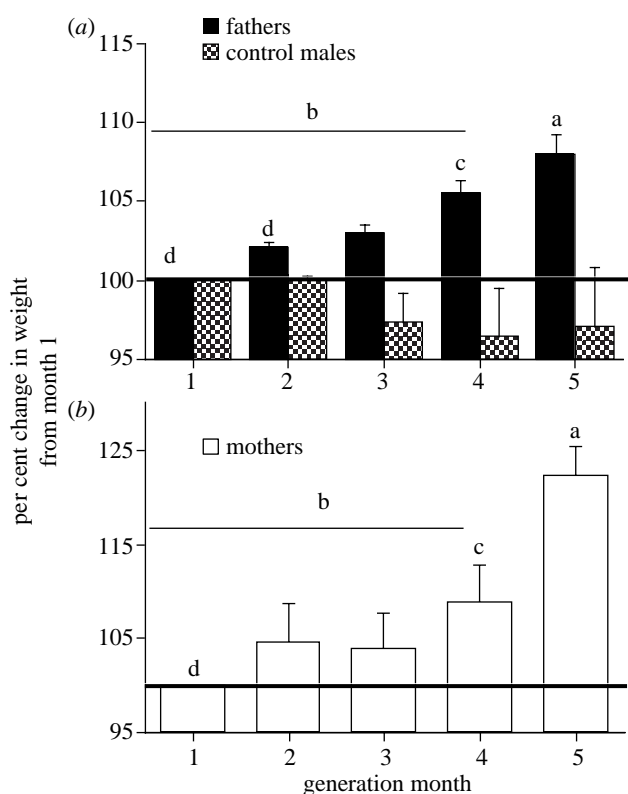


Figure 1. (a) Per cent change in male and (b) female body weight over the gestational range in common marmosets. Dark bars indicate expectant fathers and light bars indicate control males weighed for five consecutive months. A dark line is drawn across the 100% line. Letters indicate months significantly different from each other. For expectant marmoset fathers, month four was significantly higher than month one ($Z=2.4$, $p=0.02$) and month two ($Z=2.2$, $p=0.03$) but not months three and five. Month five was significantly higher than month one ($Z=2.9$, $p=0.004$), month two ($Z=2.8$, $p=0.005$), and month three ($Z=2.05$, $p=0.04$) but not month four. For mothers, month five was significantly higher than months 1–4 ($Z=2.6$ – 2.7 , $p=0.01$ – 0.008) and month four was significantly higher than month 1 ($Z=2.07$, $p=0.04$).

$n=14$, $p=0.002$) whereas control males did not ($p>0.05$), figure 1. The greatest change in weight for expectant male marmosets occurred in the fourth and fifth months.

The mean weight of expectant tamarin males was 556 ± 22 for the first month of gestation and increased to 568 ± 22 by the sixth month. There was no difference in tamarin expectant males' weight in month one from control males (567 ± 24 , $t=0.2$, $p=0.9$). Control males showed no significant differences whereas expectant tamarin males showed that month one was significantly different from month two ($t=3.6$, $p=0.004$), month four ($t=6.3$, $p=0.0001$), month five ($t=7.5$, $p=0.0001$) and month six ($t=6.5$, $p=0.0001$). Expectant tamarin males showed significant weight change across the six gestational months (1–8%, $F=14.3$, $n=14$, $p=0.01$) whereas control males showed no significant weight change, figure 2. The greatest weight change occurred in the last three months of gestation (4, 5 and 6).

Both female marmosets and tamarins also showed significant increase in weight over the gestational

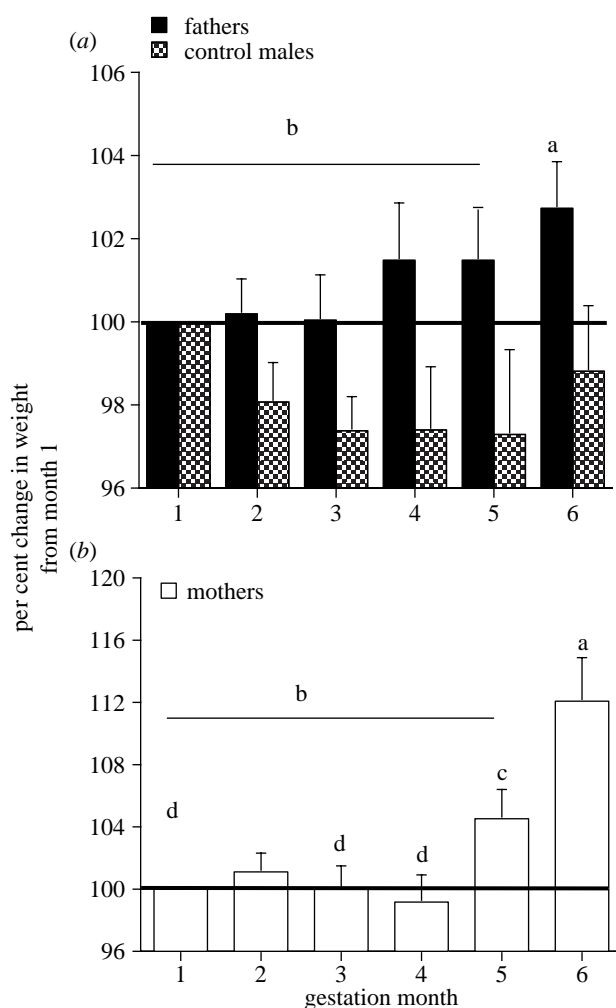


Figure 2. (a) Per cent change in male and (b) female body weight over the gestational range in cotton-top tamarins. Dark bars indicate expectant fathers and light bars indicate control males weighed for six consecutive months. A dark line is drawn across the 100% line. Letters indicate months significantly different from each other. For expectant tamarin fathers, month six was significantly higher than month one ($Z=2.6$, $p=0.01$), month two ($Z=2.0$, $p=0.05$) and month three ($Z=2.1$, $p=0.04$) but not month four or five. For mothers, month six was significantly higher than months 1–5 (Z 's=2.8–3.2, p 's=0.001–0.005) and month five was significantly higher than months one, three, four (Z 's=2.27–2.9, p 's=0.02–0.005).

months (marmoset: $F=18.6$, $p=0.001$; tamarin: $F=27.1$, $p=0.0001$; figures 1 and 2). The average weight of female marmosets in the first month of gestation was 364.1 ± 13.3 g (mean \pm s.e.m.) and weight increased to an average of 441.9 ± 8.1 g by the last gestational month. Tamarin females weighed on average 529 ± 17.7 g during the first month of gestation and increased to an average weight of 599.7 ± 17.3 g by the last month before birth.

4. DISCUSSION

Expectant males of both species showed significant weight gain during their mate's pregnancy. This is the first demonstration of an incremental increase in weight in non-human primate expectant fathers. Male marmosets showed a greater change in weight than did the male tamarins, but this might have been due

to the different weighing methods or factors unknown. The weight gain occurs on a different timetable than female weight gain and has a clear adaptive potential in these males.

The only other species of primates which has been reported to have weight gain during their mate's pregnancy are men, but no systematic study has been reported. Sympathetic pregnancy symptoms in men are referred to as 'couvade' (derived from the French 'to incubate or hatch'), indicating that men share some of their mate's pregnancy symptoms (Klein 1991). These symptoms include weight gain, nausea, headache, irritability, restlessness, backache, colds and nervousness (Clinton 1986). In one study of 81 expectant fathers, 47% experienced weight gain during the third trimester of gestation (Clinton 1986). Most reports of pregnancy symptoms in men have been thought to be psychosomatic, without a physical or biological basis for the symptoms (Klein 1991).

Neither the marmosets nor tamarins had their food supply increased during the pregnancy. However, without further research into the eating patterns of both sexes during the gestational period, it is unknown whether there is an increase in food intake to cause the weight gain or whether the males experience a change in metabolism in preparation for parturition. Both species receive more food than they normally eat within a day. Males begin to increase their weight prior to females, who show their highest increase in weight either during the last month of gestation (marmosets) or during the last two months of gestation (cotton top tamarins) when the greatest foetal growth occurs. This phenomenon suggests that expectant males are not following the trajectory of females, which might occur if they were eating sympathetically. Non-human primates are fed a complete diet on a daily basis, unlike humans who are able to change caloric intake over gestation.

It is clear that expectant fathers of these species are physiologically responsive to their mate's pregnancy and the impending birth. Males need to be prepared to engage in infant care immediately after birth and this requires carrying multiple infants weighing up to 20% of their adult body weight. Both the hormonal and the physical weight change suggest that marmoset and tamarin males prepare for the demands of infant care.

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