American Journal of Primatology 52:199–205 (2000)

BRIEF REPORTS

High Incidence of Supernumerary Nipples and Twins in Formosan Macaques (*Macaca cyclopis*) at Mt. Longevity, Taiwan

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A population of Formosan macaques at Mt. Longevity exhibits an unusually high incidence of supernumerary nipples (polythelia: between 1–6 accessory nipples and/or areolae on 33% of adults), as well as a high rate of twinning (about 1% of births). The coexistence of these unusual traits suggests a connection, which is further supported by a tendency for mothers of twins to have accessory nipples and for twins to be born in troops with high incidence of polythelia. Am. J. Primatol. 52:199–205, 2000.

Key words: polythelia; twin; development; founder; *Macaca cyclopis*; Taiwan

INTRODUCTION

The Formosan macaque (*Macaca cyclopis*) evolved from a rhesus macaque (*M. mulatta*) ancestor when they became isolated on the island of Taiwan [Hoelzer & Melnick, 1996]. At present they are restricted to coastal rainforests in the south and mountainous forests in the east. They are considered Threatened and are fully protected, though some poaching does continue (personal observations). Although field surveys have been conducted to determine their status and distribution [Lee & Lin, 1991], little is known about their population ecology, reproductive parameters, and social behavior. Social behavior and troop size data are limited to a single troop studied in Kenting [Wu & Lin, 1992; Wu & Lin, 1993]. We have been monitoring 16 troops of Formosan macaques at Mt. Longevity, southern Taiwan, since 1993 [Hsu & Agoramoorthy, 1999; Hsu et al., 2000]. In this work, we present data on the occurrence of supernumerary nipples among these monkeys and discuss them in light of the unusually high rate of twinning at this site.

Contract grant sponsor: National Science Council, Republic of China; Contract grant number: 88-2313-B-020-023.

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Received 5 June 2000; revision accepted 14 September 2000

METHODS

The study population of about 790 monkeys occupies Mt. Longevity, a 1,116 ha protected area covered with tropical lowland rainforest, located within the city limits of Kaohsiung. Observations began in January 1995, and currently 16 troops are monitored on a regular basis. Subjects mentioned in this work are individually known. Kin relations and ages were verified from genealogical records compiled by the authors (unpublished). Troop compositions and polythelia prevalences reported here are from July 1999.

Troops are monitored at least three times per week during the birth season and twin births were inferred by the presence of two neonates nursing from a single female who continues to care for both. It is possible but highly unlikely that some "twins" could represent permanent neonatal adoptions; it is somewhat more likely that perinatal death of a twin might not be detected. Because observation conditions are good, and these potential problems bias results in opposite directions, we believe our reported twinning rate is very close to the actual one.

The term polythelia covers a range of eight types, from morphologically and functionally normal extra breasts (type 1) to "polythelia pilosa," a patch of hair only [Leung & Robson, 1989]. All are associated with histologically identifiable glandular tissue [Camacho & Gonzalez-Campora, 1998]. Animals were visually inspected without restraint for presence of supernumerary nipples or areolae (types 5–7). Without capture, distinguishing small nipples from areolae is difficult, and they are not differentiated here. Polythelia can be difficult to detect within the fur (especially on males), and we included only individuals for whom we were confident supernumerary nipples/areolae would have been detected if present. Both the color and prominence of supernumerary nipples/areolae are hormone-dependent, and they may not appear prior to puberty [Grossl, 2000; Zuckerman, 1935]. Because of this the sample is restricted to adults.

Statistical analyses were performed using StatView (version 4.5).

RESULTS

Supernumerary Nipples

Eighty-nine of 211 females (42.2%) and 20 of 117 males (17.1%) possess between 1–6 accessory nipples or areolae (Tables I and II; Fig. 1). Nursing from accessory nipples has never been observed. Since polythelia is less visible on males, the sex difference may be partially artifactual, although we were aware of this possible bias and attempted to avoid it (see Methods section). Among humans, the commonest form is a single accessory nipple, but here 63.9 % of cases exhibit two or more; the commonest pattern is two bilaterally symmetric nipples above the normal pair (52.3% of cases). All extra nipples observed occur roughly along the mammary line(s). Nipple/areola number is asymmetric in 43.1 % of individuals. There is no left-right bias in asymmetry (right side with more nipples than left, 23; left > right, 22; contra reports of a left-side bias in non-humans [Hartman, 1927]), but females appear more likely to be asymmetric (females: 48 symmetric, 41 asymmetric; males 16 and 4, respectively; $P < 0.06$, chi-square with Yates correction for continuity).

The prevalence of polythelia among adult females varied from 8% to 90% across troops (mean 39% ± 21%, n = 16 troops); in only four troops was the prevalence over 50%. For males, prevalence ranged from 0–75% (mean 20% ± 19%), with only one troop with more than 50%. Prevalence across troops among males and females was correlated ($P < 0.05$) but this was due almost entirely to high

TABLE I. Adult Females With Supernumerary Nipples Among Free-Ranging Formosan Macaques at Mt. Longevity, Taiwan

Troop name	Total no. of adult females in troop	Number of supernumerary nipples						Total of females with supernumerary nipples in troop (N, %)	
		1	2	3	4	5	6		
A	10	1	2	0	0	0	0	3	30.0%
B[a]	17	7	0	1	2	0	0	10	58.8%
C	17	1	7	0	0	0	0	8	47.1%
D[a]	10	2	3	0	0	0	0	5	50.0%
E	10	0	2	0	1	0	0	3	30.0%
F[a]	17	2	3	1	0	0	0	6	35.3%
G	17	3	4	0	0	0	0	7	41.2%
Aa	5	0	1	0	0	0	0	1	20.0%
I[a]	15	4	4	0	0	0	0	8	53.3%
J	14	2	1	0	0	0	0	3	21.4%
K[a]	26	8	7	2	0	0	0	17	65.4%
Ia	8	0	1	0	0	0	0	1	12.5%
M	10	1	1	1	0	0	0	3	30.0%
N	11	1	1	0	1	0	0	3	27.3%
O	13	0	1	0	0	0	0	1	7.7%
Ib[a]	11	3	6	0	0	0	1	10	90.9%
Total	211	35	44	5	4	0	1	89	42.2%
%	100.00	16.6	20.9	2.4	1.9	0.0	0.5	42.2	

[a]Indicates troops in which twins occurred.

TABLE II. Adult Males With Supernumerary Nipples Among Free-Ranging Formosan Macaques at Mt. Longevity, Taiwan

Troop name	Total no. of adult males in troop	Number of supernumerary nipples				Total of males with supernumerary nipples in troop (N, %)	
		1	2	3	4		
A	7	0	0	0	0	0	0
B	11	0	3	0	1	4	36.4
C	10	2	0	0	0	2	20
D	8	0	1	0	0	1	12.5
E	3	0	0	0	0	0	0
F	11	1	1	0	0	2	18.2
G	9	0	0	0	0	0	0
Aa	4	0	1	0	0	1	25
I	6	0	1	0	0	1	16.7
J	9	0	1	0	0	1	11.1
K	10	0	1	0	0	1	10
Ia	3	0	1	0	0	1	33.3
M	3	0	1	0	0	1	33.3
N	9	0	1	0	0	1	11.1
O	10	0	1	0	0	1	10
Ib	4	1	1	1	0	3	75
Total	117	4	14	1	1	20	17.1
%	100	3.4	12.0	0.9	0.9	17.1	

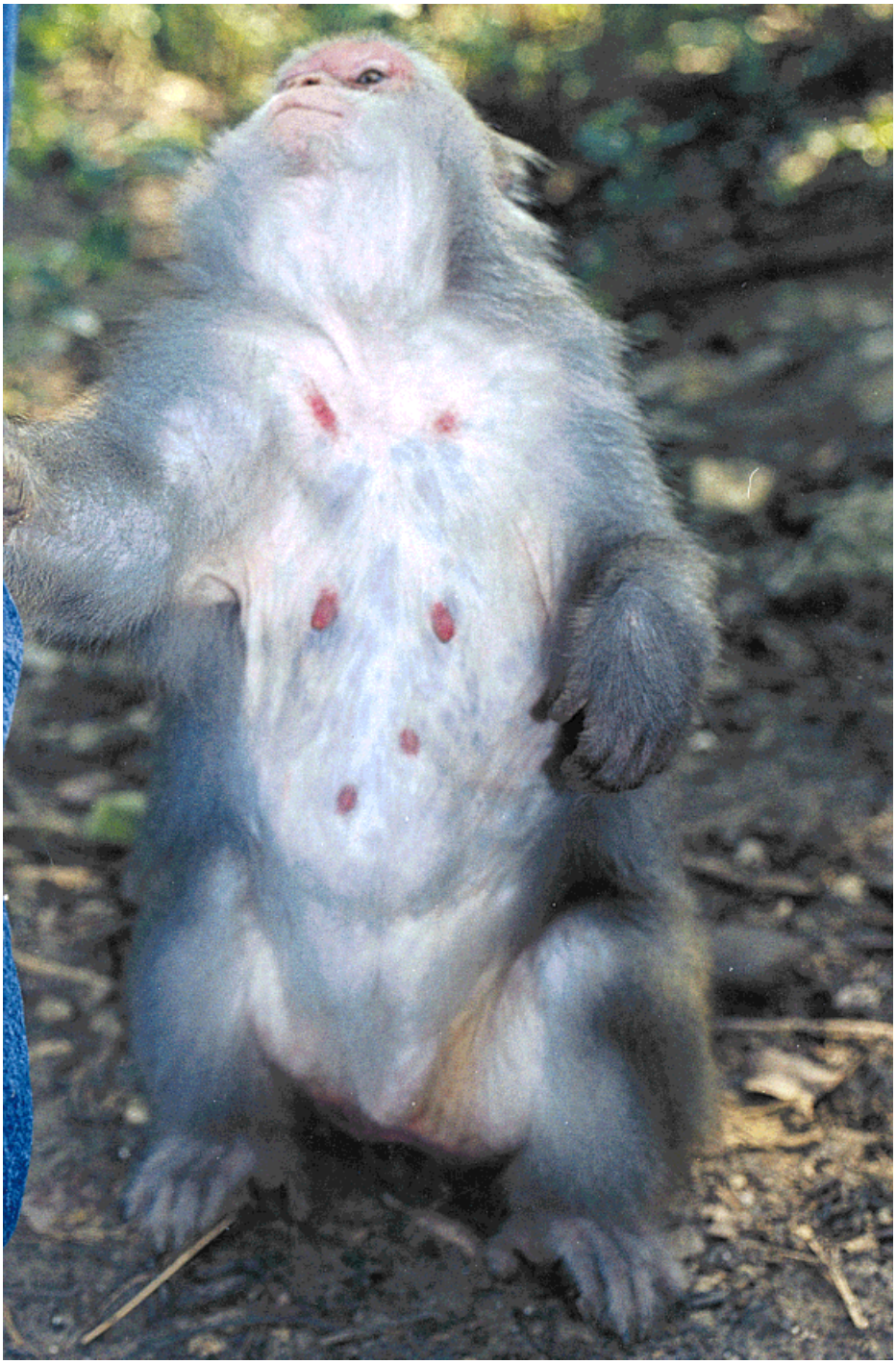

Fig. 1. Adult female Formosan macaque at Mt. Longevity with two symmetric pairs of supernumerary nipples/areolae.

prevalence in Troop Ib (10 of 11 females, 3 of 4 males) and may be spurious. Future research at the site will address this issue.

Twins

Six pairs of twins (11 live births) have been observed since 1996, out of 596 births (1.01%, or 0.84% for 5 sets of live births only) (Table III) [Hsu et al., 2000]. Both twins survived past 36 months in two cases, and both died within one week in one case. One of the infants (female 6) died after being carried for three days by a juvenile aunt, and presumably died of starvation. The cause of death is unknown in the other cases.

Co-Occurrence of Polythelia and Twinning

All six of the females who produced twins have supernumerary nipples. This is more than twice the overall prevalence (Fisher exact probability $P = 0.005$) and suggests a link between polythelia and multiple births. This is further supported by an association between incidence of polythelia in troops and presence of twinning: the six troops in which twins were born had the highest incidences of polythelia (Table I; Mann-Whitney U-Test, U = 2.0, n = 6, 10, $P < 0.01$).

DISCUSSION

Polythelia among monkeys and apes is occasionally commented upon (e.g., "Several (of > 1,000 rhesus) have one or two non-functional supernumerary nipples" [Koford et al., 1966]) but there has been little quantitative work on patterns and incidence [see Buss & Hamner III, 1971; Schultz, 1956]. With three exceptions, previous reports of incidence have been in the range of about 1–5%, similar to that reported for humans [Grossl, 2000; Schultz, 1948]. The exceptions are a report by Thorington et al. [1979], who found supernumerary nipples on five of 13 immobilized male red howlers (*Alouatta seniculus*); a statement by Itani et al. [1963] that among Japanese macaques "[i]n T-troop of Shodoshima ... nearly half of females there had extra nipples (Itani and others, unpublished)"; and a report by Zuckerman [1935] that three of 12 adult female chacma baboons he shot had extra nipples. The Mt. Longevity Formosan macaque population has more individuals with polythelia than have to date been reported for all non-human primates combined.

TABLE III. Twin Births at Mt. Longevity

Troop	ID	# N	Birthdate	Sex	Outcome	Other births
I	8	2	5/11/96	F, F	Survive	97F, 98M, 99M
I[a]	17	2	5/11/96	F, M	Survive	97-, 98M died < 2 mos, 99M
D	6	1	4/5/98	F, F	1 died < 1 month	96F, 97M, 99F
K	11	1	5/4/98	M, M	1 died < 1 month	96M, 97M died < 1 day, 99M
B	2	2	5/15/99 & 5/24/99	F M	F dead < 1 day, M dead < 1 week	96F, 97M, 98M stillbirth
F	8	1	3/17/00 & 5/11/00	? M	Abortion	96F, 97F, 98F died at 2 mos (accidental), 99F died < 3 mos

[a]Female F.I.17 moved to Ib when this new troop formed in October, 1998.
N, no of supernumerary nipples.

Most supernumerary nipples result from a failure to terminate mammary bud development, consistent with over- or underexpression of Hox genes [Schmidt, 1998]. They occur in 1–5% of humans, are usually asymmetrically expressed, and are associated with increased risk for urogenital malignancies. The nature of possible causal relationships between gene defects, polythelia, and urogenital disease is unknown [Casey et al., 1996; Urbani & Betti, 1996]. It is hoped that ongoing studies at Mt. Longevity can elucidate such possible biomedically relevant associations in Taiwanese macaques.

Polythelia is anecdotally linked to multiple births in humans. Confirmatory data are lacking [Leung & Robson, 1989], however, and the connection is currently thought to be spurious [Grossl, 2000]. Our data suggest that the connection merits reevaluation. Twins appear to be rare among macaques. At Cayo Santiago the rate is under 0.1% [Koford et al., 1966; Rawlins & Kessler, 1986]. Hendrickx and Nelson [1971] give rates ranging from about 0.2–1% for several macaque and baboon colonies; the higher rates either include abortions and stillbirths or have $n < 100$. In their largest sample, two twin live-births were recorded among 838 rhesus (0.2%). Schultz [1956] has argued that the rate of twinning is similar in humans and nonhuman primates (about 1%), but this is based on aggregating nonhuman taxa, and the rate for macaques in his data is about 0.3%. The rate at Mt. Longevity is apparently between 3–10+ times greater than that of other macaques.

The cause(s) of the high incidences of twinning and polythelia at this site is unknown, but founder effect and/or inbreeding in an isolated population are obvious possibilities. A high rate of twinning is reported for an island population of mouflon founded by a single pair [Boussès & Réale, 1998], and the troop-specific high incidences of polythelia reported by Itani et al. [1963] and Zuckerman [1935] also suggest a matrilineal founder effect. This is the first report in any nonhuman showing a clear association between the phenomena. Ongoing noninvasive studies of the Mt. Longevity macaques should help to elucidate the population genetics and fitness consequences of both phenomena, as well as to study the relationship between multiple births, polythelia, and (potentially) urogenital abnormalities.

ACKNOWLEDGMENTS

Partial funding for the ongoing field research on Formosan macaques at Mt. Longevity has been provided by the Republic of China's National Science Council through a research grant (NSC 88-2313-B-020-023) awarded to G. Agoramoorthy and M.J. Hsu. Thanks to Jasmine Tan for her assistance.

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