DIET PREFERENCES AND HABITAT USE IN RELATION TO REPRODUCTIVE STATES IN FEMALES OF A WILD GROUP OF *MACACA MAURA* INHABITING KARAENTA FOREST, SOUTH SULAWESI

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PASCASARJANA PROGRAM

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MAKASSAR

2012/2013

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Thesis

Required to Achieve Master

Study Program

Forestry

Prepared and Submitted by

CRISTINA SAGNOTTI

To

PASCASARJANA PROGRAM

HASANUDDIN UNIVERSITY

MAKASSAR

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THESIS

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Who Stated

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ACKNOWLEDGMENTS

This research was part of the Dr. Monica Carosi's research project "Ecology, costs & benefits of sexual swelling in *Macaca maura*", in cooperation with Tor Vergata University (Italy), Hasanuddin University and Bantimurung Bulusaraung National Park (Indonesia). Funding was provided by the Ministry of Education, University and Research of Italy.

I acknowledge Dr. Monica Carosi for allowing me to conduct this research at Karaenta forest (South Sulawesi) and for providing all equipment needs to live in the field (including the courage and confidence), and valuable advice.

I thank all my graduate committee, in particular: Prof. Dr. Ir. Ngakan Putu Oka, M.Sc., Dr. Risma Illa Maulany, S.Hut, M.Sc and Dr. Monica Carosi for providing advice, insight and mentorship. I thank Dr. Erin P. Riley for sharing her GPS data, experience and advices and Iskandar Kamaruddin for elaborating the home range map and helping me in many occasions.

Special thanks go to the Rektor of Hasanuddin University, Prof. Idrus A. Paturusi, MD., for all the help and the trust that has given to me during these three years in Indonesia.

Ph.D., Dr. Dwia Aries Tina P., MA, Prof. Dr. Ir. Muh. Restu, MP and Prof Etty Bazergan are acknowledged for their support and encouragement despite difficulties.

I thank also Pak Haro and all National Park staff for the field assistance. Thanks to my family and all my friends, for the patience and the courage that they transmitted to me from far away.

A special thanks to Amir for his indispensable help without which I could not finish my studies.

Thank you all…

ABSTRAK

CRISTINA SAGNOTTI. Pemilihan Pakan dan Penggunaan Habitat dalam hubungannya dengan kondisi reproduktif pada kelompok betina liar *Macaca maura* di Hutan Karaenta, Sulawesi Selatan .

Kondisi lingkungan dan ketersediaan sumber daya makanan yang memadai dapat mempengaruhi hasil reproduksi mamalia betina. Kebutuhan energi terutama pada primata betina sangat besar (masa kehamilan yang lama, menyusui, pengasuhan bayi), oleh karena itu mungkin dapat mempengaruhi tingkat konsepsi dan dalam jangka panjang dapat mempengaruhi jumlah populasi. Kami meneliti bagaimana pakan (diet), aktivitas harian dan variasi penggunaan habitat dalam status reproduksi yang berbeda pada betina *Macaca maura* di hutan Karaenta (Taman Nasional Bantimurung Bulusaraung). Kelompok kera diikuti selama 6 hari / minggu dari Agustus 2010 hingga Februari 2011 (7 bulan). Data perilaku dikumpulkan melalui scan sampling. Betina *M. maura* mengonsumsi berbagai macam makanan (74 spesies tanaman dan jamur), tetapi buah lebih mendominasi pola makan (82%) dan kebanyakan bergantung pada buah *Ficus* (31%). Betina dalam fase peri-ovulasi menunjukkan keragaman makanan yang paling berbeda dalam komposisi spesies pakan/diet (tumbuhan, jamur, dan serangga), sementara betina yang hamil menunjukkan keragaman yang paling tinggi dalam hal bagian tanaman (buah, daun, bunga, pucuk dan batang) yang dikonsumsi. Alokasi waktu kegiatan terkait dengan pemanfaatan strata hutan bervariasi tergantung pada status reproduksi: betina yang menyusui menghabiskan sebagian besar waktu mereka di tanah dengan kegiatan yang dominan yaitu bergerak (30%) dan istirahat & interaksi sosial (51%); sedangkan betina periovulatory cenderung berada di strata yang lebih tinggi (2-10 meter) di mana kegiatan yang pokok adalah mencari makanan dan makan (62%).

ABSTRACT

CRISTINA SAGNOTTI. Diet Preferences and habitat use in relation to reproductive states in females of a wild group of *Macaca maura* inhabiting Karaenta Forest, South Sulawesi

Environmental conditions and adequate availability of food resources may affect the reproductive outcome of female mammals. Energetic requirements are large on especially female primates (long gestation, lactation, carrying of the infant), possibly affecting conception rate which, in the long-term may affect local population size.

We investigated how diet, activity budgets, and habitat use may differ in different reproductive states in wild female moor macaques (*Macaca maura*) in Karaenta (BABUL NP). Monkeys were followed 6 days every week for 7 months (August 2010-February 2011). Behavioral data were collected using scan sampling method. Results of this study indicated that female moor macaques consume a wide range of foods (72 plant and 2 fungi species), but are predominately frugivorous (82%) and relied heavily on fig fruits (31%). Females in the *peri-ovulatory* phase showed the most dietary diversity in terms of different items consumed (plants, fungi, and insects) while pregnant females showed the most diversity in terms of plant parts eaten (fruits, leaves, flowers, shoots and stems). Activity budgets differed depending on vertical (forest strata) use of the habitat and reproductive state: lactating females spent most of their time on the ground with predominant activities being locomotion (30%) and resting & social interactions (51%); *peri-ovulatory* females tended to be at higher strata (2-10 meters) where main activities were foraging and feeding (62%).

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CHAPTER I

INTRODUCTION

A. Background

Sulawesi is the largest Indonesian island in the ecoregion of Wallacea, South East Asia, which is very important in a biogeographical perspective. This is due to its location at the biogeographic crossroads between Asian and Australian continental shelves which has placed Sulawesi as an important conservation area at a global level. Sulawesi, especially for mammals, shares some elements of its fauna with that from both the Asian and Australian continents which are also characterized by high levels of endemism (Cannon *et al*., 2007). The object of this study is an endemic primate species of Sulawesi, *Macaca maura* (moor macaque).

M. maura is classified as endangered according to IUCN (2008). This spesies has experienced ≥ 50% decline of its population over the last three generations (30-36 years). At present, the populations of this species are extremely sparse in highly fragmented habitat, and are increasingly restricted to South Sulawesi limestone karst areas (Supriatna *et al*., 2008), with only 50 percent of that particular ecosystem included in protected areas (Achmad, 2011) such as Bantimurung Bulusaraung National Park.

In order to maintain adequate population size of moor macaque therefore to counteract the progressive risk to extinction, it is necessary to protect an appropriate “quantity” and “quality” of habitat which is suitable for the species. While the extension of potential habitat of moor macaque is guaranteed by the extension of protected areas (such as Bantimurung Bulusaraung National Park), habitat quality can only be ensured by a detailed knowledge of the species needs.

One of the most important factors that affect the effective population size (*Ne*) of a species is its reproductive success (Stiver *et al*., 2008). In mammal species, and particularly in k-selected species as primates, females are key factors in ensuring reproductive success as they have to deal with considerable energy costs associated with reproduction itself and maintenance of the offspring. Beyond body basic metabolism, moor macaque females need energy to face costs related to reproductive states and phases such as those possibly related to the *peri-ovulatory* phase which in this species is characterized by a particular swelling of the *ano-genital* area; to pregnancy, lactation and prolonged infant carriage. Energetic constraints impact reproductive function in female primates (Key and Ross, 1999).

By analyzing some aspects of the female interaction with their habitat in terms of both behavior and diet selection, this study aims at identifying elements which may be crucial in their impact on female reproductive function and success, which, in turn, are essential for the maintenance of proper population size. This study is also aimed to expand our knowledge about moor macaque female biology and ecology with particular emphasis on how wild adult female moor macaques use the habitat (forest strata) and allocate their time across different activities (feeding, foraging, locomotion, social and resting) depending on different reproductive states, which have been identified as follows: *peri-ovulatory* phase females (around the likely conceptive period); pregnant females; lactating females; and neutral phase females (not experiencing any of the previously mentioned conditions). These elements, in addition to a fine analysis of diet composition and nutrient content, will be discuss in light of a more general framework of energetic/nutrient balance depending on dietary inputs and energetic outputs (maintenance of basic metabolism, daily activities, and likely demanding reproductive states) (Murray *et al*., 2009).

Based on the above mentioned, females in different reproductive states are expected to show differences in terms of diet selection (detectable from nutrient composition of different plant species and plant parts) and this, in turn, might be reflected by a different use of the forest strata according to different edible/preferred plant species distribution along the vertical axis of the forest. Females in high energy demanding reproductive states are expected to optimize the balance between energy inputs/energy outputs by either increasing inputs (switching the diet selection towards high energy food) or decreasing outputs (avoiding energy consuming behaviors, e.g., locomotion, and/or increasing resting, or else avoiding upper levels of canopy by increasing time spent on the ground). Lactating phase is usually considered as the most energetic demanding reproductive phase in a female mammal (see Murray *et al.*, 2009). In the present study, we will consider high energetic reproductive states lactating females as well as *periovulatory* phase females, based on the potential high energetic cost due to the formation of the anogenital swelling at every single cycle.

To test these hypotheses, a detailed analysis of the female diet in terms of plant species and specific plant parts consumed, the nutritional content of those foods, and pattern of habitat use is required.

This study took place in Karaenta, *ex Nature Reserve* now within the boundaries of Bantimurung Bulusaraung National Park, and focused on diet, habitat use and behavioral activity budgets of females living in a social group (known as Group B), with particular attention to the relationship between reproductive state and estimated energetic demands.

B. Research Questions

The research questions of this study are:

1. How do *M. maura* females use the habitat and divide their time across different activities in order to balance energetic inputs and outputs throughout their reproductive cycle?
2. What is the diet composition of moor macaque females and what nutrient contents are they likely searching for throughout their reproductive cycle and in different reproductive states?

C. Objectives of the study

The objectives of the study are to:

- determine the home range of the targeted social group and to develop a home range map of the group.
- examine the daily use of habitat (forest strata) by adult females throughout their reproductive cycle
- investigate daily time allocation in different activities (feeding, foraging, locomotion, social and resting) of adult females throughout their reproductive cycle
- examine the adult female diet in terms of plant species eaten, specific parts of plant eaten and nutritional content per specific item eaten

D. Applications of the study

This study focuses on females of a wild group of moor macaques located in a particular protected area (Karaenta, Bantimurung Bulusaraung National Park) characterized by a unique limestone karst ecosystem that still harbors patches of intact forest. If we assume that the ecological conditions of the habitat studied are optimal for the persistence of this species, we can then compare this condition with that of other groups inhabiting different habitats in South Sulawesi. This would allow to understand the level of adaptability of moor macaques as well as identify new important areas for the conservation of this endemic species.

Through a systematic study of this species that includes an ecological approach is possible to identify new strategies for the conservation of the species and the ecosystem in which it lives. For example, data about diet, in terms of plant species composition and proportion of time spent feeding on it, could be used to identify key plant resources that should be protected throughout the species' range and identify additional areas in their overall range that could be designated as new protected zones. Data on habitat use are important to understand which forest strata are used for feeding, foraging, moving, resting or socializing. For example, if moor macaques (living in limestone karst ecosystem) prefer high forest strata (>10m) for feeding and foraging, we may assume that the most important food resources in this habitat are allocated on high trees and also likely on karst rocks. For this reason, we could recommend an expansion of protected areas to include all limestone karst ecosystem present in South Sulawesi province, in order to promote the conservation of an endemic species such as *M. maura.* In addition, home range data could be used to understand the minimum relative area sufficient for the survival of each social group in a given ecosystem. We could then use these data to extrapolate the minimum size of potential protected area necessary for the survival of this species for future generations on the basis of data coming from investigations on population size and rate of reproduction (Zeigler *et al.*, 2010).

CHAPTER II

LITERATURE REVIEW

A. Taxonomy, Morphology and Genetic Characteristics

Macaques constitute a monophyletic group of the *Cercopithecinae* subfamily. There are three main lineages of extant macaques, corresponding to three dispersal waves from Africa to Asia and within Asia itself since 5-6 million year ago (Table 1).

Table 1. Macaque species and geographical distribution of the three main lineages in the world (Thierry, 2007)

	Common name	**Scientific name**	**Distribution**
***Silenus-sylvanus* lineage**	Liontaled macaque	*Macaca silenus*	Southwest India
	Barbary macaque	*Macaca sylvanus*	Algeria, Morocco
	Siberut macaque	*Macaca siberu*	Mentawai: Siberut Island
	Pagai macaque	*Macaca pagensis*	Mentawai: Pagai and Sipora islands
	Pigtailed macaque	*Macaca nemestrina*	Indochinese peninsula, Sumatra, Borneo
	Black Crested macaque	*Macaca nigra*	North Sulawesi
	Gorontalo macaque	*Macaca nigrescens*	North Sulawesi
	Heck's macaque	*Macaca hecki*	North Sulawesi
	Tonkean macaque	*Macaca tonkeana*	Central Sulawesi
	Booted macaque	*Macaca ochreata*	Southeast Sulawesi
	Muna-Butung macaque	*Macaca brunnescens*	Southeast Sulawesi
	Moor macaque	*Macaca maura*	Southwest Sulawesi

Table.1 Continued

***Sinica-arctoides* lineage**	Toque macaque	*Macaca sinica*	Sri Lanka
	Stumptailed macaque	*Macaca arctoides*	South China, Indochinese peninsula
	Bonnet macaque	*Macaca radiata*	South and West India
	Assamese macaque	*Macaca assamensis*	Continental Southeast Asia
	Arunachal macaque	*Macaca munzala*	Northeast India
	Tibetan macaque	*Macaca thibetana*	East and Central China
***Fascicularis* lineage**	Longtailed macaque	*Macaca fascicularis*	Indochinese peninsula, Indonesia, Philippines
	Rhesus macaque	*Macaca mulatta*	Continental South and East Asia
	Japanese macaque	*Macaca fuscata*	Japan
	Taiwan macaque	*Macaca cyclopis*	Taiwan

1. ***Silenus-sylvanus* lineage**

Silenus-sylvanus lineage has the patchiest geographical distribution, indicating an early dispersal. The pig-tailed macaque is the only species among the others with a large distribution range. The lion-tailed macaque is limited to the evergreen forests of Southern India. The other species of the lineage inhabit Sulawesi and Mentawai Islands.

2. ***Sinica-arctoides* lineage**

Sinica-arctoides lineage may be the second lineage to have dispersed because it has a moderately fragmented distribution in Southern Asia. Four of its species are found in tropical and subtropical continental areas, while the fifth species, the toque macaque, lives on Sri Lanka.

3. *Fascicularis* lineage

Fascicularis lineage is likely to be the third lineage to have dispersed because it is the most broadly and continuously distributed lineage. The long-tailed macaque is found in equatorial and tropical regions; the other three species in subtropical and temperate Asia (Thierry, 2007).

4. Sulawesi macaques

Fooden (1976) classified Sulawesi macaques into seven species: *Macaca maura*, *Macaca tonkeana*, *Macaca hecki*, *Macaca nigrescens*, *Macaca nigra*, *Macaca ochreata* and *Macaca brunnescens* (Figure 1).

Macaca maura is one of the seven species of macaques endemic to Sulawesi Island (*silenus-sylvanus* lineage) and it inhabits the Southwestern peninsula which is part of the South Sulawesi province (Okamoto *et al.,* 2000).

According to Rowe (1996), morphological characteristics that distinguish *M. maura* from other species are evident. The body fur is brown to dark brownish with a pale brownish gray rump patch. The male head and body length is 640-690 mm and the female head and body length is 500-585 mm.

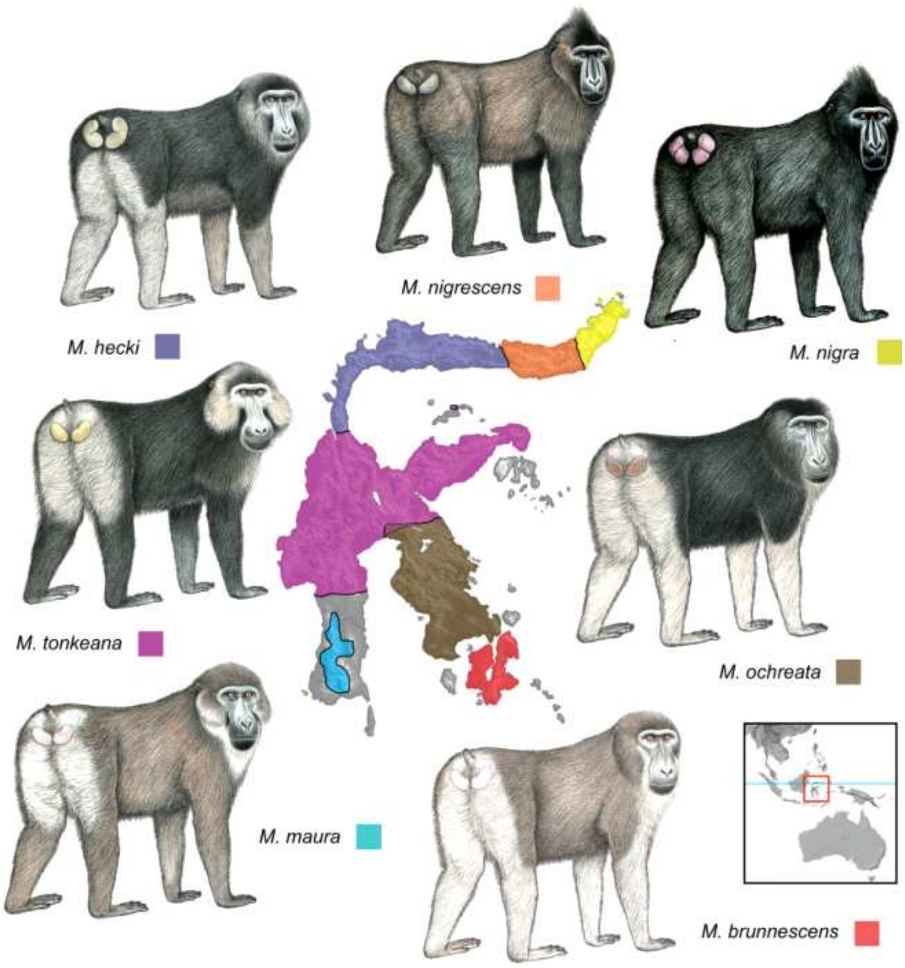

Figure 1. Sulawesi macaque species and their geographical distribution (Riley, 2010)

Ischial callosities of *M. maura* are pink. *Ischial callosities* are specialized regions of skin and subdermal tissue in the form of fibro-fatty cushions with a tough, non-slip surface, situated on the buttocks. They occur in primates of the families *Cercopithecidae* and *Hylobatidae*. *Ischial callosity* usage helps animals to adopt stable sitting postures on the tops of branches, particularly during feeding, resting and sleeping (Rose, 1974).

M. maura is classified as semi-terrestrial *quadrupedal* species. Animals that move *quadrupedally* tend to have hindlimbs with same length as their forelimbs. The commonest index calculated to include a primate species in a locomotion category is the "intermembral index" which is effectively the forelimb length/hindlimb length × 100% (Napier and Napier, 1985). The Old World Primate species, in which moor macaques is included, show an intermembral index value between 77-100, that is typical for *quadrupedal* species (Napier and Napier, 1985).

A portion of *M. maura*'s distribution area is in contact with that of *M. tonkeana.* Despite their contact zone and the level of hybridization, *M. maura* and *M. tonkeana* clearly represent two distinct species because they have diagnosable distinct morphology, monophyletic *mtDNA* and microsatellite differences. A phylogeny of *mtDNA* of macaques on Sulawesi and the Sunda shelf suggests that *M. maura* and *M. tonkeana* may be derived from separate dispersal events of *M. nemestrina* from Borneo to Sulawesi (Evans *et al*., 1999). The hybrid zone between *M. maura* and *M. tonkeana* is probably maintained by a balance between dispersal of males from each species into neighboring *philopatric* groups and selection against resulting hybrid progeny. However, the selection is not so severe as to prevent second- and third-generation backcrossing (Evans *et al.,* 2001). Hybridization occurs among all *parapatric* species of Sulawesi macaque except the insular species *M. brunnescens.*

Behavioral data on Sulawesi macaques seem to support the hypothesis of gene flow between all populations. Little difference in mating season seems to be present between the various species (Ciani *et al.,* 1989). Alarm vocalizations seemed to be different but clinal, from low barks in *M. maura* to high-pitched trills in *M. nigra.* Watanabe and Brotoisworo (1985) suggested the absence of any major behavioral differences between the various Sulawesi species.

B. Distribution, population density and habitat use

Macaca maura can be found from 5.5° to 5.6° S to North of Tempe Lake at approximately 3.4° to 3.5° S, 116° to 121° E (Supriatna *et al*., 1992). In the North of its range this species is found in rainforest as well as karst “islands”, while in the Southern parts it tends to occur in mosaics of forest with some grasslands. They occur below 2,000 m above sea level (Supriatna *et al.*, 2008).

The habitat of *M. maura* is fragmented into small forest patches. Supriatna *et al.* (1992) reported that moor macaques live mostly in unprotected forest, with less than 2% of their range overlapping with nature reserves.

The forest of the Southwestern province of Sulawesi (Figure 2) is highly modified by human activity with only scattered and highly isolated pieces of good forest. The large area of lowland alluvium (0-850 m) has been completely converted (less than 0.1% remaining in good condition) and lowland intermediate forests (0-850 m) have little more than 1% in good conditions forest. The scattered pieces of Limestone karst in the midwestern area contain some of the best condition forest and represent a unique ecosystem that contains a high level of endemism (*M. maura* included). The mountainous area in the South is characterized by montane (1500-2200 m) and tropalpine (> 2200 m) forest (Cannon *et al*., 2005).

Moor macaques have been studied by Japanese researchers since 1981 at Karaenta Natural Reserve (now included in Bantimurung Bulusaraung National Park). This site (1000 ha) is characterized by Limestone Karst ecosystem with a mixture of primary and secondary forest. Most groups in the reserve consisted of 15-40 individuals and home range size was 20–30 ha (Okamoto *et al.*, 2000). The home range size of moor macaque is relatively small if compared with the mean home range of 216 ha for Black Crested macaques (*M. nigra*) in North Sulawesi (Riley, 2010). The population density reported by Matsumura in the 1998 was 3.5 groups/km2 or more than 70 individuals/km2. Population density of moor macaques in Karaenta Nature Reserve appears relatively high, this particular condition may be a result of two important characteristics of the area: the high density of fig trees (23.3 trees/ha) as well as the partial isolation of this site from other forest tracts. In addition, the relatively small home range of moor macaques at Karaenta Nature Reserve could be due to the combination of these two factors (Riley, 2010).

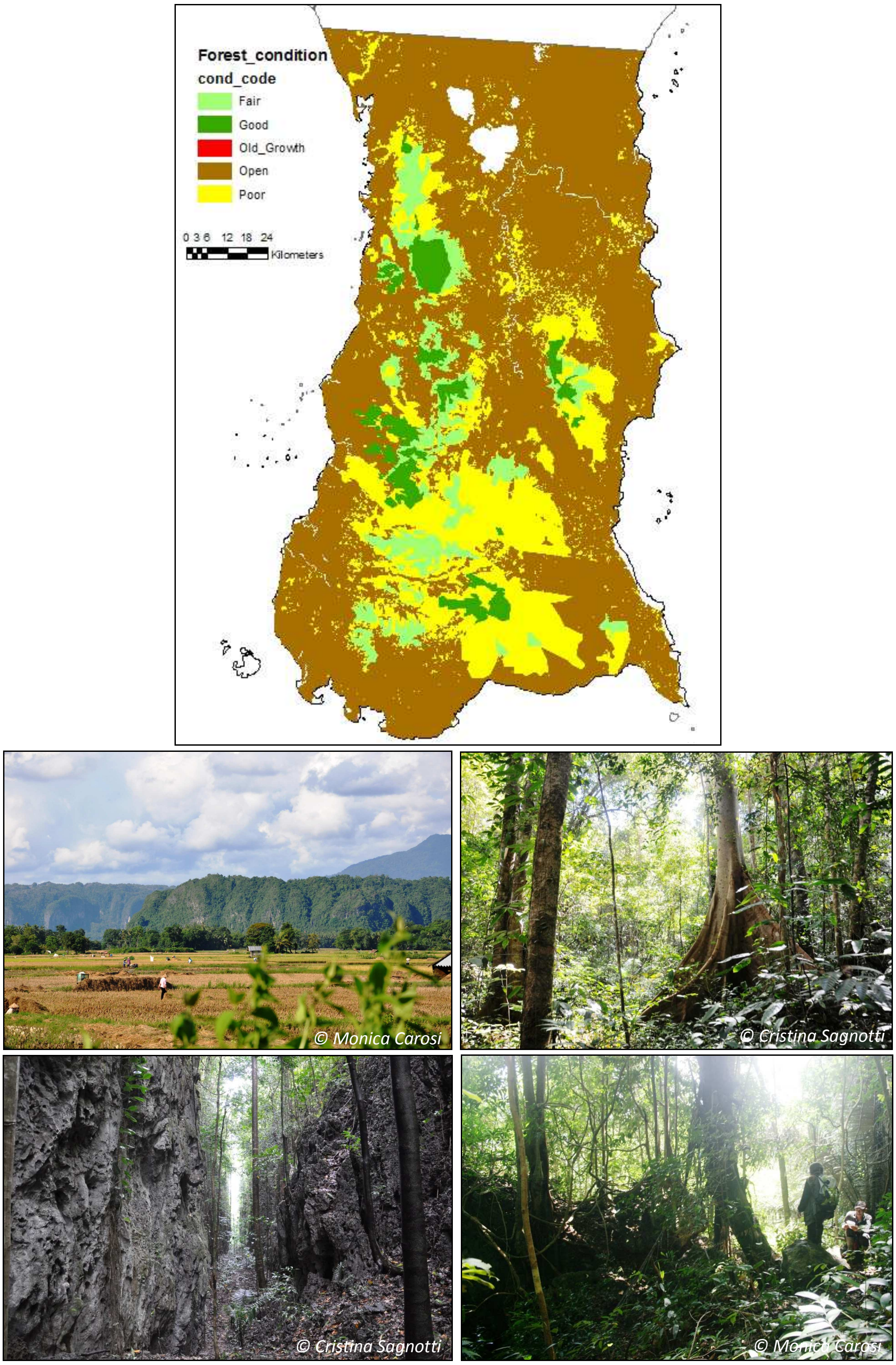

Figure 2. Forest condition of Southwestern part of Sulawesi: map (Cannon *et al*., 2005), lowland forest converted in rice field (first picture on the left) and habitat condition in limestone karst ecosystem (second, third and fourth picture)

Sulawesi macaques show differences in the use of forest strata in their habitat. Following O'Brien and Kinnaird (1997), Black Crested macaques spent most of their time on the ground (60% in the day), while Tonkean macaques show differences between groups living in minimally altered habitat and groups living in heavily altered habitat. Groups in good forest condition spent most of their time on the canopy (86% of the observation records) and groups in poor forest condition spent a significantly greater proportion of the observations on the ground (Riley, 2008). To date, there are no data about the use of forest strata for *M. maura*.

C. Characteristics of reproduction

Matsumura (1993) reported that the *perineum* of wild adult female moor macaques shows repeated and regular swelling (Figure 3). The average *ovulatory* cycle length is 36.2 days. The mean duration of swelling is 11.9 days. The first swelling experience occurs when females are between 4–6 year old, and the first birth could happen when females are in the age of 6 to 7 year old (Okamoto *et al*., 2000). The estimated duration of gestation is around 176 days (Matsumura, 1993).

The inter-birth interval following the first successful birth is 32 months on average (Okamoto *et al*., 2000).

There seemed to be a peak in birth from the end of the rainy season to the beginning of the dry season. Moor macaques are categorized as moderately seasonal breeders who have 33–67% of their births in a single three-month period (Okamoto *et al*., 2000). The peak may be related to annual increases in food availability, and in particular to an increase in fruit production. As fruiting is reported to peak just before the rainy season (Whitten *et al*., 1988), the birth peak (June) of moor macaques seemed to occur about four months before the peak of fruit season (October) (Okamoto *et al*., 2000).

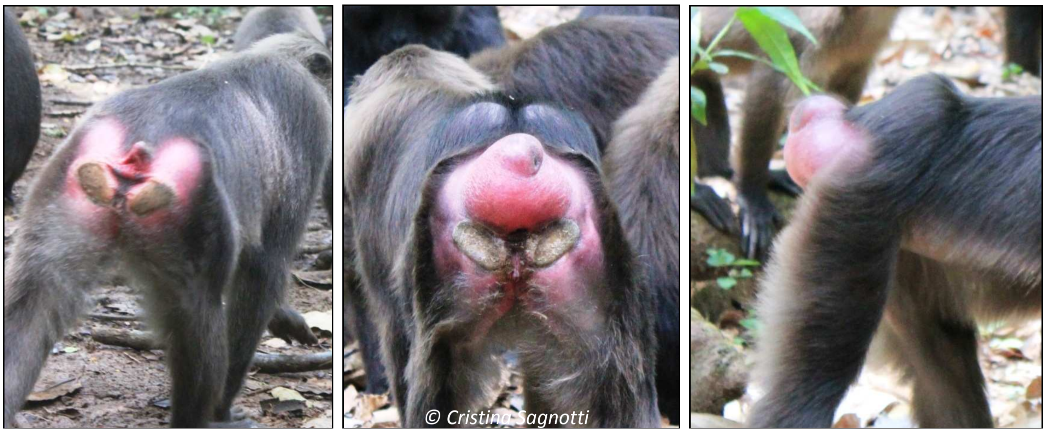

Figure 3. *Perineum* of wild adult female moor macaque. From the left: without sexual swelling, with sexual swelling from behind and from the right side.

As in other macaque species, gene flow among social groups is mostly guaranteed by males, who leave their natal group to move between different groups while females stay in their natal groups. There is considerable variation among macaque species in relation to the age of male natal dispersal. On average, male macaques leave their natal groups at around 4–6 years whereas moor macaques males leave their natal group at 7–9 years (Okamoto *et al.*, 2000).

D. Energetic requirements

Theoretical considerations suggest that, in adult mammals, female energetic costs should be higher than male energetic costs. This is because females are biologically obliged to meet the energetic costs of gestation and lactation (Key and Ross, 1999).

The energetic investment in female primates - and more generally in female mammals - is limiting element for the reproduction. In a female primate, strain energy related to the reproduction includes the energy required for menstrual cycle and ovulation, conception, pregnancy, lactation and also to transport the infant. A successful reproduction is strongly influenced by the availability of suitable habitat and food resources. Females in fact, consume food not only for the maintenance of their body, but also for transferring energy to the offspring as well as for enhancing their development. Most studies have considered gestation and lactation as the most important reproductive events with respect to energy expenditures. The amount of energy required (calories consumed) by female mammals increases 20% during gestation and 80% during lactation (Gittleman and Thomson, 1988).

In terms of conservation, the study of females and their energetic needs, may lead to the individuation of the basic ecological characteristics necessary to the survival of the population in a given site, and, in perspective, the comparison among populations inhabiting areas with different ecological characteristics can help assessing the degree of adaptability of the species and intervention priorities for conservation programs.

E. Activity budgets

The time spent in different activities is highly influenced by food resources availability and habitat quality. Different sex-age classes partition their time differently. In *Macaca nigra,* adult males moved and rested more but fed, foraged and socialized less than adult females. Small juveniles socialized more and fed less than large juveniles and adults (O'Brien and Kinnaird, 1997).

Among adult females there are differences in the activity budget depending on their reproductive states. Murray *et al.* (2009) reported that pregnant female chimpanzees in Gombe National Park reduced their physical activity and spent less time traveling than females in other reproductive states. This energy conservation strategy may allow pregnant females to store fat that can later be used in lactation for milk production. In addition, lactating females fed on fruits more than pregnant females. A study on the activity budgets may provide in depth understanding on how moor macaque females respond to different energetic demands throughout their reproductive cycle and in different reproductive states.

F. Diet

Dietary composition of non-human primates is primarily constrained by resource availability and habitat quality. Riley (2007) reported that Tonkean macaques living in heavily altered forest had a lower dietary diversity, fed more on insects and 50% of the plant specific diet was a single palm, *Arenga pinnata*. In contrast, macaques living in a good forest condition showed a higher dietary diversity and fed less on insects.

Moor macaques are prevalently *frugivorous* (Watanabe & Brotoisworo, 1982), though eating a variety of other plant parts and insects as well.

According to Matsumura (1991), *M. maura* consumed around 61 plant species, however, many of them have been only identified bymeans of the local name. The diet was composed primarily by species belonging to the family of *Moraceae*. The food items list included fungi, insects and lizards also. The list provided by Matsumura (1991) shows food items of moor macaques inhabiting intact mixed primary and secondary forests of Limestone karsts ecosystem in Karaenta ex Natural reserve. Instead, Supriatna *et al.* (1992) reported that moor macaque range is composed primarily by heavily disturbed forest and areas of human habitation. For this reasons *M. maura* is considered as a crop raider species and information by farmers reported the list of crops eaten by Moor and Tonkean macaques (Table 2) (Supriatna *et al.*, 1992).

According to Achmad (2011) there are additional 15 plant species eating by moor macaques which are not reported by Matsumura (1991).

Interestingly, although the social group studied by Achmad (2011) lived in a different habitat from that studied by Matsumura, all plant species eaten are reported to be present in both field sites (Achmad, 2011).

Table 2. Crops raided by *M. maura* and *M. tonkeana* (Supriatna *et al.*, 1992).

Common name	**Family**	**Botanical name**
Corn	Poaceae	*Zea mays*
Banana	Musaceae	*Musa paradisiaca*
Tomato	Solanaceae	*Lycopersicum* sp
Coconut	Arecaceae	*Cocos nucifera*
Long Bean	Fabaceae	*Vigna sinensis*
Soybean	Fabaceae	*Phaseolus radiatus*
Peanuts	Fabaceae	*Arachis hypogaea*
Bushbean	Fabaceae	*Phaseolus vulgaris*
Eggplant	Solanaceae	*Solanum* sp
Cassava	Euphorbiaceae	*Manihot utilissima*
Sweet Potato	Convolvulaceae	*Ipomoea batatas*
Jackfruit	Moraceae	*Artocarpus heterophyllus*
Cacao	Malvaceae	*Theobroma cacao*
Orange	Rutaceae	*Citrus* sp
Cashews	Anacardiaceae	*Anacardium occidentalis*
Guava	Myrtaceae	*Psidium guajava*
Mango	Anacardiaceae	*Mangifera indica*

Differences in diet composition (plant species) of these two social groups are likely due to both differences in relative abundance of plant species in the two field sites (*i.e.*, groups' home ranges) and/or different periods of data collection. Diet composition may vary throughout time (*e.g.*, seasonality, weather condition) and space (*e.g.*, habitat).

Faced with variations in food quantity and quality at diverse spatial and temporal scales, animals must adjust their diets to meet their nutrient requirements (Rothman *et al.*, 2008). For this reason, diet composition varies also depending on the nutritional needs of individuals at different stages of their life cycle. For example, in adult female chimpanzees there is a relationship between mean dietary quality and waiting time to conception that suggests a cumulative effect of dietary quality on reproductive capacity (Thomson and Wrangham, 2008). To understand needs in terms of nutrients, it is necessary to accumulate data over time and compare results between individuals of moor macaque groups living in different ecosystems.