

## Feeding and reproductive strategies of ranging behavior in male Japanese macaques

Yosuke Otani

### Introduction

Many primates generally range with other individuals or form social groups. Previous studies have shown that group formation provides costs and benefits, which may vary depending on the environmental and social status. Individuals may increase their benefits or decrease the costs by deciding to range with a group depending on circumstances. Japanese macaques (*Macaca fuscata*) form stable bisexual groups. However, often males are temporarily separated from the group they belong to. Here I study the method of association within groups and management of cost and benefits of group formation in male Japanese macaques, and I discuss the reason for frequent alternation in social and ranging behavior.

### Methods

This research is based on two different spatial scales. I first conducted a broad-scale census of Japanese macaques (*Macaca fuscata yakui*) in Yakushima and assessed the presence of spatial variation in the density of solitary individuals. I also observed a specific group to assess the costs and benefits of ranging without groups, particularly in relation to their feeding and reproductive strategy.

### Results & Discussion

The density of males ranging alone did not differ among different types of vegetation, despite vegetation having an effect on overall population density. The density of males ranging alone during mating season was a third of that in the non-mating season. During mating season, males exhibit strong cohesiveness with a group, probably searching for resident estrous females. Outside mating season, 25% fewer males ranging alone were found in the lowlands, which otherwise present a high population densities and strong within-group competition, compared with the highlands. The total density of males ranging alone was estimated to be 1.2–5.7 individuals/km<sup>2</sup>. On the other hand, the group and population densities were 1.25 individuals/km<sup>2</sup> and 19.3 individuals /km<sup>2</sup>, respectively, suggesting that a considerable number of males remained outside groups, and males establish flexible links with existing social groups depending on ecological and social circumstances.

Group males frequently separate from the group for short periods, leaving the company of females and ranging on their own for periods averaging 68 minutes. However, the males did not venture outside the group's home range. When a male was seen ranging separately from the group, it spent more time feeding, particularly on fruit, stayed longer in each feeding tree, and fed at a lower rate than when ranging with the group. These behavioral changes suggest that males can avoid within-group feeding competition by ranging alone. However, this behavior was also associated with higher traveling costs, and these separated males were more vulnerable to intergroup competition and had fewer opportunities for social interaction. The frequency of separate ranging was lower for the areas where the main food source is highly patchy plant species. Lower ranked males, who are often the target of aggressive behavior from conspecifics, more frequently ranged separately from the group. This behavioral flexibility with respect to group cohesion may allow males to reduce the costs of group living without completely losing the benefits.

During the mating seasons, separated males ventured outside the group ranging area, but not during the non-mating season, and succeeded in mating with other group females. Males could increase the potential number of mating partners by ranging separately from the group. High-ranking males would mostly range with their group and had high tendency of staying in central part of their group regardless of season. In mating season, high-ranking males would apply the strategy of mate guarding, but conduct separate ranging only when the reproductive potency is extremely low. Low-ranking males, in non-mating season, conduct separate ranging frequently, and even when they range with their group, tended to stay in the periphery of the group than high-ranking males do. By contrast, in mating season, low-ranking males decrease the time for separate ranging, and when ranging with their group, stay in the central part of the group as much time as high-ranking males. However only when they copulate with their group females, they move more to the periphery.

Considerable number of Japanese macaque males remained outside the groups, and their group cohesiveness varied by region and season. Independent ranging had both costs and benefits associated with feeding, social, and reproductive behavior. By ranging separately from the group for short periods, males could avoid within-group feeding competition; however, they lost grooming opportunities, became more vulnerable to intergroup competition, and incurred higher travel costs. Males could copulate with females from other groups by moving away from their group. Males left their group temporarily when they could not copulate in their group because of low reproductive potential or their social position.