

Ecological studies of *Saguinus fuscicollis* and *Saguinus labiatus* with reference to habitat segregation and height preference

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ABSTRACT. Ecological studies of two sympatric species of genus *Saguinus* were carried out with special reference to difference of forest utilization in western Pando, Bolivia from July to December 1979. *Saguinus fuscicollis weddelli* and *S. labiatus labiatus* made intraspecifically territorialistic groups consisting of 2 to 7 individuals, and often made interspecifically associated groups. They moved in associated groups in the day time. However, there were differences in height preference for moving and in the size of the insects consumed by the 2 species. The animals also had their own parturition seasons and sleeping sites. *S. labiatus* is larger than *S. fuscicollis* in body size, and the intermembral index showed a larger value for *S. fuscicollis* than for *S. labiatus*.

INTRODUCTION

The tamarins *Saguinus fuscicollis weddelli* and *S. labiatus labiatus* inhabit sympatrically with *Callimico goeldii* in western Pando, Bolivia (IZAWA, 1978b). *S. labiatus* has a local distribution and *C. goeldii* has a relic distribution, whereas *S. fuscicollis* shows wide distribution in the upper Amazon (HERSHKOVITZ, 1977). Comparative ecological studies and research of the interspecific relationships of *Saguinus* are required for phylogenetic examinations of callitrichid monkeys in the area where the tamarins inhabit with *Callimico*. The present work aims to show the difference between the two species of genus *Saguinus* in population structure, daily activity, forest utilization and breeding.

STUDY AREA

The work was carried out in the eastern part of the study area in Mucden (IZAWA and YONEDA, 1981). The study area measures 192.5 ha and consists of 142.5 ha of primary forest (74.1%), 45.4 ha of secondary forest (23.6%), and 4.6 ha of cleared area (2.4%). Secondary forest are distributed in the western and southeastern areas. The western limit and a part of the northern limit of the area are bounded by a 30 m wide road. The topography is flat except for a brook which flows through the northern part of the area and two brooklets in the eastern area. Native paths extend for 5.5 km in total; the total length of the observation trails made for the study is 20.9 km.

The study was carried out from July 6 to July 9, 1979 and July 12 to December 30, 1979.

METHODS

The author walked along the observation trails or native paths, traced the groups of monkeys he encountered, and investigated their home ranges, groups sizes, composition, and forest utilization, etc. Group identification was made by distinguishing prominent individuals

in each group and/or development of infants. The height occupied by animals was measured by camera with a 300 mm telephoto lens at an interval of 5 minutes and classified into the following 5 zones : 0–2 m, 3–5 m, 6–10 m, 11–20 m and above 20 m. Habitat preference was studied by investigation of the utilization hours and behavior in each type of forest. The identification of feeding plants was committed to the Smithsonian Institution (under examination). The author's presence had some influence on the monkeys' activity and behavior at first; however, many animals became accustomed to him after several hours of tracing and observation.

RESULTS AND DISCUSSION

1. Contact time and tracing distance

Approximately 243 hours of contact time, 38,500 m of tracing distance for *S. fuscicollis*, and 131 hours, 22,900 m for *S. labiatus* have resulted in the data presented here. Since the contact time and tracing distance for the former was longer than those for the latter, better observations of *S. fuscicollis* than *S. labiatus* could be made.

2. Denstiy

Thirteen groups of *S. fuscicollis* and ten groups of *S. labiatus* were identified in the study area. Both species lived in small, compact groups consisting of 2 to 7 individuals and moved in stable home ranges. The size of the groups is shown in Table 1. The Table excludes two encounters with a solitary *S. fuscicollis* and one case with *S. labiatus*. Groups observed only for a few hours in the study area were regarded as temporary staying groups and were excluded from the Table.

Densities of both species were estimated from the number of monkeys (Table 1) and the effective census area. If all groups visiting the study area were counted, a diameter of a home range was added to the surrounding line of the study area for calculation of the effective census area. The diameter of a range was assumed to be 600 m. From this calculation of the effective census area, the densities were estimated at 10.4 indivs./km² (12.8 indivs./km², including infants) for *S. fuscicollis* and 7.2 indivs./km² (8.6 indivs./km²) for *S. labiatus*. When half of the groups inhabiting the surrounding and connecting areas of the study area were counted, the radius (300 m) of the range was added to surrounding line for the calculation of the effective census area. From this assumption, the densities were estimated at 16.9 indivs./km² (20.8 including infants/km²) for *S. fuscicollis* and 12.2 indivs./km² (14.7 indivs./km²) for *S. labiatus*. From the former assumption, the number of groups were 2.2 groups/km² for *S. fuscicollis* and 1.7 groups/km² for *S. labiatus*. According to the latter assumption, there were 3.6 groups/km² for *S. fuscicollis* and 2.9 groups/km² for *S. labiatus*. The densities and number of groups may be close to the results obtained from the former assumption for the calculation of the effective census area, because all groups whose home ranges were distributed more or less in the study area were probably counted.

POOK and POOK (1979) have mentioned that the density of *S. fuscicollis* was 33 indivs./km² and *S. labiatus* was 22 indivs./km². As they probably did not consider the effective census area for the density calculation, they obtained these high density values. The mean density in eight locations in Peru is 13.50 indivs./km² for *S. fuscicollis* and 3.78 indivs./km² for *S. labiatus* (ENCARNACIÓN and CASTRO, 1978). IZAWA (1978a) has reported that the density of *S.*

Table 1. Group size of *S. fuscicollis* and *S. labiatus*

No. of indivs. per group	No. of groups <i>S. fuscicollis</i>	<i>S. labiatus</i>
2	1	1
3	2	3
4	3	2
5	3	1
6	2	3
7	2	—
Total	13	10
Mean indivs/group	4.7	4.2

nigricollis was 10–13 indivs./km² in Colombia. The densities obtained in this study were similar to those of ENCARNACIÓN and CASTRO, and IZAWA. However, since large numbers of *S. labiatus* were captured for commercial use by the natives, POOK and POOK (op. cit.) suggested that the density of this tamarin has decreased in northern Bolivia.

3. Interspecific association

Territoriastic behavior was seen intraspecifically between the groups of both species, and interspecific association was generally observed in one group of *S. fuscicollis* and *S. labiatus*. The associated group moved in the forest as a flock and fed on the same trees coordinately. However, there were differences in height preference, resting and sleeping sites, etc., between the two species. The associated hours decreased after one group of the pair had infants, and after this, moving as separate groups increased. An intraspecifically associated group was observed once for *S. labiatus* but not at all for *S. fuscicollis*. However, two or more groups which congregated 20 to 50 m apart from each other and had shrilling calls were often observed for *S. fuscicollis*. Although the pairs of associated groups were comparatively stable, some exchanges of partners occurred. *S. fuscicollis* and *S. labiatus* also often associated groups with *C. goeldii* or *Callicebus moloch*.

4. Home range

The home range was considerably stable for all groups in both species. The range size of four groups of *S. fuscicollis* averaged 32.8 ha (25.9–40.1 ha). It was found that the range size of the groups inhabiting the primary forest was generally larger than that of the groups inhabiting the secondary forest. Round or oval ranges with a diameter of 550–700 m were observed in many cases. The range was stable but overlapped with adjacent groups. Percentages of overlap among the three adjacent groups of *S. fuscicollis* were 79 % between the area of Groups F–A and F–B, 44 % between that of Groups F–A and F–O, and 58 % between that of Groups F–B and F–O.

The range size of *S. labiatus* was slightly more variable than that of *S. fuscicollis*. The average size of the ranges of four groups of *S. labiatus* was 33.5 ha (23.2–40.7 ha). Large overlaps of the home ranges among adjacent groups were also found for *S. labiatus*.

Conflict and chasing among intraspecific groups were observed. Conflict occurred in so many cases in the marginal areas of the home ranges that this interaction was considered to be a defensive reaction against the home ranges. Threats between the *S. fuscicollis* and *S. labiatus* which formed associated groups were observed on several occasions while the animals were feeding on trees, but interspecific fightings were not apparent.

IZAWA (1978a) has reported that the range size of *S. nigricollis* was 30 to 50 ha. The sizes of two associated groups of *S. fuscicollis* and *S. labiatus* were 33 ha and 22 ha respectively, and the percentage of the overlap between the two associated groups was 15% (POOK and POOK, 1979). These previous reports show results similar to those of the author, with the exception of the small overlap of ranges of the two associated groups reported by POOK and POOK.

5. Daily activity

S. fuscicollis repeated moving with foraging of insects in the middle or lower layers of the forest, fruit-feeding, and resting at suitable sites in their daily nomadism. The activity was thus distinguished to the three categories, and the hour utilized for each activity was counted. In Group F-A, which was intensively observed for the longest period of hours (a total of 136 hours), the feeding hours were long (27.1 % of the total observation hours) in the morning (6:00–8:00), whereas the resting hours were short (14.1 %) and the moving with foraging was comparatively long (80.2 %) in the evening (16:00–18:00). However, the hour utilization observed at two hours intervals in the daytime (8:00–15:00) was similar to that for each time zone, moving with foraging of insects being 68.2 %, feeding 7.2 %, and resting 24.6 % on the average. *S. fuscicollis* left their sleeping site at 6:23 (5 observations) and returned at 16:46 (23 observations) on the average; the mean activity hours was 10 hours and 23 minutes per day.

Similar behavior was observed in the daily nomadism of *S. labiatus*; however, the number of resting hours was shorter than that of *S. fuscicollis*. From the tracing of Group L-A of *S. labiatus*, which was observed for the longest period of time (88 hours), it was found that their moving hours with foraging was 76.2 %, feeding 17.7 %, and resting 6.1 %.

6. Moving activity

Velocity of moving was calculated from the distance traced and the observation hours for 2 groups of *S. fuscicollis*. The average velocity of Group F-A was 129 m/hr because they moved while resting and feeding for 17,550 m for a total of 136 hours and 33 minutes. The calculated velocity was 136 m/hr before parturition, and it decreased to 113 m/hr after parturition of a female in the group. It appeared that the infant was restricted in the movement of the group. The same tendency to show a decrease in movement after parturition was also shown by Group F-B, whose velocity of moving was 151 m/hr before parturition and 108 m/hr after it. It was thought that the movement of a group may recover in about three months after parturition when the juvenile obtains sufficient ability to move.

From the velocity of moving and activity hours, the mean nomadic distance in a day was calculated as follows: 1,450 m per day before parturition and 1,190 m per day after for Group F-A, and 1,590 m per day before and 1,140 m per day after for group F-B.

The velocity of moving for *S. labiatus* was similar to that of *S. fuscicollis* because both formed associated groups on several occasions.

7. Habitat preference

There was no prominent difference in habitat preference according to vegetation types between *S. fuscicollis* and *S. labiatus*. The animals used both habitats, the primary and the secondary forests. However, Group F-A of *S. fuscicollis*, which had 10.9 ha (42 %) of the secondary forest as its home range (total of about 25.9 ha), spent about 94 hours (69 %) during the observation hours (about 126 hours) in this type of forest, thus showing a preference

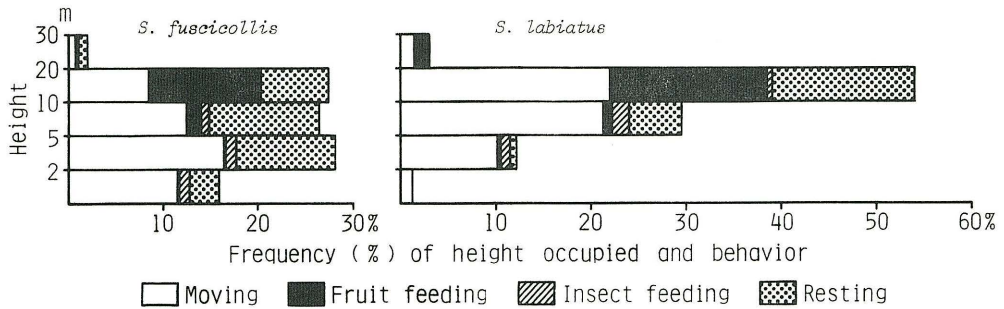


Fig. 1. Comparative vertical forest utilization of *S. fuscicollis* and *S. labiatus*.

for the secondary forest. Group L-A of *S. labiatus*, whose range also stretched over both types of forest, showed a preference for the secondary forest as it utilized the secondary forest longer than the primary forest. Habitat preference for the secondary forest may be attributed to the fact that it contained more feeding trees than did the primary forest during the study period. However, since many groups inhabited the study area containing only the primary forest, it was considered that the two species adapted to both types of forest.

8. Vertical segregation of forest utilization

Vertical segregation of forest utilization was observed between *S. fuscicollis* and *S. labiatus*. The height utilized and the behavior of individuals were censused at regular intervals for observation of stratified use in the forest. Observation of an individual at one time was counted as one point, and the height preference was determined from the total sum of the points.

A contrast was obtained from the distribution of the heights occupied; *S. fuscicollis* used every layer from the ground to 20 m in height, whereas *S. labiatus* used mainly the upper middle forest layer at a height of 11 m to 20 m (Fig. 1). The upper middle forest layer was used mainly for fruit-feeding and resting by *S. fuscicollis*, whereas it was used for moving as well as fruit-feeding and resting by *S. labiatus*. The lower forest layer, especially the forest floor, was almost completely monopolized by *S. fuscicollis* when it moved in an associated group. The forest floor was also used extensively by *C. goeldii* (POOK and POOK, 1979; IZAWA, 1979); the competition between this monkey and *S. fuscicollis* in this habitat should be noted.

When the height utilization between the primary and the secondary forests was compared, *S. fuscicollis* showed a preference for the higher layer in the primary forest rather than the secondary forest (the mean height of utilization calculated from the observation of height utilized was 7.3 m for the secondary forest and 9.0 m for the primary forest). However, there was no notable difference in height used for either forest type for *S. labiatus* (the mean height of utilization was 11.8 m for the secondary forest and 11.6 m for the primary forest). From this observation, it could be assumed that differences in forest utilization between both species are enlarged in the secondary forest.

9. Foraging of insects

Both species of the *Saguinus* monkey spent many hours foraging insects during their daily activity hours. Individuals in a group moved slowly, foraging and feeding on insects in open order when they were not resting or feeding on fruit. There were also differences in foraging behavior, height preference, and the size of insects captured between the two species. *S. fusi-*

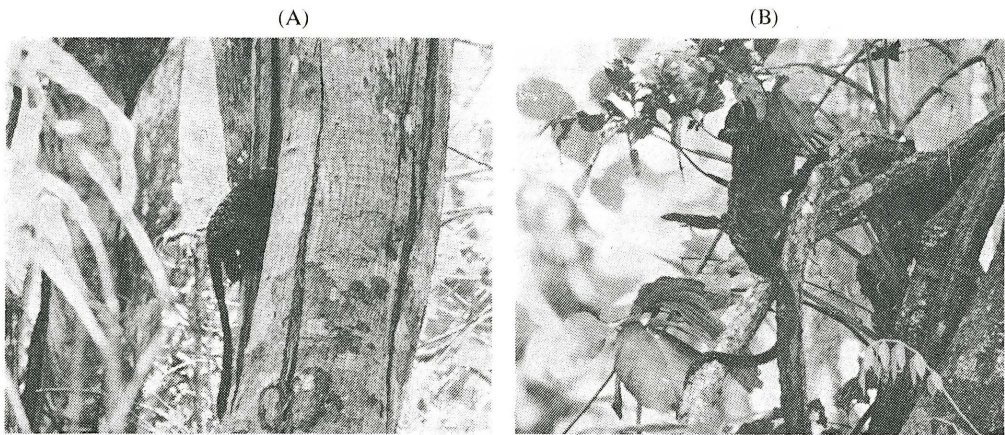


Fig. 2. Typical behavior of insect-foraging on a split of tree (A) for *S. fuscicollis* and on a leafy twig (B) for *S. labiatus*.

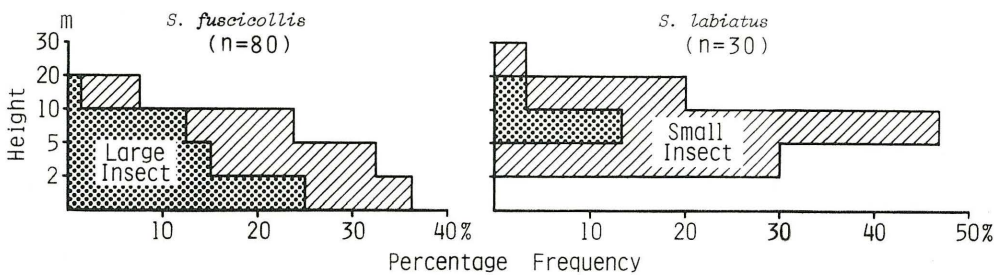


Fig. 3. Comparative size of insects consumed and height of capturing by *S. fuscicollis* and *S. labiatus*.

collis often foraged at tree hollows and at the bases of large trees in the lower forest layer, while *S. labiatus* which foraged on branches and leaves spent many hours in the middle forest layer at a height of 6 to 15 m (Fig. 2). The height for hunting and the size of insects consumed were recorded by tracing the groups. The hunting times of insects in the lower forest layer, ground to 5 m in height, occurred in more than two-thirds of the total observation times for *S. fuscicollis*, whereas the same occurred in the middle layer for more than 50% of the times for *S. labiatus* (Fig. 3). The hunting of large insects, which the monkeys clasped and consumed for several seconds, was observed for 54% of the total times of the insect hunting for the former species. The foraging behavior and the high proportion of large insect hunting of *S. fuscicollis* were similar to those of *S. nigricollis* mentioned by IZAWA (1976, 1978a).

10. Mode of travel

There was also a difference in the mode of travel between *S. fuscicollis* and *S. labiatus*. Both species showed movements characterized by running in the trees and jumping from tree to tree, but when they crossed the road, they walked on the ground. The difference of mode of travel was observed by the height and the part of the tree used for jumping and landing. The mode of jumping was classified into the following three types: 1) trunk to trunk; 2) branch to trunk (or trunk to branch); and 3) branch to branch. One jumping by a individual was count-

ed as one time, and the results were obtained by the percentage of frequency in the three types of jumping

The jumping from trunk to trunk added to the branch to trunk movement occurred in more than 80 % of the total observations ($n = 171$) for *S. fuscicollis*, whereas, for *S. labiatus* that from branch to branch occurred in more than 50 % ($n = 100$). Jumping was observed for about 60 % in the lower forest layer, from ground to 5 m, for *S. fuscicollis*, whereas it was performed about 80 % in the middle forest layer, from 6 to 20 m, for *S. labiatus*.

11. Breeding season

The parturition season differed significantly between the two species. Parturitions of *S. fuscicollis* were observed from September to December, the peak of which occurred from late September to late October (6 out of 10 observations). The parturition season of *S. labiatus* began in October, and its peak was in November (4 out of 6 observations). Litter size counted just after parturition was 1.5 on the average ($n = 10$) for *S. fuscicollis* and 1.7 ($n = 6$) for *S. labiatus*.

12. Measurements of body size and skull

The body size of both species, including the monkeys captured for commercial use by the natives, was measured (Table 2). Table 2 shows that the body size of *S. labiatus* was larger than that of *S. fuscicollis* and that the females were larger than the males in both species. From the proportion of body size, it was suggested that the intermembral index of *S. fuscicollis* is larger than that of *S. labiatus* (Table 3).

Cranial measurements of both species are shown in Table 4. *Saguinus mystax*, which were collected at Rio Yaraca, Peru, are included in the Table for comparison of the three species

Table 2. Body sizes (cm) of *S. fuscicollis* and *S. labiatus*

Species	Sex	(N)	Wt(g)	Total Length	Tail L.	Frontal Foot L.	Hind Foot L.
<i>S. fuscicollis</i>	♂	(4)	405	55.9	34.8	13.6	15.2
	♀	(3)	415	56.8	34.7	13.5	15.3
<i>S. labiatus</i>	♂	(17)	491	62.1	38.6	12.2	15.1
	♀	(12)	495	61.5	38.3	11.8	15.5

Table 3. Proportion of body size (%)

Species	Wt. ♂/♀	Tail L./ Total L.	Frontal Foot L./ Total L.	Hind Foot L./Total L.	Frontal F.L./ Hind F. L.
<i>S. fuscicollis</i>	97.6	61.8	24.1	27.1	89.5
<i>S. labiatus</i>	99.2	62.3	19.4	24.7	78.4

Table 4. Cranial sizes of three species of *Saguinus* (cm)

Species	(N)	Great Length	Basal Length	Molar tooth Row Length	Zygomatic Width	Brain Case Width
<i>S. fuscicollis</i>	(7)	46.7	32.8	9.1	31.1	26.5
<i>S. labiatus</i>	(3)	50.5	34.4	9.4	34.6	28.6
<i>S. mystax</i>	(2)	52.0	36.0	10.3	36.3	30.0

of genus *Saguinus*. The Table also shows that the cranial size of *S. labiatus* was larger than that of *S. fuscicollis* and suggests that *S. mystax* is larger than *S. labiatus* in body size.

13. Relationships of *C. goeldii* and *Saguinus*

S. fuscicollis and *S. labiatus* often associated interspecifically in daily nomadism. However, a segregation in habitat utilization was observed; *S. fuscicollis* preferred the lower layer of the forest and foraged larger insects than did *S. labiatus*. But, they used common trees for fruit-feeding in the upper and middle layer of the forest. *C. goeldii* seems prefer foraging insects and moving further into the lower layer of the forest than does *S. fuscicollis*. *S. fuscicollis* and *S. labiatus* adapt to both types of habitat, the primary and the secondary forest; however, the movement of *C. goeldii* is restricted to the 'shabby forest' (IZAWA, 1978c, 1979). The segregation of forest utilization as seen in the vertical and different habitat preference among these monkeys might be caused by interspecific relationships associated with phylogenetic evolution and by their adaptation to the histrical succession of the Amazonian forest.

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