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Aspects of the Ecology and Social Organization of Free-ranging Cotton-Top Tamarins (*Saguinus oedipus*) and the Conservation Status of the Species

ABSTRACT

Fifty-three *Saguinus oedipus* were live-trapped, marked, and released in one section of a relatively mature secondary forest located in the Western Carribean coastal lowlands of Colombia. In a total of over 2,500 active field hours, approximately 750 hours of contact were made with marked and unmarked groups of tamarins.

Captures were made with decoy-type live traps and several types of collars were used for marking. Trapping and marking methods are discussed in detail since they may be applicable to future callitrichid field studies.

Certain groups containing between three and thirteen members restricted their movements to a well-defined home range. Although some groups changed considerably in size and composition during the study, they continued to occupy the same areas. Contact with neighboring groups or intruding individuals could usually be characterized as agonistic, including frequent "Rasp" vocalizations, vocalizations associated with separation of members from the group ("Dips" and "Long Calls"), frequent short chases, and occasional body contact. Encounters occurred most often in the overlap areas entered frequently by both groups, and terminated with the two groups gradually drifting apart.

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Groups of from one to five were present occasionally within the home ranges of "established" groups. Some "transient" groups contained individuals which previously had been observed with "established" groups. Usually "transients" were chased vigorously by the resident group on contact, but two strange individuals joined resident groups with no sign of antagonism. Individuals examined from "transient" groups were adults whose age (based on weight and tooth wear) ranged from young to rather old. Both sexes were included.

Home-range sizes for three groups were 7.8, 7.8, and 10.0 hectares, with the corresponding group size (maximum and minimum numbers) ranging from 13 to 5; 5 to 3; and 6 to 3 individuals. Adjoining group home-range overlap was 20 to 30 percent. Density based on these three groups ranged from 0.3 to 1.8 tamarins per hectare.

Movement patterns, daily routine, group cohesion, and relations with other species are briefly described. Most of the 25 observed sleeping sites were broad tree forks, but a few were dense branch masses. Sites were frequently reused. In all but two cases, all individuals of a group slept together.

Food items included fruits of trees, vines and epiphytes, insects, newly sprouting leaves or buds, leaves, leaf stems, and in one case a frog. Unidentified material was gathered from flowers, surfaces of certain fruits and tree branches or trunks, and the decayed parts of certain trees.

Variation in tooth wear indicated a probable spectrum of ages among the adults of the larger groups examined (eight members). Only one or a pair of infants or juveniles were observed in any group. Present data are not sufficient to support or reject the "extended family" social organization advanced by various workers (Epple, 1972b; Eisenberg, Muckenhirn, and Rudran, 1972); However, the changes in group size and composition observed in this and other studies on *Saguinus* (Dawson, 1976, 1977; Thorington, 1968; Durham and Durham, in press; Castro and Soini, 1977; Izawa, 1976) argue against the suggestion.

It is suggested that the availability of *Saguinus oedipus* to exporters is a misleading index of their abundance. The habitat destruction now occurring is the major threat to this species' future in the wild. The immediate establishment of adequately protected reserves can assure its long-term survival. The need for broad long-term policies on fauna preservation and financing of basic research, especially on callitrichids, is emphasized.

SUMARIO

Cincuenta y tres *Saguinus oedipus* fueron atrapados vivos, marcados y posteriormente liberados en un area de un bosque secundario relativamente maduro, ubicado en la costa Oeste del Caribe, en Colombia. De un total de 2,500 horas de trabajo activo en el terreno, 750 hrs fueron de contacto con grupos marcados y no marcados de dicha especie.

Las capturas fueron hechas con trampas de señuelo vivo fabricadas con alambre por la gente del lugar. Collares de cuero, envueltos en cinta plástica en colores, medallas numeradas hechas de "Formica", y pequeñas campanitas fueron utilizadas en el marcaje. El método de captura, marcaje y determinación de la edad relativa de los individuos se discute en detalle puesto que pueden ser utilizados en futuros trabajos similares con otros Callitrichidae.

Algunos grupos restringieron sus movimientos a 'home ranges' (área de actividad) bien definidos, conteniendo entre 3 a 13 miembros. A pesar de que algunos de estos grupos cambiaron considerablemente en tamaño y composición durante el estudio, permanecieron sin cambios en los límites de los 'home ranges'. Los contactos con grupos vecinos o individuos que pretendieron entrar al área pudieron ser, en general, caracterizados como agonísticos, que incluyeron pequeños enfrentamientos, aumento considerable en la cantidad de vocalizaciones emitidas, persecuciones, y ocasionales contactos cuerpo a cuerpo. Los encuentros ocurrieron en las zonas de sobreposición de las áreas de actividad de los grupos, terminando con una gradual separación de estas.

Grupos de uno a cinco individuos estuvieron temporariamente presentes en varias oportunidades dentro las áreas de los grupos 'establecidos' descritos más arriba. En varios casos, contenían individuos marcados previamente observados con algún grupo establecido. En general, los visitantes fueron perseguidos vigorosamente por el grupo residente; sin embargo en dos ocasiones un individuo ajeno al grupo pasó a formar parte del grupo residente sin ningún signo de rechazo. Los individuos en estos grupos transeuntes cuya edad se pudo estimar basada en peso y desgaste de dientes, fueron en su mayoría adultos maduros, y de ambos sexos.

El tamaño del 'home range' en tres grupos fue de 7.8, 7.8 y 10.0 hectáreas, respectivamente, con un amplitud de variabilidad correspondiente en el tamaño del grupo. Los mínimos y máximos dados a continuación fueron determinados durante el estudio: 13 a 5; 5 a 3; y 6 a 3 individuos. La sobreposición entre grupos contiguos fue de 20 a 30 por

ciento. La densidad basada en estos tres grupos tuvo una variabilidad de 0.3 a 1.8 tamarinos por hectárea.

Los patrones de movimiento, actividad diaria, cohesión de grupo y sus relaciones con otras especies se describen brevemente. Las características de 25 sitios para dormir se resumen. Estos sitios fueron a menudo reutilizados. La mayoría de ellos eran esencialmente árboles con gruesas ramas laterales, unos pocos fueron densas masas de ramas. La cantidad de cobertura presente fue altamente variable. Con la excepción de dos casos, todos los miembros de un grupo dormían juntos.

La alimentación consistió basicamente en frutos e insectos. Los frutos provenían de árboles, enredaderas y algunas epífitas. Con menor frecuencia fueron ingeridas hojas nuevas o yemas, hojas, tallos, y en un caso, una rana. Material no identificado fue recogido de algunas flores, valvas de ciertas frutas, ramas o troncos y de algunas porciones aereas de ramas en descomposición.

La variación en el desgaste de las dientes, probablemente indica un espectro de edades entre los adultos de los grupos más grandes examinados (8 miembros). Sólo uno o un par de infantes o juveniles fue observado en algun grupo. De tal modo, los datos aquí presentados no son suficientes para decidir si los grupos pertenecen al tipo de familia extendida, hipotetizada por varios autores basados en trabajo de laboratorio (Epple, 1972b; Eisenberg, Muckenhirn and Rudran, 1972). No obstante, la hipótesis no predeciría los substanciales cambios en el tamaño y la composición del grupo observados en este estudio y algunos recientes tratando de ostras especies de *Saguinus* (Dawson, 1976, 1977; Thorington, 1968; Durham and Durham, en imprenta; Castro and Soini, 1977; Izawa, 1976). Estudios a largo plazo en poblaciones marcadas son necesarias para completar el esquema parcial que tenemos ahora de la estructura social de estas especies.

El presente estado del hábitat de *Saguinus oedipus* es discutido en extension con énfasis en el hecho de que las cifras otorgadas por los exportadores llevan fácilmente a errores con respecto a la abundancia de esta especie. El substancial agotamiento del hábitat que está ocurriendo actualmente es la mayor amenza para la especie. Sólo a través del establecimiento inmediato de reservas protegidas puede asegurar su superviviencia. A pesar de los problemas la singular riqueza de la fauna colombiana hace que esta medida sea valiosa de tomar.

Introduction

Saguinus oedipus[2], the cotton-top tamarin, was one of the first callitrichids to become well known in the United States. The proximity of its range to Barranquilla, Colombia's second major animal export center, ensured that this species early became one of the cheapest and most easily available New World primates for the North American pet and biomedical market. However, despite the large numbers that have been held in captivity, there have been relatively few studies of its basic biology. Some information is available on the following: reproductive behavior and physiology (J. K. Hampton et al., 1966, 1971; Epple, 1967, 1970); general behavior (J. K. Hampton et al., 1966; Wendt, 1964); vocal repertoire (Epple, 1968; Muckenhirn, 1967); scent marking behavior (Epple, 1972a); skin and scent gland morphology (Wislocki, 1930; Perkins, 1969) and cytotaxonomy (DeBoer, 1974). Some of these topics have been treated for three other species of *Saguinus* in captivity: *S. geoffroyi* (Moynihan, 1970; Muckenhirn, 1967); *S. fuscicollis* (Epple, 1970, 1971, 1972a, 1972b, 1977); and *S. midas* (Mallinson, 1971). Substantial information has accumulated on the maintenance and propagation of these species in captivity (Epple, 1970; Lorenz, 1972; J. K. Hampton et al., 1966; S. H. Hampton and J. K. Hampton, 1967; S. H. Hampton et al., 1972).

Field observations of callitrichid species have been short-term or lacking, except for a one-year study of *Saguinus geoffroyi* (Dawson, 1976, 1977). Reports based on one to several weeks of field observation are available for the following species: *S. geoffroyi* (Moynihan, 1970; Muckenhirn, 1967); *S. midas* (Thorington, 1968; Durham and Durham, in press); *S. nigricollis* (Mazur and Baldwin, 1968—semi-natural conditions); *S. fuscicollis* (Izawa, 1975, 1976; Castro and Soini, 1977); *S. mystax* (Castro and Soini, 1977); *Cebuella pygmaea* (Ramírez et al., 1977; Izawa, 1975, 1976) and *Leontopithecus rosalia* (Coimbra-Filho, 1977; Coimbra-Filho and Mittermeier, 1973). Studies of free-ranging populations are completely lacking for the remaining 23 callitrichid species (cf., Napier and Napier, 1967), and for *Saguinus oedipus.*

This paper restricts itself to group characteristics, general aspects of the use of space and resources, and relations with other species by cotton-top tamarins in a single study area, plus a review of problems concerning conservation of the species. Methods have been described in some detail because of their possible applicability to future field studies of callitrichids. Other results and conclusions from the study will be presented in subsequent publications.

[2]Although Hershkovitz, 1966, suggested that the rufous-naped tamarin (*S. geoffroyi*) and cotton-top tamarin (*S. oedipus*) be considered subspecies of *Saguinus oedipus*, they will be considered as separate species in this paper in accordance with Hernandez and Cooper (1976).

Study Area

The study area was located about 15 km to the east-northeast of Tolú, Sucre, on the Caribbean coast of Colombia, at about 9°34′N, 75°27′W (Figure 1). It forms part of an alluvial plain at about 100 m elevation at that point, formed from the San Jacinto hills lying just to the east (560 m maximum altitude). The area appears level, but after a heavy rain the standing water can be seen flowing along the surface of the ground and the area drains rapidly into a network of gullies (*arroyos*), 3 m to 7 m deep and 5 m to 15 m wide which carry the water seaward.

Using the Holdridge classification, Espinal and Montenegro (1963) described the region as one capable of supporting "very dry tropical forests," with relatively low rainfall (500 mm to 1000 mm annually) distributed in a highly seasonal pattern. Between December and April when there is practically no precipitation, an estimated 60 percent of trees lose their leaves. During the heavy rainfall months of August through November, large areas of the forest become flooded. About 30 percent of the study area was flooded to three feet or less at the worst of a very rainy year (1974). In the preceding very dry year, the forest floor remained nearly dry during the same period. Even during the wet season three to four days without rain—a not uncommon happening—has a marked effect in drying out the forest floor. During the dry season, the water found in *arroyos* is the sole water supply for the entire area.

The study area is in one of the larger remnant forests still existing in that part of Colombia (Figure 1), totaling about 600 hectares, and surrounded by pasture. It contains an essentially isolated population of *S. oedipus,* although some dispersal is possible via fence lines which connect to *arroyos* since both often are lined with trees. The study groups frequented the southeastern corner of the forest block (about 45 hectares) plus an adjoining strip of forest along a fence line and *arroyo* (about 7 hectares) (Figure 2).

Human exploitation of the forest probably dates

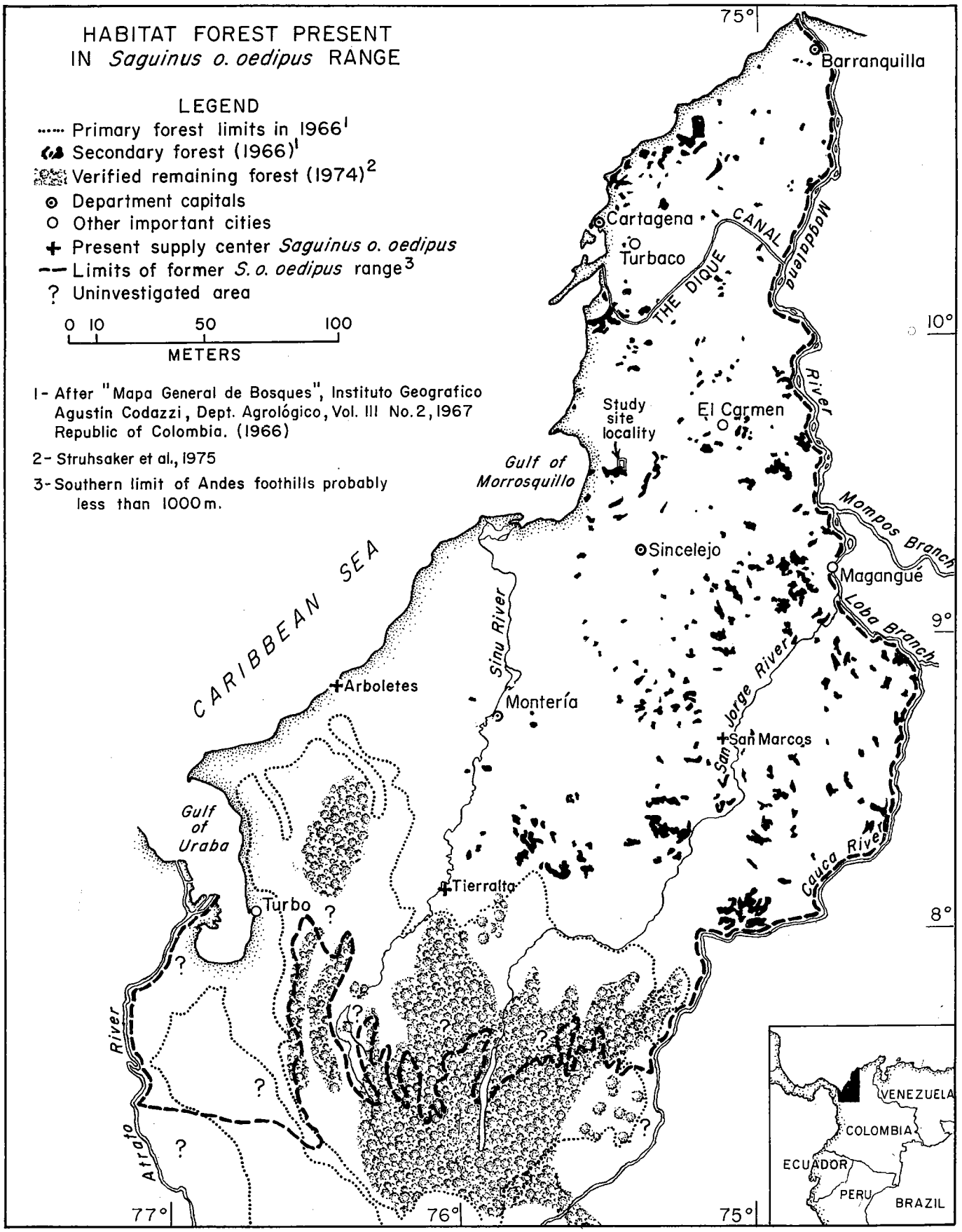
HABITAT FOREST PRESENT
IN *Saguinus o. oedipus* RANGE
LEGEND
Primary forest limits in 1966[1]
Secondary forest (1966)[1]
Verified remaining forest (1974)[2]
Department capitals
Other important cities
Present supply center *Saguinus o. oedipus*
Limits of former *S. o. oedipus* range[3]
Uninvestigated area
0 10 50 100
METERS
1- After "Mapa General de Bosques", Instituto Geografico Agustin Codazzi, Dept. Agrológico, Vol. III No. 2, 1967 Republic of Colombia. (1966)
2- Struhsaker et al., 1975
3- Southern limit of Andes foothills probably less than 1000 m.
75°
Barranquilla
Cartagena
Turbaco
CANAL
Magdalena
THE DIQUE
10°
River
Study site locality
El Carmen
Gulf of Morrosquillo
Mompos Branch
Sincelejo
Magangue
Loba Branch
9°
CARIBBEAN SEA
Sinu River
Arboletes
Montería
San Jorge River
San Marcos
Gulf of Uraba
Tierralta
Cauca River
Turbo
8°
River
Atrato
77°
76°
75°
VENEZUELA
COLOMBIA
ECUADOR
PERU
BRAZIL

Figure 1. Location of study site and distribution of forest remaining in the original range of *Saguinus oedipus* (as given by Hernandez and Cooper, 1976). This is a composite showing 1966 forest limits together with 1974 aerial reconnaissance estimates of remaining forest in the southernmost section (Struhsaker et al., 1975). Part of the latter may be primary forest, but extensive clearcutting was already occurring there in 1966. Forest designated in 1966 as secondary is shown as black patches. Many of these may no longer exist.

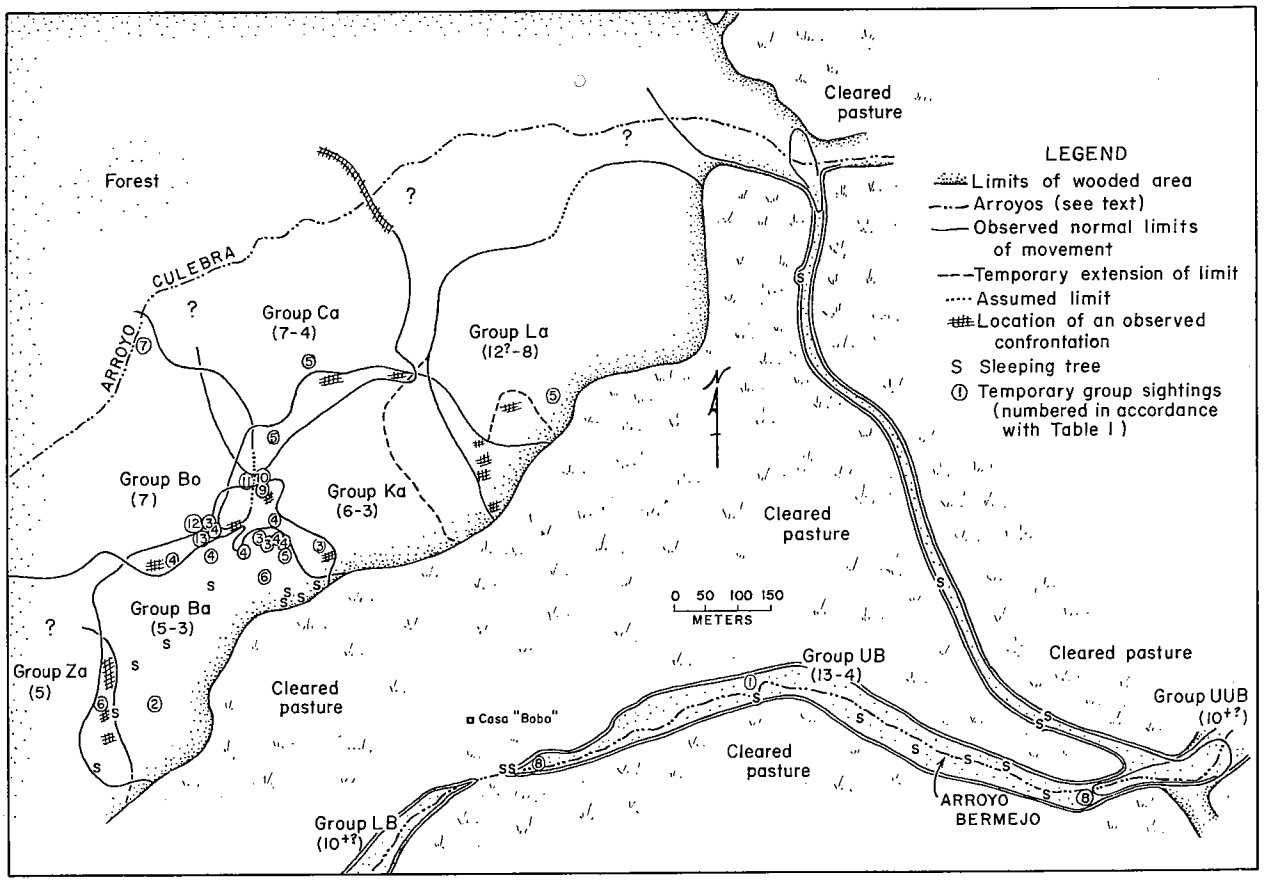

Figure 2. Map of main study area (see text). Surrounding areas are pasture, as indicated. Partial or complete limits of eight "established" groups in and adjacent to the study area are shown, together with observation locations of "transient" or temporary groups. The latter are numbered in accordance with Table 3. Sleeping trees for the Ba and UB groups are indicated. Maximum and minimum size of groups shown in parentheses. Hatched areas show points of inter-group encounters.

back to at least precolonial times, as Indian remains are common in nearby areas. The pastures are fairly recent in origin; those immediately adjoining the study area were cleared less than fifteen years ago. Exploitation of the forest is continuing. Middle-stratum trees are utilized for fence posts, corrals, houses, and bridges. Also some selective cutting is occurring, chiefly for *Cedrela, Ceiba, Bombacopsis,* and *Lecythis.* Few usable large specimens of the first three species remain. Hunters also frequent the study area. As far as is known, the resident primates (*Alouatta seniculus, Cebus capucinus,* and *Aotus trivirgatus* in addition to *S. oedipus*) are not presently subject to hunting pressure; however, they are commonly chased when encountered in vulnerable places, such as on fence lines, on the ground, or in low vegetation. The notable shyness of *A. seniculus* suggests that they may have been molested in the past. They react to an observer by hiding, often sitting without moving for long periods, and attempting to sneak away. This contrasts with the typical alarm patterns which this species shows in other forests in northern Colombia (branch shaking, grunting, urination, and defecation).

Common easily recognizable tree species are those typical of secondary forests in northern Colombia: *Luehea* sp., *Bursera simaruba, Anacardium excelsum, Cavanillesia platanifolia, Pseudobombax septenatum, Cecropia* sp., *Inga* sp., *Spondias mombin, Pithecellobium saman, Lecythis magdalenica, Gustavia* sp., *Triplaris* sp., *Calycophyllum* sp., *Guazuma ulmifolia, Brosimum* sp., *Muntingia calabura, Swartzia* spp., *Garcia nutans, Sapium* sp., *Ormosia* sp., *Cassearia* spp., *Mayna* sp., *Nectandra* sp., *Trichilia* sp., *Urera* sp., *Hybanthus prunifolius, Clavija* sp., *Picramnia* sp., *Randia* sp., *Panopsis* sp., *Quararibea* sp., and others including various species of palms (e.g., *Bactris* spp., *Astrocaryum* spp., and *Sabal* sp.) Much less common, but also present are: *Ceiba* spp., *Bombacopsis septenatum, Cedrela* sp., *Enterolobium cyclocarpum, Prioria copaifera, Fagara* sp., *Sterculia apetala, Cochlospermum* sp., and *Cordia aliodora.* In many places the forest floor is dominated by a very spiny palm which branches from ground level (tentatively identified as *Astrocaryum* sp.). In other areas, a mixture of saplings and low palms (cf., *Cryosophila* and *Heliconia* spp.) predominates. In places more recently cleared and therefore receiving more sun, the *Heliconia* may form dense stands to over 3 m in height. All areas can be penetrated with the aid of a machete, though not always at the speed necessary to maintain contact with a *Saguinus* group.

The relative scarcity of densely vined areas and the openness of the floor in most places suggest forest of some maturity. Nevertheless, the brokenness of the canopy is marked—only infrequently is travel possible for more than 50 m in any one direction at a height of over 15 m. Breaks in the canopy are due to both selective logging and tree falls occurring during seasonal high winds (September–November). In 1973 a high wind blew over so many trees in one section of the study area that a continuous canopy did not remain at any level. Also, the fall of one large tree always causes extensive damage to adjacent trees.

Methods

Between August 1973 and August 1975 about 750 contact hours were spent with free-ranging cotton-top tamarin groups. Total active field time was conservatively estimated at 2,500 hours.

Basic procedure consisted of searching for groups and following them until contact was lost. Success in following was greatest with one group (UB) which frequented the narrow forest strip of 7 hectares (Figure 2) and with those groups in which one member was marked with a bell (see below). Over half of the total contact time was spent with the UB group. The three most-studied groups (UB, Ka, Ba) became somewhat conditioned, but always showed nervousness if observed intently, especially if binoculars were used. Their disquiet could often be allayed by rapidly glancing away whenever they began to stare at me, but frequently attempts to observe them even from a distance of 20 m resulted in their moving to more hidden branches or leaving the area completely. Conditioning such small animals is complicated by the fact that the observer is constantly disappearing and reappearing in their visual field as they forage.

Minimal data were obtained on unmarked groups, as it was not possible to distinguish individuals (except in one case), or to be certain whether the same group was encountered on different days in a given location. Age and sex composition of groups, often used by field workers to identify troops, was not helpful here. Tamarins cannot be sexed at a distance, and the rapid growth of juveniles renders them indistinguishable from adults after the age of about ten months if seen from a distance (unless adjacent). Group size was not a useful criterion either, as difficulties in detecting all members of moving groups often rendered group counts questionable. Marked ani-

mals were indispensable therefore for group and individual identification as well as for making complete group counts. Some individuals were always bolder than others and were seen repeatedly while others, particularly juveniles and adults carrying young, tended to hide.

The route followed by a group was crudely marked with a machete in order to follow or map its route later. An attempt was made to keep the noise to a minimum. The tamarins did not emit alarm vocalizations, make avoidance movements, or show other apparent signs of disturbance during this activity. Alarm was given only when I actually came into view again.

The Trapping Program

The trapping program was initiated in January 1974 and the first animals marked in May 1974. National Live Traps similar to those successfully used by Dawson (1977) in the capture of *S. geoffroyi* and using the same bait (*Musa* sp.) proved ineffective. This was probably due to the greater variety of strata available for movement and the lack of predictable crossing routes reachable by climbing in this study area. The National traps also required more labor to set and maintain than the decoy-type traps finally used. The latter were fabricated locally from wire and measured 1 m × 1 m × 0.8 m

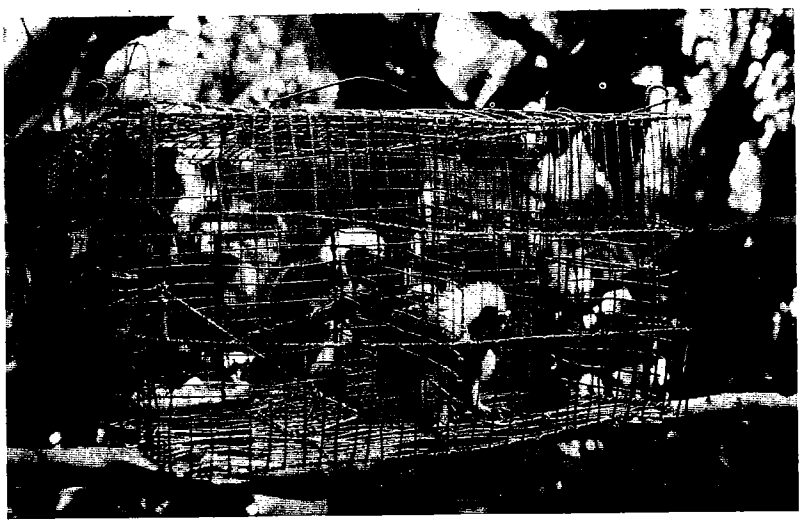

Plate 1a. Trap unit containing captured cotton-top tamarin (nearest) and decoy. Door is still set open in compartment opposite the captured individual. Protective wire mesh covering the decoy's half can be clearly seen.

Plate 1b. Cotton-top tamarin wearing collar and bell. This "jingle" type bell was not very satisfactory for localization purposes, despite its size (see text).

Plate 1c. Sleeping tree, *Lecythis magdalenica*, used by *S. oedipus* group. Sleeping site and animals are circled.

Plate 1d. Sleeping tree, *Pseudobombax septenatum*, with the site and animals circled. The cotton-tops are clearly visible.

(Plate 1a). The trap units were placed on poles tied between trees at a height of about 1 to 1.2 m, in an area with visibility from above (yet shaded from the midday sun) and where vines or trees provided easy access for approaching tamarins. A live decoy tamarin was maintained continually in the trap as an attractant, and nearby tamarins would respond to its calls and approach. There was usually only a few days' delay before catching the first animals if the trap was placed in an area where the resident group had recently been seen.

With these traps, 118 captures were made in a total of 1,016 trap-days (12 percent "success"). Fifty-three individuals were caught, 21 of which were recaptured one or more times (one enthusiastic tamarin was retrapped eight times and various others were recaptured four or five times).

Trap Design Problems

Visiting tamarins were often aggressive towards the decoy. In order to prevent injury, double walls or an extra layer of wire mesh were added to the decoy's section. A protected corner was insufficient because rather than retreat to it when surrounded, the decoy jumped back and forth in panic, thus exposing itself to being bitten by one individual while trying to escape from another. The double wall design eliminated actual injuries to the decoy, but did not of course reduce the considerable stress involved in the experience.

A further design problem was the protection of the decoy's tail. An open wire mesh floor was used at first, as it conveniently allowed excrement and food residues to drop through, but the decoy's tail often hung outside the cage and was thus vulnerable to mauling by visitors. A solid cage floor was also unsatisfactory, since the tail was then dragged repeatedly through food and excrement. These sticky substances soon were transferred to the rest of the fur. A compromise solution was a solid partition or tray placed a few inches below the wire floor; this reduced the contact of the tail with waste to a tolerable level and still protected it from outside attacks. Openings in the sides of the cage large enough for the visitors to reach in had to be eliminated; otherwise they could grab the decoy and draw it to within biting reach. Food and water were placed so that visitors could not reach or disturb it and fecal matter would not fall into it. One corner was provided with a shelf for sleeping and covered with plastic to provide protection from rain.

It was most convenient to manufacture the trap section of the unit separately from the decoy section to facilitate transportation to or through the forest (by mule or foot). The trap section was subdivided (as in the complete unit) into two compartments (Plate 1a). On arrival at the trapping site a trap and decoy section were wired together. By adding a second and third trap section on top of the two original sections, the trap's capacity could be increased to a maximum of six compartments. Additional trap sections without an adjacent decoy were sometimes placed a few feet away.

Tamarins were captured in the latter despite being farther from a decoy, indicating that the bait (*Musa* sp., "platano") had an attractive effect. On the other hand, many captures were made in unbaited compartments adjacent to a decoy, indicating that the trap was entered during the course of interactions with the decoy.

Decoy Maintenance

Maintaining live decoy tamarins was difficult in a remote area with an irregular and scarce supply of fruit and protein. Obtaining food for them required frequent time-consuming trips to the nearest reliable supply of fruit and eggs, in this case a city some three hours travel one way. The lack of refrigeration limited the quantity of supplies that could be bought in any one trip.

Marking Methods

By drawing them into reach from outside the trap using the tail, captured animals were administered the anaesthetic "Ketalar" in the tail or thigh. They were fitted either with a leather collar about 0.8 cm wide wrapped with colored fiber-backed plastic tape in different color combinations and designs (Plate 1b), or with a light neck chain bearing a numbered tag (18 mm diameter). The tag was attached to the chain by a wire ring, which assured that the tag faced forward. The tamarins were measured, weighed, and examined for dental wear, signs of reproductive state, and external parasites. In some cases, a drop of blood was taken by a puncture in the heel of the forefoot. (The toes yielded no blood.) Most animals were released as soon as they recovered from anaesthesia but some were kept overnight or several nights and used as decoys to attract the remainder of their group, a tactic that was often successful.

Animals recaptured many months after marking were found to be in good condition. They showed no hair loss below their collars and generally the collars were undamaged. One captive, however, developed hair loss and lesions under a too-snug collar, although it exhibited no signs of distress such as pulling at the collar. Another managed to get the collar in its mouth but could not free

its jaw, illustrating a possible danger of a collar that is too loose.

Chains and tags are probably preferable to collars since they appear more comfortable to the animal. Light-weight ordinary ball-link chain is suitable, providing the linking piece is crimped with pliers (uncrimped chains were opened in at least two cases.) The tags, however, can only be read when the wearer is stationary and facing the observer. The identity of an animal overhead could often not be ascertained because the face of the tag was not visible. On the other hand collar colors were sometimes difficult to distinguish. Yellow and white, red and orange, and green, blue and black may be confused in the deep shade frequented by the tamarins. For example, an orange and yellow collar appeared red and white until it was possible (after observing the animal for some time) to see it in the sunlight.

A third promising marking method (R. Cooper, pers. comm.) utilizes colored plastic beads (about 3/8-inch diameter) on a chain. These should be more comfortable for the animals than the collars while retaining the desired readability, providing nonconfusable colors are used. Also they may prove more durable, since leather and plastic tape could succumb to tropical heat and high humidity over a long period. Movement of the beads around the chain is simply prevented by placing a chain-link connector on either side of the group of beads.

One or two animals in each group were marked with a bell as an aid in following the group. The bells of lowest tone were the most easily localizable and carried furthest—the sound of the "jingle bell' type shown in Plate 1b did not carry far. The bell with the lowest tone doubled the range of detection (normally a maximum of 15 to 25 meters), and facilitated tracking without visual contact, as when a group entered a dense viny area, or when I fell behind. Nearly all bells were lost almost immediately, probably through continual twisting of the wire with which they were attached. Bells and attachment should be cast in one piece—an inserted or soldered wire is easily worked loose.

Animals wearing tags, collars, and bells seemed to be accepted normally by group members since they participated in social interactions such as grooming and continued to travel with the same group with which they were observed when captured.

Age Estimation

Three measures were taken as possible indices of age: weight, head and body length, and dental state. Written descriptions of the teeth of captured individuals were fitted into two juvenile and four adult "dental age" categories, defined as follows:

- J1 Upper permanent canines not yet erupted
- J2 Upper permanent canines partly erupted
- A1 Fully grown permanent canines, very new white teeth with no visible wear
- A2 Slightly worn canines and incisors, teeth quite white
- A3 Canines and incisors moderately worn, teeth somewhat to quite discolored, tooth decay sometimes evident
- A4 Very worn canines and incisors, teeth very discolored, one or more canines frequently broken

Ease of examination and measurement dictated the focus on incisors and canines. These are rooted teeth and undoubtedly of great importance in feeding; there is no reason to suspect they would not wear according to age.

Molar eruption was not examined since all but one of the juveniles exhibited partly erupted permanent canines. Permanent canines in marmosets are too strikingly different from deciduous ones to be confused, and are probably the last permanent teeth to erupt, as in *Callithrix jacchus* and *S. nigricollis* (Johnston et al., 1970; Chase and Cooper, 1969). Tooth eruption sequences have never been published for *Saguinus oedipus.*

The juveniles captured were about ten to fourteen months old (Figures 3 and 4). They were still distinguishable from the adults by various nondental characters. Overall size and weight was smaller (Figures 3 and 4). Also they still retained the typically juvenile extra facial hair and had a shorter topknot than the adults (see photographs in S. H. Hampton and J. K. Hampton, 1967). Lastly, in the male, testicles measured only about 3 to 6 mm (as compared to 13 to 15 mm in the adults), and the circumgenital gland in the females was not developed. All A1 adults, however were indistinguishable from the other adult dental-age classes in these characters.

In Table 1 the "dental age structure" of various groups is presented. The interpretation of these findings is hindered by the lack of a known-age series of teeth with which to estimate actual ages. Apparently A1 and A2 embrace a growth phase, since seven of eight recaptured individuals from these categories showed a weight gain seemingly unseasonally related (Figure 3), and the two classes also were nonoverlapping with respect to weight in the expected direction. The A3 and A4 catego-

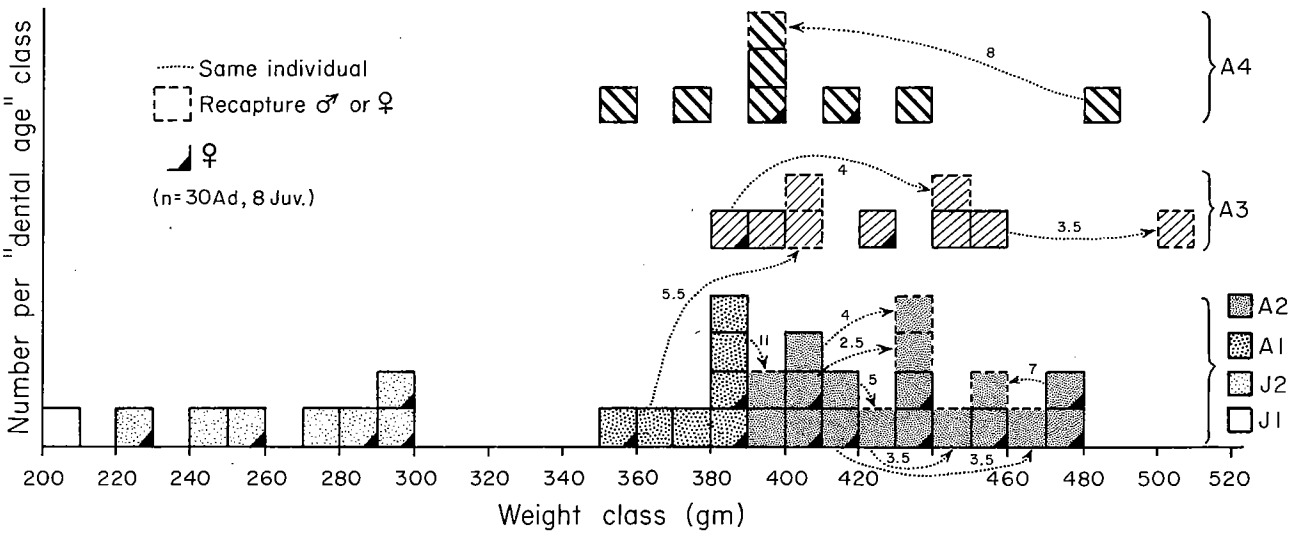

Figure 3. Weight distribution of individual *S. oedipus* in each "dental age" category (see text). Dotted lines connect different weights for a given individual; the arrow shows direction of change. Figures beside arrows are approximate number of months between captures.

Table 1. Age-sex composition of six *S. oedipus* groups during the month indicated (1975).

"Dental Age" Class	*Definition*	*La (Mar)* M	F	*Ca (Mar)* M	F	*Za (July)* M	F	*Bo (Feb)* M	F	*Ba (Jan)* M	F	*Ka (Jan)* M	F
J1	Permanent canines not yet erupted	1											
J2	Permanent canines partially grown		1[i]		**1**[i]		2[i]	1				1	1[i]
A1	Teeth very white, sharp, no wear	2	1[i]	1	**1**[i]	1							
A2	Teeth white, barely noticeable wear		1[d]				1[d]			1	1[i]		
A3	Definite wear, and discoloration			1	**1**[m]	1		**2**	1*	1			
A4	Very discolored— canines very worn/broken, incisors worn down	1	1[m]	1								1	
A?	Teeth not examined							2	1		**1**[i]	1	
	Juveniles	1	1		1		2	1				1	1
Subtotals:	Adults	3	3	3	2	2	1	4	2	2	2	2	
	Adults not captured			1									
Group totals		8		7		5		7		4		4	

Nipple-length designation
n—nipples undeveloped (nulliparous) (½–1 mm long)
i—intermediate development (1-½–2 mm)
d—well developed, possibly parous (3–4 mm)
m—maximal development, probably parous (5 mm)
(not all females were examined for this character)

Boldface individuals left group before August 1975.

*This female (Lo) had increased weight by 60 gm since 4 months previously, nipples had changed from i to m, and she "seemed fat." Possibly pregnant—twins seen in this group late in April.

ries overlapped both with each other and with the A1 and A2 categories. Longitudinal growth probably ceases or becomes too slight to detect at an earlier age than weight gain: there was no difference between the adult "dental-age" classes in head and body length distributions. A more repeatable length measure depending on fewer growing elements, such as knee-heel length, might be a more sensitive measure of growth.

Males and females were combined in Figure 3, as within dental-age class means showed no significant difference, due to the wide distribution and low number of values. The lack of sexual dimorphism in weight and body length (Figure 4) is evident at all ages. Nor was a sexual difference in canine length or breadth evident, as reported for *Callithrix jacchus* (Johnston et al., 1970).

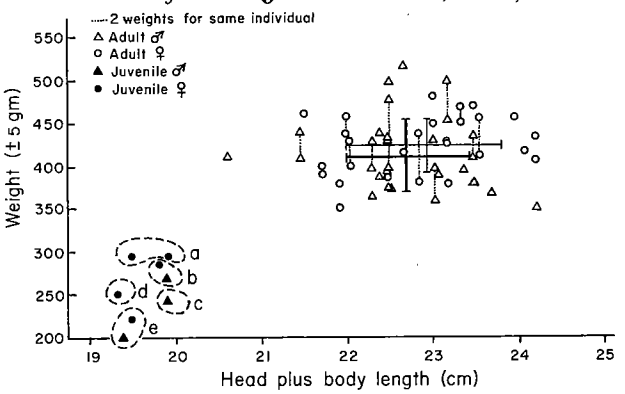

Figure 4. Relationship between weight and head and body length in *S. oedipus*. Cross arms are one standard deviation in length (heavy line = males, light line = females). Juveniles from differing groups are circled, "a-e." The birth date of pair "b" (Ka group) could be placed within an 11-day period: at the date of capture, they were nearly a year old (352-363 days). Pair "e" was known to be around 10 months old when captured (group La). The latter had considerable facial hair (see text), while the year-old ones had very little remaining. Pair "a" was about 13-14 months old (estimated by weight) and had extremely little, if any, extra facial hair, and their upper canines were almost the adult length (about 4½ mm—adults range 5 to 6 mm maximum).

Nipple length was taken on many females (Tables 1 and 3) as a possible means of distinguishing between parous and nulliparous adults. The nipples of parous females become more elongate (R. W. Cooper, pers. comm.). Whether some elongation may also occur at sexual maturity or in parous females who lose their young and do not suckle is not known.

In this sample, length ranged from 1/2 to 5 mm. The measurements fell into four classes (see legend for Table 1). The 5 mm class contained only A3 and A4 females while the lowest (1/2 to 1 mm) group contained all the juveniles and A1 adults. Aside from this, there was no clear correlation with "dental age": A2 females occurred in all three lower classes and an A4 female occurred in the 3 to 4 mm class. One A3 female (Lo), moved from the 1-1/2 to 2 mm class to the 5 mm class in four months; on the latter occasion, she appeared pregnant (Table 1). Thus, some females can show seasonal (?) changes. There was a tendency for nipple color to darken with age (whitish or pinkish to dark); but a few had dark though small nipples (1/2 to 1 mm).

Results

Group Size and Composition

Groups frequenting established home ranges in or adjacent to the study area (hereinafter referred to as "established" groups) contained between three and thirteen individuals, including carried young (Table 2). Groups only temporarily present in the study area ("transient" groups) consisted of one to five individuals.

The age-sex composition of six groups is analyzed in Table 1. None of these (or any other group observed) contained more than two juveniles. Two to six adults were present, of both sexes, except in one group (and later also possibly a second) which lacked females. No more than three adults of a given "dental age" were present but not all ages were represented in every group. Five groups whose composition was known in early 1975 contained a total of 31 individuals: 6 juveniles about 6 to 10 months old (3♂♂, 3 ♀♀) and 25 adults (15 ♂♂, 9 ♀♀, 1 sex unknown). By the end of July the composition of a sixth group was known and the other groups had undergone changes. The six groups then contained 30 animals: 7 juveniles (3 ♂♂, 4 ♀♀) and 23 adults (15 ♂♂, 7 ♀♀, one sex unknown). The sex ratio among adults in these samples is insignificantly unbalanced in favor of males (1.8:1, omitting the one of unknown sex). The sex ratio among juveniles up to one year is about equal.

Various changes in composition were observed in "established" groups, despite the fact that they were followed in some cases for only a few months. These changes are summarized in Table 2 and Figure 5, but the Ka group's history may serve as an example. When first observed, this group consisted of three animals—two adult males and an adult female. It increased to five with the birth

Table 2. Size of "established" groups in the study area and adjacent areas, cause of changes therein, and known facts concerning individuals involved.

Group	*Dates*	*Group size*[1] *Begin–End*	*Born*	*Cause for change in group size*[5] *Appearance*	*Reappear*	*Disappear*	*Death*	*Leave*
UB[6]	8/72–8/75	13 5	4	?	?	11	1+?	?
Ka	3/73–8/75	3 4	2	1(MA4)[4]		2(FA,MA)	?	
Ba	7/74–8/75	5 3		1(FA2)		1(J)	?	2(FA2,FA)
Bo	7/74–8/75	7 7?[7]	2		2(2MA)			3(2MA)
Ca	2/75–8/75	7 4						3(FA3, FA1,FJ)
La	3/75–7/75	8 7?[8]						

The following only observed one or a few times, as shown by dates:

La?[2]	3/74–4/74	Min.[3] 12
Ua	5/73	Min. 8
	7/74	Min. 9
	7/75	4
Za	4/75	5
UUB	9/72	Min. 10
LB	10/72	10
	4/75	6
F	8/72	Min. 8

[1]Includes carried infants and juveniles;

[2]Unmarked group followed for over a month in the same area which the La group (marked later) occupied—could have been La group;

[3]Min. = minimum, the number actually verified; but due to visibility conditions, observer felt there was a relatively high probability that not all group members were seen. (Counts lacking "Min" felt to be complete);

[4]A = adult; J = juvenile, the numbers following A or J designation indicate "dental age" (as per Table 1) M = male; F = female;

[5]For category definitions, see text. Animal "disappearing" could have wandered into rest of woods (study area constituted only 52 hectares of a 600 hectare woods). This was suspected in cases of "disappearance" but was not differentiatable from death. If the individual was observed at least once apart from its group, it was considered to have "left" its group;

[6]Uncertainties in UB group are due to its containing very few or no (most of study) marked members;

[7]Only one infant seen of two possible (3 mos. old), but both could well have been present;

[8]Bad visibility, 8th may well have been present.

of twins, and then to six by the addition of another adult male (Oa). When the twins were about six months old the female disappeared, followed soon afterward by one of the original males. Eight months later, at the end of the study (August 1975) the group still consisted of the same two adult males and two juveniles, then 17 months old. One other group (Ca) lost three of its seven members (all females) in the month after it was marked. Some groups maintained their numbers, however, during this same period. Four of the six established groups showed an overall decrease in size during the period observed (5 to 22 months depending on the group). The group whose size decreased most (UB) may have had some members captured by local people, since its home range was a narrow strip of woods flanking a well traveled footpath. There was no reason, however, to suspect human interference of other groups.

Fluctuations in numbers prevented the calculation of an "average" group size, as any method of selecting data from the varying time periods that the different groups were under observations is arbitrary and does not give a sample from which a central tendency can be derived. Nor can data from study area groups be combined with that of unmarked infrequently observed peripheral groups (Table 2, lower half). Until more detailed data are available, it seems better to view cotton-top tamarin groups in terms of maximum and minimum size rather than average size.

Regular group splitting or coalescing such as reported for *Saguinus fuscicollis* (Castro and Soini, 1977), and *S. midas* (Thorington, 1968; Durham

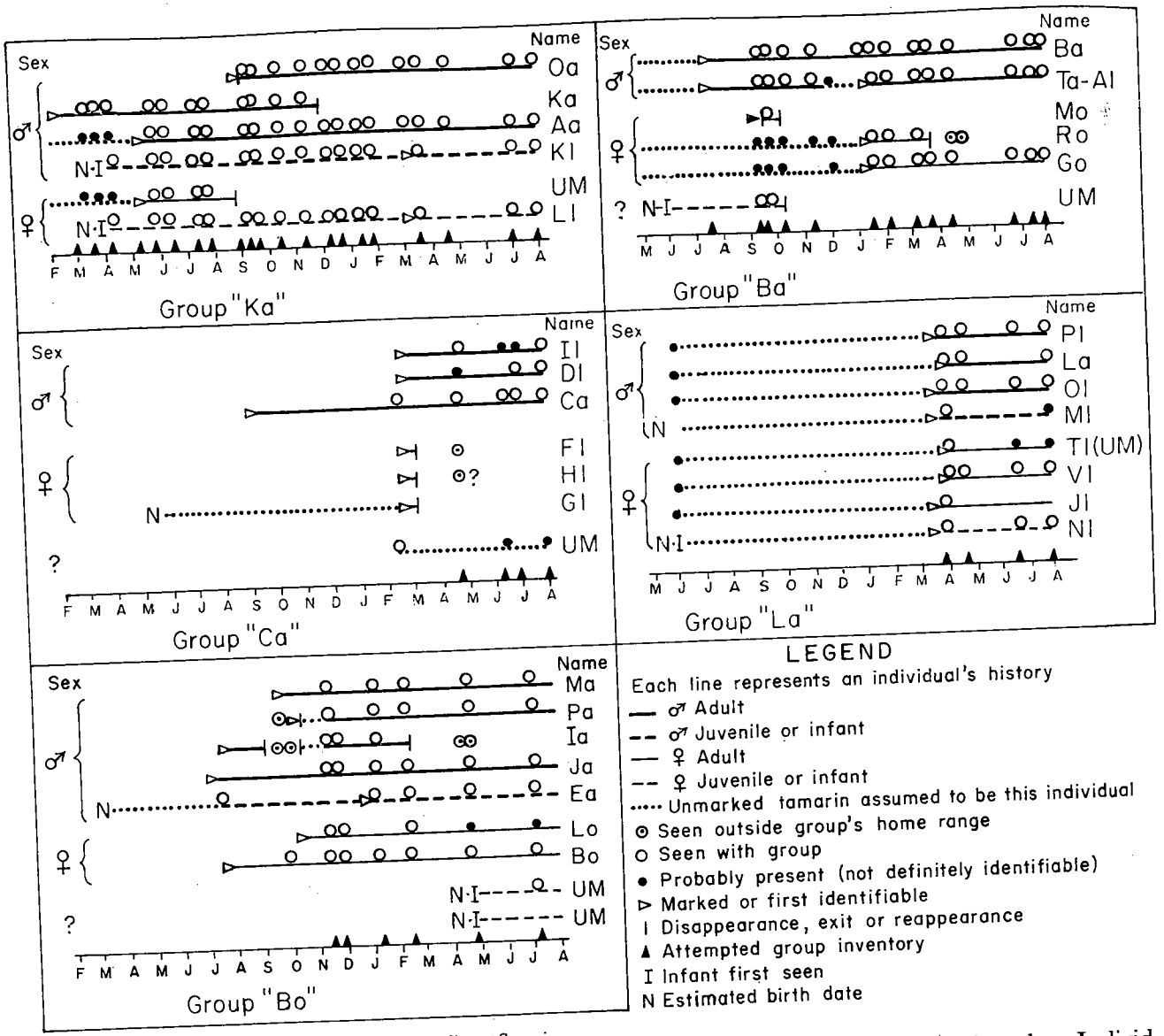

Figure 5. Changes in composition of five *Saguinus oedipus* groups over 5 to 18 months, ending in August 1975. Shaded triangles indicate those occasions on which a reasonably complete group count was obtained. Group size on those dates equals the total number of horizontal lines (solid, dotted, or dashed), each of which represents an individual's history in the group. Named individuals were all marked. UM = unmarked, (UM) = marking lost. In three groups (Ka, Ca, La) one adult remained unmarked. The Ka group UM individual must have been a female, since infants appeared and the other two group members were males. Infants and juveniles were assumed to remain with the same group, and so are figured as identifiable although unmarked.

and Durham, in press) did not occur in the established groups studied. In over 300 hours of contact with group UB, no instance of prolonged splitting or joining of subgroups was seen.[3] Two cases of temporary splitting were observed. In both cases the separated subgroups exchanged contact vocalizations until one moved to join the other. Individuals separated from their group typically ran back and forth through the trees calling loudly ("Long Calls," Figure 6). When other group members vocalized in response such isolated animal(s) moved toward the source of the sound, and the exchange of calls ceased as soon as they rejoined the group. Thus, a certain group cohesion was evident, apparently reinforced by the tendency of separated individuals to find and rejoin their groups. Nevertheless, individuals did at times lag behind the rest of the group by several minutes. More important, some individuals were observed to leave their home groups. The most striking case was that in which an adult male previously seen with the Bo group

[3]The UB group numbered 13 when observations began in August 1972 and 7 in July 1973.