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STUDY OF THE MAINTENANCE BEHAVIOR OF THE RED-BELLIED TREE SQUIRREL, *CALLOSCIURUS ERYTHRAEUS*

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Lien-Siang Chou, Yao-Sung Lin and Hin-Kiu Mok (1985) Study of the maintenance behavior of the red-bellied tree squirrel, *Callosciurus erythraeus*. *Bull. Inst. Zool., Academia Sinica* **24**(1): 39-50. The maintenance behaviors of the red-bellied tree squirrel, *Callosciurus erythraeus*, were studied from November 1981 through October 1982 at the Taipei Botanical Garden. The patterns of locomotive, alert, exploratory, feeding, debarking, caching, autogrooming and resting behaviors are described and the monthly change in the latter 5 behavioral activities are analysed. The behavioral patterns are more similar to those of other tree squirrels than those of other ground squirrels. This may be due to the difference in arboreal and terrestrial life styles. Monthly change in feeding and resting activities may be related to energy adjustment. The initiation of the peeling-feeding in debarking behavior may be due to the attraction of some chemical contents in the bark. Caching behavior appears frequently in autumn, and is elicited by certain kinds of drupes and their falling periods.

The red-bellied tree spuirrel, *Calloscirus erythraeus*, is widespread from low lands to high altiude (above 3000 m) in Taiwan. Its distribution is restricted to Malaya, southern China and Taiwan (Corbet & Hill, 1980).

In recent years, foresters and biologists have devoted considerable attention to the damage of the red-bellied tree squirrel to conifers. They have studied the reproductive biology (Tang and Alexander, 1979; T'sui *et al.*, 1982), population control (Hwang *et al.*, 1979; Wang and Kuo, 1980) and ecology (Chang, 1976; Lin and Yo, 1981; Chang, 1982) of the red-bellied tree squirrel and the relationship between chemical content of the bark and its damage degree by squirrels (Kao and Fang, 1980; Hwang, 1981; Lion, 1982). Behavior of the red-bellied tree squirrel was first studied by Lee (1981). However, no work has been published on the detailed description of the red-bellied tree squirrel's basic behavior patterns. For the purpose of providing information on the behavior of red-bellied tree squirrel which is valuable to ethology and may also be essential to forest management. The present study is conducted to describe the maintenance behavioral patterns of the red-bellied tree squirrel, to analyze their monthly appearance and to compare them with those of other squirrels.

STUDY AREA AND METHODS

We chose the Taipei Botanical Garden of Forestry Research Institute as the study area, in which the topography is flat. The vegetation complex includes 202 familes, 1573 species and varies of vascular plant (Anonym, 1978). The monthly average temperature from November 1981 to October 1982 was between 15.7°C and 28.8°C, and that of precipitation was between 1 mm and 55.5 mm.

The 0.8-hectar experimental area was divided into 3 observation sections, each with a crossing trail. And the observations were made along these trails.

Twenty six cages (28×14×16 cm) for trapping squirrels were placed in experimental area during the period from July 1981 to March 1983. Before trapping, banana baits were give for two weeks. When the red-bellied squirrels were captured, ear tags were clipped on the left ear for male and the right ear for female. Human hair dye was used to mark the fur. Trapping was conducted at intervals of about 45 days, and each trapping period lasted for three days. More than 90% of captured squirrels can be recognized afterwards.

From November 1981 to October 1982, squirrel's behaviors were observed for three good weather days per month when not trapping. Observation began at 30 minutes before sunrise, and ended at ten to twenty minutes after sunset. Observation was carried out along each of the three trails in turn. One hour was spent on each of them, and the starting trail of each sampling day was changed on regular rotation basis.

Through 8×24 binoculars, we traced a randomly selected squirrel for 45 minutes each hour at each observation section and recorded its complete behavioral repertoire (such as locomotive, alert, exploratory, feeding debarking, caching, autogrooming, resting and nest-building behaviors) and the time and duration of these behaviors in sequence. The complex structure of the uncommon caching and the short autogrooming behaviors made it difficult to measure the element frequency and duration accurately. As such, only their bout frequency was recorded. The monthly behavior activity was calculated by dividing the monthly total frequency and duration of a certain behavior pattern with the total individuals seen in that month. When the squirrel was eating or caching, the food was recorded in regard to what tree species was and which part of the plant was consumed.

RESULTS

A total of 700 hours was spent observing the squirrel behavior. The sample size of squirrels observed in each month ranged from 7 to 20. During the study period, 36 squirrels (20 females and 16 males) were marked.

Description of behavior patterns

Locomotion

The pace of walking is quadrupedal which is usually accompanied by some sort of slow motion, such as searching and exploring. The carriage of squirrel's body is various, ranging from extending the belly close to the ground in an alert state to elevating the belly well off the ground in a relaxed state. A series of hops is used for rapid locomotion—skipping, with a speed of over three meters per second. In skipping, the squirrel's forelegs and hindlegs move alternately in pairs. When a squirrel wants to jump a distance of one to three meters, a sequence of movements is noted. First, it stares at the target point, moves to and for several times within no more than 50 cm, stops, prostrates the anterior part of its body, arches the rump and finally jumps over to the target spot, usually with a drop no more than one meter. The squirrel leaves the base point in a horizontal plane and completes the jump with the head upward and body parallel to the tree trunk. Sometimes it loses holding and falls to the ground. However it will climb up the tree quickly, with no signs of hurt.

Alert behavior

The red-bellied tree squirrels display alert behavior in two postures under different situations. One is an upright posture used during feeding time (Fig. 1a). When strange sounds or objects are noticed, the squirrel will stop feeding, put the food into its mouth, and stand on its hindlegs silently. The other is a quadrupedal-down posture (Fig. 1b) with the head lifted up, the belly slightly extended, the eyes staring at no certain target and the tail bristling. In case of increasing degree of

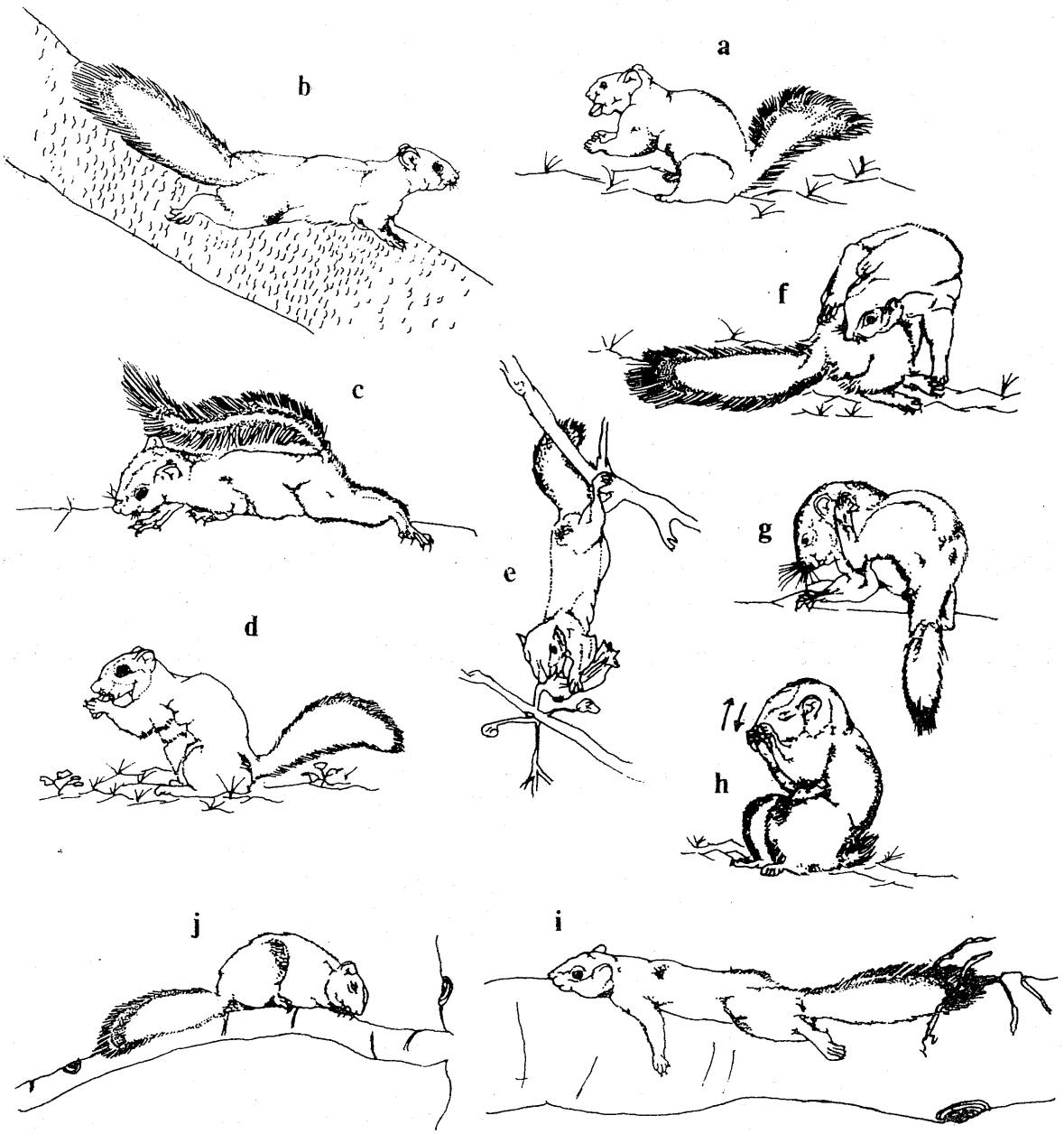

Fig. 1. Behavioral patterns of the red-bellied tree squirrel (*Callosciurus erythraeus*). a-b, alert behavior in upright and down posture; c, exploratory behavior; d-e, feeding in sitting and in hanging up-side-down posture; f-h, licking, scratching and wiping elements of autogrooming behavior; i-j, resting posture in summer and winter, respectively.

alertness, the tail changes from a posteriorly pointed orientation to flipping and to anteriorly pointed orientation.

Exploratory behavior

The posture of exploratory behavior is similar to the quadrupedal down alert posture, except that extension of the body is conspicuous (Fig. 1c). The squirrel lays most of its weight on its hindlegs, with the forehands touching the ground unstably, as in the jerky gait. The tail always flips quickly and usually extends straight foreward. Its neck is craned in the direction of a certain target. The squirrel waves its head from side to side while keeping the eyes staring at a particular target.

Feeding behavior

This behavior is displayed most frequently. It comprises foraging and eating elements. A squirrel usually walks foreward on the tree with its nose sniffing the tree branches, new leaves, flowers, buds or fruits, and somtimes raises its foreleg(s) to draw the target. When it forages on the ground, it usually places its nose close to the ground and moves its head from side to side. When a squirrel eats, it either sits (Fig. 1d) or hangs itself up-side-down with food in its forelegs (Fig. 1e). Sometimes it chews food in a standing posture. As usual, a squirrel adopts the standing posture to eat the bulky or food adhered on the stem, and uses the sitting posture for small food items which can be handled, while the hanging posture is used most often for food on slender, soft stems, such as the fruits and flowers of *Cinnamomum camphora* or *Killenga pinnata*. The eating behavior may be interrupted by abrupt environmental changes, such as strange noise or moving objects. In these cases, it will stand in an upright alert posture and keep motionless for a while: then it may continue to eat at the same place or skip to a higher branch to continue its meal either by sitting or by hanging posture.

For the whole year, 46 species out of 220 tree species in the experimental area were eaten by squirrels. According to the 312 consuming counts, the squirrels are found basically vegetarian, feeding on fruit (63%), bloom (19%), leaf (14%) and fungus (3%). But they are found feeding on the insect larvae (gall of *Unilachnus*) has occasionally been observed in July and August.

Debarking behavior

The definition of debarking is biting or pulling off the bark from a tree. Usually, squirrels debark stems in a standing or prostrating posture. When biting the bark, the squirrel stretches its forehands forcefully against the trunk and by lifting its head up to tear the bark off. Sometimes a squirrel simply throws away the peeled bark (defined as peeling), or clasps the bark and eats the inner layer (defined as peeling-feeding). We have never found that it takes the bark away for nest material in the study area.

The debarking pattern varied considerably. Some species such as the *Elaeocarpus serratus*, *Semecarpus gigantifolia* and *Cinnamomum camphora* were debarked in strips. The length of the strip was above 10 cm. Most of the tree species had been debarked in small flakes, with a diameter about of 1 cm to 3 cm.

When several trees of the same species grow in a cluster, the red-bellied tree squirrel often debark a single tree, even at the same debarked point, such that the scar gradually enlarges. These situations have been observed in one cluster of three *Elaeocarpus serratus* and two *Semecarpus gigantifolia* clusers with eight and three trees respectively.

Caching behavior

This behavior is usually displayed after the squirrel has eaten or foraged for sometime. At first, the squirrel displays searching behavior. After obtaining a piece of food, the squirrel chews it for a while, then looks around and skips away with the food in its mouth. In skipping, the squirrel would usually stop suddenly and look around. These actions are maintained until the squirrel arrives at a certain place, and caches the food. The

squirrel would move its snout repeatedy, and quickly stuff the food into the surface soil, a tree hole or the base of a leaf stalk of a palm tree. On some occassions, the squirrel suddenly stops the caching action, then grasps the food and puts it back into its mouth, and repeats the searching behavior to find another suitable place to deposite the food. Caching behavior is ended by the squirrel scratching in the air 2 to 4 times over the caching position with its forepaws. There is no special behavior displayed for marking the hiding place at the end of caching behavior. Sometimes, when a squirrel walks on the ground or on tree branch, it would suddenly picks up food which was cached by itself or other squirrels.

Autogrooming behavior

The terms used to describe the squirrel's body are divided into 14 body sections, such as head-muzzle, chin, neck-shoulder, thorax, forelegs, back, flank, belley, rump, thigh, urogenital area, hindlegs, proximal tail and distal tail. These body sections can be groomed by any of the following four methods:

a. Chewing or licking its limbs or posterior trunk (Fig. 1f).

With its mouth and teeth, the red-bellied tree squirrel can clean the four legs and all the posterior parts behind its thorax and neck-shoulder. And this method can be applied to 10 body sections. When the squirrel cleans its fore-limbs, thighs or tail, it adopts a sitting posture. For grooming the thigh and the proximal portion of the tail, the squirrel twists the forequarters sideway, and the foreleg corresponding to the turning side is crossed over the back at the same time. The tail is usually groomed from base to tip. When squirrel wants to groom the distal part of its tail, it picks up the tail from the side to its mouth and holds the tail with its forepaws in a sitting posture.

b. Wiping or washing its muzzle or head region with the thumb pad (Fig. 1h).

While performing this action, the squirrel adopts a sitting posture. At first, its grooms the muzzle part by a rapid back-to-front movement of the forelegs. The degree of this movement is then extended to groom the face, and to the top of the head. These movements occur in a series of 4 to 10 times. The eyes are shut as the forelegs pass over them. The movements of the forepaws or forelegs are simultaneous or alternate. And then it passes the flank, and reaches the tail part. Therefore, this method is able to clean two, the head-muzzle and the flank, body sections.

c. Scratching the anterior body rhythmically by one hindleg (Fig. 1g).

The hindfeet are used for scratching the anterior parts, such as the head-muzzle, chin, neck-shoulder, back, flank, belley and forelegs. And this autogrooming method covers seven body parts. For convenience, the squirrel bends the head sideway to the scratching hindleg, or lifts the forelegs to bare the thorax and breast. The scratching display is used quite often.

d. Rubbing the muzzle against other object.

This is often displayed after eating some wet or sticky food.

By matching the 14 body sections and the four grooming methods, 20 elements in grooming behavior were identified in our study. In total, 761 bouts of autogrooming behavior has been observed. However, only 597 bouts were recorded in detail. Among the 597 bouts, 63% had only one element, 27% had 2 to 5 elements and the remaining 8%, which are defined long term autogrooming behavior, had more than 5 elements. Long term autogrooming usually occurred after resting. The maximum frequency was 42 recorded at 14:00 h. on September 10, which lasted for 3 minutes.

Restig behavior

The squirrel often rests on tree branch during the day. As its nests, its head leans

against the forelegs or tree branch with either eyes opend or closed. The extent to which its body is stretched differs between the summer and winter months. In summer, the squirrel rests in a sprawled lying posture, i.e. lying on its belly with the four limbs spread out (Fig. 1i). While in winter, it crouches the body on its four folded up limbs (Fig. 1j).

Monthly change of activity

The monthly change in feeding activity showed obvious seasonal variation, with the lowest activity in summer (June-July), and higher activity in autumn (Sept.-Oct.) and winter (Dec.-Feb., Fig. 2). The feeding activity expressed by frequency and duration showed difference in two periods, from Nov. 1981 to Feb. 1982 (winter) and Sept. to Oct. 1982 (autumn). This may be due to the change in the food types. In winter, the main food was drupes of *Elaeocarpus serratus*. It took at least ten minutes to half an hour to eat a drupe; thus the activity expressed in duration was higher than that expressed in frequency. In autumn, the berries of *Syzygium cumini* or the flowers of *Killenga pinnata* were eaten most frequently. The time spent in every food item was less than thirty seconds, so the activity as expressed in higher frequencies. On the whole, the feeding activity was higher in winter and autumn, but lower in summer.

Debarking activity was divided into two parts, peeling activity and peeling-feeding activity. The monthly change of peeling activity was irregular, however, the monthly change of peeling activity both in frequency and duration showed only one conspicuous peak in March (Fig. 3a). And the percentage of peeling-feeding to total feeding abruptly increased to 37% in March, while this percentage was between 0% to 13% in the other months (Fig. 3b). Therefore, bark probably became an important food resource in March. However, food resources in the experimental area were not in short supply in March, be-

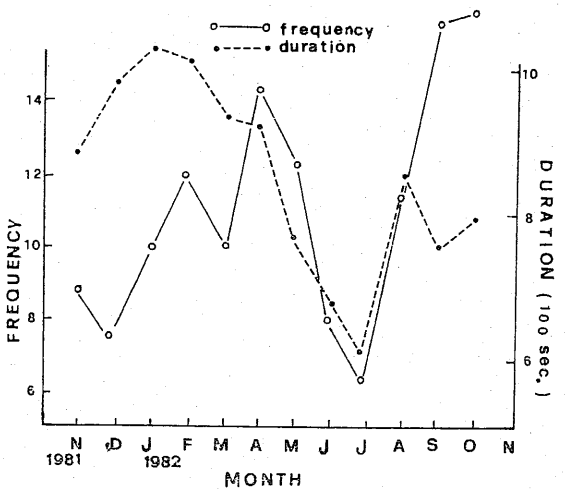

Fig. 2. Monthly change of average frequency and duration per squirrel in feeding activity. Total frequency=1735, total duration=122660 seconds.

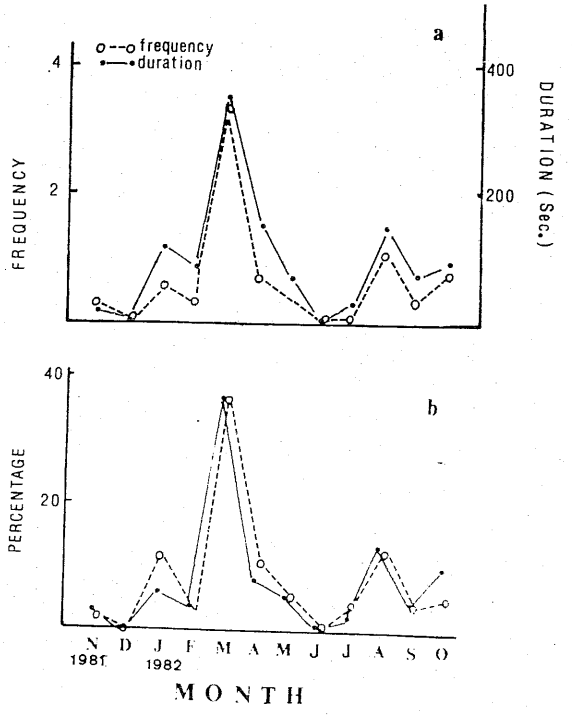

Fig. 3. Monthly change of (a) peeling-feeding activity presented in average frequency and duration per squirrel, the total duration of peeling-feeding activity is 15027 seconds, and the total frequency is 441. (b) percentage of frequency and duration of peeling-feeding activity to those of feeding activity.

TABLE 1
List of food plants, the consumed parts and its consuming frequency by the red-bellied tree squirrel in the experimental area
(B, bloom; F, fruit; L, leaf)

Species	Consumed parts	Month											
		N	D	J	F	M	A	M	J	J	A	S	O
Semecarpus gigantifolia	F, B	1	4	1	2	2	2	1	1		2	1	1
Elaeocarpus serratus	F, B	3	3	6	2	1					1	3	
Livistona chinensis	F, B	1		1		6	1	2	3	1			2
Bauhinia aculeata	B, L	4	2				4	9	1	3		1	2
Artocarpus heterophyllus	F	1	2				3	2	1		7		2
Leucaena leucocephala	F, L	1	1	2		2	1			4			
Phaphiolepis indica	F	2	8							1		1	
Albizia lebbeck	F, B, L		1	2	1	1		4	1		1	1	
Machilus thunbergii	F					1	5	1					
Ficus benghalensis	F							2	8	9	1		
Aleurites moluccana	F							1			4	6	11
Mangifera indica	F, L							2	2				
Erythrina variegata	B							20					
Cinnamomum camphora	F								1	3	11		
Ficus benjamina	F									2	16		
Ficus drupacea	F										4	2	
Artocarpus altilis	F										6		2
Killenga pinnata	B											9	6
Syzygium cumini	F											1	5
Pongamis pinnata	L											1	6
Others	F, B, L	3	1		1	6				2	1	1	2
Fungi		2				1			4		1	1	1
Gall of *Unilachnus* sp. (in the branch of *Styrax suberifolius*)										3	1		

cause eleven species of edible flower, fruits, new leaves and buds were recorded in March (Table 1), and there's no sign of deficiency of those food items on the trees. Among the debarked tree species, eight species which sprout in spring were deciduous or semideciduous.

The caching activity showed seasonal change (Fig. 4). Among the 40 bouts of caching behaviors recorded in a year, 33 occurred in September and October and coincided with the ripening of the drupes of

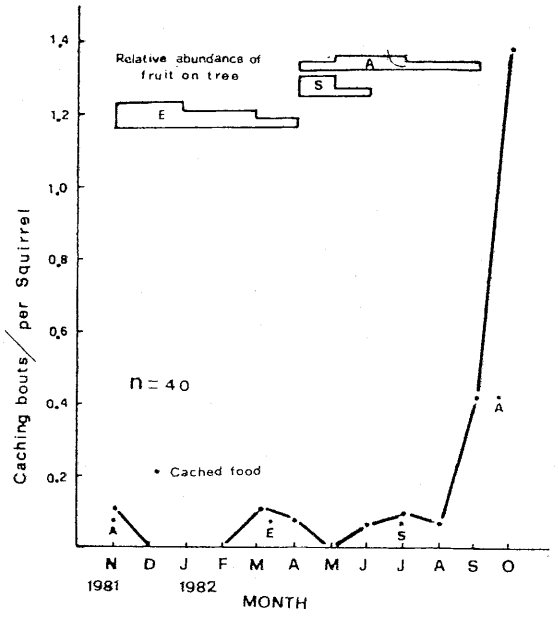

Fig. 4. Monthly change of average caching bouts per squirrel and the relative abundance of fruit on tree.
*, caching food: A, *Aleurites moluceana*;
E, *Elaeocarpus serratus*;
S, *Semecarpus gigantifolia*;
n, total number of caching bouts.

TABLE 2
Monthly change of autogrooming activity (average bouts per squirrel) in different sex and maturity

Years	Month	Average bouts	Adult Female	Adult Male	Immature
1981	Nov.	5.4	7.0	3.5	7.0
	Dec.	3.2	8.5	3.5	2.3
1982	Jan.	3.5	10.0	4.0	9.0
	Feb.	4.3	11.0	0	9.0
	Mar.	5.9	4.0	4.0	3.5
	Apr.	4.0	4.1	0	2.0
	May.	4.2	6.4	3.7	5
	Jun.	4.4	2.5	2.7	5.0
	Jul.	4.5	0.5	7.5	7.8
	Aug.	6.6	7.7	14.0	5.7
	Sep.	5.0	6.0	4.7	1.6
	Oct.	4.8	18.0	8.0	3.0
Mean			7.14	4.53	5.08

These log transformed means are significantly different at $p<0.1$ by F-test.

Aleurites moluccana. The squirrel also displayed this behavior by the time fruits of *Elaeocarpus serratus* and *Semecarpus gigantifolia* fell (March-April and June respectively). Therefore, its occurrence is probably related to the ripening and falling of certain kinds of fruit.

The autogrooming activity is higher in March and August (Table 2). The average annual bout frequency of autogrooming behavior displayed by females was slightly greater than by male and immature individuals.

The monthly change of resting activity (Fig. 5) revealed that this activity increased in winter (Jan.-Feb.) and summer (July-Aug.). In the former period, the squirrel sometimes basked on bare branch for long time. We have recorded once in February 1982 that the squirrel rests for more than one hour.

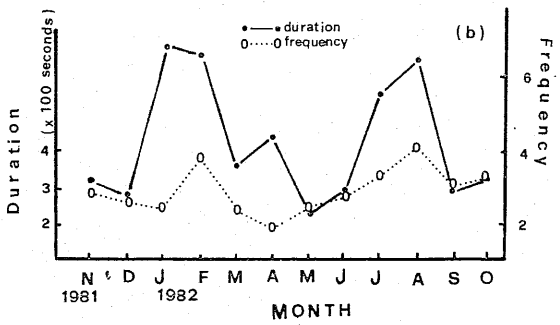

Fig. 5. Monthly change of average frequency and duration per squirrel in resting activity. Total frequency=326, total duration=70579 seconds.

DISCUSSION

Comparisons of behavioral patterns

The behavioral patterns of the red-bellied tree squirrel are more similar to those of other tree squirrels such as grey squirrel (*Sciurus carolinensis*) and red squirrel (*Tamiasciurus hudsonicus*) than those of chipmunk (*Tamias striatus*) and ground squirrels (*Spermophilus* sp.). This fact supports the suggestion that the tree squirrel diverged from the chipmunk and ground squirrel lineage during the Oligocene (Ellis and Maxson, 1979; 1980). The red-bellied tree squirrel, red squirrel and grey squirrel are primarily arboreal, agile on tree (Hatt, 1929; Schwartz and Schwartz, 1981), while the chipmunk and ground squirrels rarely climb trees, and are not able to leap from branch to branch (Wolfe, 1966; Schwartz and Schwartz, 1981). The red-bellied tree squirrel uses only quadrupedal down posture

for exploratory behavior, while the chipmunk displays both down and upright posture in exploratory posture (Wolfe, 1966). Wolfe (1966) suggested that the upright posture in chipmunk may be used for improving visual reception of environmental information in their terrestrial life. But to the arboreal red-bellied tree squirrel, the upright exploratory posture seems to be unnecessary. All the squirrels mentioned above display autogrooming behavior in a similar posture except the difference in the tail licking posture between tree squirrel and ground squirrel. The red-bellied tree squirrel, red squirrel and grey squirrel, lick their own tails by picking up the tails only from one side to their mouths while the ground squirrel is able to pick up the tail either between the hindlegs or from the side to the mouth. The reason for the difference is probably related to the different requirement in balance of gravity, which is more important for tree squirrels when they put all of their body weight on the hind-quarters on tree branch to groom their tails. Differences in locomotive, exploratory and autogrooming behavioral patterns between tree squirrels and ground squirrels could reveal their respective adaptation to arboreal and terrestrial life.

The distributions of frequency of various autogrooming methods and the autogrooming elements within a bout of the red-bellied tree squirrel are similar to that of the red squirrel (Ferron, 1976) and chipmunk (Wolf, 1966). Among the autogrooming, scratching is expressed most frequently by all of these squirrels. Most autogrooming bouts include only one element. Ferron (1976) noted that there is a sequence among the autogrooming elements. However this kind of sequence have not been found in the red-bellied tree squirrel.

The red-bellied tree squirrel adopts two kinds of resting postures, sprawled lying and crouching, while the red tree squirrel has additional sitting posture (Ferron, 1976). The kind of posture adopted by squirrels could be influenced by weather. In summer, the red-bellied tree squirrel adopts sprawled lying posture. While in winter, it usually crouches its body to rest. Nevertheless, on a warm sunny day in cold winter, it would bask (sometimes sprawled lightly) on a bare branch to warm up its body for a long time. This behavior was also observed in the red and Abert's squirrels, *Sciurus aberti* (Ferron, 1976; Golightly and Ohmart, 1978). Ferron (1976) suggested that the heat transfer factor probably influence the kind of resting posture adopted.

The caching behavioral pattern is different between tree squirrel and ground squirrel. Without inner cheek pouch, the red-bellied tree squirrel, similar to other tree squirrel, could hold only one food item in its mouth at one time, while the ground squirrel is able to carry several food items in its inner cheek pouch (Schwartz and Schwartz, 1981). The storage site also varies among squirrels. The ground squirrel stores food in the chamber of underground burrow system, while the red-bellied tree squirrel usually stores its food under the ground surface, which is also displayed by grey squirrel (Thompson and Thompson, 1980). Besides this place, the red squirrel will store their food in small ground pockets, the crotches of trees, underneath the loose bark of trees, the hollows of trees, hollow logs, or large underground chambers (Hatt, 1929).

The function of caching behavior of the red-bellied tree squirrel is not so obvious as that in the red and grey squirrels. The latter two finish the caching behavior by covering the stored food with some leaves or soil (Hatt, 1929; Thompson and Thompson, 1980), but the former doesn't show obvious covering component in their caching behavior.

The wiping and rubbing muzzle autogrooming displayed by the ground squirrel distributes the secretion of apocrine sudoriferous glands (at the oral angles of the muzzle) over the head or other objects, as a sign of recoginition or scent marking (Steiner,

1973; 1974). In red-bellied tree squirrel, the wiping element in autogrooming shows a rapid circular movement of forepaw(s) from the oral angle to the face or to the head. Since the head area is an important target for allogrooming (Chou, 1983), it is possible that an olfactory sign is smeared on the head by wiping autogrooming. Although there are no report on the scent gland of the red-bellied tree squirrel, this action may indicate that it has a similar function as that of the ground squirrel. Nevertheless, the muzzle-rubbing movement seems to be different from that of ground squirrel. This behavior is usually displayed after the squirrel has eaten some wet food, and is probably used for drying the wet fur but not for scent marking.

Monthly Change of Activity

The feeding, debarking and caching activities of the red-bellied tree squirrel had different seasonal variations but all had low activity in the summer. This is probably related to the low requirement for energy to maintain the body temperature in summer.

In March, the peeling-feeding activity made up 37% of the total feeding activity, which was higher than that of the other months. This increment coincided with the increasing damage of conifer stems by tree squirrel from February to April at Chi-Tou (Chang, 1976; Liou, 1982). Both Chang (1976), Wang and Kuo (1980) indicated that the squirrel's debarking of tree stem was a consequence of the deficiency of food supply. However, at the Taipei Botanical Garden, 46 species out of 220 tree species were fed upon by the squirrel. These tree species supplied the annual food resource and no evidence of food deficiency in March was noted. Therefore, the increase of peeling-feeding activity might not be merely due to the food shortage, but to some other factors. Liou (1982) noted that the sugar contents of the seriously damaged *Cryptomeria japonica* and *Cunninghamia lanceolata* were higher than that of less damaged species, *Taiwania cryptomerioides*. The sugar content in the bark of the former two species was also significantly higher in February to April than those in other months. At the Taipei Botanical Gardern, most of the debarked species were deciduous or semideciduous. In spring, they sprouted and grew, and abundant starch would be transformed into monosaccharides or oligosaccharides (Siminovitch, 1953). Therefore, the increment of peeling-feeding activity in spring may be due to the increase in some carbohydrate content in the bark, rather than a food shortage during that period.

The squirrels not only ate the bark for nutrition, but peeled bark for nest material or ate insects adhered to or parasitized in the bark. It was noted that ants moved along the branch of *Phaphiolepis indica* just after it was debarked. Chang (1976) found that the proportion of the insect in the stomach content increased to 30% in October and November. So, the squirrel probably debarked for foraging insect. At the Taipei Botanical Garden, the red-bellied tree squirrel debarked the coir of palm trees to build the inner layer of their leaf-nests, and cut little twigs for the outer layer. At the *Cryptomeria japonica* plantation, the squirrel also used the tree bark fiber as nesting material (Chang, 1976; Lee, 1981). Besides the above mentioned stimulators for debarking behavior, rubbing tooth (Davison and Adams, 1973) and aggression in courtship of male (Taylor, 1966) may also release the debarking behavior of the grey squirrel. However, it is not known whether these factors play a similar role in the behavior of the red-bellied tree squirrel in Taiwan.

Both the red-bellied tree squirrel and grey squirrel showed very specific selection in food for caching, hard drupes for the former and husked nuts for the latter. The caching activities of the red-bellied tree squirrel occured mainly in September and October, when the drupes of *Aeurites moluccana* ripened and dropped. The caching behavior was also

observed occasionally in March and June, when the fruit of *Elaeocarpus serratus* and *Semecarpus gigantifolia* were ripe. Thompson and Thompson (1980) found that the grey squirrel only showed one peak of caching activity in autumn when numerous nuts were mature. These evidences may suggest that the caching activity is related to the ripening of specific food type. However, it is still not known how the season, the fruit type and the surplus of food supply relate to this behavioral activity of the red-bellied tree squirrel.

The resting activity showed two peaks in winter and summer respectively. In summer, after intense activity, such as running, foraging, playing and chasing, the red-bellied tree squirrel tended to rest under the shade of tree canopy to facilitate cooling. In winter, in order to diminish the loss of energy, the squirrel became motionless. Therefore, the resting behavior seems to be a method of thermoregulation.

The autogrooming activity of the red tree spuirrel showed only one peak from June to September in Canada (Ferron, 1976), while the red-bellied tree squirrel displayed two peaks, from January to February and June to July, which occurred just at the end of breeding season (Chou, 1983). The stimuli which elicit this behavior may be several. During breeding season, the female displays this behavior probably for cleaning the abdominal vulvar region before and after parturition or licking nipples in lactating period. The male displays its probably for cleaning penis after mating or pseudo-copulation. In addition, this behavior also has the function of removing ectoparasites from fur, cleaning pelage to maintain insulating properties, licking wounds, and displaying in aggressive or cohesive bouts (Ferron, 1976; Thompson, 1977; Eisenberg, 1981).

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赤腹松鼠 (*Callosciurus erythraeus*) 個體行爲之研究

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自 1981 年11月至 1982 年10月在臺北植物園進行赤腹松鼠（*Callosciurus erythraeus*）個體行爲之研究。本文分別描述赤腹松鼠之位移，警戒、探測、攝食、啃樹皮、貯藏、自我修飾及休息等行爲模式，並分析後 5 種行爲活動的月變化。赤腹松鼠的行爲模式與其他樹松鼠較爲相近，而與地松鼠相差較遠，這可能是因牠們採用樹棲或地棲生活型態之不同所致。攝食與休息活動之月變化可能與能量調整有關。樹皮內某些化學成分可能是引發剝食（peeling-feeding）樹皮行爲的因素之一。貯藏行爲在秋季表現最頻繁，可能爲某些樹種的核果及熟落所引發。