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Daily Activities and Social Pattern of two Himalayan Pikas, *Ochotona macrotis* and *O. roylei*, Observed at Mt. Everest[1][2]

By

Takeo Kawamichi

Zoological Institute, Hokkaido University

(*With 9 Text-figures and 3 Tables*)

As typical glacial relics, most species of pikas are confined to either high latitudes or high altitudes of the Holarctic region. Within their distribution ranges, the Great Himalaya and Tibetan Highland are outstanding by the concentration of many species. Seven among 12 species hitherto described from Palaearctics are recorded from this area, even though with no detailed information on the mode of their life. Moreover the possible vertical segregation of two species, *Ochotona macrotis* and *O. roylei*, was suggested by the 1921 Expedition to Mount Everest reconnoitred from the Tibetan side (Thomas and Hinton, 1922). This problem, however, has been left without further confirmation just for a half century, obviously due to various difficulties to make field surveys in this area.

Stimulated by this supposed interspecific segregation, the author made a series of observations upon ethology, ecology and sociology of the two Himalayan pikas, large-eared pika, *O. macrotis* and Royle's pika, *O. roylei*, in Khumbu region from October 1969 to January 1970. Following the previous report on *O. roylei* observed in central Nepal (Kawamichi, 1968), the present paper deals with vertical segregation, daily activities and social pattern of the two species, especially of *O. macrotis*.

Henceforth, the species are cited by specific names alone. Their full names are listed here:

macrotis: *Ochotona* (*Ochotona*) *macrotis* (Günther) 1875.
roylei: *Ochotona* (*Ochotona*) *roylei* (Ogilby) 1839.
yesoensis: *Ochotona* (*Pika*) *hyperborea yesoensis* Kishida 1930.

Methods: Various observation procedures including individual recognition are the same as used in *yesoensis* (Kawamichi, 1969 & 1970). The sexes were

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[1] Contribution No. 886 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan, 060 and Contribution from the Thetys Society No. 9.

[2] Studies on the genus *Ochotona* Link (Mammalia, Lagomorpha, Ochotonidae), IV. *Jour. Fac. Sci. Hokkaido Univ. Ser. VI, Zool. 17, 1971.*

partly confirmed by dissection after trapping. Traps employed are the ordinary mouse traps, using each one pumpkin seed as bait, coated either with peanut butter or flavours, a drop of banana or vanila essence. Traps were set in interspaces between rocks with heaps of excrements as well as at principal "musing points" on rocks within "sets" (cf. Kawamichi, 1970).

Comments on taxonomy: Twenty-three specimens were captured at various places (cf. Fig. 1) during the observation period (cf. Table 1), and among them fifteen were identified as *macrotis* and eight as *roylei*, after the key by Ellerman and Morrison-Scott (1951).

At field *macrotis* is easily distinguished from *roylei* through binocular telescope (×9), especially by the hair coat, greyish instead of reddish brown, and some behavioural differences mentioned in the later sections.

Concerning *macrotis*, the populations on Tibetan and Khumbu sides seem to show a slight deviation. Thirteen specimens collected on the Tibetan side were described by Thomas and Hinton (1922) first as a new species *O. wollastoni*, which was later regarded as *O. macrotis wollastoni* by Ellerman and Morrison-Scott (1951). Recently Biswas and Khajuria (1955 & 1957) and Khajuria (1957) recorded two specimens of *O. macrotis ?macrotis*, noting ear length (23.5 & 24.5 mm), shorter than *O. m. wollastoni* (31～36 mm in nine adult topotypical specimens). In addition ear length of 16 adult specimens of *m. macrotis* is recorded as ranging from 23.5 to 30 mm in the collection of the British Museum and the Bombay Natural History Society (Biswas and Khajuria 1957). The ear length of 15 *macrotis* specimens captured by the present author varies 23.1–29.0 mm (average, 26.8 mm), but still longer than that of *roylei* (21.3～24.4 mm, average 22.7 mm in five measurable specimens). Thus it must be noticed that ears of all 18 specimens so far collected on the Khumbu side do not reach even the shortest length exhibited by the Tibetan side specimens, nevertheless the latter were collected at only 15 km apart from the locality where the specimens were taken by the author. It is probable that the ridge of the Great Himalaya with well developed glaciers even at the lowest col, Lho La (6,006 m), plays an important role as an effective barrier for the isolation of two populations.

Biswas and Khajuria (1955) also described another species, *O. angdawai* based upon one specimen taken in the vicinity of Periche, that is, within the area occupied by *macrotis* (Fig. 1). Although the critical solution must be postponed until the detailed comparison of the specimens is made, it is probable that *angdawai* is a mere individual variant of *macrotis*, judging from the distribution and the mode of life described subsequently.

Habitat Preference and Distribution

The genus *Ochotona* is divided into two ecological groups by the habitat preference, rock and field dwellers (Kawamichi, 1969). *Macrotis* and *roylei*, like *yesoensis* in Japan, belong to the former, preferring only slide rock areas (Fig. 8) and living between and under slide rocks. In these three species preference for types and sizes of rock is seemingly absent, except for avoiding flowable places along river. At higher altitudes moraines formed by glaciation are widely utilized by *macrotis*.

The synanthropic tendency is distinct in *roylei* (Kawamichi, 1968). At Dewche village, they not rarely live within native houses, walls of which are made by a heap of rocks. They run through the interspaces of walls and their excrements are found on shelves in the sitting-room. Their daily life is spent in and around

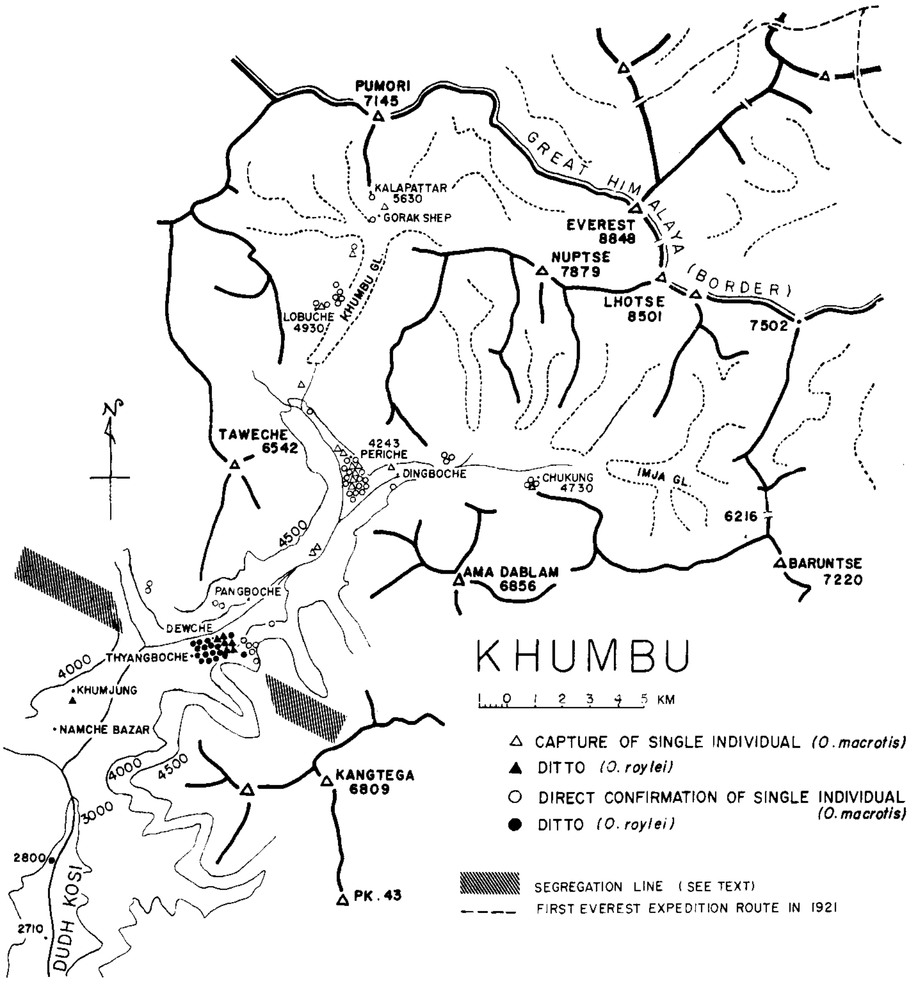

Fig. 1 Map showing distribution of *macrotis* and *roylei* with special reference to their vertical segregation.

the houses, probably rather independent from natural conditions. Such trait was not observed in *macrotis* at Periche village. A few natives in Dingboche, a village within the range of *macrotis*, told to the author that "Thyapo" (local name of pika) carried away potatoes and stalks and grains of wheat stored in their houses.

Distribution of two species in Khumbu: Both *macrotis* and *roylei* are abundant in Khumbu, where it is rare to encounter the slide rock areas without traces of their excrements. But their distributions show a clear segregation without overlap (Fig. 1). While *macrotis* occupies the northern Khumbu area, covering from 4,000 to 5,630 m in altitude, *roylei* is found at the southern area, lower than the range of *macrotis*, from 2,800 to 4,150 m.

a) *macrotis*: At the top of Kalapattar (5,630 m), the highest point of the habitat just below the eversnow ridge of Mt. Pumori (7,145 m), numerous heaps of old excrements prove their residence in the barren alpine zone, where black lichens on the surface of rocks are predominant, while other plants are very scarse, only represented by scattered patches of grasses. Glaciers and ever-snow layer appearing usually at altitudes higher than 5,500 m must limit the upward extension of the distribution topographically, not climatically. This is inferred from the record of *macrotis wollastoni* on the Tibetan side even at 6,126 m (20, 100 ft.) (Thomas and Hinton, 1922), that is the altitude much higher than the snow line in Khumbu side. In Khumbu U-shaped glacial valleys descend down to 4,000～4,200 m, approximately corresponding to the range of *macrotis*. Therefore, the moraines are one of their principal habitats. At the lower side of range, *macrotis* is in contact with *roylei*.

b) *roylei*: Within the area surveyed, the distribution is confirmed vertically from 2,800 m along the Dudh Kosi (River) to 4,150 m at Makyong near Dewche. The coincidence of the lower limits, 2,800 m, both in Khumbu and central Nepal, suggests their lower boundary of the distribution approximately at this altitude. The lowest record was obtained at Seti Gompa (Temple, 2,650 m, situated between Phaphlu and Those) by excrements.

At Ummakha valley (4,000 m) two species are separated only by a narrow stream of 3～5 m wide. Probably they are in contact with each other at the head of the stream at 4,200 m. The similar segregation is also suggested at the opposite side of River Dudh Kosi (cf. Fig. 1). On the Tibetan side, they are seemingly segregated between 3,965～4,421 m (13,000～14,500 ft) according to a brief note by Thomas and Hinton (1922). In central Nepal, one specimen of *macrotis* was captured at Gosainkund 4,300 m (Abe, 1971), and *roylei* were collected from there continuously down to 2,800 m (Kawamichi, 1968), suggesting the segregation at 4,300 m. Therefore, it is indicated that *macrotis* occupies the zone higher than that of *roylei* anywhere.

Concerning the environmental conditions in habitats, *macrotis* generally dwells in arid alpine zone, in contrast with *roylei* in relatively humid forest zone, because the line of segregation generally coincides with the timber line. It must be noticed, however, the timber line runs in Nepal Himalaya at different heights between sunny southern and shaded northern slopes (Mani, 1962), for instance, at Dewche at 4,300 m in the northern slope and 3,900 m in the southern one. But Ummakha valley was so thoroughly covered by rhododendron forests that no marked difference was noticed between the habitats of two species.

Although macroscopically the pattern of vertical segregation must be an outcome of the specific difference for altitudinal preference, a direct competitive relation is likely to appear at the line of segregation as suggested from a repulsive social relation even within the same species described subsequently.

Observation stations: In order to compare their modes of life, two stations were settled, one at Periche (4,243 m, Fig. 8) near Dingboche village for *macrotis* and the other at Dewche (3,800～4,000 m) for *roylei*. Although two stations are only 8 km apart from each other, the vegetation is quite different, St. Periche in the alpine zone and St. Dewche in the rhododendron forest zone around the slide rock area. Both stations were chosen at the distance of a few minutes walk from the villages. Most continuous observations were made for *macrotis* at St. Periche, with several visits to St. Dweche for *roylei*. Main topographical and ecological conditions of the two stations are summarized in Table 1.

Table 1 Conditions of two stations chosen for continuous observation.

<table>
<tr><th>Station</th><th colspan="2">St. Periche (<i>macrotis</i>)</th><th colspan="2">St. Dewche (<i>roylei</i>)</th></tr>
<tr><td>Location</td><td colspan="2">Periche in Khumbu
(near Dingboche village)</td><td colspan="2">Dewche and Makyong in Khumbu
(near Thyangboche Gompa)</td></tr>
<tr><td>Altitude</td><td colspan="2">4,243 m</td><td colspan="2">3,800～4,000 m</td></tr>
<tr><td>Vegetation</td><td colspan="2">Dried alpine zone</td><td colspan="2">Dense rhododendron forest</td></tr>
<tr><td>Topography</td><td colspan="2">Western slope (cf. Fig. 8)</td><td colspan="2">Western slope</td></tr>
<tr><td>Insolation</td><td colspan="2">Sunny (cf. Fig. 3B)</td><td colspan="2">Relatively shady by forest</td></tr>
<tr><td>Period observed</td><td colspan="2">X 18～19, '69
XI 3～XII 1, '69
XII 8～9, '69
XII 15～24, '69
XII 31, '69～I 4, '70
I 19, '70
32 days at St. Periche
in total 45 observation days
in <i>macrotis</i></td><td colspan="2">X 15～17, '69
XII 26～28, '69
I 7～10, '70
I 13, '70
I 15～16, '70
13 days at St. Dewche
in total 15 observation days
in <i>roylei</i></td></tr>
<tr><td rowspan="5">Temperature in Periche (including night)</td><td></td><td>XI 8～30, '69</td><td>XII 1～27, '69
(except 5,13&14)</td><td>I 1～15, '70</td></tr>
<tr><td>absolute minimum</td><td>-10.3°C</td><td>-14.0°C</td><td>-13.7°C</td></tr>
<tr><td>mean minimum</td><td>- 4.1</td><td>-7.9</td><td>-11.6</td></tr>
<tr><td>mean maximum</td><td>10.2</td><td>5.8</td><td>1.2</td></tr>
<tr><td>absolute maximum</td><td>13.2</td><td>12.7</td><td>3.4</td></tr>
<tr><td>Weather in Khumbu</td><td colspan="4">X 15, '69～I 19, '70 finest days continued and snow covering is only one day (XI 10, '69, 10 cm deep)</td></tr>
</table>

Behaviour and Activities

In this section, some behavioural aspects, especially elementary behaviour patterns, diurnal rhythm, daily activities and winter activities studied through extranidal activities are described and discussed. Social behaviour will be treated in the following section.

1) *Elementary behaviour*: Elementary behaviour patterns of *macrotis* and *roylei* are basically the same as those of *yesoensis* (Kawamichi, 1969) except for some differences in calls, food hoarding, etc. At first the behaviour patterns common to three species are briefly referred to.

Common behaviour patterns: *Locomotion* consists of leaping and running. Occasionally they stand for inspection or food intake, but always leaning fore paws against rocks or twigs. Food is taken and transported by mouth alone, never with fore paws. While *scratching* is common and frequently observed, *biting* some areas of shoulder or breast is common to *macrotis* and *roylei*, but quite rare in *yesoensis*. *Face "washing"* is seen occasionally. *Two types of excrements*, one dry dung of globular shape, the other soft one, are deposited in *defecation places* usually on and under rocks, mostly within *sets*.

Musing: This immobile sitting on rocks is frequently observed in three species, being similar in posture, duration and selection of musing points.

a) *macrotis*: According to the duration varying from several seconds to 22 min., as shown in Fig. 2, musing is divided arbitrarily into three types; short (within one minute), intermediate (from one to three min.) and long musing (longer than four min.). Under the similar behaviour pattern, musing seems to signify several different functions, some of which are still unexplained. Here are cited in reference to the duration some cases, the function of which is relatively obvious.

Inspection musing is frequently seen, always expressed as short musing,

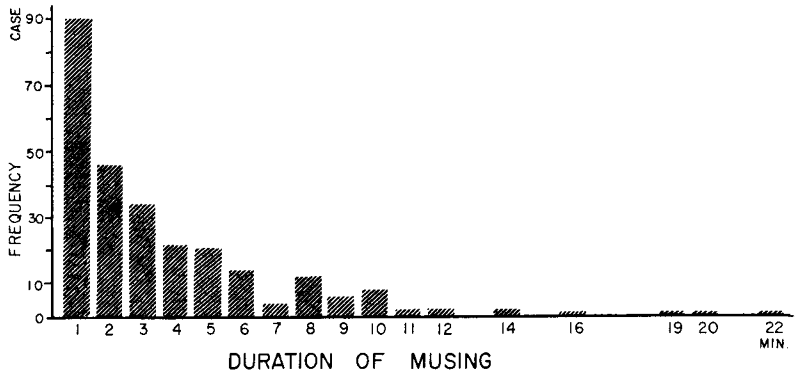

Fig. 2 Duration of musing. (In Figs. 2∼5, short term behaviour lasting less than one min. is rounded to one min.).

mostly ceasing within a half minute. This musing is especially found during prolonged extranidal movements as in Case 1. A short musing made just after appearance, before the next extranidal behaviour, seems to have the same function.

Case 1: (4th Nov. Bp, 8:40) Making musing three times during movement for about 33 m via three sets. Bp appeared at one set, then leaped to the second set, 12 m apart, where mused for 10∼15 sec. before the next start, which was repeated at the third set. Arriving at the fourth set the pika again mused for 15 sec. on a rock before entering into a nest hole.

Among intermediate musing, some cases probably correspond to the warning type as described in *yesoensis* (Kawamichi, 1969), especially when made near the observer or by the approach of the observer. During intermediate and long musings, loud cries or sudden motions by the observer result in quick escapes into nest holes, but soon they reappear and return to the previous place to continue musing. In one case, the musing lasting 1.5 min. was two times interrupted, each for 15 sec. by such escape.

Some of long musings appear to have the function of sunbathing or resting as in the next case, though typical sunbathing seen in *yesoensis* (Kawamichi, 1969) could not be found.

Case 2: (23rd Nov. Cp_1) Musing lasted in total 40 min. during 9:11∼9:52 at the same musing point on a rock; 9:11, beginning of musing under the sun. 9:22, interruption with shaking the head twice followed by locomotion. 9:23, return to the previous point to muse after one quick rounding of the body. 9:27, moved about two steps on the same rock, then again musing. 9:31, biting the shoulder and entering into a nest hole. 9:33, return to the previous point from a neighbouring set, scratching, then again musing. 9:52, biting the shoulder, then moving to the edge of the rock to muse for 20 sec. before entering into a nest hole.

b) *roylei*: In accordance with its diurnal rhythm described later, musing of *roylei* is mostly performed under dim light. But both inspection types at appearance from the nest hole and during movements and warning type are recognized from fragmentary observations. In long musing up to 13 min., *dreamy musing* is occasionally seen, musing in crouching and dropping the head, without responding to very loud cries produced by the observer standing 10 m apart.

All these types of musing, inspection, warning, long musing including both sunbathing and dreamy type are confirmed in *yesoensis*, too (Kawamichi, 1969 & unpubl.).

Calls: Although the pikas are famous for their characteristic calls, the two Himalayan species dealt here are noteworthy by the weak development of calling system. Calling posture on sitting is common to all three species.

a) *macrotis*: The calls of *macrotis* are rare and weak in both sexes, most of which hardly audible from the distance of 25 m, while in *yesoensis* strong calls audible from 200 m (Kawamichi, 1969). Two types of calls, produced either by opening or closing mouth once heard "Kfuts", are uttered mostly within sets. Of the calls heard only 26 times during winter (Observation period, cf. Table 1), most

Table 2 Various types of calls in *roylei* and *macrotis*.

roylei	*Pyi (2)	Pypy (10)	Pyípypy (7)	Pyípypypy(5)
	*Pyíː(1)			
	*Pisu (7)	Pisupisu (2)		
		Pisú(i)su(i) (3)	Pìsúsusu (4)	
	*Pítz (8)			
	Pitźi (2)	Pìtźitzi (6)	Pìtźitzitzi (2)	
		Tźitzi (3)		Tźitzitzitzi(2)
	*Píːtz(1)			
macrotis	*Kyi(1)			
	Pítz(4)			
	*K(y)ítz (8)	Kikítz (4)		
		Kìtźitzi (5)		
	Kfui (1)			
	Kfutz (1)			
	Kyei (1)			
	Kyukyu (1)			

*: similar calling types heard also in *yesoensis* (Kawamichi, 1969 & unpubl.)
(N): frequency of calls recorded

were produced during food intake (8 times) or musing (7), then on appearance from nest holes (4). Calls were heard from underground, but not confirmed at locomotion.

b) *roylei*: Calls of *roylei* in Khumbu are rather frequent, but so faint that almost impossible to hear from 10 m apart, something like faint and high tone bell ringing. Calls are frequently uttered, for example, 63 of total 65 calls were heard during two days (both 15th & 16th Oct.) produced by three individuals (L, M & N, cf. Fig. 3) in one nest range, mostly in morning and evening trip periods. As to the situations where calls were produced, 21 out of 43 distinct calls were produced at locomotion. The other 22 cases at standstill were made during musing, eating, etc. Various types of calls in both species are given in Table 2. Their particular functions are still not well analysed.

Compared with *yesoensis*, seemingly so weak and poor are the calls of *macrotis* as a communicative device. Even when they rapidly enter into nest holes by dangerous signs such as approach of bird flocks, crows, birds of prey or the observer, they do not utter calls as *roylei* and *yesoensis* do under similar situations. Some common characteristic in calls in three species are as follows: Single tone "Pítz" is commonly heard except for strength, and "Pìtźitzi" in *roylei* quite resembles "Kìtźitzi" in *macrotis*. Calls with communicative significance, such as mutual response calls in *yesoensis* (Sakagami, *et al.*, 1960, Kawamichi, 1969) were never confirmed in the two Himalayan pikas during the observation period, although crucial interpretation must be postponed until confirmed by observations in other seasons, especially during breeding period.

Food hoarding: Abundant food hoards for wintering seem a wide spread habit in the genus (cf. Table 3). But in *macrotis* and *roylei* such hoards were never found during winter in the places where numerous hoards must be discovered in *yesoensis*. A single exception was a small hoard consisting of 14 plant pieces porbably of *macrotis* found on 27th Dec. For setting traps, conspicuous defecation places of more than 150 in *macrotis* and 70 in *roylei* were examined in Khumbu, but no suggestion of hoard was obtained. In both species hoarding was also never observed, even in October, the hoarding season in *yesoensis*, except carrying a piece of food into a nest hole for twice in *roylei* and once *macrotis*. Often they appear from nest holes in mumbling, but frequent extranidal food intake of *macrotis* during winter and the fact that food is mostly consisted of mosses and lichens (cf. section daily behaviour) suggest the absence of hoards even in other hiding places. The absence of hoards is also reported in *macrotis* at Tien-Shan (Bernstein, 1970). Considering a marked inactivity of *roylei* in winter, however, it is still unsolved how they fulfil their nutritive requirement during winter.

"Trembling": A peculiar behaviour pattern found in *macrotis* and *roylei*, not in *yesoensis*, is trembling by momentary standing. It is difficult to identify whether this action is made by shoulders or by elbows alone. Trembling, scratching and biting, all probably performed to avoid the nuisance by parasites, are frequently released during extranidal activities, either isolately or mixingly. Ten out of 36 observed tremblings were made during musing and 16 at the end of musing (cf. Case 2).

Inspection: During extranidal activities, inspection is essential for daily life. Various behaviour patterns probably functioning as inspection are observed frequently.

a) *macrotis*: Turning the head to some suspicious sources of stimuli is a reflective and basic behaviour pattern of inspection. Further, such stimuli stop their movements. In case of dangerous signs, they hide themselves in the shade of rocks and inspect by stretching neck and standing ears. In addition to inspectional musing described previously, inspection at food intake is ordinarily observed. Food is eaten after carried on rocks where the perspective for surroundings is easily made with probable inspectional function, one to six times, repeating food carrying and eating, or with frequent alternation of eating and raising head at the spot: In one instance, the head was first raised 21 times during five minutes at the shade of rocks, then the intake of lichens covering the top of a rock continued for a while without the head raising. The head was again raised ten times during eating under a rock.

b) *roylei*: Inspections both at musing and at eating the carried food on rock are also observed. Another typical case is added to here: After rapid entering in a hole near the observer, one individual soon exhibited from the same nest hole its head alone, then again disappeared.

All three types of inspection are also observed in *yesoensis* with similar textures.

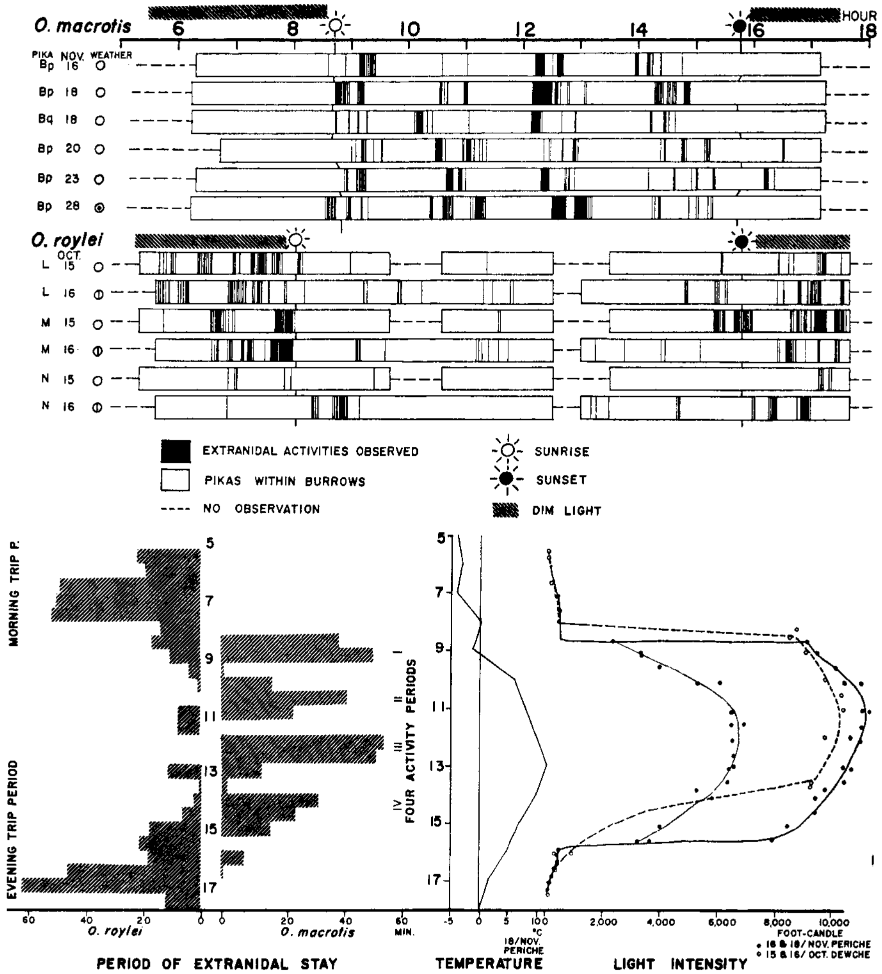

Fig. 3 (A, top) Diurnal rhythms of *macrotis* and *roylei*. (B, bottom left) Period of extranidal stay shown in (A) is clearly correlated with light intensity (B, bottom right). In Figs. 3B & 4, duration of extranidal stay and food intake, and frequency of musing observed per each 30 min. (For example, counts at 7:00 means total counts during 7:00～:29.) Light intensity at Periche is recorded by both ways, intensity at direction showing maximum value (right) and at horizontal level (left).

2) *Diurnal rhythm*: Diurnal activities of *macrotis* and *roylei* are quite different for each other. Whereas active periods of *roylei* are clearly concentrated to the periods before sunrise and after sunset, those of *macrotis* usually begin after sunrise and end before sunset. Thus, activities of the latter are more diurnal than in the former. Figure 3 shows some representative cases of diurnal rhythm of two species.

a) *macrotis*: Four active periods during daytime are recognized from Fig. 3, more typically in individuals Bp and Bq¹⁾. As the qualitative analysis of this pattern consisted of four activity periods is mentioned in the next section, here is given a comment on the formation of such pattern: In *yesoensis*, inactive hours (1∼1.5 hrs.) after evening trip named evening rest (Kawamichi, 1969) are probably spent for resting after active movements. If such resting period is essential for pikas, the pattern of *macrotis* could be interpreted as repeated alternations of active and resting phases. This comment will be confirmed by the appearance of more than four periods at longer daytime in summer.

Beginning of activities in the morning does not, however, simply controled by sudden increase of light intensity. Each observed individual appeared at the fixed period from the cessation of darkness, in spite of the difference in start of sunshine hours due to topographical condition of their nest ranges as follows:

> *Case* 3: In the eastern slope near Dingboche, sunrise began at 7:49 on 13th December, far earlier than in Periche (9:05, 16th Dec.). But one individual became active from 8:55 and two others from 9:00, that is, approximately at the hours comparable to that in Periche, where four individuals started activities respectively from 8:55, 8:58, 8:59 and 9:10. Two other individuals observed near Pangboche also started activities at 9:07 and 9:17 in spite of earlier sunrise (7:52, 30th Dec.).

However, the seasonal delay of sunrise affected the start of activities in five individuals observed at *B* and *C*. Not only the start of the first active period, but also those of other succeeding periods seem to show some delay, corresponding to the delay of sunrise and that of increase of light intensity. Between these two factors, the former, that is, the beginning of projection of sunbeams to the habitat seems to be critical for the start of activities from the observations given in Case 3. Although more observations at different seasons are required, this sliding delay of activity periods favours the comment given above on formation of four activity periods in daytime.

b) *roylei*: As shown in Fig. 3B, activities begin at the hours so dark that the bodies are still not clearly visible. Compared with *macrotis*, the bimodal pattern of auroro-crepuscular type is apparent in *roylei*, as in *yesoensis*.

3) *Daily behaviour*: Combination of diurnal rhythm and elementary behaviour forms daily behaviour.

a) *macrotis*: Extranidal behaviour is peculiar in three points, active

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1) Observations at St. Periche were mostly made with individuals Bp, Bq, Cp_1 Cp_2, Cq, Dp and Dq in nest ranges *B*, *C* and *D*, as frequently cited in the section social pattern.

extranidal locomotion, tolerance to wind and diurnal rhythm with four active periods. At locomotion they mostly move extranidally exposing the bodies, not highly utilizing interrock spaces as in *yesoensis* in spite of the ample presence of such slide rocks. Further, extranidal activities of *macrotis* is not much affected by breeze, so strong to turn the fur coat, nevertheless such degree of breeze is sufficient to cease extranidal activities of *yesoensis* (Kawamichi, 1969).

Food[1] is taken mostly in four activity periods, especially in the first period, 8:30~9:30 (in Nov.) as shown in Fig. 4. Out of these four periods, some additional intakes are occasionally made during 16:00~16:30.

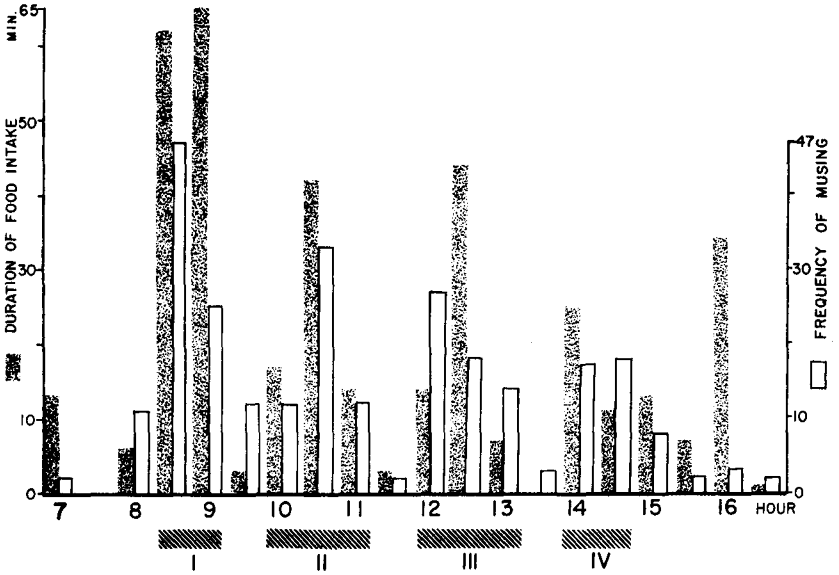

Fig. 4 Distributions of food intake and musing of *macrotis* in diurnal rhythm with four activity periods, observed 7:00~16:59 during nine days in Nov. (3~6, 16, 18, 20, 23 & 28 except interruptions 13:00~:30, 13:15~14:00 & 14:20~:50 each for once).

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[1] Food is mostly consisted of lichens and mosses in *macrotis* and grasses and bush plants in *roylei* at observed places. Among 595 min. in total, covering 257 observations in food intake in *macrotis*, durations of intake of various kinds of food were as follows; lichens and mosses (67%), bush plants (15%) sedges and other grasses (2%) and unconfirmed matters (16%). Among lichens eaten, black coloured species growing on rock surface was predominant, the intake of hairmosses and of snow (16:19~:20, 16th Nov.) were observed each once.

In *roylei*, total 300 min. of 141 observed cases of food intake are classified as follows; grasses including sedges and ferns (18%), lichens and mosses (10%), fallen leaves (9%), bush plants (7%) and unconfirmed matters (56%). Thus the foodstuffs of two species clearly correspond to the vegetation of their habitats, apart from whether it is due to specific preference, or not.

Frequency of musing apparently corresponds to the diurnal rhythm with four activity periods. Four peaks of activities shown in Fig. 3 are mostly occupied by musing and food intake as in Fig. 4.

b) *roylei*: Excluding two dim light activities at dawn and dusk, mostly spent by food intake and musing, their extranidal behaviour is quite scarce. Rare daytime appearance are mostly consisted of quick locomotion between nest holes.

4) *Activities and Behaviour during Winter*: Thanks to the succession of very fine days and virtual absence of snowing during the period Nov. '69～Jan. '70, some comments on behaviours peculiar in winter (cf. Hingston, 1925) are referred to here.

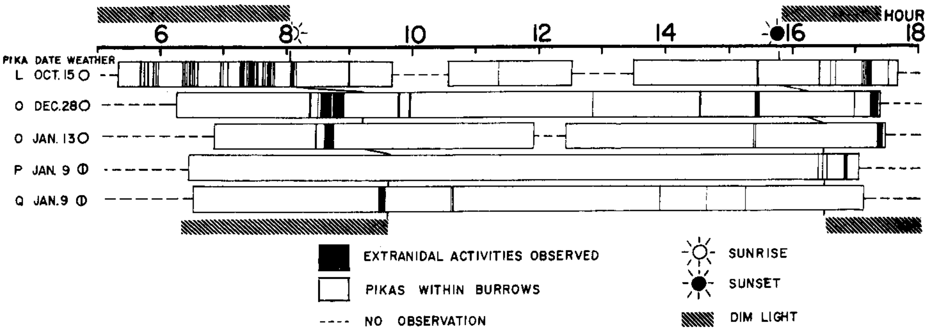

Fig. 5 Winter inactivity of *roylei* in contrast with active phase in October.

a) *macrotis*: Even at the level higher than 5,500 m, they do not cease their activities in December. They are quite active at least from the beginning of November to that of January, though a shift of diurnal rhythm corresponding to the delayed sunrise is suggestive.

b) *roylei*: The inactivity during winter is noticeable during middle October～end of December, in spite of the absence of snow layer. But several observed individuals showed the extranidal behaviour same to that in October, except the absence of long musing. In addition to the decrease of extranidal activities, the bimodal diurnal rhythm also become obscure (Fig. 5). The most inactive individual, N, in Fig. 3A, seems to show the decrease of activities already at middle October. Although the crucial evidence is still absent, they seem to continue the activities, however in low degrees, during the winter without entering into real hibernation.

Social Pattern

Comments on nest ranges and social pattern of *macrotis* and *roylei* so far examined are here referred to in comparison with those of *yesoensis*.

1) *Nest range*: Term nest range used for *yesoensis* (Kawamichi, 1969) is also applied here. The structure of each nest range is common to three species, including set, defecation place and musing point. The difference is the absence of

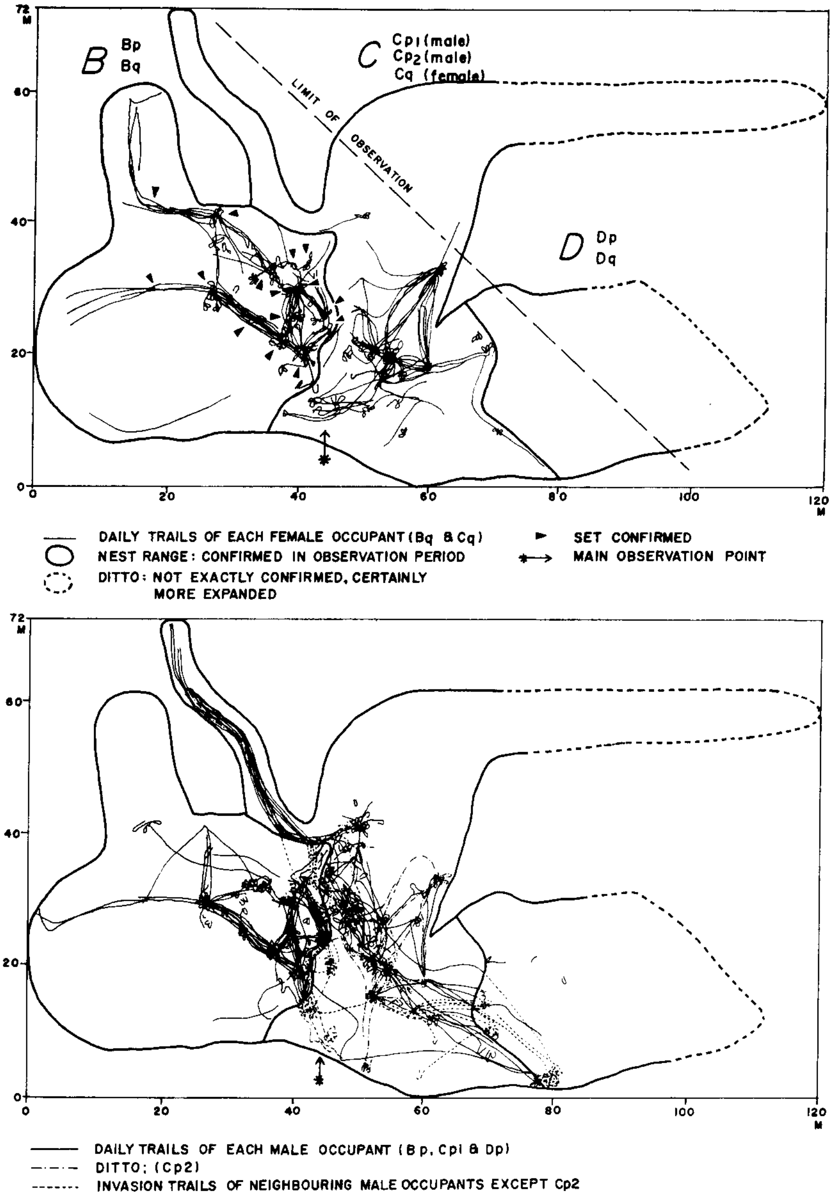

Fig. 6 (A, top) Contour of nest ranges based upon daily trails of each female occupant. (B, bottom) Daily trails of males including invasions. Broken lines in *B* are invasion trails by Cp_1 and those in *C* by Bp (left side) and by Dp (right). No invasion of Cp_2 was observed.

hoards in *macrotis* and *roylei.*

a) *macrotis*: The daily trails of two particular females (Bq and Cq, Fig. 6A) for 15 observation days after confirmation of individually recognition and contour of nest ranges show the absence of overlap between two nest ranges. Some nest ranges more or less confirmed are shown in Figs. 7 and 8, in which small patches of slide rock area are occupied by one nest range (*A*), but larger ones by more than one range (cf. *B*, *C* and *D*). Boundaries and extents of such nest ranges were quite stable during the observation period from 3rd Nov. '69 ~ 19th Jan. '70 for *B*, *C* and *D*. The constancy of nest range is also suggested by the artificial removal of occupants as follows:

Case 5: Among three successive nest ranges *B*, *C* and *D*, three occupants of *C* were trapped, Cp_1[1] (male) and Cp_2 (male) both in 25th Dec. and Cp (female) on 4th Jan. After each removal, invasions into *C* were observed for Bp (once) and Dp (twice) during both 2nd and 19th Jan., but remained unaltered as before removal. No invasion of two females, Bq and Dq to *C* was observed on 2nd and even on 19th Jan. after removal of Cq.

The structure of several nest ranges is shown in Fig. 6A. The prolonged observations proved the communal use of 15 sets in *B* by Bp and Bq, though the frequency of the use for each set is different among individuals. Frequent users showed no particular response at the use of their favourite sets by other occupants or even invaders.

b) *roylei*: Possession of nest range was confirmed for three ranges. At least two pairs stayed in definite ranges each for six days, so that the term nest range is also applicable here. The constancy of ranges is probable, but could not be confirmed within limited observations.

Consequently the demarcation and constancy of each nest range observed in *yesoensis* (Kawamichi, 1970) is applicable to *macrotis* and probable to *roylei*, too, indicating the basic structure of nest range, at least the set, common to three species.

2) *Occupant*: As far as observed by the author, the term "occupant" used for *yesoensis* (Kawamichi, 1969) is also applicable for two Himalayan species by the lasting attachment of particular individuals to each nest range.

a) *macrotis*: Several nest ranges in Figs. 6 and 7 are each possessed by one to three occupants, mostly by two (pair, 6 cases), rarely by one (solitary, one case) and three (trio, one case). One pair (*F*) was consisted of one male and one female, and trio (*C*) of two males and one female (Cp_1, Cp_2 and Cq) confirmed by anatomical examination. All individually recognized seven occupants stayed in their own nest ranges (cf. Fig. 6) throughout the observed period without change of extent and shape of their nest ranges even after trapping occupants (cf. Case 5).

b) *roylei*: Two nest ranges were possessed each by a pair and one by a trio;

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[1] Q means female and p, male, each identified from the social behaviour as referred to later. The sexes are confirmed by dissection in Cp_1, Cp_2, Cq, Fp and Fq.

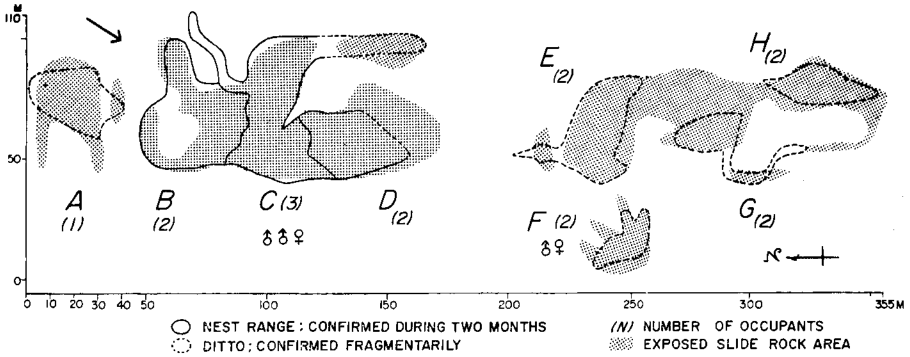

Fig. 7 Slide rock area at St. Periche partitioned by several nest ranges more or less confirmed, mostly each by a pair. Arrow indicates direction of photo in Fig. 8.

Fig. 8 View of St. Periche in January showing nest ranges illustrated in Fig. 7.

the former confirmed for six days in January and the latter only for three days in October.

In *yesoensis*, most nest ranges are occupied by a pair almost decidedly consisting of a male and a female (Kawamichi, 1970), showing a social structure essentially identical to that in *macrotis*, probably also to *roylei*, though the occupation by a trio of two males and one female was not observed in *yesoensis*.

3) *Social behaviour*: The social structure mentioned above, a mosaic of nest ranges, each possessed by constant occupants, postulates for an intimate intra- and inter- pair relations. As the patterns of elementary behaviour and diurnal rhythm are common to both sexes, some behavioural differences between sexes and interindividual behaviour are mentioned in this section, with special reference to *macrotis*.

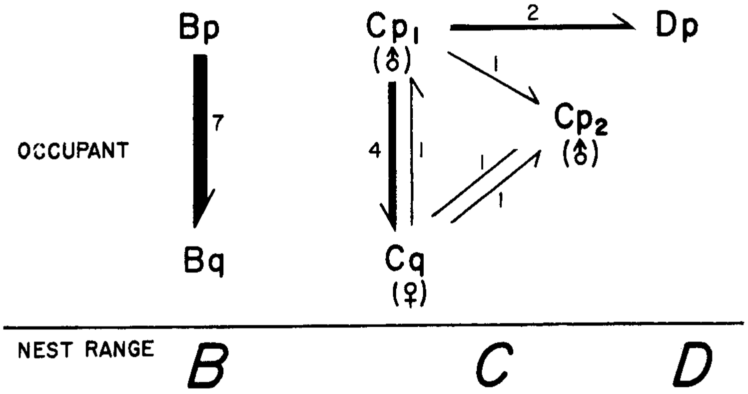

Fig. 9 Diagram showing 17 encounters observed between individually confirmed occupants.

a) *macrotis*: From the observation with individual recognition, each occupant is divided into two groups, one of which stays always within the own nest range, and the other occasionally invades to adjacent nest ranges. Various case observations suggest that these two types correspond to sexual difference as follows:

Case 6: Among three occupants, Cp_1, Cp_2 and Cq in *C*, Cp_1 (male) frequently invaded into two adjacent nest ranges, *B* and *D*, as shown in Fig. 6B. On the contrary, Cq (female) was active but stay within *C* like inactive Cp_2 (male), as in Fig. 6A.

Case 7: One individual of the pair, Bp, invaded to *C* for 22 times while the other Bq always stayed within *B*, as shown in Fig. 6A & B. The similar difference was also seen between Dp and Dq, the occupants of *D*.

Judging from the same behaviour in *yesoensis*, invasions into adjacent nest ranges are the characteristic of males and a high sedentarism within their own nest ranges, that of females.

Invasions were observed for 46 times in total for all males Bp (22 times), Cp_1 (14) and Dq (10) except Cp_2, for 15 days during 13th Nov.～19th Jan. During seven days observed from dawn to dusk, the average of frequency of invasion is 3.9 times, the most frequent day for 6 times. The duration of each invasion was variable according to the case from several seconds, usually several minutes. The invaded males take fixed routes and use sets of the invaded ranges as in their own nest ranges.

Each occupant of a given nest range moves separately but communally use same set, musing points and extranidal routes. Although there is an individual partiality for particular sets, such free movement occasionally causes *encounter* between two partners of the pair and rarely between invader and occupant. Eighteen encounters observed are divided into four types: A; approach of "winner"[1] to "escaper" (10 times), B; the reverse case of A, approach of escaper to winner (4), C; probable underground encounter (3) D; special case (1). These types are explained each by a representative case:

Case 8: (Type A): (28th Nov.) As soon as Bp appeared at 11:06 at one set where Bq was taking musing since 11:04, Bq quickly entered into a rock crevice, while Bp visited to other sets with indifference to Bq.

Case 9: (Type B): (22nd Dec. 15:13) As soon as Bq approached from one set, where Bp was eating lichens, Bq turned aside for about one metre from Bp, then took musing on the spot for two minutes.

Case 10: (Type C): (28th Nov. 14:36) Soon after an individual quickly appeared at a set and went away, the other appeared from the same set incessantly and took musing for four minutes there.

Case 11: (Type D): (18th Nov.) When Bq was eating lichens since 14:36, Bp appeared at a neighbouring set and took musing from 14:37. 14:38, Bq approached to Bp at the interindividual distance of less than one metre, then they took musing, as showing lateral sides for each other. About 15 sec. after this mutual musing, Bq escaped for five metres to take further musing, while Bp entered into a nest hole.

Figure 9 shows diagrammatically all distinct 17 encounters found during the observation period. Among them, the most frequently observed combinations, Bp versus Bq and Cp_1 versus Cq, correspond to the sexes, that is, the winner is the male and escaper the female, suggesting the fixed social order within a pair, mainly determined by sexes in principle. Additional encounters between Cp_1 and Dp were twice observed at the border of two nest ranges, *C* and *D*. In these cases it is not certain which the invader was. At anyway, such fixed social order postulates for the individual recognition between participants at least by escaper. No call was produced at all encounters.

b) *roylei*: Social behaviour of *roylei* was not precisely observed. Of three encounters at the trio range on both 15th & 16th Oct., individual L (cf. Fig. 3) behaved as winner to other two individuals M (twice) and N (once), all sexes

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[1] Terms winner and escaper are here chosen, avoiding terms *dominant* and *dominated* connected with functional signfiicance in animal sociology.

unknown. Further the chase of L after M was once observed. In this species, frequent but faint calls could possibly serve for a communicative device (cf. section calls).

4) *Social pattern*: The constancy of nest range and the sedentary nature of occupants, usually a pair consisting of a male and a female, are the social pattern basic to *macrotis* and probably to *roylei*, like as in *yesoensis*.

a) *macrotis*: Existence of the fixed nest range, especially clarified by the daily trails of females, suggests the loci of some social relations like repulsive responses between females, but direct territorial behaviour was not shown. Coexistence of two adult males in *C* is peculiar compared with *yesoensis* (Kawamichi, 1970). Further, invasions during winter seem much frequent than in *yesoensis* (Kawamichi, unpubl.). Even if these two tendencies are generalized, the inter-male relation in *macrotis* may be looser than in *yesoensis*. Encounters between individuals are frequent in *macrotis*, but quite rare in *yesoensis* (Kawamichi, unpubl.), though this partly depends on the observation easier in *macrotis* than in *yesoensis* for active extranidal locomotions. Compared with rare production of calls in *macrotis*, frequent calls in *yesoensis* may take part in decreasing inter-pair encounters.

Difference in activities of roylei in Khumbu and central Nepal: The behaviour and activities of *roylei* observed in Khumbu show some remarkable differences from those observed in Gosainkund and Drandi Khola areas, central Nepal (Kawamichi, 1968), nevertheless without noticeable morphological difference between these two populations, judging from the comparison of thirteen specimens from Gosainkund and eight from Khumbu.

The altitudes of habitats, synanthropic tendency, elementary behaviour patterns and basic social structure including communal use of a nest range by a pair do not differ between them. The differences are: 1) Food hoarding: Several hoards were found in central Nepal, though incomparably fewer and poorer than in *yesoensis*, while completely absent in Khumbu. 2) Calls: Although calls are much faint than in *yesoensis*, produced very rarely in central Nepal, while much frequently in Khumbu, in frequency comparable to *yesoensis*. 3) Winter activities: In central Nepal, winter activities are relatively high, governed by the bimodal rhythm, while in Khumbu incomparably low, accompanied with disappearance of bimodal rhythm in same months.

Such eco-ethological differentiation of two populations may be conditioned either by direct response for environment or by genetic differences between them, or by the combination of these two factors. It is still premature to conclude the relative role played by these two factors in the present case. But the possible genetic difference, irrespective of deserving of specific or infraspecific level, is not excluded from the isolation of two populations. Two habitats are distand 122 km and separated by two rivers, Bhota Kosi and Bhote Kosi descending from Tibet and penetrating the Great Himalaya, both flowing into R. Sun Kosi, which may act as effective barriers for the dispersal of pikas.

Concluding Remarks

In the present paper, a comparative field study of two Himalayan pikas, *macrotis* and *roylei*, was presented, with special reference to vertical segregation,

Table 3 Various aspects of life pattern in the genus *Ochotona* shown preliminarily.

Genus *Ochotona*									
Subgenus *Ochotona*					Subgenus *Pika*				
(Palaearctics)					(Palaearctis)				
Species	Habitat preference	Diurnal rhythm	Hoard	Call	Species	Habitat preference	Diurnal rhythm	Hoard	Call
roylei (Khumbu)	Rock	Dawn -dusk	0	(⧻)	*h. yesoensis*	Rock	Dawn -dusk	⧻	⧻
(central Nepal)	Rock	Dawn -dusk	+	+	*hyperborea*	Rock		⧻	
macrotis	Rock	Diurnal	0	+	*alpina*	Rock			
rufescens	Rock				*pallasi*	Rock & Field		⧻	
daurica	Field	Dawn -dusk	⧻	⧻	*rutila*	Rock		⧻	
pusilla	Field			⧻	*ladacensis*				
thibetana	Field								
koslowi					(Nearctics)				
					princeps	Rock	Dawn -dusk	⧻	⧻
					collaris	Rock			

Habitat preference: two types, rock and field dwellers (Kawamichi, 1969)
Diurnal rhythm: two types, auroro-crepuscular (dawn-dusk) and diurnal types
0, +,⧺,⧻: indication of development of hoard and call
12 Palaearctics followed by Ellerman and Morrison-Scott (1951) and
2 Nearctics by Hall and Kelson (1959)
roylei (Kawamichi, 1968) Nepal, *macrotis* (Bernstein, 1970) USSR, *rufescens* (Misonne, 1956) Iran, *daurica* (Allen, 1938) Mongolia & (Loukashkin, 1940) Manchuria, *pusilla* (Lindholm, 1901) USSR & (Shubin, 1965) Kazakh SSR, *thibetana* (Allen, 1938) Mongolia, *hyperborea yesoensis* (Kawamichi, 1969) Japan, *hyperborea* (Kapitonov, 1961) Yakutia USSR, *alpina* (Khmelevskaya, 1961) USSR, *pallasi* (Allen, 1938) Mongolia (Stubbe and Chotolchu, 1968) Mongolia, *rutila* (Allen, 1938) Mongolia & (Bernstein, 1963) USSR, *princeps* (Hayward, 1952) USA & (Beidleman and Weber, 1958) USA, and *collaris* (Rausch, 1962) Alaska, USA.

elementary behaviour, diurnal rhythm and social pattern. Though the survey was not intensively made due to the limitation in times, *macrotis* and *roylei* seem to occupy rather exceptional positions in the genus *Ochotona* in weak developments of hoarding and calls. As to the diurnal rhythm, the diurnal type of *O. macrotis* is sharply contrasting to the auroro-crepuscular type to which all so far studied species, *O. roylei, O. h. yesoensis, O. daurica* and *O. princeps* belong. Based upon the precious information and results obtained by the author, various aspects of life pattern in the genus are preliminarily summarized in Table 3.

Greyish colouration of *macrotis* seems effective for protection to sunny greyish slide rocks at least for the observer, as well as rufous colour of *roylei* and *yesoensis* for dusky ones, irrespective of the mechanism underlying the development of colouration.

Difference in ear length of *macrotis* between the populations of Khumbu and Tibet, and various eco-ethological differences of *roylei* between Khumbu and central Nepal were described, both of which could be explained by the isolation caused by the glacial ridge of the Great Himalaya and rivers penetrating the Great Himalaya as effective barriers. This interpretation is strengthen by the fact that many species are recorded from Himalayan and Tibetan ranges even in the lumping system by Ellerman and Morrison-Scott (1951).

Finally the author is indebted to Prof. M. Yamada, Dr. Sh. F. Sakagami and Dr. H. Abe for their kind guidances and to Mr. Y. Miura and Dr. S. Honjo for invaluable helps in the participation of the author in the Japanese Everest Skiing Expedition 1969. Sincere thanks are also due to Mr. K. Takahashi and Mr. H. Fujise for their helps in obtaining information and laborious mapping on Khumbu pikas.

Summary

Behaviour and activities of two Himalayan pikas, *Ochotona* (*Ochotona*) *macrotis* (Günther) and *O.* (*O.*) *roylei* (Ogilby) were continuously observed at the foot of Mt. Everest, Khumbu region, Nepal, during October 1969 to January '70.

The preferred habitat common to two species is restricted into the areas provided with ample accumulation of loose slide rocks. In addition *roylei* dwells in native rocky cottage. The vertical segregation of two species is apparent, *macrotis* occupying the upper part, 4,000～5,630 m, while *roylei*, the lower part, 2,800～4,150 m. Probably they contact with each other at 4,000～4,200 m. The elementary behaviours, diurnal rhythm and social pattern were studied by individual recognition, especially in *macrotis* and the results were compared with the Japanese pika, *O. hyperborea yesoensis* Kishida. Elementary behaviour patterns are mostly common to all three species, but weak developments of calls and hoarding in two Himalayan pikas, quite rare and weak calls of *macrotis* and frequent but faint of *roylei*, and complete absence of food hoard in both, seem peculiar compared with their developments in other forms.

Difference in diurnal rhythm between *macrotis* and *roylei* is clear, the former showing diurnal type and the latter auroro-crepuscular type. The inactivity of *roylei* during winter is noticeable in spite of active movements of *macrotis* in the same period.

Basic social structure, set and nest range systems, clarified in *yesoensis* are identical to those in *macrotis* and probably in *roylei*. Nest ranges are possessed by one or more occupants, mostly by a pair consisting of one male and one female in *macrotis* and probably in *roylei*, too. Various items of evidences suggest that in pair occupants, females are usually sedentary and males occasionally invade into adjacent nest ranges. Free movements of each individual causes occasional encounters between pair-occupants and even between occupants and invaders. In this case, the relation between "winner" and "escaper" seems rather fixed, mainly determined by sexes in principle. Thus the constancy of nest range and sedentary nature of occupants, usually forming pair consisted of a male and a female are the social pattern basic to *macrotis* and probably to *roylei*.

The probable importance of the glacial ridge of the Great Himalaya and rivers penetrating them as effective barriers was suggested from morphological difference in *macrotis* between Khumbu and Tibet and eco-ethological differences in *roylei* between Khumbu and central Nepal.

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