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Annual Cycle of Behaviour and Social Pattern of the Japanese Pika, *Ochotona hyperborea yesoensis*[1)2)]

By

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(*With 3 Text-figures*)

Since 1968, the author has participated in the comprehensive eco-ethological studies of the Japanese pika, *Ochotona hyperborea yesoensis* Kishida, at Station Oketo, Kitami Province, Hokkaido. Some results on general aspects of behaviour and daily activity rhythm as well as social pattern were published elsewhere (Kawamichi 1969, 1970). The present paper gives a preliminary sketch of the annual cycle observed at Oketo, leaving detailed studies of particular aspects for the future.

The full understanding of the life of pikas based upon intensive observations throughout the year confronts some difficulties due to their firm attachment to slide rock area, usually situating at high altitudes remote from urban districts, and covered with deep snow nearly for a half year. Apparently caused by these difficulties, no detailed report on their annual cycle covering all seasons has so far been published, nevertheless such study is basic to understand their mode of life precisely. The best way to overstep this obstacle may be to make year-round observations at a suitable place and to use the results of this continuous or *longitudinal* survey as a basis for the *cross-sectional* or *transverse* comparison of the results obtained at other more inaccessable areas, where observations can inevitably be made only discontinuously.

Station Oketo lies vertically near the lowermost boundary of the distribution range of the Japanese pika. But just by this fact the place was ideal to stay there and to make observations continuously, without much obstacles by severe climatic conditions, especially in winter and by difficulties in supplying materials necessary for research and daily life. Thanks to this favourable location, the author could make observations covering every season, which have hitherto been

1) Contribution No. 903 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

2) Studies on the genus *Ochotona* Link (Mammalia, Lagomorpha, Ochotonidae), V.

achieved with no other ochotonid species. This is the main reason why the author presents the outline of the annual cycle here, in spite of still incomplete results in many particular aspects. The perspective given in the present paper may serve as a nucleus upon which further detailed studies will be crystallized.

The results in the present paper are the outcome of observations made during 1st May, 1968~13th April, '71. Periods of stay are concentrated in the seasons without snow laying (April~November), supplemented with several visits during winter. The observation hours per day are variable depending upon climatic conditions at period of two high activities, *morning and evening trips* (Kawamichi 1969). The total observation days in each month during three years are shown.[1] Besides these regular observations, the continuous camping at the studied slide rock area brought numerous items of fragmentary information almost every day. Most items of information at St. Oketo subsequently described were obtained from the slide rock area (cf. Kawamichi 1970, Figure 4).

Results and Discussions

The wide altitudinal distribution of the Japanese pika within their preference for slide rock areas (Kawamichi 1969) suggests a difference of local climates confronted by different populations. Here twelve months were divided into four seasons as in Fig. 3, based upon local climatic conditions at St. Oketo (alt. 650 m).

1) Daily rhythm

The Japanese pika has a clear auroro-crepuscular rhythm with concentration of activities in hours of morning and evening trips. These two active periods are not chronologically fixed through the year, but shift corresponding to photoperiodical cycle. Although the time to start activities and duration of each trip are individually variable, it is evident that the frequency of calls and extranidal activities in general correspond to photoperiod especially in snowless May~November as shown in Fig. 1, so that the shift of each trip period reaches more than two hours. Furthermore, this correlation also affects the duration of daytime resting phase and nocturnal phase, the former the longest and the latter the shortest in summer, while reversed in winter.

2) Moulting

As in many other mammals, the Japanese pika changes pelage twice per year, at spring and autumn. Winter pelage after autumn moulting is denser than summer one. The colour at back is generally dark brown as compared with reddish brown in summer, though the difference is not so distinct and a minor colour variation is observed among individuals. At field observations, however,

1) Jan. (10 days), Feb. (3), Mar. (19), Apr. (14), May (35), June (44), July (57), Aug. (51), Sept. (28), Oct. (17), Nov. (24) and Dec. (21), totally 320 days.

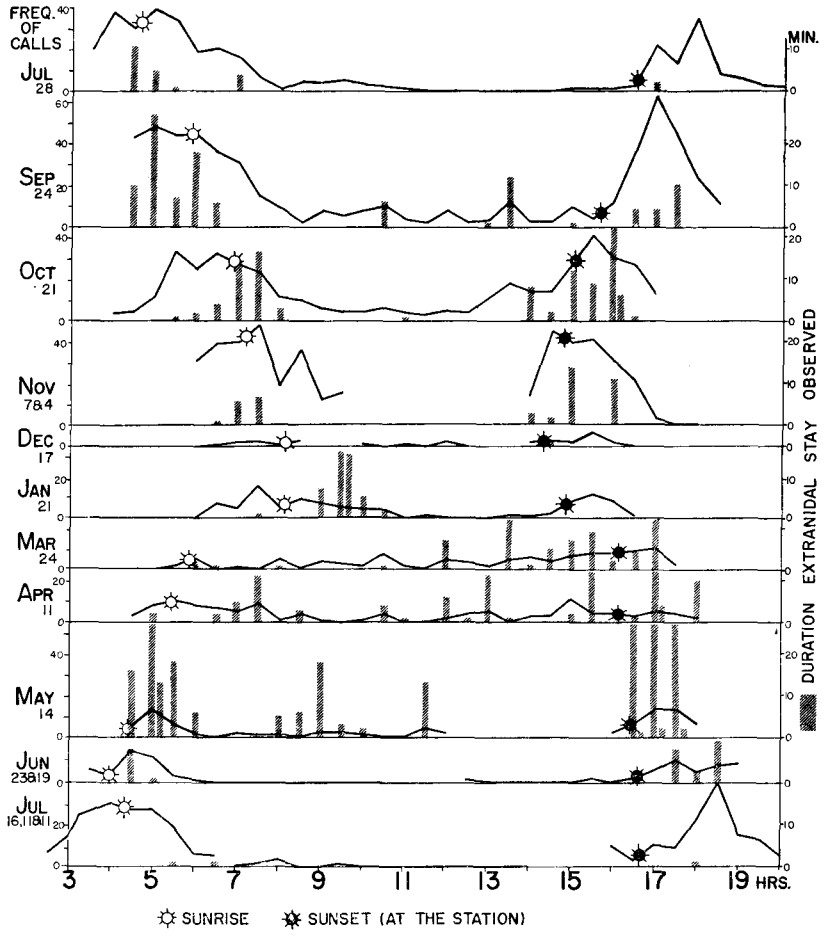

Fig. 1. Annual shift of bimodal rhythm both in calls and extranidal stay in finest and calm day in '68～'69. (Frequencies of calls and duration extranidal stay were observed per 30 min., count at 6:00 means the frequency during 6:00～:29; extranidal stay is total duration by one or two individuals).

it is difficult to distinguish two pelages precisely. Individuals under spring moulting are found from April to the end of June, and the moulting seems to begin at the neck-shoulder part and to precede postward in bodies, similarly to winter moulting found from August to September.

3) Hoarding

One of the characteristic habits of pikas is *hoarding*, which involves two

different types; fragmental hoarding during spring and autumn, and intense hoarding for wintering during summer and autumn.

Fragmental hoarding[1] is observed most frequently during May to June. This behaviour is clearly separable from hoarding for wintering by the amount of hoards never attaining that of winter hoards, and by the distribution widely spread under many slide rocks, not restricted at several fixed points within each nest range[2] as in winter hoards.

Abundant food for wintering is gathered during summer and autumn at several hoarding points under rocks. No particular difference was noticed in hoarding between sexes and ages, both adults and yearlings. Winter hoards, the earliest one, started from mid July in some individuals, become conspicuous here and there in slide rock areas at mid August. The most intensive hoarding period lies between mid August and late September, and much quantities of hoards are accumulated at the end of September. Repetitious hoarding is usually not observed after early October[3] correspondingly to the defoliation of most plants, replaced by fragmental addition such as one or two pieces of food to each hoard.

In some nest ranges, for instance, *B* (mid Dec. '68) and *A* (mid Dec.~ mid Jan. '68), all winter hoards at several hoarding points were carried into deeper places after snow laying. In other nest ranges, hoards were gradually consumed or abandoned without use at the level of the ground surface covered with deep snow.

4) Food and food intake

Being a euryphagous animal, the local difference of pika's dietary list depends primarily upon the difference of vegetation at habitats, conditioned by geography, topography, altitude and season, though some plants are particularly preferred to.

Here three peculiarities concerning food and food intake are cited and discussed:

a) *Presence of small food stores in spring and summer*: Fragmental hoarding in spring and summer mentioned in the last section certainly indicates a temporary storage before intake, as supported by their preference to half dried foods in laboratory (Haga 1960) and by intake of fallen leaves even in spring to autumn in the presence of abundant fresh plants in field.

b) *Winter hoards*: As far as confirmed by observations, pikas do not consume

1) Virtually it is difficult to distinguish this from a mere intake after carrying back food into nest holes (cf. Kawamichi 1969) in case of single hoarding, unless the individual entered in a nest hole soon reappeared, that is, within an interval too short to be regarded as spent for intake, or presence of a piece of food.

2) Term nest range was introduced by the author for this serial study (cf. Kawamichi 1969).

3) Rarely some individuals hoard even after October, for example, individual Ip continued to hoard till late November, in '70 before snow laying and to gather dried grasses, herbs and fresh twigs of pine, etc.

winter hoards before snow laying, even in early December, but depends on dry fallen leaves and still remained green plants. After snow laying food is taken mostly from hoards, together with additional intake of bark of *Aralia elata* Seem and fresh evergreen leaves and bark of afforested Scotch pine *Pinus sylvestris* L. Probably consumption of winter hoards is quite different between at St. Oketo and higher altitude, for example, at St. Hakuun (cf. Kawamichi 1969) due to the duration of snow laying. Comparison of gathered and consumed foods at such different places will be an interesting problem for future studies.

c) *Pine intake during winter*: Scotch pine is not only remarkably consumed during late autumn and whole winter, but also abundantly added to winter hoards, though intake during favourable seasons, spring and summer, is so far not observed. (First and final observations of pine intake are respectively 29th Oct. '68, 11th Nov. '70 and 15th May '69.) This special preference for conifers during cold season is seemingly similar to the case of Bedford's Red-backed Vole *Clethrionomys rufocanus bedfordiae* (Thomas) (Ota & Jameson 1961, Ueda *et al.* 1966). In this instance, it is said that the lowered blood sugar value by cold temperature accelerates intake of larch *Larix kaempferi* Sarg. (Inukai *et al.* 1954).

5) Calls

Frequent call production famous in many ochotonid species is also characteristic to the Japanese pika. As calls in diestrous season (Kawamichi 1969) and sexual difference (Kawamichi 1970) were already described, here the differentiation of calls in oestrous and diestrous seasons is referred to.

a) *Oestrous calls*: Calls in oestrous season are characterized first by [Succession of strong "Kítz" Call] (SKC) in males.[1] Strong male calls are expressed always by this SKC since mid March, completely replacing [Strong single "Kítz" Call] (KZC) characteristic of diestrous season.

In parallel with the establishment of male call SKC, females enter into *mute* state at least since March with the disappearance of strong calls. Thus in spite of their active extranidal movements, only male SKC dominates over the slide rock area. Thereafter, females begin to produce [strong "Pyú:tz" Call] (PUC) and [strong "Pítz" Call] (PZC) frequently since late May,[2] which spread among all females at the slide rock area, with or without young.

Shift from oestrous to diestrous calls occurs mainly in July, when most adult individuals of both sexes except yearlings enter in mute state for about two to three weeks. But individual difference in shift, both in period and interval of mute state, is considerable, and some individuals do not seem to pass such mute

1) The identification of sex is principally made by sexual call difference (Kawamichi 1970) at field observations.

2) Frequent PUC and PZC were recorded at 30th May '69 and 21st May '70. Exception: female D1q kept mute state until early August in '70. (As to individual names, cf. Kawamichi 1970, Fig. 3.)

state. Mute state, indicating the end of oestrous period, does not always synchronize between occupants forming a pair. This mute period is unfavourable for observations by difficulties to trace activities audio-visually due to lack of calls, thick growth of vegetation, and probably decreased extranidal activities.

b) *Diestrous calls*: After the postoestrous mute state mentioned above, male calls are mainly composed of KZC, though several SKC still remain in each trip period, at least till late January for all males. Not only the frequency, but also the repetition of syllables (number of "Kítz") in each unit call decreases to 4～6 in diestrous, in contrast with 8～10 or more syllables in oestrous.

As to adults not passing postoestrous mute, males gradually decrease the frequency and syllables of SKC, in parallel to start and further increase of KZC.

c) *Juvenile calls*: According to Haga (1960), calls of juveniles start from the eighth day after birth, heard in field since mid May for early appeared ones, but mostly since July. Juvenile calls are higher and sharper, heard as something "nervous". Sexually linked tones, SKC for males, PUC for females[1] are already recognized since relatively early periods. The start of PUC and PZC of females in late May seems to well match with the beginning of juvenile calls, which is reasonable from their significance for mother-children communication (Kawamichi unpubl.). The distinction of juveniles and adult calls becomes gradually difficult and almost impossible since August to September, about two to three months after birth.

At any rate, calls of both sexes including adults and yearlings stabilize in late August as follows: Male calls are composed of mainly KZC with inclusion of SKC in each trip period, and female ones a mixture of PUC and PZC. The addition of single calls in males makes the sex identification by calls a little difficult since summer, because discrimination betwern KZC and PZC is sometimes delicate.

d) *Winter calls*: After snow laying since mid December, call types mentioned above are continuously heard in both sexes as far as rock crevices are still not closed by falling snow, but the frequency of calls decreases considerably (Fig. 1). The change from winter to spring phase is suggested by the following observations: During 20 observation hours on 28th Feb. ～ 2nd Mar. '71. no call was recorded on the snow surface, and only a few open tunnels on snow were secured. The next observation was made during 24th and 25th Mar. '71, with 23.5 hours and at the same spot. In this instance, 26 calls were recorded, nevertheless the number of open snow tunnel did not increase from the previous time. Similar calls were already started in 16th Mar. in '69. These suggest the start of oestrous season approximately in mid March at least in males. Enlarged testes are reported as early as 22nd Mar. in *O. princeps* (Richardson) (Dalquest 1948), but no such study has been made with the Japanese pika.

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1) PUC types are predominant in females but uttered exceptionally by some "males" (individuals possessed of SKC, cf. Kawamichi 1970) only in diestrous season.

6) Annual cycle of social pattern

Following the social pattern of the Japanese pika reported previously (Kawamichi 1970), its annual cycle is sketched here, dividing the year into four phases based upon social activities in each nest range: a) Spring, b) Family, c) Rearrangement and d) Stable phases.

a) *Spring phase* (Mar.~June): As in other pikas (*O. princeps*, Hayward 1952; *O. alpina* (Pallas), Khmelevskaya 1961; and *O. pusilla* (Pallas), Shubin 1965), the Japanese pikas have one breeding season per year during spring to summer. This phase is defined as the period from start of SKC in mid March to appearance of young in May~July, usually in June~July, and characterized by three features: 1) Tattered condition of male pelages, 2) Frequent invasion of males to adjacent nest ranges and 3) Oestrous calls of both sexes as mentioned in the last section.

As in *O. roylei* (Ogilby) and *O. macrotis* (Günther) observed in Nepal Himalaya (cf. Kawamichi 1968 & 1971), the pelage hair of the Japanese pika is easily detached, for instance, by a gentle picking up with fingers. Pelage of individuals after snow thawing, especially of males, is spoilt. Scars are further added to, resulting in the tattered pelage in most males, contrasting with more intact female pelage. After autumn moutling, winter pelage of both sexes is kept free from much scars till snow laying. This means the absence or scarcity of any behaviour tending to increase scars after autumn moulting. Furthermore, spring moulting period lies during this period, and all three males with the latest moulting into summer pelage during late June~early July kept their pelages nearly intact till the next autumn moulting, indicating the absence of behaviour increasing scars since late June in this instance.

Such kinds of behaviour are not directly observed, but probably connected with rutting or social dominance, though some scars may be made accidentally.

Extra-range stay: Sedentary nature of pikas is particularly stressed by female occupants. On the contrary, male occupants, especially in spring and family phases, have a weaker tenacity to own nest ranges, often staying out of their own nest ranges. The duration of stay is quite different among invaders, from less than half an hour to more than a few hours. After spring phase, the sedentary nature within own nest ranges comes back as in females.

There are two kinds of extra-range stay; one is the invasion into adjacent nest ranges, and the other, the stay at unoccupied area. The former includes the invasion into the nest ranges possessed either by pairs or by solitary females. (No invasion into a solitary male range was confirmed in the studied area.) During invasion, the males behave as in their own nest ranges, calling in SKC, taking food and "musing" (cf. Kawamichi 1969). Direct fighting and chasing between invader and occupant males was, however, observed only once among numerous invasions observed. Courtship behaviour is not yet observed due to their daily life spent mostly underground.

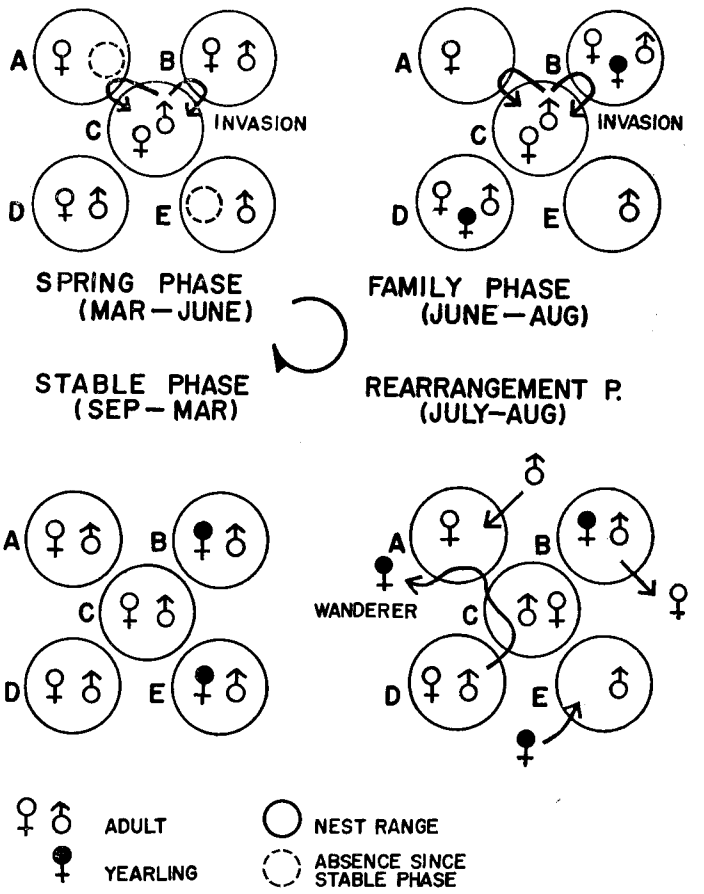

Fig. 2. Annual cycle of social pattern shown schematically. Five cases in rearrangement phase are illustrated by actual examples and other cases showing more or less general tendencies.

b) *Family phase* (June~Aug.): This phase, defined as the period of stay of young within maternal nest ranges, is characterized by the appearance of families. The Japanese pika seems to produce one litter or more, at least two per year.[1] The production of more than one litter per year is also recorded in other species: (*O. daurica* (Pallas), Loukashkin 1940; *O. princeps*, Severaid 1950, Hayward 1952; *O. roylei*, Abe 1971 and *O. pusilla*, Shubin 1965). Number of young per litter is

1) One female specimen captured on 30th June, '70 at St. Oketo had three remnants of corpora lutea and a still undeveloped embryo. Three half grown but active young were confirmed in her nest range since late May, so that the embryo would belong to the second litter.

one to five so far confirmed by trapping pregnant females[1] and one to three by field observations.

Birth of pikas is confirmed in field always only after the juvenile calls produced from underground *set*, heard from mid May for the earliest young, but mostly during June~July. After a while young individuals appear on the ground and take plants. Their locomotive activity gradually increases, but they stay within the nest ranges of their "mother" or "parents"[2] during family phase.

No direct observation on maternal care was obtained, but even at a relatively early period, all mothers and also "fathers" moved about during morning and evening trips not accompanied with young.

c) *Rearrangement phase* (July~Aug.): The term rearrangement means first the disintegration of family into pair condition, and secondly unstability due to the appearance of some "wanderers" as a result of such disintegration.

The break down of families is mostly observed from late July till the end of August. Wanderers most frequently appear during the same period, though found even in early November, but not confirmed after snow falling usually beginning at late November. Each nest range is succeeded, even if rearrangement occurs by new occupants usually without changing its shape and size. Some nest ranges do not produce young or are not interferred by wanderers, and in some other ranges the produced young quickly disappears. Obviously such ranges virtually do not pass the rearrangement phase, keeping the social pattern unaltered since the spring phase or even the previous year.

d) *Stable phase* (*winter phase*; Sept.~Mar.): All nest ranges enter in stable phase usually by early September. The occupants continue to stay in each range till early March, except for disappearance of some individuals, highly probably due to death. The end of this phase in mid March is marked by the start of SKC calls and high activity of males mentioned in spring phase.

Annual cycle of social pattern consisting of these four phases is schematically shown in Fig. 2, and monthly distribution of various types of behaviour schematically in Fig. 3. The annual cycle may change at higher altitudes, with prolongation of winter stable phase, and correspondingly shortening and shifting of spring and rearrangement phases.

Concluding Remarks

As particular aspects of behaviour were already described and discusesd in preceding section, here are given some remarks on the annual life of the Japanese

1) Among 11 females collected in and after pregnancy, the number of young per litter was as follows; one (1 case), two (3), three (4), four (2), and five (2) confirmed by number of young or of embryo or of remnants of corpora lutea (From Ishiwata 1935, Haga 1960, Yamasaki 1968 and Kawamichi, cited above).

2) These two terms as well as "father" are here defined as each female or a pair staying in their nest ranges with very young individuals, highly probably born there.

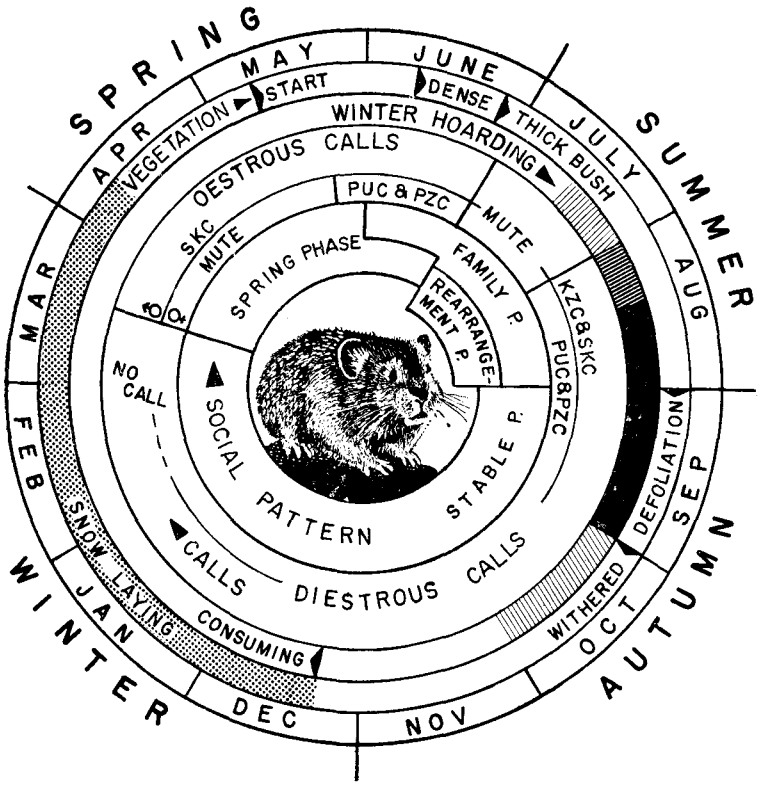

Fig. 3. Annual cycle of the Japanese pika shown schematically.

pika as a mountainous mammal.

Snow laying season continues about four months even at the lowest habitat (St. Oketo) and over eight months at St. Hakuun, one of the highest habitats. This long snow laying period must affect profoundly the basic life pattern of pikas. As shown in Fig. 3, most of their activities, for particularly reproduction and winter hoarding, at St. Oketo are all concentrated in snowless seasons with ample food available.

As in any animals, the present life pattern of pikas is an outcome of the continuous responses to environmental actions since the appearance of the genus in Pliocene. Therefore, the reflection to past environment is indispensable to understand their present day's life completely. Leaving such historic consideration elsewhere, here are given four provisional assumptions to explain their skillful life in severe environment, mainly based upon their present day's life and corresponding environmental conditions under the two following limitations:

1) Although closer observations have mainly been made at St. Oketo, the

homeland of the Japanese pika is the areas of higher altitudes. Therefore, the subsequent comments are given to explain their life at such high altitudes, though based upon observations at St. Oketo, the lowest boundary of their vertical distribution.

2) The remarks are given to stress, partly even intentionally the adaptive significance of some particularities, in habits and social pattern, without reference to the possible process of the evolutional features.

First of all, the euryphagous habit of pikas is regarded as favourable to survive in the severe habitats of high altitudes. The vegetation growing in the habitat preferred by them, the slide rock area, is sparse and variable in species composition according to the altitudinal change. The euryphagous habit makes the wide distribution through different altitudes possible irrespective of vegetational shift, and enables the maximum use of poor standing crop reinforced by another peculiar habit, hoarding.

Secondly, two major activities of pikas, reproduction and winter hoarding, are chronologically separated within short summer at least at Oketo, that is, appearance of young in early summer and winter hoarding in mid summer and autumn. This separation may bring first an economic distribution of adult energy expense and secondly, helped by the euryphagous habit, enables an economic exploitation of food source, avoiding an overgrazing due to the synchronization of two major activities.

In this connection, the appearance of young in early summer, popularly known to other mammals, is reasonable in points of plenty food and comfortable condition. In addition their rapid growth (Haga 1960) and winter hoarding even by yearlings could be highly adaptive, in order to keep the high hoarding efficiency of the total population in late summer to early autumn. The early production young and rapid growth are also favourable to increase their physical resistance before the coming winter and to mobilize their highest capacity for winter hoarding.

Thirdly, the continuous pair formation is also regarded as adaptive in connection with the assumption given above. To have young in early summer, rutting must be started before snow thawing,[1] even if gestation is short as in most small mammals. The continuous pair formation makes the search for the partner and subsequent intrapair accomodation unnecessary. In addition, such system could maintain a high winter survival by communal use of hoards and snow tunnel (Kawamichi 1970).

Fourthly, possession of nest range by pair through the year also gives the security for the points of food, hoarding and continuous pair formation.

Four features enumerated above were interpreted as adaptive, in spite of the possibility of other interpretations, only to show the presence of problems to be solved. The assumptions held above could serve as working hypotheses for further studies, which may confirm or reject these assumptions.

1) Oestrous calls of SKC were heard on 9th & 10th June, '67 at St. Hakuun, when ground was still mostly covered with snow.

Finally it must be stressed that generalization of the life pattern must be made based upon precise comparative studies. For instance, the Japanese pika is seemingly not particularly resistant to severe climatic conditions. In spite of the residence at high altitudes, they are a quite sensitive animal, remarkably inhibited the activities by wind, rains (Kawamichi 1969) and adverse temperature (Koyanagi & Nakamura 1970). On the other hand, the Himalayan pika *O. macrotis* with a longer activity period rather restricted to daytime seems to be more resistant, being active under strong light intensity and fresh breezes (Kawamichi 1971). Thus detailed comparative studies of each species must be preceded before giving a premature generalization of the group specific habits at least in the genus *Ochotona*.

The author is indebted to Prof. M. Yamada, Dr. Sh. F. Sakagami and Dr. H. Abe for their valuable advice to the present work.

Summary

Annual cycle of the Japanese pika *Ochotona hyperborea yesoensis* Kishida was studied at Station Oketo, Kitami Province, Hokkaido, from July 1968~April '71.

1) Daily rhythm: Two active hours in auroro-crepuscular rhythm are not fixed but shift corresponding to the photoperiodical cycle.

2) Moulting: There are two moultings per year, spring and autumn.

3) Hoarding: Two types of hoarding are distinguished, fragmental hoarding mostly made in spring, and winter hoarding in summer and autumn. Winter hoarding started from mid July are most intensively made between mid August and late September, and fragmentarily observed since first October. In some nest ranges, all winter hoards are carried into deeper places after snow laying.

4) Food and food intake: Three peculiarities are cited and discussed; a) presence of small food storage in spring and summer, b) winter hoard and c) pine intake during winter.

5) Calls: Differentiation of calls in oestrous and diestrous seasons is referred to. Oestrous calls are characterized in males by [Succession of strong "Kítz" Call] (SKC) since mid March, while in females by a complete disappearance of strong calls, followed by [strong "Pyú:tz" Call] (PUC) and [strong "Pítz" Call] (PZC) since late May. After passing postoestrous mute state in both sexes of most adults during June~July, diestrous calls are produced which mainly consisted of [strong single "Kítz" Call] (KZC) with admixture of SKC in males, and a mixture of PUC, and PZC in females. Juvenile calls are higher and sharper, but SKC and PUC for each sex are already recognized since relatively early period. These diestrous calls continue till the end of January under shallow snow laying, then no call is heard in late February under deep snow till the start of SKC in mid March.

6) Social pattern: Annual cycle is divided into four phases: a) *Spring phase* (Mar.~June), defined as the period from start of SKC in mid March to

appearance of young, and characterized by three features; 1) tattered male pelages, 2) frequnet invasion of males to adjacent nest ranges and 3) oestrous calls of both sexes. b) *Family phase* (June~Aug.) characterized by the appearance of families. c) *Rearrangement phase* (July~Aug.) passing first the disintegration of family into pair condition, and then the unstability due to the appearance of some "wanderers" as a result of family disintegration. d) *Stable phase* (Sept.~Mar.) with stability of nest ranges each possessed by a pair till next spring phase.

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