# RHESUS MONKEY DISTRIBUTION IN THE LOWER HIMALAYAS AND SECONDARY FOREST SUCCESSION[1]

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*(With a text-figure)*

Rhesus monkeys are found throughout Southern Asia in various habitat conditions, and utilize actively artificial habitats such as terrace fields and streets. They prefer *Pinus*-dominated forest and secondary mixed broad-leaved forests which are affected by human activity.

It seems that the *Pinus*-dominated forest expanded by the cutting of previous primary forests, and was maintained by continuous human activity. At present, deciduous broad-leaved forests are distributed patchily, whereas before expansion of *Pinus*-dominated forests, broad-leaved forests were common.

Rhesus monkeys would predate humans in inhabiting the deciduous and evergreen broad leaved forest with conifers, so after expansion of human activity, the monkeys would have acquired terrace fields and streets as newly appeared habitat, and their distribution area and population levels would not have been remarkably reduced.

## INTRODUCTION

Recently, ecological studies of Rhesus monkeys are increasing in the Indian Subcontinent focussing on distribution, troop structure and habitat utilization etc. (Mandel 1964, Neville 1968, Lindburg 1971, Mukherjee & Mukherjee 1972, Lindburg 1976, Makwana 1978, Teas *et al.* 1980, Koyama & Shekar 1981 and Wada 1983). We can also find studies of typology of vegetation and forest succession (Puri 1960, Kanai 1966, Numata 1967, Stainton 1972, and Ohsawa, Shakiya & Numata 1973).

I found Rhesus monkeys utilizing terrace fields and forests (Wada 1983). If Rhesus monkeys are forest inhabitants, it is a most interesting problem to determine how Rhesus monkeys acquired the newly appeared field as a habitat.

Based on Wada (1983), I try to presume the process acquiring terrace fields as a habitat of Rhesus monkeys.

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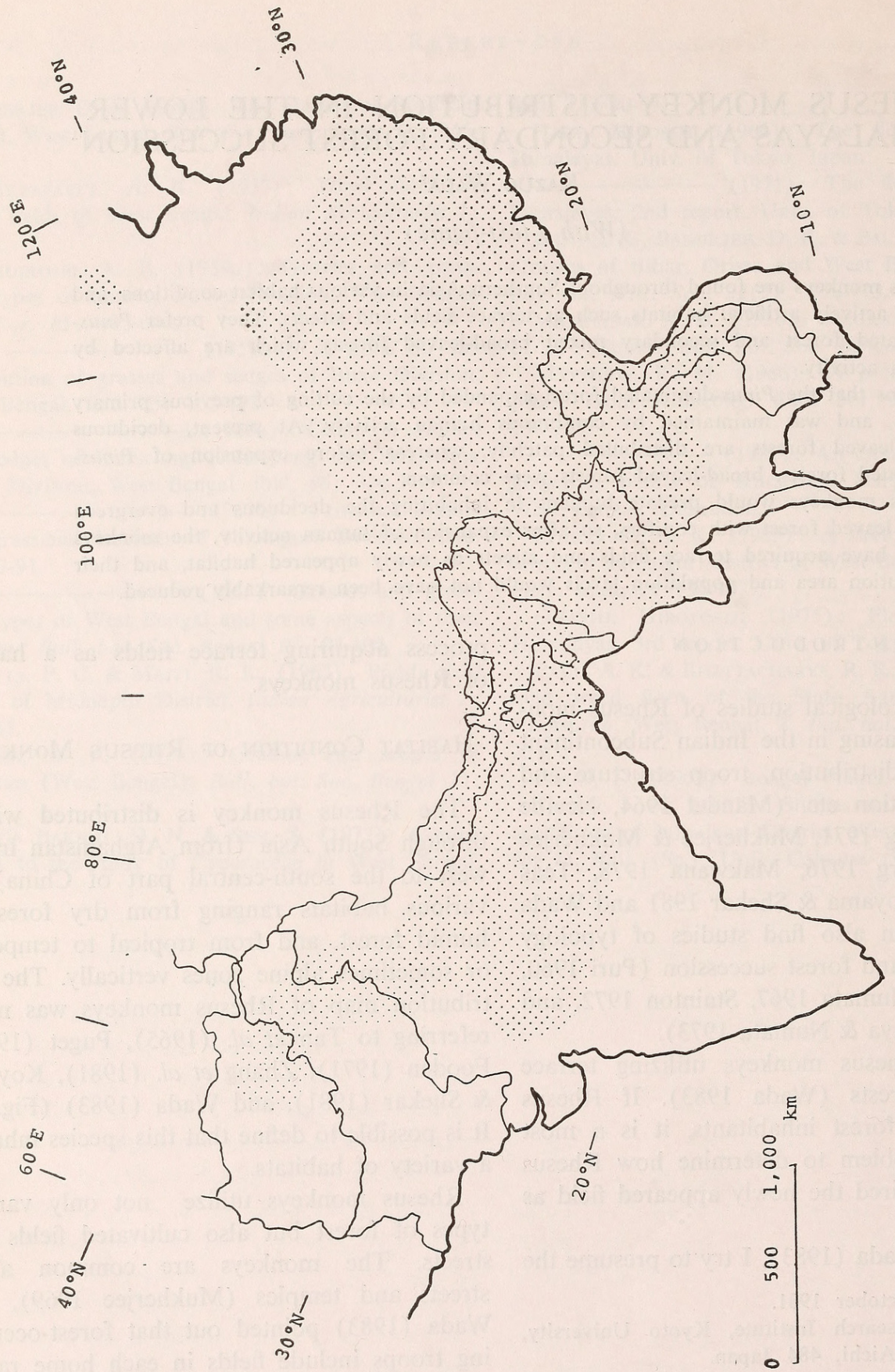
## HABITAT CONDITION OF RHESUS MONKEYS

The Rhesus monkey is distributed widely through South Asia (from Afghanistan in the west to the south-central part of China), in various habitats ranging from dry forest to humid forest, and from tropical to temperate or sometimes alpine zones vertically. The distribution map of Rhesus monkeys was made referring to Tan *et al.* (1965), Puget (1971), Fooden (1971), Zhang *et al.* (1981), Koyama & Shekar (1981), and Wada (1983) (Fig. 1). It is possible to define that this species inhabits a variety of habitats.

Rhesus monkeys utilize not only various types of forest but also cultivated fields and streets. The monkeys are common along streets and temples (Mukherjee 1969), and Wada (1983) pointed out that forest-occupying troops include fields in each home range,


40°N
30°N
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10°N
120°E
100°E
80°E
60°E
40°N
30°N
20°N
0
500
1,000
km
Distribution area of Rhesus monkeys

Fig. 1.

and they are distributed continuously in both habitats, avoiding *Cedrus deodara*-dominated, and *Quercus* dominated huge forests.

Rhesus monkeys prefer fruits, seeds, leaves of trees and grasses, especially seeds of *Pinus wallichiana* and *P. roxburghii*, leaves of *Berberis aristata*, leaves and stems of *Trifolium repens* and fruits of *Vitis himalayana* in the temperate forest, and corn, potatoes, peas and young leaves of wheat in fields. Lindburg (1976) listed 92 species of their foods in the subtropical forest, Wada (1983) listed 35 species in forests and 14 species in fields and streets in the temperate forest. But, they met with a scarcity of foods in *Cedrus deodara* and *Quercus*-dominated forests, so they moved to mainly *Pinus*-dominated forests and secondary mixed broad-leaved forests where they can easily obtain food.

Generally, when human activity deteriorates the habitats' condition for animals by the exploitation of forests and utilization of domestic animals, their distributional area will shrink, and their activity also will be weakened. But the Rhesus monkeys' attitude is different from that of other animals, it seems that the monkeys adapted to the newly appeared habitat, and did not reduce their distribution range.

Crops are important food for Rhesus monkeys in the lower Himalayas. This may be related to changes in the secondary forest succession resulting from human activities.

## Discussion

### *Origin of* Pinus*-dominated Forests in the lower Himalayas*

*Pinus*-dominated forests containing *Cedrus deodara*, *Picea* and *Quercus* are common not only in Himachal Pradesh but also in the lower Himalayas in India and Nepal. In Himachal Pradesh, *Pinus*-dominated forests form a zone between 500 m above sea level (a.s.l.) and 2,500 m a.s.l.

The forest types in Nepal were classified by Stainton (1972) as follows: (1) tropical and subtropical, (2) temperate and alpine broad-leaved, (3) temperate and alpine coniferous, and (4) minor temperate and alpine associations. As the survey areas ranged from warm temperate to subtropical zones, little natural forest remained due to human impact. It is possible to estimate natural forest characteristics from the remaining secondary forest.

The existence of the deciduous broad-leaved forest (cold temperate forest) can be presumed on the basis of the small deciduous broad-leaved forest remaining around Hatoo Peak (3,200 m a.s.l.), 64 km North-East of Simla and along the Kulu valley, 100 km North-West of Simla. Directly under Hatoo Peak, there is a deciduous broad-leaved forest including dominant *Acer* and *Betula*. In the areas between 2,500 m a.s.l. and the upper limit of the forest zone along Kulu valley, coniferous forest is distributed with *Acer* and *Salix* in the lower region, changing to *Betula*-dominated forest in the upper region. It seems reasonable to conclude that the deciduous broad-leaved forest would have been distributed in nearly the same forest zone as *Quercus semecarpifolia* forests.

According to Puri (1960), in the western and central Himalayas there is a middle oak zone (1,500-2,400 m a.s.l.) where *Quercus dilatata*-dominated forests occur with *Q. incana*, *Acer*, *Aesculus* and *Litsaea* etc. My observations confirm that Kulu valley contains coniferous mixed forests with *Aesculus indica* and *Acer*.

There are locally mixed forests of *Quercus* and deciduous broad-leaved trees in the *Quercus semecarpifolia*-dominated (2,400-3,800 m a.s.l.) and *Aesculus-Juglans-Acer* forests (1,900-

2,800 m a.s.l.) of Humla, Jumla and the west midlands, and in the lower and upper temperate mixed broad-leaved forests (1,500-3,200 m a.s.l.) (Stainton 1972). Ohsawa, Shakya and Numata (1973) noted the existence of *Acer*-dominated forests in the cold temperate zone in eastern Nepal.

Kanai (1966) described 5 forest types in a vertical distribution in the Singalila range, East Nepal, where deciduous broad-leaved forests are distributed patchily in evergreen oak forests (1,700-2,800 m a.s.l.) and in Rhododendron conifer forests (2,500-4,000 m a.s.l.).

Deciduous broad-leaved forests, which dominate in the northern part of the Japanese Islands, are distributed in the northern and central parts of China, and have become rare in the eastern parts of the Himalayan ranges. There, this forest is mixed with oak or coniferous forests without forming an original vegetation zone, but sometimes constitutes a locally dominant zone.

The Oak forest occupies the temperate zone as climax in the Kumaon Himalayas and Central Himalayas (Puri 1960, Stainton 1972). In these areas, *Pinus wallichiana*-dominated forest appeared as a secondary forest. After desolation of terrace fields and overgrazing of undergrowth or burning of the forest, *P. wallichiana* invaded these areas to form a dominant forest. Numata (1967) suggested that at 900-2,300 m a.s.l. in eastern Nepal, *Pinus roxburghii* becomes dominant as secondary forest, while at 2,300-2,800 m a.s.l. *P. wallichiana* is dominant. The undergrowth is poor due to chemicals released from pine leaves, and strong erosion in the monsoon season.

These authors do not mention the changing process from oak forest to pine forest in detail. One factor may be the over utilization of undergrowth by domestic animals, inhibiting young tree growth of the dominant species, and another may be accelerated surface layer erosion. Thus, natural forest regeneration is first inhibited by overgrazing of domestic animals, and erosion leads to loss of the fertile ground surface layer. In such areas, pine trees can grow more easily than other kinds of trees, so secondary succession to pine-dominated forests would be favoured.

We can refer to the secondary pine forest formation process in Japan in discussing the conversion process to pine forest in the Himalayas. From the standpoint of secondary forest, *Pinus roxburghii* and *P. wallichiana* occupy an ecological niche similar to that of *P. densiflora* in Japan.

The ecological character of *Pinus densiflora* was described by Kato (1972) as follows: *P. densiflora* is widely distributed from the lower plains to the alpine zone in Honshu, Shi koku and Kyushu. This pine can flourish even in poor soil conditions where other kinds of trees cannot invade. *Pinus densiflora*-dominated forests are regenerated with the pine trees growing quickly as sun trees fixed to almost naked substratum after cutting or burning. The pine forests gradually change to broad-leaved forests with the undergrowth of the pine forest as the lower layer.

In the Indian subcontinent, oak forests, *Cedrus-Picea-Abies* coniferous forests and mixed forests are exploited as grazing areas for domestic animals until the timberline abuts against the glaciers; the undergrowth is completely grazed, and the animals' paths form a downtrodden mesh. Oak-tree leaves, including branchlets, around villages are utilized as food by domestic animals in winter.

Thus, it can be concluded that oak forests or mixed forests are destroyed by long-term nomadism of domestic animals and by the forest-exploiting activities of humans and burning, then at an altitude of 1,500-3,000 m a.s.l.,

pine forests penetrate them as secondary forests in regions where natural regeneration is inhibited and soil erosion has occurred in warm temperate and cold temperate zones. If pine forest once formed is neglected, it changes to other types of forest, but it is normally maintained by incessant activity.

Such secondary pine forests are distributed all over the Himalayan and Mahabharat ranges. Stainton (1972) indicated that secondary forests of *Pinus wallichiana* are well distributed in central and west-central Nepal, and Puri (1960) mentioned that similar forests are widely distributed in the temperate zone of the Punjab and Garhwal Himalayas. At the western parts of the Himalayas from Sikkim the human population is denser, and the secondary forest area of pine trees should be more extensive.

## Rhesus monkey distribution in the alpine zone

Rhesus monkeys should be distributed up to the upper boundary of crop cultivation. Japanese trekkers who have visited Nepal have said that Rhesus monkeys are found in all regions of Nepal. The upper boundary of crop cultivation is in the areas between 2,400 m and 3,000 m a.s.l. in Nepal (Kanai 1966, and my unpublished data), and this upper boundary nearly coincided with the upper limit of Rhesus monkey distribution in Nepal (Richie *et al.* 1978, Teas *et al.* 1980, and my unpublished data).

In Shanshi, China, near the northern limit of Rhesus monkey distribution, *Betula*- and *Quercus*-dominated deciduous broad-leaved forests at 1,000-2,000 m a.s.l. provide a habitat for monkeys, since areas below 1,000 m are occupied by cultivated fields (Tan *et al.* 1965). In South-west China, Rhesus monkeys reach at 3,400 m a.s.l. in altitude (Zhang *et al.* 1981). Evergreen broad-leaved forests in the southern and eastern parts and deciduous broad-leaved forests in the central part of China provide habitats for Rhesus monkeys. As Rhesus monkeys also take many kinds of crops for food in these areas (Shaw ed., 1962), it is thought that Rhesus monkeys inhabit the natural forest (Tan *et al.* 1965), areas of mixed natural forest and cultivated fields, as found in the highlands of India and Nepal.

As in China, Rhesus monkeys inhabit deciduous and evergreen broad-leaved forests. There are oak forests including deciduous board-leaved forests and coniferous forests in the Mahabharat as well as the Himalayan ranges, and if forest destruction due to human activity was less in such areas, Rhesus monkeys could inhabit mixed oak-dominated forests with deciduous broad-leaved trees and conifers.

As regards the vertical distribution of Rhesus monkeys, the upper limit may rise to the level of the upper boundary of crops, but there have been other opinions: within deciduous broad-leaved forests (1,000-2,000 m a.s.l.) in Shanshi, China, Rhesus monkeys occupied alpine zones before humans expanded their activity into these regions.

## Rhesus monkey adaptation to environmental changes

Rhesus monkeys have been faced with the problem of adaptation to increasing areas of terrace fields and waste lands newly formed by humans. It may be suggested that more kinds of trees were present in evergreen forests, deciduous broad-leaved forests, or in mixed forests than in coniferous forests, so that fruits, nuts and leaves in the former were more abundant than in the latter during all seasons. It is very difficult to estimate the availability of fruits or leaves to monkeys in such forests, but

TABLE 1

VERTICAL DISTRIBUTION OF VEGETATION ZONES IN THE NEPAL HIMALAYAS (*after Stainton, 1972 with some modifications by the author*)

| Kind of vegetation zone | No. of tree species in each forest storey (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Sal forest | | | | |
| Bhabar and Terai Sal fr. | 15 | 7 | 4 | |
| Hill Sal fr. | 8 | 5 | 4 | 2 |
| Tropical Deciduous Riverain fr. | 17 | 9 | 5 | 10 |
| Tropical Evergreen fr. | | | | |
| East Nepal | 32 | 15 | 24 | 11 |
| West Nepal | 13 | 10 | 5 | 6 |
| Subtropical Evergreen fr. | 23 | 11 | 3 | 7 |
| Subtropical Deciduous Hill fr. | 23 | 5 | 3 | |
| *Schima-Castanopsis* fr. | 9 | 10 | 8 | 1 |
| Subtropical Semi-evergreen Hill fr. | 21 | 23 | 17 | 11 |
| *Pinus roxburghii* fr. | | | | |
| West Midlands | 1 | 5 | | |
| *Quercus incana-Q. lanuginosa* fr. | | | | |
| West Midlands | 2 | 7 | 13 | 7 |
| *Quercus dilatata* fr. | | | | |
| West Midlands | 14 | 18 | 15 | 8 |
| *Quercus semecarpifolia* fr. | | | | |
| West Midlands | 1 | 9 | 8 | 4 |
| *Castanopsis tribuloides-C. hystrix* fr. | 3 | 12 | 9 | 8 |
| *Quercus lamellosa* fr. | | | | |
| Central and East Nepal | 3 | 21 | 8 | 10 |
| *Lithocarpus pachyphylla* fr. | 3 | 20 | 5 | 2 |
| *Aesculus-Juglans-Acer* fr. | | | | |
| West Midlands | 8 | 8 | 7 | 2 |
| Humla-Jumla area | 17 | 13 | 11 | |
| Lower Temperate mixed Broad-leaved fr. | | | | |
| West Midlands | 13 | 13 | 4 | 7 |
| Central and East Midlands | 21 | 21 | 19 | 12 |
| Upper Temperate mixed Broad-leaved fr. | 28 | 21 | 11 | |
| *Betula utilis* fr. | | | | |
| Central Midlands | 2 | 10 | 1 | |
| Humla-Jumla area | 1 | 18 | 3 | 1 |
| *Abies spectabilis* fr. | | | | |
| Central and East Midlands | 2 | 5 | 13 | 1 |
| Jumla area | 1 | 11 | 24 | 3 |
| West Midlands | 1 | 2 | 5 | |
| *Tsuga dumosa* fr. | | | | |
| West Midlands | 4 | 9 | 17 | 6 |
| *Pinus excelsa* fr. | | | | |
| Humla-Jumla area | 5 | 21 | 33 | |

TABLE 1 (Contd.)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *Picea smithiana* fr. | | | | |
| Rara lake | 2 | 9 | 9 | |
| Humla area | 3 | 11 | 21 | 4 |
| *Abies pindrow* fr. | | | | |
| Humla area | 3 | 13 | 13 | 3 |
| *Cedrus deodara* fr. | 3 | 9 | 1 | |
| *Cupressus torulosa* fr. | 1 | 15 | 2 | |
| *Populus ciliata* woods | 4 | 15 | 3 | |
| *Juniperus wallichiana* fr. | | | | |
| West Midlands | 4 | 18 | 2 | 1 |

(1) Trees which form the top canopy
(2) Trees forming a second storey
(3) Smaller trees and shrubs
(4) Climbers and epiphytes

it is possible to compare the kinds of trees in each forest. Stainton (1972) divided the forest structure into 4 layers which were described as follows: (1) trees constituting the top canopy, (2) trees forming the second layer, (3) lower trees and scrubs, and (4) vines and epiphytes. In areas at 1,500-2,500 m a.s.l. surveyed this time, there are lower and upper temperate mixed broad-leaved forests, *Tsuga dumosa* forests, *Pinus wallichiana* forests, *Picea smithiana* forests, *Abies pindrow* forests and *Cedrus deodara* forests. Among these forests, the number of tree species in different coniferous forests is fewer than in broad-leaved forests (Table 1). However, Rhesus monkeys may take the bulk of their food from the bigger and more abundant seeds of *Pinus wallichiana*. There are no monkey troops with their entire home ranges in pine forests alone, and it may be very difficult to maintain troop movement in such a forest only because of the simplicity of monkey habitat condition.

The other change of habitat for Rhesus monkeys is the appearance of terrace fields. Grasslands would have existed before the human advance to the midland and alpine regions, but they did not greatly influence the habitat conditions of Rhesus monkeys, since the forest fringe would supply abundant food. The destruction of forests and forest undergrowth by domestic animal grazing and the disappearance of forests due to the expansion of terrace fields caused deterioration and disappearance of the original habitat of the monkeys. However, Rhesus monkeys were able to find food in terrace fields as a new habitat. Further, the quantity and quality of monkey food were high even under the original, relatively primitive agricultural conditions.

At present, the monkey troop distribution is continuous, and monkey troops are abundant throughout survey areas. Thus, the species is dominant even now. Human activity has affected their habitat, but food is still available, i.e., seeds of pine trees, some kinds of undergrowth and fruits of vines. Thus, their distribution area and population level would not have been remarkably reduced.

The ability of monkeys to accommodate newly appearing habitat conditions into their

modes of life may be closely related to the fact that they were originally, eating young leaves, buds, fruits, nuts, seeds and roots of plants. Langurs inhabiting the same forests as Rhesus monkeys rarely enter terrace fields.

Active acquisition of terrace fields as habitats by Rhesus monkeys was found during feeding within fields. When there are no watchmen, monkey troops feeding in fields are dispersed, even near the farmers' houses. If farmers or dogs pursue the monkeys, they escape to trees around the terrace fields, then wait there. Sometimes, highly ranked males face dogs without running away. The above-mentioned behaviour was found in the case of Japanese monkeys. Such behaviour may be related to the acquisition of new habits or population dynamics in response to the impact of human activities.

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