The Geographical Journal

Vol. LXV No. 3 March 1925

ANIMAL LIFE AT HIGH ALTITUDES

Major R. W. G. Hingston, I.M.S., Naturalist to the Mount Everest Expedition of 1924

Read at the Meeting of the Society, 12 January 1925.

THIS paper is a condensed account of certain observations in Natural History made while serving with the Mount Everest Expedition. It refers to life on the Tibetan plateau, especially with regard to the struggle for existence in those bare inhospitable tracts above the limit of the Himalayan tree-line.

First a word as to physical features. Tibet is a desert, a high-altitude mountainous desert at an elevation of about 14,000 feet. This is a point we must thoroughly realize, for the life of Tibet is in many particulars the life of a desert waste. Compare it for a moment with a lowlying wilderness, such as the sweeps of open sand in Arabia, Sahara, or Sind. It differs from these in one particular: it has none of their intense heat. But otherwise Tibet is essentially a desert, empty, bleak, and bare. As we travel across it we see all the features of the desert, the wide tracts of brown and barren soil, the vast distances spread out before the eye, the fierce display of light. Here, as in the desert, we meet tracts of sand, often loose and crumbling and at the mercy of the wind. In one place we see how its surface is rippled, in another how it is covered with a saline incrustation, in another how it stupefies the scanty vegetation or piles itself into crescent dunes. Here too we observe the same cloudless skies, the same glare from the plateau soil, how the air rises in shimmering waves or clothes the surface in a true mirage. There is the great range of temperature characteristic of the desert, often 50 degrees between day and night. The rainfall is scanty. The atmosphere is so dry that it splits the skin and nails, and prevents the ordinary decomposition of flesh. Fierce winds blow across it from the main range, and these might be compared with the Sirocco or Shamal. Frequently they raise up vortices of dust which career over the empty plain. As in the desert, we observe the same scantiness of vegetation, the monotonous growth that gives no colour to the landscape, the absence of trees, the thorniness of the plants, the short active season in which flowers rapidly bloom and

as rapidly die away. These are some of the desert features which we meet with in our journey through Tibet.

Let us consider the life of this high-altitude desert. How do the creatures live? How do they protect themselves? By what means are they adapted to the conditions of the heights?

Any one who has travelled in a lowlying desert knows how important is protective coloration in the general scheme of things. It is exactly the same in Tibet. Examples are apparent on every side. Most of the common animals of the plateau are inconspicuous against the soil. But we must remember that the plateau is littered with stones, and, not like many lowlying deserts, an even layer of sand. This gives an additional advantage to the animals. For not only do their colours blend with the surface, but their shapes and outlines are often lost to view, being confused with the scattered stones.

I will give some examples of protective colour in Tibet. Everywhere on the plateau we meet with colonies of Pikas, delightful little creatures which sit near their burrows and blend with the sandy soil. In the gorges of the main range we find another species. Its surroundings are more gloomy; it lives amongst rocks, and in accordance with this its coat is darker so as to fit it to these special haunts. The marmots likewise blend well with the altitudes. They like to occupy the bare passes as high as 17,000 feet. The Tibetan hare is a good example of harmonization, especially when it sits amongst fallen stones. Some of the larger animals are protectively coloured. The Tibetan gazelle is the colour of the plateau, and a herd of burhel is inconspicuous against a hill.

The majority of the birds are protectively coloured. The different kinds of mountain finches, the Tibetan skylark, the short-toed lark, the calandra lark, the Mongolian sand-plover, are all coloured so as to harmonize with the soil. They all live on the open plateau where there is nothing to conceal them from view. Two of the birds have conspicuous markings, but these do not interfere with the concealing effect. The desert chat, for example, has white patches on its wings which disappear from view when the bird alights. The horned lark has black markings on its neck and breast, but these are sufficiently well concealed from a hawk or other enemy soaring overhead. The Tibetan sand-grouse is an excellent example of harmonization; so is the magnificent Tibetan snowcock when feeding amongst the boulders and crags. The cliffs and torrents also provide examples. The wall-creeper lives around the fort at Shekar, and as it climbs about the slaty rocks the colour of its back blends with the stone. The ibis-bill is a more striking instance. As it feeds amongst the boulders in the bed of the torrent it is lost to view in the midst of the stones.

Some of the birds are not thus protected. But in such cases they are able to defend themselves from enemies or have special places into which

they can escape. The raven, the steppe eagle, the kite, for example, are so powerful that they need no protection. Certain little birds, like the sparrows and accentors, are conspicuous, but they keep near villages or piles of stone amongst which they can escape from birds of prey.

We see numerous examples amongst other creatures. The lizards on the plateau are very variable in coloration. Some are uniformly sandy, others coarsely speckled, but all harmonize with the arid soil. There are different kinds of grasshoppers that haunt special situations. One, a large Central Asian migratory species, is rich green in colour and lives in patches of fresh grass. Another, a new genus minute and wingless, lives on the moraines and decomposing granite as high as 18,000 feet. It is finely mottled in grey and black, and difficult to see because it closely resembles one of the granite flakes. There is a third kind which keeps to tracts of coarse loose sand. In its colour scheme are patches of blue and red, and these harmonize with similar colours in the grit. Still another kind haunts the water-worn pebbles on the banks of the Chiblung Chu. This little grasshopper is a uniform blue colour, and exactly the same shade as the layer of stones.

It would be tedious to mention all the other examples. But I must refer to the high-altitude moths which frequent the moraines at 17,000 feet. These resemble a species of tiny *Anarta*. Their under surface is very conspicuous, but is concealed when the insect alights on the rock. Their upper surface, on the other hand, is a mottled grey, which blends with the granite and the decomposing grit.

Thus we see how important is protective coloration in the struggle for existence at these great heights. It is in the vast and open tracts, the deserts, the snows, the elevated wastes, that we have this principle most lavishly displayed. The reason for protection of this kind is clear. In the wilderness hiding-places are seldom available. There are no trees, no scrub, no profusion of grass in which the animals can conceal themselves when enemies approach. To avoid destruction they must seek evasion of some sort. Their only chance is to resemble their natural surroundings and escape by being passed unseen.

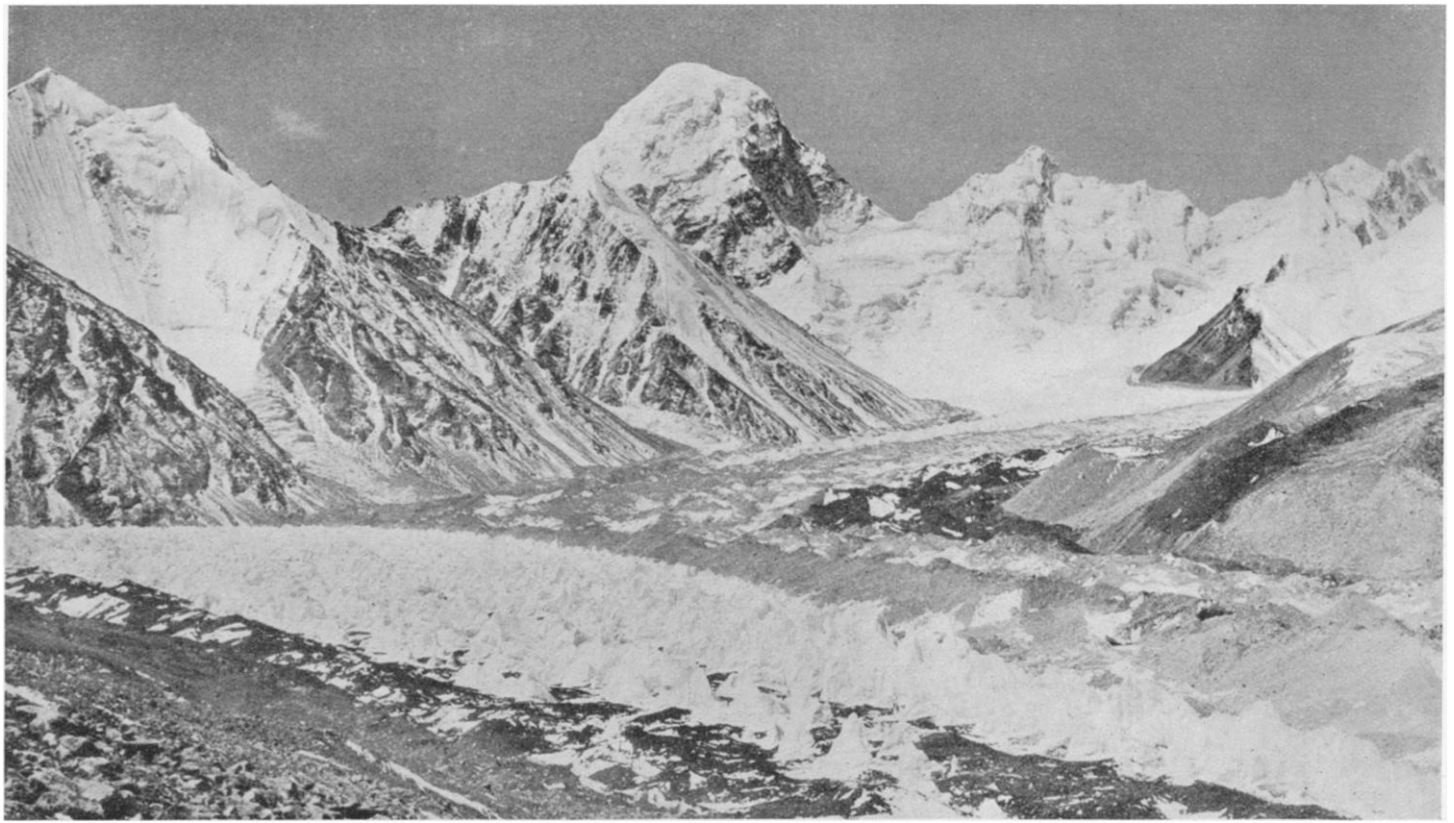
I pass to another problem. How do the animals of these high altitudes adapt themselves to the physical conditions that exist? Consider first their reaction to the wind. Tibet is notorious for its fierce winds. The morning sun heats the surface of the plateau, the hot air rises, and in order to fill the deficiency the wind sweeps down from the main range. Near our base camp we saw an excellent example of its force. The camp stood in a contracted gorge through which the wind poured down from the mountain to the plain. Round about the camp were piles of boulders which the Rongbuk glacier had deposited in the gorge. These boulders were remarkably eroded by the wind. Deep pits and furrows had been eaten into them; they were polished, and broad grooves had been cut into their surface, in places an inch in depth. They were com-

posed of granite and recently deposited, yet from their windward side they looked like lumps of coral while their sheltered surface was ordinarily smooth.

Let us see how the animals react to a wind which can eat into the granite rock. The mammals are often clothed in thicker coats of hair. We see this in the herds of domesticated goats, delightful little animals with long hair that hangs down like a kilt around their legs. The Tibetan dogs are often thickly clothed. Sometimes we may see them in the early summer shedding large patches of winter wool. Near Gautsa I saw pigs at 12,000 feet, and they were covered in a thick rusty-coloured hair quite different from the half-naked animals of the plains. The Tibetan hare has a dense coat, and it ascends to 17,000 feet. But the ordinary yak is the best example. Next its body is a layer of wool. Over this is a hairy coat which hangs down like an apron from its huge body, especially around its legs. Its neck is provided with a strong mane, and behind it supports a large tail of thick and bushy hair. When the yak is grazing we see the value of this coat. The animals like to feed with their backs to the wind. The thick tail then acts as a kind of wind-proof screen; the long hair around the hind legs adds to the shield, while the head, being kept low, is sheltered by the body and protected above by the hairy mane.

Everywhere we see the birds adapting themselves to the wind. The little birds escape it by getting behind obstacles. Thus we often see the larks, the finches, the ground choughs feeding on the sheltered side of villages and walls. When in the open they persistently face the wind; if they stand across it they may literally be lifted off their feet. The larger birds follow a similar habit. The choughs face the wind when feeding on the pastures; the ravens do likewise when scavenging for refuse; the lammergeyer always heads it when descending for bones; the kites persistently come round to windward before swooping down to take garbage from the ground. Those birds that live around rocks and habitations creep into some shelter when the wind blows. We see the sparrows hiding in the holes of the houses, choughs getting into the lee of rocks, rose-finches nestling under ledges and stones. A great number of the birds make their nests in holes, and in this way shelter their offspring from the wind. The mountain finches and the ground choughs place their nests in pika-burrows, often at a great depth. The magpie builds an enormous nest. I think it serves the parent birds as a permanent shelter in addition to serving as a home for the young. The birds that build on the ground place their nests behind tufts. The short-toed lark showed in one case an interesting modification: it built a rampart of pebbles on the exposed side of its nest so as to protect the structure by an artificial wall.

Certain of the butterflies show interesting adaptations. The Parnassius or Apollo butterflies are characteristic of high altitudes.



RONGBUK GLACIER

SLANDS OF MORAINE IN TROUGH OF GLACIER FREQUENTED BY SPIDERS

In Tibet they haunt the passes up to 17,000 feet where the wind sweeps furiously across the range. They are capable of only feeble flight, and are easily carried along by a gale. They escape being swept away by their unwillingness to fly, except when the air is comparatively still. Moreover, when disturbed, they make but short flights ; also when they settle down they choose sheltered nooks, and their resting attitude is to spread their wings, pressing them down close against the ground so as to offer the least resistance to the air. Furthermore, their wings are stiff and rigid and not likely to be torn when being battered about. Also their bodies are clothed in fur, which must serve as a protection against both cold and wind.

The Swallow-tails and Vanessidæ also haunt the plateau. They used to come about our base camp at 17,000 feet. But these butterflies are particularly powerful fliers, and by their strength alone can contend with the wind. Other kinds live at slightly lower altitudes. There is a *Melitea* on the plateau which has the habits of the Apollos. It escapes the wind in the same way by flattening itself tight against the ground. The Lycænids like to keep in sheltered places. One kind gets into the tufts of vetches, another conceals itself in coarse grass. The high-altitude moths that resemble *Anarta* adapt their habits to the fierce winds. They haunt the tracts of fallen rock, the bare hills and deposits of moraine. They fly about by day, alighting on the sand. When the wind is strong they enter clefts in the rocks or else shelter between the stones. Their flight is swift and of short duration. When they alight they behave like the Apollo butterflies, flattening themselves with outstretched wings against the rock, thus offering the smallest obstruction to the wind.

The Diptera that haunt the cliffs at 16,000 feet like to keep close in amongst the stones and rocks. Moreover, they make only short quick flights. Their actions are more like the leaps of a grasshopper than the ordinary movements of a fly. There is one kind, a *Tachinid*, which haunts boulders at the edge of the rivers. It has a black hairy body, a spined abdomen, and grayish speckled wings. Now this fly seems almost incapable of flight, so reluctant is it to take to the air in a wind. Its habit is to seek for shelter beneath boulders, and, when these are upturned, it can be taken in the fingers, allowing itself to be captured rather than escaping by flight. There is another kind of the genus *Gonia* which likes thorny bushes. It comes out on sunny mornings when the air is calm. But its flights are short, only a few feet, as if it feared to trust itself to any distance in the air. Moreover, it strives to keep within the shelter of the scrub, flitting about from twig to twig or coming to rest on the sand beneath. Thus it manages to evade the wind, partly by reason of its short flights and partly by keeping within the scrub.

Some of the digger-wasps avoid the wind in the same way. They have learnt to keep close in amongst the boulders, also to make only quick short flights in order to avoid being swept away. Many of the

insects on the plateau are wingless. Numbers find continual shelter under stones. Grasshoppers ascend to 18,000 feet. But at this altitude they are minute and wingless and escape the wind by their inability to fly. The *Pseudabris* beetles provide an interesting example. These beetles are conspicuous and brilliantly coloured with alternate bands of black and red. They usually hang in clusters on the vetches, where they feed on the young shoots and flowers. Watch them when a strong wind suddenly springs up. They let go their hold and throw themselves to the ground. There they lie, all apparently dead. Each is on its side; its head is bent at right angles to its body; its antennæ are turned downwards; its legs are collected into a cluster and thrust out like lifeless tags. They all lie in the attitude of death like a crowd of corpses strewn over the ground. When the wind lessens they quickly revive, they run over the soil, regain the vegetation, and climb back to their places on the vetch.

Thus we observe that the animals of high altitudes contend with the wind in many different ways. Some grow denser coats, others seek sheltered places, and there is a great tendency to burrow in the soil. Certain butterflies and moths flatten themselves on the ground; many insects make only quick short flights; certain flies keep in amongst stones and bushes; high-altitude grasshoppers and other kinds are wingless; certain beetles throw themselves for safety to the ground.

Let us pass to another phase in the struggle. How do the animals at high altitudes contend with the scarcity of food? The domestic animals show us how severe is the struggle. It is wonderful to see a herd of yaks grazing on the hillsides. To all appearances the mountain is absolutely barren, yet the animals manage to pick up some food. When snow is on the ground they dig through it to the vegetation. The Tibetans said that they scraped up roots. I have seen them eating the fresh dung of a pony which had been well fed on grass and grain. In April, when the grass is just commencing to appear, the sheep struggle hard to obtain food. With their fore feet they dig into the soil and shuffle aside the superficial sand in order to get at the buried blades. When food is scarce, the ponies do likewise. I have seen them cutting up the ground with their hoofs in order to expose the hiden roots. Also they wade into icy lakes, where they feed on the water-weed that grows up from beneath. The mules and donkeys will sometimes eat quantities of yak-dung, which does not seem to do them any special harm. The pikas show an excellent example of husbandry. They store up quantities of seeds in their burrows to serve as a winter supply of food.

The bills of certain birds seem specially suited for penetrating frozen soil. This is of importance for the insectivorous species, since in winter, when the ground is hard, all insects are hibernating underneath stones or in the superficial layer of the earth. Compare the bill of the chough, an inhabitant of high altitudes, with that of its allies,

the rook and crow. The chough's bill is proportionately longer and sharper and better fitted to penetrate the frozen soil. It is also used as a kind of lever with which the bird upturns the lumps of dung in order to reach the good things underneath. The ground chough is a delightful Tibetan bird of a sandy colour that harmonizes with the soil. It is about the size of a lark, but is supplied with a long and powerful bill, slightly curved like that of a chough. Now this bill fulfils an important purpose. The bird is an insect-feeder, and must find great difficulty in securing food during the cold months of the year. All insects are then in a state of hibernation. But the ground chough can dig them from their places of retirement. We may often see the bird boring in the soil, driving its stout bill into the hard plateau until it finds the insects hidden underneath. Unless it had this special instrument of excavation it could scarcely exist through the winter months.

The larks supply another example. In India there are two kinds of Calandra larks: one the Eastern Calandra lark, which lives on the plains; the other the long-billed Calandra lark, which occupies the plateau of Tibet. They are powerful birds of heavy build, and utter a loud call-note when in flight. Compare the bills of these two species. That of the plain bird is comparatively small, about $\frac{4}{5}$ inch in length. That of the Tibetan bird is distinctly longer, its length being $1\frac{1}{5}$ inches. The longer bill of the Tibetan bird is explained by its environment. It ploughs into the ground after the manner of the ground chough, hammering the surface with its powerful bill and securing its food by boring into the soil. And since the soil is often frozen and difficult to penetrate, this species of the plateau must have a sharper bill than the closely allied species of the plains.

That remarkable bird, the ibis-bill, provides an excellent example of how the bill of a bird is adapted to its method of securing food. It is a high-altitude wader with a long hard and slender bill curved something like that of a curlew. This bird is met with in the mountain torrents that pour from Tibet into the Himalayan range. It specially likes those places where the stream is broad and meanders through a bed of stones. There it runs about upon the layer of boulders, sometimes wading into the torrent up to its breast, thrusting its long bill under the stones in the hope of finding insects beneath. Sometimes it curves its bill around the front of the stone, sometimes inserts it from one side. The bill is an excellent instrument for this purpose. Were it straight, it would not suit the roundness of the pebbles. The curve is a necessary feature of the implement and is excellently adapted to the habits of the bird, for it is curved in such a way that it fits neatly around the boulders when the bird is probing for food.

The peculiar environment of the Tibetan plateau has caused some of the high-altitude birds to change their customary habits of life. Some

kinds, owing to the absence of trees, have become almost exclusively village birds. Thus the tree-sparrow is to be found near every habitation. The accentors, which usually haunt bushes, in Tibet live amongst houses and in streets ; also the rose-finches, which naturally like jungle, are frequently seen on the village walls. The magpies are like house-crows in the way they keep to the villages, and, like choughs, they frequent precipitous cliffs. Many of the wildest birds have lost their sense of fear. The ruddy sheldrake and the bar-headed goose, which in India are amongst the most timid of birds, in Tibet swim about the ponds near the villages as fearlessly as in a city park. The hill pigeons fed as boldly at our Everest base camp as if they were the tame birds in a London street. We observe the same tameness in the case of some of the mammals. Wild sheep, for example, are naturally very timid, yet at the base camp they came within 20 yards of our tents, and they are said to visit the caves in the mountains, where they take food from the hermits' hands. Thus we see how pliable is animal instinct. This unusual tameness must be due to the absence of persecution, and shows that the sense of fear is not altogether innate, but is developed as a result of persecution by man.

Certain birds of the plateau have formed communities with other animals, this being a help to them in securing food. The most interesting of these is the mouse-hare community. The mouse-hares are most engaging little animals about the size of a large rat. They live in burrows on the open plateau, where they are usually seen feeding at the entrance or running from hole to hole. A number of birds associate with these mouse-hares. Amongst them were three kinds of mountain finches, and Elwes' horned lark. All these little birds were remarkably tame ; there was a perfect confidence between them and the mouse-hares, the whole making a charming society of protectively coloured mammals and birds. What is the object of this friendly association ? It is one of the ways in which the birds of the plateau contend with the scarcity of food. For these birds are seed-eating species, and find special attraction near the mouse-hare's holes. The mouse-hares possess an instinctive forethought. They store up a winter supply of seeds, which they carry into their dens. But where storage takes place there must certainly be some refuse. Little seeds will lie about in the vicinity of the burrows, and it is these waste fragments that attract the birds. Very possibly the birds also pillage the mouse-hares, for we often observed them entering the holes.

At greater heights, on the almost barren mountains, a less conspicuous society may occasionally be seen. This is an association of choughs and wild sheep. The chough sits on the wild sheep's back, where it searches for insects in the animal's hair. The sheep seems pleased with the bird's attention, and remains still while being explored. It is an interesting association at the highest altitudes. I have seen it on the crumbling

snow-clad slopes as high as 17,000 feet. Thus the stress of food at these elevations drives certain birds to associate with mouse-hares, others to keep company with wild sheep. The wild sheep at high altitudes are continually displacing small rocks and stones. At different times my notice was first attracted to the animals by the clatter of stones falling down the slope. It is thus likely that these animals play no small part in the denudation of high altitude cliffs.

I pass to another point. How do the animals escape the cold of winter? A number, of course, migrate to lower altitudes; but of those which remain, most go into hibernation and sleep the winter through. When we reached the plateau early in April, we found it almost destitute of animal life. Everything was hibernating underneath stones or in clefts of the rock or in the surface earth. The ants were hidden in subterranean galleries. Under stones were weevils quite motionless, also Carabid beetles so torpid that they were scarcely able to move. We found centipedes rolled into motionless coils, spiders lying dormant in the interior of snail-shells, earwigs in a sluggish state with their antennæ thrust back along their sides. Under some stones were numbers of dead insects, as though many had sought concealment in the autumn and died during the winter cold.

Hibernation must be a valuable protection to the animals. At the base camp I made an artificial burrow like that in which the pikas are accustomed to hibernate. At a foot beneath the surface its temperature was almost uniform. From 8 a.m. to 9 p.m. it remained at 33° F., while during the same period the temperature of the air varied through 19° F. Thus by burrowing the animals gain great advantage. They escape extremes of temperature and find uniform conditions. In winter they gain it even still more when they hibernate in the soil under thick snow. The conditions under a stone are also favourable for hibernation, though not to the same extent as a burrow in the soil. At an altitude of 17,000 feet the temperature beneath a stone varied through only 12° F. during the twenty-four hours. In the same period the temperature of the air varied through 44° F. Thus the beetles, the spiders, and many other creatures gain more equable conditions by hibernating under stones.

The hot springs of Tibet supply a place of refuge in which animals can escape the cold. In one place we found these springs bubbling through the soil and flowing away in warm streams. The temperature of the water was 60° F. A varied life inhabited these springs, chiefly crustacea and different kinds of shells. The only snake from the Tibetan plateau that I know inhabits the hot springs. In my original report on the fauna of the plateau mention was made of small leeches found at a height of 16,000 feet. It was found, however, on more careful examination, that these little animals were in reality planarians.

In the struggle for existence at these great altitudes many animals are driven to extreme heights. It indicates how relentless is the force of

Nature to spread into every habitable corner of the Earth. The wild sheep and mountain hares struggle up the ranges even to the barren slopes at 17,000 feet. There is a little redstart which places its nest at the same inhospitable height. We found grasshoppers at 18,000 feet, near the furthest limit of vegetable growth. We frequently saw the magnificent lammergeyer soaring round the mountain at 20,000 feet. We found bees, moths, and butterflies at 21,000 feet, spiders at 22,000 feet, choughs at the immense height of 27,000 feet. We found traces of a permanent animal existence far above the Himalayan snow-line and 4000 feet above the last vegetable growth. These were small spiders, and are the highest existing animals on the Earth. They live in islands of broken rock surrounded by snow and ice. There is no sign of vegetation or living creature near them, and for food they eat one another.

Nothing illustrates better this high-altitude struggle than the manner in which animals secure a livelihood on tracts of snow and ice. We found an interesting fauna on the Rongbuk glacier at an altitude of 17,000 feet. The surface of this glacier was deeply fissured and to a large extent covered with broken rock. It seemed at first sight utterly barren, yet some grass grew amongst the rocky fragments, and patches of lichen appeared on the stones. Certain animals found existence in this desolation. I have seen a herd of wild sheep sitting on the glacier surrounded by pinnacles of ice and stones. Certain birds used to frequent the icy tract. The snowcock came down to it from the sides of the gorges, perhaps to find a little food on the surface moraine. I saw Guldenstadt's redstart high up on the glacier where nothing existed but *débris* and ice. A little stint, while migrating through the gorge, halted for a rest near a glacier pool. A tortoiseshell butterfly was sometimes seen on the glacier at 17,000 feet. A number of protectively coloured moths used to live on its surface moraine. Beetles and small spiders found a shelter on it. It was the home of some minute flies. Even in the deep blue pools on the surface of the ice some creatures managed to secure a place. These pools were so cold that, after sweeping them with a net, the gauze remained frozen into a rigid bag. Yet in these pools were the larvæ of both stone flies and mayflies, and other equally delicate kinds skated on the surface of the water.

We may sum up with the impression that the struggle is fierce in the high altitudes of the Mount Everest region. We have seen that numbers escape death through protective coloration ; that many kinds have devices for escaping the strong winds; that at certain seasons the struggle for food is intense ; that some birds are specially equipped to dig into the soil ; that other birds are forced to change their habits of life, and some to form communities with mammals ; that burrowing and hibernation are the great resorts by which animals escape the extreme cold ; and finally that the ceaseless and relentless competition has driven animals to

extreme altitudes, where they live above the snow-line and on the surface of the glaciers in one of the most inhospitable regions of the Earth.

Before the paper the PRESIDENT said: Our lecturer this evening requires little introduction to an audience of this Society, for he is well known to you as the Medical Officer and Naturalist of the last Mount Everest Expedition, and uppermost in our minds, no doubt, will be that outstanding exploit of his when he conducted Colonel Norton, after he had become incapacitated by snow-blindness, safely down from the North Col of that formidable mountain. Many of you will also recall with interest the technical paper which Major Hingston gave to us at one of our afternoon meetings upon the effect of high altitudes on the human organism. He had already studied that subject when he attended as Medical Officer, I think, the survey expedition which carried out a programme of triangulation upon the high peaks of the Pamirs in 1913. It was no doubt their appreciation of what he had done in this direction that induced the authorities to release him from his command of the Royal Air Force hospital in Mesopotamia in order that he might join the Mount Everest Expedition. But besides these qualities for the post he has always been also a keen naturalist, and it is of the geography and its accompanying fauna of the high plateau of Tibet that he is going to speak to-night. The distribution of animal life in these high and inhospitable regions and the methods which that life adopts for its protection is well calculated to provide a fascinating story in competent hands, and it is with complete confidence in the power of Major Hingston to do justice to the subject that I now call upon him to give us his paper.

Major Hingston then read the paper printed above, and a discussion followed.

Dr. A. W. HILL, F.R.S. (Director of Royal Botanic Gardens, Kew): Major Hingston has told us a very interesting story of how the animals and birds have mastered the problem of protection at inhospitable heights. We at Kew now possess, through the kindness of the Joint Committee, all the plants that have been collected on the expeditions to Mount Everest. With the plants, of course, the problem of how to protect themselves in the adverse conditions under which they grow is as important as that with which the animals are faced.

I happen to have travelled in the Andes among the mountains around Lake Titicaca and collected plants growing at between 13,000 and 17,500 feet, and there, I fancy, from what we have heard to-night, the conditions must be very similar to, though rather less severe than, those in Tibet. In the Andes the plants are, of course, entirely different from those of the Himalaya, yet the methods of protection assumed are very closely similar. In the case of all high alpine plants the great thing to be aimed at is reduction of the transpiring surface; the leaf area is reduced to the smallest possible dimensions; the plants are very slightly raised above the surface of the soil, often not more than 1 inch, and they generally have a dense woolly protective covering. One of their chief characteristics is that they possess a long tap-root which goes deep down into the soil and thus enables them to get the necessary moisture from the ground below the level affected by frost. As Major Hingston has pointed out, the difference between day and night temperatures is very great, and the upper layers of the soil are often frozen. The leaves are closely imbricated and protected by the fibrous remains of

older leaves. Plants belonging to totally different families and genera show very similar adaptations; some of the Crucifers, such as the Drabas, the Androsaces belonging to the Primulaceæ, the Saxifrages, and the Gentians, to mention a few, are so alike in their vegetative characters that without flowers it is impossible to tell to which natural family or genus they may belong. I have no doubt that Major Hingston, in making his remarkably fine collection of plants, which contains some five hundred specimens, had considerable difficulty in discovering those minute plants, and, especially at the higher altitudes, in distinguishing them among the stones and gravel in which they were growing.

Major Hingston has referred to life at the highest altitudes he reached, but I do not think he collected plants from quite some of the highest points to which he climbed. The highest-growing plant that we know from Mount Everest is *Arenaria muscosa*, collected by Mr. Wollaston at 20,400 feet on the first expedition, and that we believed until quite recently was the highest recorded plant. But I find that the Swiss naturalist, Dr. Jacot Guillarmod, collected *Delphinium glaciale* at 20,600 feet when he was on Kangchenjunga in 1905.

In addition to the interesting Alpine herbaceous plants collected by Major Hingston, which included *Gentiana amœna*, also found by Mr. Wollaston, *Androsace sessiliflora*, and the beautiful new Primula, which the late Sir Isaac Bayley Balfour named after Mr. Wollaston, *Primula Wollastonii*, all from about 17,000 feet, there were also several dwarf shrubs. Three of these are dwarf Loniceras (Honeysuckles) one being probably an undescribed species, and there are also two Rhododendrons, *R. setosum* and *R. anthopogon*. The Rhododendrons are interesting because they afford a striking morphological contrast. We are apt to make definite statements in regard to plants and to say that those from high altitudes are characterized by being covered with woolly hairs, and this is commonly the case, but of the two rhododendrons I have mentioned, one is densely woolly while the other has no protective hairs at all, though no doubt it has a well-developed cuticle. These two plants form an interesting parallel to the unprotected human beings and the hairy animals who inhabit this region.

The genus *Pedicularis* is richly represented by some ten species in Major Hingston's collection, and it is interesting to find so large a number of these semi-parasitic plants at these high altitudes.

Another feature of interest in the collection, especially in association with human habitation, is the occurrence of several common weeds at these high altitudes. *Brassica campestris* was found at altitudes from 12,000 to 14,500 feet. The common Shepherd's Purse (*Capsella*), a common weed in our gardens, was found up to 14,500; whilst a weed of American origin, *Galinsoga parviflora*, occurred at 10,000 feet, and the ubiquitous Dandelion was found at 14,500 feet. *Glaux maritima* was also collected at 14,500 feet, and this, as botanists know, is a plant confined to the seashore in this country; *Polygonum viviparum*, a plant which at high altitudes has the flowers replaced by bulbils, was also found on the slopes of Mount Everest at 14,500 feet.

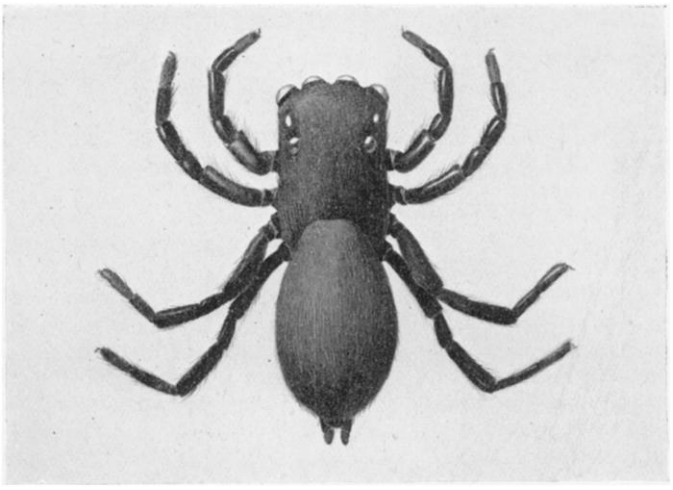
The highest plant brought back by Major Hingston is the common alpine Edelweiss from about 17,500 feet.

All these plants form a very interesting addition to our knowledge of plants from high altitudes. Taking into consideration the difficulties that must have been met with—and the same can be said of the earlier collections

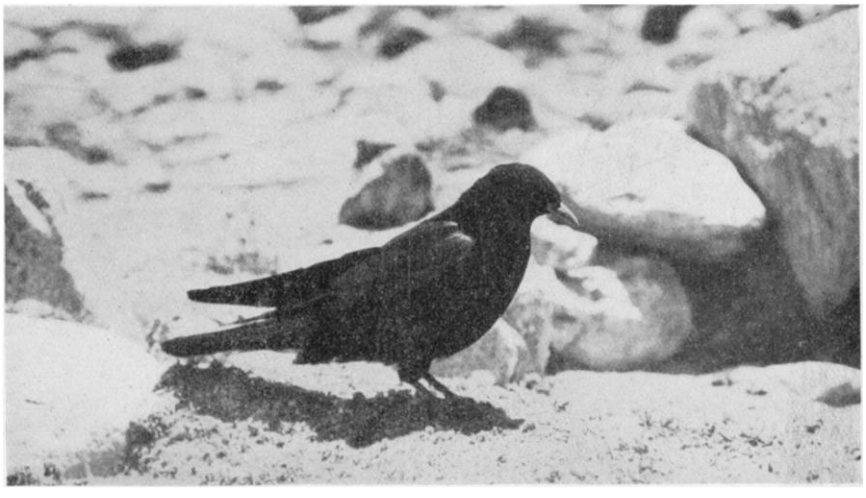
YOUNG OF TIBETAN SNOWCOCK

BURHEL ON CLIFFS NEAR BASE CAMP

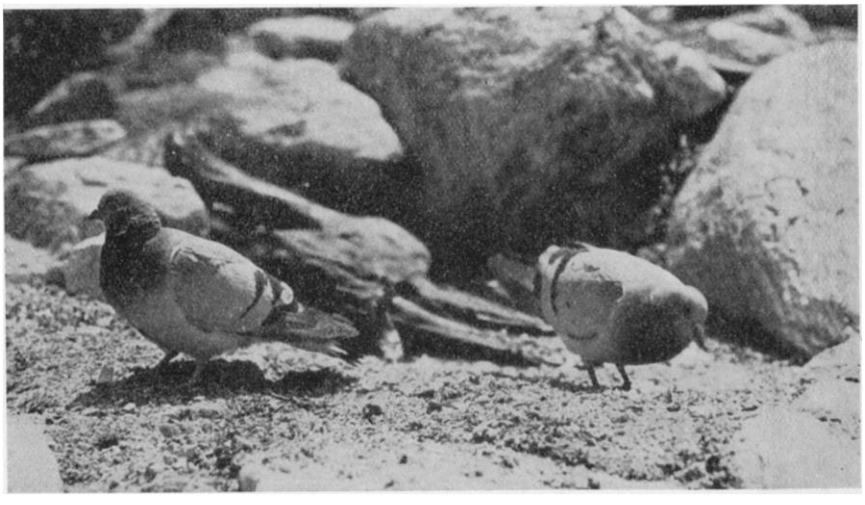
A YAK



ATTID SPIDER FOUND AT 22,000 FEET



YELLOW-BILLED CHOUGH IN BASE CAMP



BLUE HILL PIGEONS IN BASE CAMP

—the condition in which they were preserved and sent home has been remarkably good, and it has been possible to name them without any very great difficulty. A few of the plants probably represent undescribed species, but at the moment we have not had time to work through them critically. They will however be carefully determined and a full list published in due course.

Mr. A. F. R. WOLLASTON: I have listened to Major Hingston's lecture with intense interest. He makes me very much ashamed of the scanty observations and collection we brought back in 1921. Listening to his account of the ways in which animals protect themselves and are protected against the rigorous climate, one is struck by a very important omission. The dogs, the yaks, the sheep, the pikas, the very little pigs themselves have their fur coats, but nothing is said of man! The Tibetan is a singularly hairless creature. His only protection from the weather is the dirt that he accumulates. He has not contrived any kind of protection. It is a serious reflection this, that we are really such very recent upstarts in the order of things!

Talking of that same cold weather, I think the bird population in the plateau is very small in winter. When we were at Kharta in October we found at the altitude of 12,000 feet, which is well below the high regions, tens of thousands of desert forms crowding down the valley, and I have no doubt that in a week or two they would have gone still further down, so that I think the bird population in the plateau is very small in the winter except about the villages. Many of the mammals hibernate, so they have no trouble.

One of the most interesting observations that Major Hingston mentioned is that of the choughs following the mountain-climbers up to 27,000 feet, which is exactly what they do in the Alps; they follow climbers up to the tops of peaks, hoping for some crumbs from luncheon. I only wish Major Hingston had seen the lammergeyer flying over the top of Mount Everest. I have no doubt they do. We saw them fly certainly 26,000 feet, and surely they can go higher.

There is one small point in which my experience differs from that of Major Hingston. He thinks that fear is not innate in wild creatures. I think fear of man is innate. For instance, I have been in high regions in the middle of Africa in Ruwenzori and in very high regions in the snow mountains in Dutch New Guinea where certainly no man, white or black, had ever been seen before, and it was noticeable how very shy and how very difficult to approach were the small birds in both those regions. I think when a small bird first sees a man it is necessarily frightened. The birds and mammals in Tibet have learned by association with the Buddhists that they are not going to be molested and so they lose fear. But I believe fear is innate. I may be wrong.

A year or two ago I had the privilege of reading a paper to this Society on the natural history observations which were made in 1921 on the first Mount Everest Expedition. As I left the meeting I walked down the street in front of two Fellows of the Society. One said to the other, "That is not the sort of thing I expect at the Geographical." The other said, "I think I shall write to the Secretary." I do not know whether he did write to the Secretary nor what the Secretary replied to him. But with all deference I venture to differ very strongly from those two Fellows. I think that if a traveller is only a geographer and not in some part a naturalist he misses, I should like to say, almost half the pleasure of travel. I have no further observations to make, except to congratulate Major Hingston on the most interesting discourse to which we have listened.

The PRESIDENT: I offer, on your behalf, our sincere thanks to the lecturer for the pleasure which he has given us this evening. It is only too painfully obvious, I suppose, to every one that the struggle for existence at these high altitudes is extremely severe, and it was extraordinarily interesting to learn of the various devices which these different forms of animal life evolve in order to meet the severity of the conditions under which they live. One thing that certainly struck me was the patent futility of all such devices. The small birds, apparently, evolve protective colouring to protect them from the larger birds which habitually prey upon small birds, yet the larger birds appear to be as successful as they generally are in living upon the smaller birds, for the lecturer told us of lammergeyers, ravens, and other large birds of prey flaunting themselves in their arrogance in non-protective colours across the range of his vision. Again, the smaller birds appear to develop specially constructed beaks which enable them, in their turn, to defeat the efforts of the insects to get away from them. It really seemed to me that the futility of life is even greater at these high altitudes than it is at more normal levels. And surely the height of futility was reached in the case of the spider which, according to the lecturer, lives at so great an altitude that there is nothing for him to live on except his father. Can you conceive a greater degree of futility than being born and struggling to exist in order that, in due course, you may become food for your son? And for your son to be born and to struggle to exist in order that, in due course, he may become food for your grandson? It seems to me that in that case we really have reached the height of futility. Finally, Major Hingston has given us much food for thought, and one of the outstanding features of his lecture, I think, though probably it was an entirely unconscious one, was the extraordinary industry, determination, and perseverance which the lecturer himself showed in making these interesting and minute observations under conditions which must have been extremely trying and in many cases involved no small degree of hardship. We are grateful to men of his type in general who are prepared in the interests of science to undergo these discomforts and hardships, and we are grateful to him in particular for the extraordinarily interesting story which he has told to us to-night.

THE ROSS BARRIER AND THE MECHANISM OF ICE MOVEMENT

C. S. Wright

Read at the Afternoon Meeting of the Society, 19 *January* 1925.

THIS paper on the Ross Barrier and the mechanism of ice movement is based on the Glaciological Report of Capt. Scott's last Antarctic Expedition, but extends to a slight extent certain views of the mechanism of ice movement dealt with in that Report, which was a joint work with Major R. E. Priestley.

The Ross Barrier is the name given to the huge mass of ice which fills the southern end of the Ross Sea. It was discovered by Ross in 1841, and the northern boundary was surveyed by him from the *Erebus* and *Terror*. The Ross Barrier is thus bounded on the north by the Ross Sea, on the west by Ross Island and the steep coast of South