THE GENERAL ECOLOGY, FLORA, AND FAUNA OF MIDLAND NEPAL

ROBERT L. FLEMING, JR.

N

to Trisuli

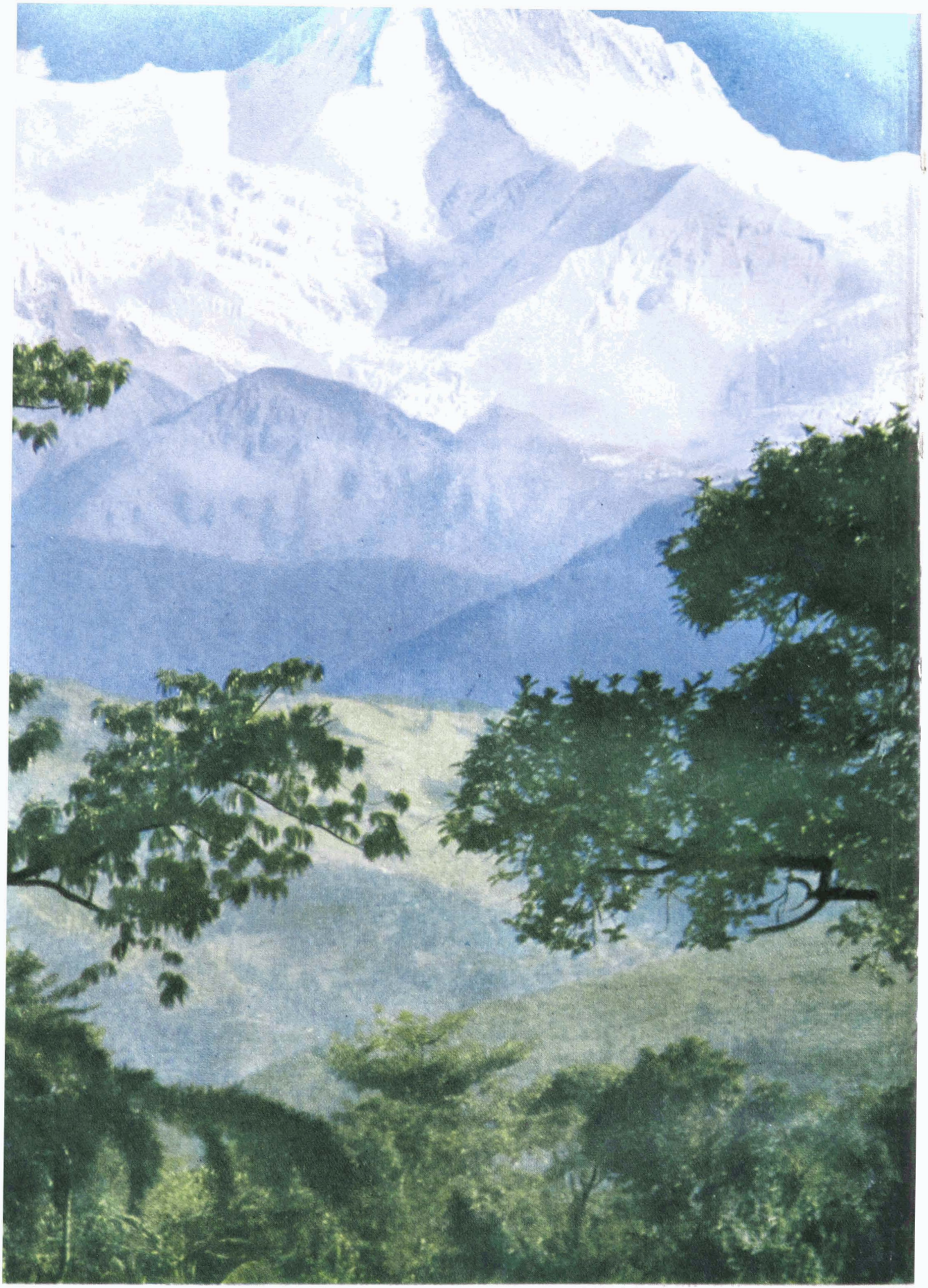
to Tribhuban Rajpath

to Dakshinkali

7601
7196
8148
SHEOPURI LEKH
Sheopuri
8962
7699
TOKHA
(Hospital)
7944
8014
7608
CHIPU
5329
Buranilkantha
7804
MANCHURI LEKH
Bishnumati R.
Δ6430
NAGARJONG
RANIBAN
Swoyambhu
5542
6179
Sundarijal
GOKARNA
KATHMANDU
Bagmati R.
SANKHU
Δ6194
Thankot
AIRPORT
Manohara R.
7950
CHANDRAGIRI
6488
KIRTIPUR
PATAN
BHADGAON
7106
7373
Bagmati R.
Surjabinayaka
5751
6680
CHAPAGAON
GODAVARI
Δ6953
TRIBENI DANDA
Bagmati R.
5424
BHAGWANPUR DAN
PHULCHAUKI DANDA

mile 1 0 1 2 miles
SCALE

KEY
- Forest area
- 5000' Contour level
- Surface road
- Unsurface road
- Foot trail



Nepal is a land of exciting ecological contrasts. In this view of Annapurna II (7,937 m. high), the mountain is framed by tropical fig trees. Near Pokhara, about 1,000 m. altitude.

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by
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Preface

NEPAL is a fascinating land. Giant mountain peaks, enveloped in snow and icy winds, tower high above the warm jungles of the lowland Tarai. Snow leopards, tree shrews, porpoises, and rhinoceroses all live in Nepal. Nature has been lavish here. Within Nepal's vast climatic range reside, to name only a few examples, about 850 varieties of birds, 300 species of ferns, 55 kinds of primulas, and many big game mammals.

For ease of discussion, Nepal may be divided into three fairly distinct regions: Lowland, Midland, and Highland. Lowland Nepal consists of the Tarai, Bhabar, Churias, Duns, and the Mahabharat up to about 1,000 m. elevation. This is warm tropical and subtropical country. Midland Nepal (from about 1,000 to 2,750 m. altitude) is subtropical; the lower edge of the temperate zone is also included. Early human inhabitants of Nepal settled mostly in this zone, for they were then above the malaria belt and below the harsh mountain climate. Highland Nepal begins with the coniferous zone (about 2,750 m. in Central Nepal) and extends up into the desolate region of rock and perpetual snow.

It has been fashionable for people in the past to write of Nepal as the land of mystery. Nepal is no longer mysterious — at least as far as the field biologist is concerned. Most of the plants and animals of Nepal have now been collected and identified. Problems of taxonomy still remain, but we do know fairly well what lives here. What we do not know very much about, and what will occupy considerable study time in the future is: what do these creatures do and how exactly do they live? Leopards, for example, are quite common in Nepal. Yet we do not know a simple thing as: how far does a leopard usually travel in a night? It is hoped that this volume may help stimulate an interest in the plants and animals of Nepal and studies of how they live together in their mountainous homes.

References mentioned in the text are those which can be found in libraries of Kathmandu. The best of these libraries are the Tribhuvan University Library, the Kaiser Library, and the Forest Resources Survey Office Library. The scientific names used here,

and found in the appendix, follow standard works such as Prater (1965), Ripley (1961), and Smith (1943).

Writing a book of this type involves the interest and assistance of many people. I would especially like to thank Dr. Morrow F. Stough, formerly Chief, USAID/Nepal Education Division, for initiating and supporting the project, and Mr. C. Wesley Brewster, Acting Chief, USAID/Nepal Education Division, for subsequent encouragement and for help with the quality of the illustrations. Dorothy Goldman, Richard Pfau, Douglas Hall, science specialists, USAID Education Division; Peter Cross, STEP Program; Dr. R. Gast, UN Science Teaching Adviser; Dr. Louis B. Alcorta, SIU/USAID Science Adviser; and Prayag Man Shresta, Science Specialist, HMG Department of Education, all spent considerable time reading the manuscript and they offered valuable criticisms. Discussions with Professor B. D. Pande, Head, Department of Botany, Tribhuvan University; Professor S. S. Singh, Head, Department of Zoology, Tribhuvan University; and Dr. D. D. Bhatt, Head, Department of Botany, Trichandra College, regarding the ecology, flora, and fauna of Nepal were always most helpful. I am also grateful to Professor Singh and Dr. T. C. Majupuria for allowing me to see the University collections and Mr. Rajendra Shresta for showing me his Anand Kuti Science College collection. Mr. P. R. Sakya, Mr. T. B. Shresta, and Mrs. Ramola Rana of the National Herbarium were generous with their time in identifying plants. Mr. Emerald Rana, former Chief of the Forest Resources Survey Office, was most kind in allowing me to use the Survey Office facilities. I am also grateful to Dhruba Raj Joshi, Teddi Grant, Dr. Robert L. Fleming, and Dr. Bethel Fleming, for typing and critical evaluations of the manuscript.

ROBERT L. FLEMING, Jr.

Kathmandu
March, 1971.

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Chapter One What is Ecology?

Introduction

WHEN you look around you in Nepal, what do you see? People, fields, soil, trees, water, houses, roads, hills, mountains, traffic, livestock, smoke in the air, birds circling above? Have you ever stopped to wonder how all these things came together at this moment in history to live or exist in Nepal?

How did people come here? Where are they from? How did the Kathmandu Valley develop such a level floor? How did the Nepal hills form? How did the Nepal forests develop? What kinds of trees are found there? What else do we find in these forests? What animals and plants live in Nepal, and how do they relate to plants and animals found in other parts of the world? How does the presence of one creature affect others?

Are there species in Nepal that are on the decline and facing possible extinction? Sabertoothed Tigers probably roamed the Nepal forests but have long since become extinct. What causes extinction? How does the presence of man affect the natural landscape? How, in Nepal, does man change nature? What would the Kathmandu Valley be like if no person had set foot here? What are the trends of nature in Nepal, and what may be expected in the days ahead; what will future generations find in Nepal? What will modern technology do to alter Kathmandu for the better? Are there also dangers?

These and many other questions can be asked by people interested in the environment and man's place in nature in Kathmandu and Nepal. Ecology is the study of environment as it relates to the lives of plants and animals. It is the study of the interactions and dependencies *among* plants, animals, and the environment.

Organizational Levels in Nature

In studying living creatures, man may examine them on one or more organization levels. The individual level, a single Common Dhaman or Rat Snake, for example, might form the focus of an

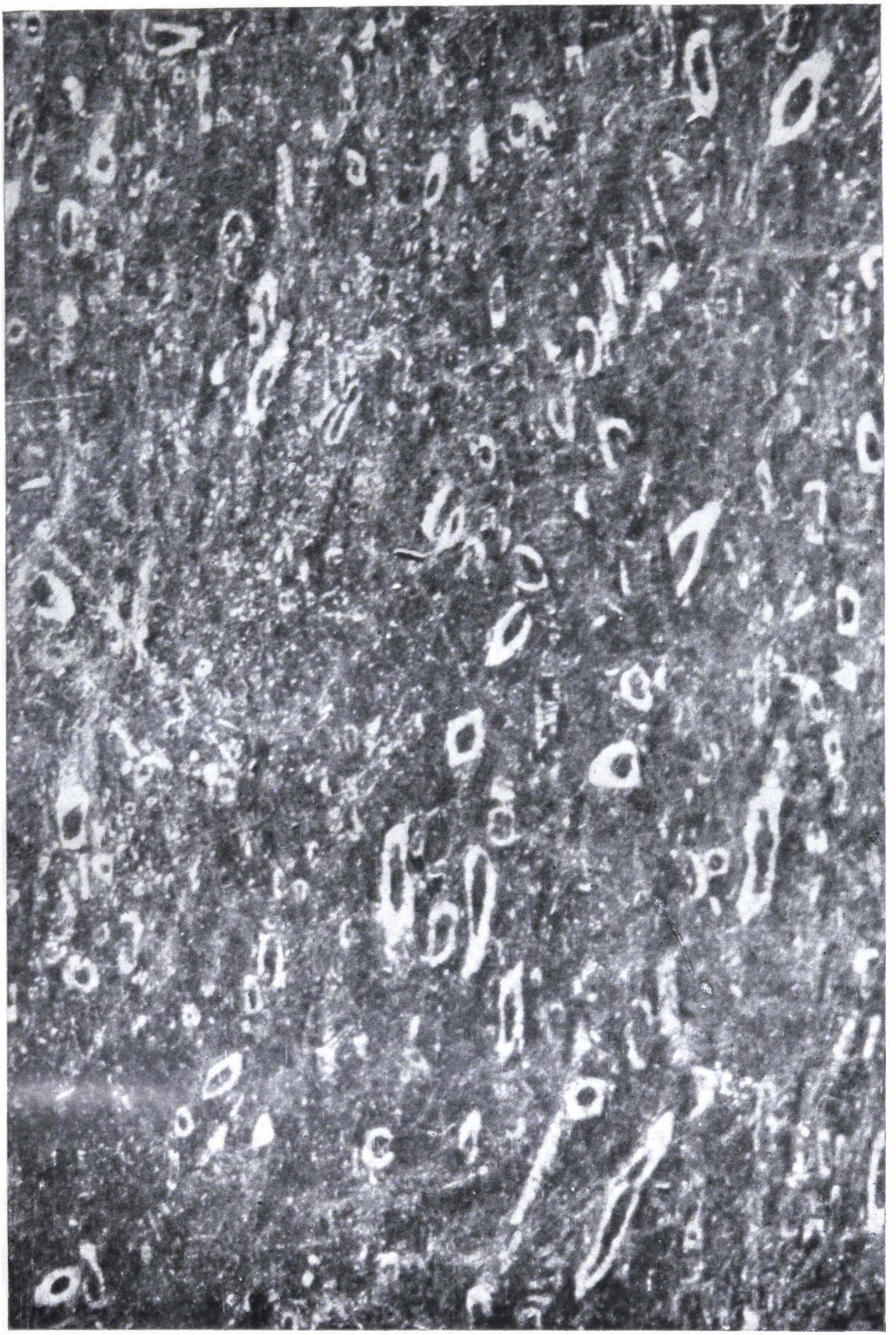
interesting investigation. But then, below the individual, one might study the snake's organs (What is the snake's tongue and what does it do?), or the tissues (What is the epithelial lining of the intestine like, and how does it assist the snake in absorbing food?), or the cell (What is a nerve cell, and how does it work?), or the intracellular components (What are mitochondria, and what do they do?). Or the scientist might wish to proceed in the opposite direction — to the more general. Above the individual level is the population (many of one species grouped together), a community (two or more populations interacting), an ecosystem (the combination of living communities with their physical environment), biomes (wide areas covered with similar-looking vegetation patterns), or realms (all or part of a continent covered with related species). Ecology, since it involves the study of interactions, focuses attention on the more general levels, although all levels, of course, are important in one's understanding of how animals and plants operate in nature. In our examination of nature in Nepal, we will discuss each level that is of special significance to us.

Web of Life

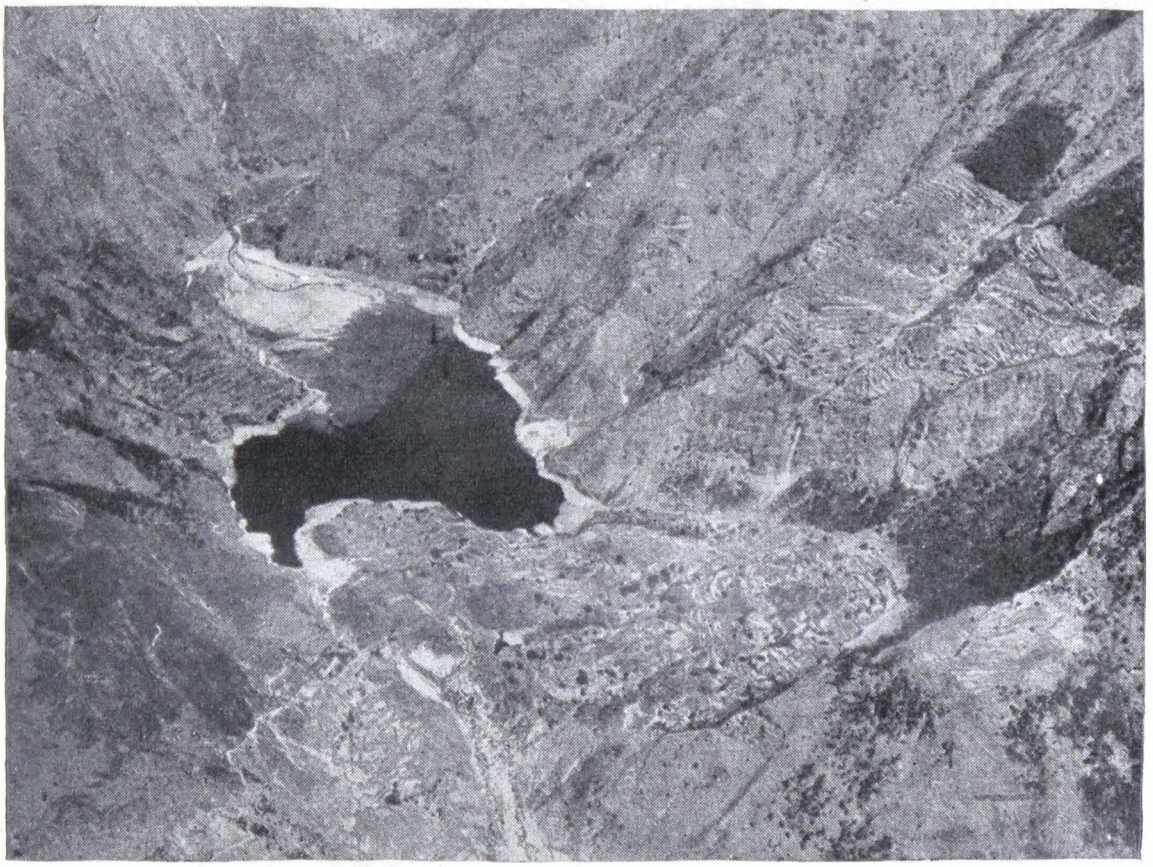
When one pauses to think about the world in which he lives, one realizes it is a very complex yet well-organized place. Non-living factors of our environment sustain and control, in part, the living aspects. The living, in turn, may alter the non-living. Even small areas, though, such as the forest around Nagarjung, near Kathmandu, are so complex that we hardly can be expected to understand all that is occurring there.

The concept, basic to ecology, that all living things are interdependent (Plants affect animals, and animals, plants) has been described aptly as the " web of life." Every creature is dependent upon many factors for its existence. An oak tree on Kaptar Ridge above Silgarhi-Doti, for example, is dependent upon topography, soil conditions, climate, the presence or absence of certain plant species, and the activities of animals — most importantly man — to name only a few.

Within a forest, the Mai Pokhari forest of Ilam, for example, mineral nutrients (and indeed energy) are of finite quantities. For plants and animals to exist in one region over many years, there must be a way of either adding more nutrients to the system or of



1. Fossils in the Godaveri Marble.

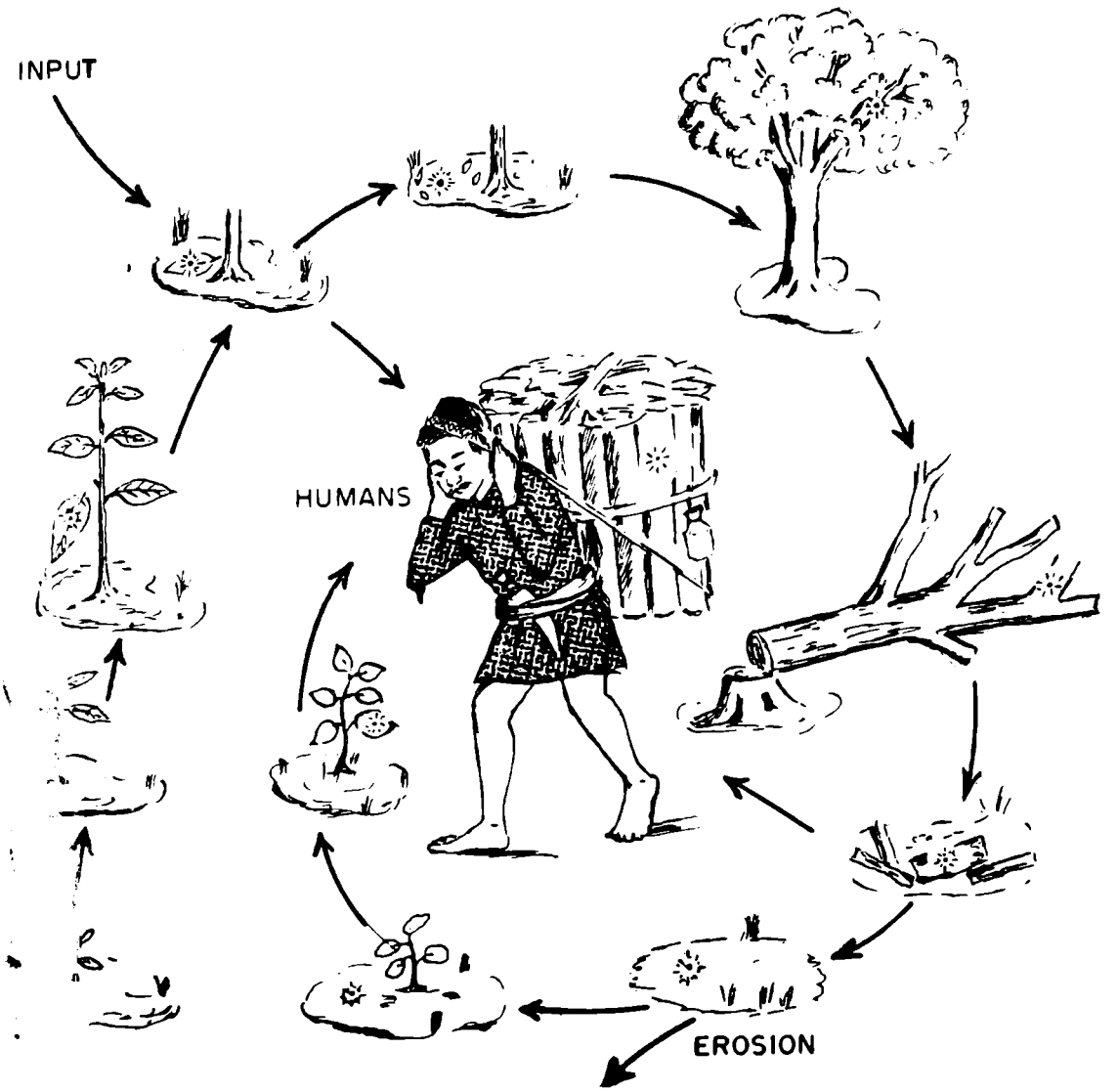


2. "Natural erosion" occurs throughout the Himalayas. This small lake, in Jajarkot District, W. Nepal, was formed by a landslide that blocked a small stream. The landslide left the scar on the hillside, right, and now forms the foundation for a small village and cultivations.

preserving the minerals already in the system. The wearing down of rocks, thereby releasing stored minerals, is one method of obtaining them. Then the recycling or re-using of minerals is nature's way of keeping them in the system.

The Ecosystem

Suppose a chilauni tree, on the ridge above Gorkha Bazaar, dies. It has used considerable quantities of phosphorus to build its cells. Now, as its body decomposes, with the aid of other plants and micro-animals, the phosphorus is released into the soil where it can be picked up immediately and re-used again by the newly forming generation of plants. In this manner minerals stay within a restricted



. In an ecosystem, minerals are used again and again. Living plants may 'e minerals that are released by decaying plants. Minerals are added to :osystem through weathering of rocks and are lost through erosion or removal by man.

zone and can be used indefinitely. Such a self-contained unit in nature in which recycling and inter-operating elements occur is called an *ecosystem.*

Theoretically, most present ecosystems on earth have developed over thousands of years, and the animal and plant species therein have attained a balance with one another and with the environment. Theoretical may not mean actual; there are many exceptions to a smooth working, ideal balance. Man, since he started farming, *i.e.*, manipulating ecosystems to produce more of one useful plant species, has altered or destroyed many an ecosystem. Indeed, man is perhaps the most unpredictable and disruptive element in most ecosystems.

The ecosystem, then, in the concept of ecology, is a basic unit in nature. Within ecosystems, minerals and nutrients are recycled while plants and animals exist in an active state of balance with one another, their presence or absence dependent in part on geologic and genetic history coupled with environmental factors such as topography, soil composition, and climate.

Biogeographical Regions

Kangaroos are plentiful in Australia, but how many have you seen living wild in Nepal? None, no doubt. Here we have the One-Horned Rhinoceros; how many of these are wild in Australia? None. Different parts of our world have different plants and animals, and geographers have found that the earth may be divided into great biogeographical *regions* or *realms.* Thus we have the *Neotropical* of South America, the *Nearctic* of North America, the *Palearctic* of Eurasia, the *Oriental* of South Asia, the *Australian* of Australia, and the *Ethiopian* of Africa (Also see Polunin, 1964: 18).

We in Nepal are fortunate, for we straddle a transition zone between the great Palearctic region to the north and the Oriental to the south. Palearctic species are found at high altitudes in Nepal. During the winter, also, a great many Palearctic birds descend from Europe and North Asia into the Nepal mountains. During the spring and autumn migrations, thousands of birds pass over Nepal on their way to or from India and Central Asia. Oriental species are found in the Nepal Lowlands. Similarly, the long days of summer bring nesting birds back to our hills from the plains of India and Pakistan. Resident species in the Nepal Midlands are often related

to Indochinese forms (Indochina forms a sub-region in the Oriental), and the distribution of many creatures is from Nepal east into the western mountains of China.

Biomes

Biogeographical regions are vast areas; the Palearctic reaches from England to Japan and also includes part of North Africa. Within such a large area you would expect some smaller divisions; these are called *biomes*. The word " tropics " refers to warm areas geographically near the equator. Within the tropics and where there is high rainfall, the " tropical rainforest " may develop. This is a distinct biome and is distinguished by certain families of plants and animals that are found throughout the tropical regions of the world.

In Nepal we have several biomes, and because of the mountainous nature of the land, you may see five distinct biomes from the plane window as you fly from Kathmandu to Janakpur. On the plains of northern Europe or North America, one may have to drive almost 800 miles in a north-south line before one emerges from the coniferous biome into the tundra. What is the situation in Nepal? Quite different! Here the coniferous belt starts at about 2,700 m. (in Central Nepal) and continues up to about 3,700 m. — a total distance of *less than a mile*. In Nepal, one can walk through the coniferous biome to emerge into the alpine, all within a morning !

The biome surrounding Kathmandu is primarily subtropical forest. Tropical elements increase at low elevations while temperate forest species live towards the tops of Pulchowki and other hills. We have, for example, Kalij Pheasants at Godaveri; these are subtropical. Beautiful tropical Bluethroated Barbets — green with blue throats and red foreheads — perch in the trees, while along the stream at Sundarijal we hear the enchanting song of the glistening purple Whistling Thrush, a temperate species.

Actually we do not know how " subtropical " Kathmandu is. No one has taken a census of small areas in the Valley and on the surrounding hills to see how many tropical, subtropical or temperate species there are. To accurately say that Kathmandu is subtropical might be more difficult than it first appears. To find out, one would have to discover and identify every species in the selected study plots. Then he would have to assign each species to its proper category. Some species, though, would not fit conveniently into any grouping

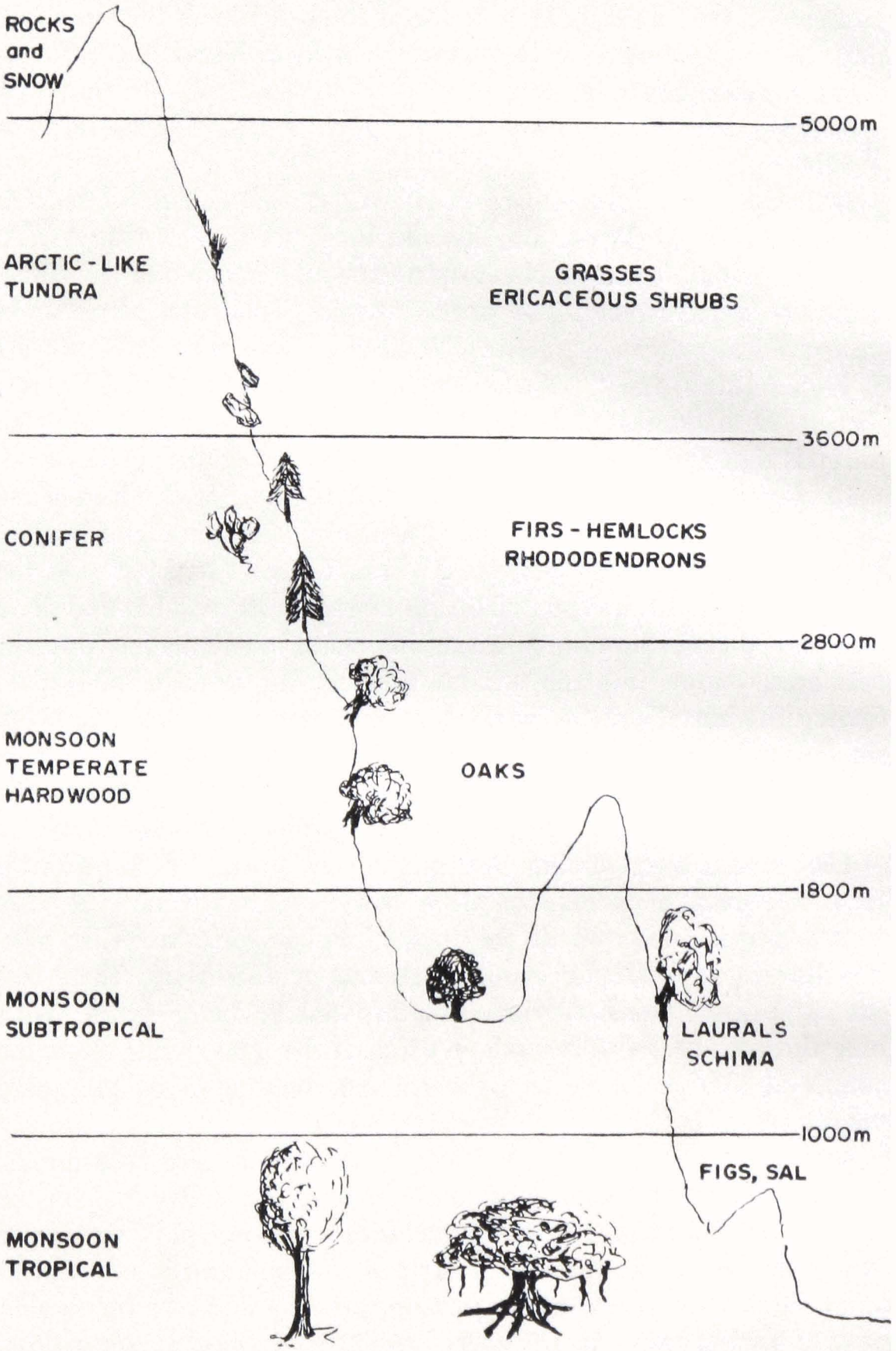
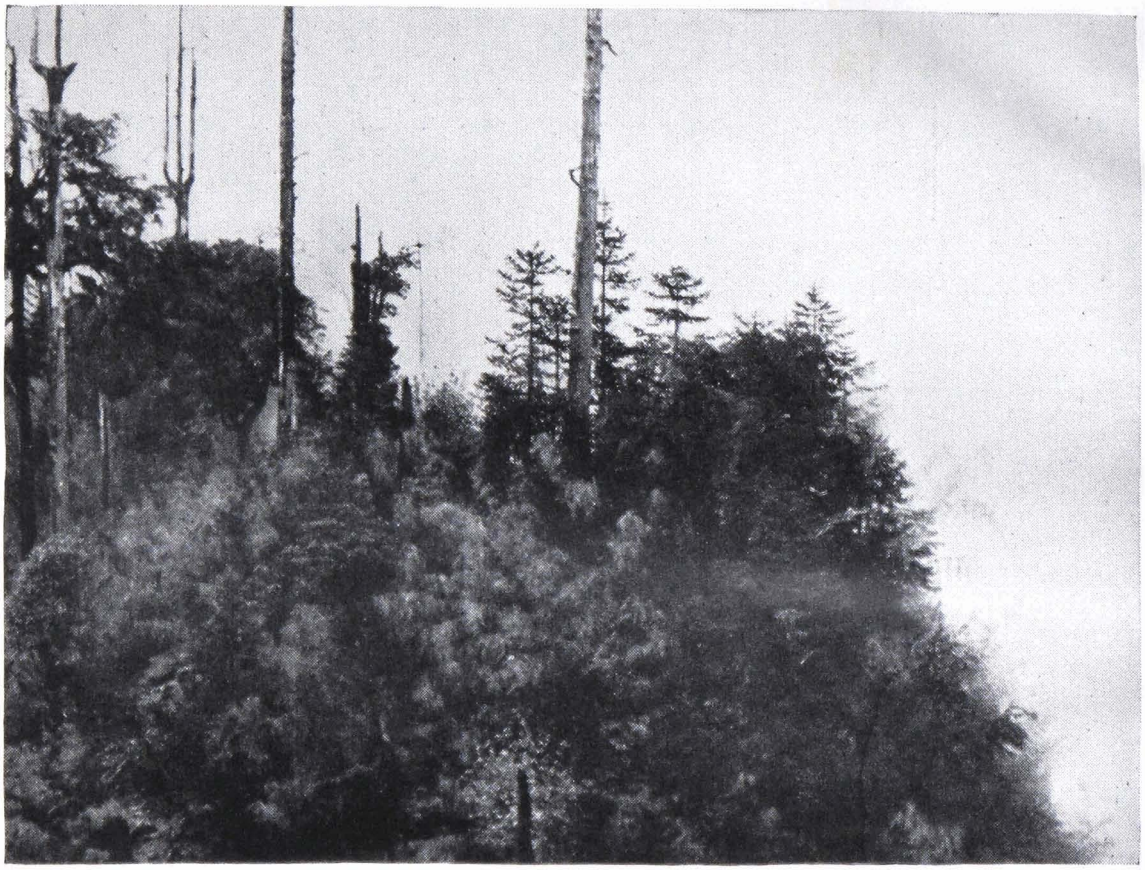


Fig. 2. Diagrammatic sketch of Biomes in Nepal.



3. Some years ago a forest fire destroyed the tall conifer trees here. Now a seral community or bamboo stage has developed, and young conifers are also sprouting. East Nepal at 3,000 m.

(because all classification systems are somewhat artificial). Then again, certain creatures or plants might be represented by hundreds of individuals living within the study plot; others by a single individual. How would you weigh each species on your " subtropical " map? Not easy. Nonetheless, to say that the fauna and flora of the Kathmandu Valley are primarily subtropical does help in one's understanding of Kathmandu in relation to other world areas.

In many parts of the world, biomes stretch over vast areas. Not so in Nepal. The biomes here are narrow and " squeezed " together. Even so, a Nepal biome, the subtropical forest is an example, is relatively complex with ever so many different factors and conditions operating.

The Community

Within biomes in Nepal are many different *communities*. A community consists of two or more (most often more) interacting populations. Usually a community has several dominant plant species around which a great many other plants and numerous animals live. In certain communities, the mountain stream tumbling down near Sallayan for example, animals are the main living things; plants here are not conspicuous.

Communities change. On a given piece of land, the community may be only temporary, with another type gradually encroaching. With a specific set of climatic, biotic and soil conditions, it is felt that a certain type of community eventually will result. This final and fairly stable community type is called a *climax community*. In Nepal, these are characterized, for the most part, by forests of oaks, conifers, and tropical broadleafed evergreens. In much of Midland Nepal, the climax forest has been cut and destroyed. But in the high regions of the country and in the lowlands, much climax forest remains (Also see Daubenmire, 1968:229-237).

The types of vegetation that appear in stages before the final climax forest are called *seral communities*. If a forest is destroyed, say by fire, eventually small plants will take root in the charred ground. Later shrubs and small trees may appear. Finally, after many years, a forest similar to the one that burned may evolve. A good example of these changes can be seen on the northwest slopes of Shivapuri hill near Kathmandu. Here a fire has burned down the original oak forest so that now Dwarf Bamboo (*ningalo*) grows in

profusion. This bamboo is a temporary or seral community eventually destined to be replaced by an oak forest.

Populations

Populations in ecology refer to a collection of animals (or plants) of any one species and thus is a step below the organizational level of the community. An important part of ecology is based on trying to find out what factors affect the growth and existence of populations. It is known, for example, that populations may expand or decline from year to year. We had an example of this variation in Nepal when, during the winter of 1968, very few Blackthroated Thrushes (*Chancher*) arrived here from their northern breeding grounds. Usually this is a common bird in Midland Nepal in winter, but in 1968 only three parties were seen by an investigator (as compared to about 100 sightings for a normal winter). What happened to these thrushes? Why were they reduced so dramatically? These are questions of interest to ecologists.

The population becomes an important study level when a species is nearing extinction. In order to maintain or re-establish the species (Take the One-horned Rhinoceros of Chitwan as a case), one needs to know what space, shelter, and food the population requires. To know and understand the interactions of the endangered animals with other species is also important for a successful conservation program.

Environmental Factors in Ecology

In the study of ecology, one is primarily concerned with the environment and how it affects the behavior and lives of plants and animals. Thus the topography (land forms), soils, and climate are of special interest to the ecologist.

Nepal is a land of mountains; these influence everything that lives here. The climatic conditions existing in Nepal can be traced directly to the presence of jagged ridges and high peaks. Likewise, the formation and movement of soil is dependent upon the structure of the mountains (and the associated weathering forces). It is appropriate, then, that we look briefly at the geology of the Himalayas. What are the Nepal Himalayas like, and how were they built?

Mountain Building

Mountains arise either by volcanic action or by the buckling of the earth's crust. Some elevated regions develop through a combination

of these forces. Many volcanic mountains appear after a violent eruption that leaves cone-shaped peaks such as Mt. Kilimanjaro of Africa or Fujisan in Japan. Other volcanic activity can be gradual with the oozing-like emergence of molten rock over a broad area. Much of the Indian peninsula was thought to have originated in this way (See Wadia, 1966: 292).

A buckling of the earth's crust, on the other hand, is probably caused by lateral pressures which force formerly low land up into the sky. Semimolten rock from beneath the crust also may be squeezed upwards at this convulsive time. One can only imagine how many incredibly intense earthquakes must accompany the rise of such mountains as the Himalayas.

The Nepal Himalayas

What, then, is the situation in Nepal? Have you seen the neatly rounded cones of recent volcanos in Nepal? Or, is most of Nepal based on heat-formed *igneous* rocks (such as basalt) that are usually found in volcanic regions? No. There are no known volcanos in Nepal. Most of our rocks here are limestones, shales, schists, gneiss, quartzite, and marbles. These are not igneous. Many of Nepal's rocks were formed through sedimentation ; others are sedimentary in origin but have been structurally changed through intense heat and pressure. Limestone is a good example of a *sedimentary* rock, while gneiss is one of the changed or *metamorphic* group. This is not to say that Nepal has no igneous rocks. Granite (the most common igneous rock in Nepal) is found at the northern edge of the Kathmandu Valley and much of the main Himalayan backbone is underlain by granite (See Hagen, 1963: 40).

When one views the tumbled ridges and intervening valleys topped off with magnificent peaks, it soon becomes apparent that to understand what is presently occurring in the mountains or how the landscape came to be where it is, is not an easy matter. How can it be that around Kathmandu we have all three major types of rocks: sedimentary, metamorphic, and igneous? Or, how is it that Godaveri marble bears fossils of sea-living animals?

Apparently the land that is now Nepal was at one time under an ancient sea. If one treks south to Narayanthan from Panaulti, in Khabre District, he can see slabs of limestone rocks with clearly visible ripple marks on their surfaces. The ancient trilobites of the

Godaveri marble and the ammonites of Mustang District speak of the sea.

If you were asked to find out the age of the Himalayas and how they were thought to have formed, what would you do ? Correct. You would look for material in books and articles on the subject. But, suppose there were no information available; then what? Correct again. You would have to travel throughout Nepal, examining in detail the rocks and geological formations found here. You would try not only to discover what types of rocks occur, but also what kinds of fossils they contain and how the rock strata are arranged in relation to one another.

If you were to do this in Nepal, you would notice (on a south-north axis) that the Churia (Siwalik) hills are composed of loose soil and conglomerates. Mammal and other recent fossils have been found here; you might be lucky enough to discover the remains of an ancient hippopotamus or other extinct creatures. To the north, the Mahabharat range rises next and you would find that some of its sedimentary rocks have pushed over on top of the Churias. Further north, you would see that the land is depressed (lower) with evidence of numerous large lakes existing here in former times. Beyond and above these midlands, you would be fascinated by the major Himalayan peaks which have very steep south faces and more gradual northern slopes. You would find these snow-covered massifs to be composed, largely, of granite underneath high-altitude sedimentary rocks which are similar to those of the adjoining Tibetan plateau. In short, you would find that Nepal is a complex place with numerous ranges and rocks of obviously different types and ages.

According to Toni Hagen, a geologist who has travelled extensively in Nepal, the geological time-table for the Nepal Himalayas can be drawn as follows: 1 — the uplift of a small mountain range between the land masses of Central Asia and India (about 20 million years ago); 2 — a second upthrust sending new material out over the original mountains (about 10 million years ago); 3 — the uplift of the Tibetan plateau (about one million years ago), and the continued deposition of Churia material in the Ganges Sea; 4 — a violent squeezing of the crust which thrust the main Himalayan peaks upward (within the last million years); 5 — the formation of the Churias (less than a million years ago); 6 — the rising of the

Mahabharat range, which now overthrusts parts of the Churias, combined with a simultaneous depression of the Nepal Midlands (about half a million years ago). For a detailed and interesting account, you may wish to consult the book, *Mount Everest* (Hagen, *et. al.*, 1963).

Thus, you can see that the Himalayas are young mountains; in fact, they are thought to be the youngest in the world. Actually, even a quick glance at a mountain system can tell you something about its age. How? When you stop to ponder that natural erosion has a continual effect on a mountain, it is logical to assume that old ranges are well worn — they are rounded and not very high. New mountains, however, are in the process of wearing down so that landslides are frequent and the ridges sharp. If you examine Nepal, what do you find? Yes, the ridges here are very sharp with steep slopes dropping away below them. These mountains are so young that they may still be growing. The frequent earthquakes here indicate tension and activity in the earth's crust beneath Nepal. We have not had a major earthquake in Nepal since 1934, but this is a very short span in geological terms, and thus we can safely predict that, because the Himalayas have not reached the end of the mountain-building period, we can expect severe earthquakes from time to time in the future.

Soils

Soil, derived primarily from rocks, is important for all land creatures. Without soil there could be little life on land. Thus ecologists are keenly interested in the composition and distribution of the earth's soils. We have a number of soil types in Nepal.

As one moves through Midland Nepal, the most conspicuous soil seen is the bright red type found near Trisuli Bazaar, below Tansen, and around Panch Khal in Kabhre District, to mention only a few places. This red *laterite* soil is typical of tropical regions that are subjected to high rainfall. After heavy rain, much water runs through the soil, " leaching " or washing away many of the soil minerals. Eventually iron and aluminium compounds are left; these make the soil red (See Aubert, *et. al.*, 1958: 26-27).

In the forested regions of the Nepal Midlands, though, the soil is thick and nearly black. This soil type occurs at altitudes where the temperatures are relatively cool. Here the growth of plants is slow (as compared to the turnover in hot tropical regions) and a rich

layer of *humus* soil, composed of decaying materials combined with decomposing organisms, builds up.

In tropical regions (in the Nepal Lowlands, for instance), the soil layer, even in dense forests, may be surprisingly thin. Life here is so active and growth of plants so rapid and luxurious that minerals are tied up in the living plant tissues so do not accumulate on the jungle floor.

Another soil which is usually rich and good for farming is found at the bottom of former lakes or along river shores where widespread flooding leaves silt. These are *alluvial* soils which have built up to great depths in the Tarai and the Kathmandu Valley. Some artesian wells in Kathmandu, for example, have been driven down to 375 meters below the surface *without* striking bed rock (See HMG's Kathmandu Valley Plan, 1969: 32). The famous "kali mati" of Kathmandu, through which these artesian wells are drilled, is a black clay deposited over many years in the ancient "Kathmandu Lake" and today is used as fertilizer because of its phosphorus content.

Besides their mineral and water content, soils also harbor incredible numbers of microscopic animals and plants. Soil bacteria, protozoa, and nemotode worms, to name only a few, are of intense interest to ecologists. Large creatures (comparatively) such as earthworms, beetle larvae, termites, and ants also function importantly in the soil.

The Climate

The climate in Nepal is extremely varied with arctic-like conditions surrounding the high peaks and tropical conditions existing in the lowlands. Midland Nepal has a mild climate with a distinct cooling trend as one climbs up the mountain slope. Nepal also exhibits the usual four seasons of the northern hemisphere; these are most distinct at high elevations.

The monsoon is a dominating climatic feature in Nepal. Without the summer monsoon rain, much of Nepal would likely be a near-desert. About 90 per cent of Nepal's rain falls in the summer (See Baidya, 1970: 6A). This means that during the winter, Okhaldunga receives only about 170 mm. of rain. Thus, without the summer contribution, Okhaldunga District would be reduced to a desert.

What Are the Monsoons ?

Monsoons are a particular type of wind current felt in South Asia, Southeast Asia, and Australia. They develop in the following way: As the great land mass of Central Asia heats during the summer, the air over the continent rises, thereby drawing in air from the cooler oceanic regions. Thus a very wide air current flowing towards Central Asia is established. In the winter, the reverse is true. The oceans are now warm (as compared to intensely cold Central Asia), and air rising over the oceans causes cool air from Asia to rush in.

We experience two monsoons in Nepal: the summer and the winter. But the winter monsoon goes unnoticed here. Why? Actually the monsoon winds themselves are not very noticeable; what we see is the rain that comes with the wind. In the winter, the air currents, when they reach Nepal, have not crossed any large bodies of water so have not absorbed moisture. We have no rain here. Later on, though, the winter winds pass over the Bay of Bengal, and so it rains heavily during the winter in South India and Ceylon.

The summer monsoon wind originates over the Indian Ocean and so is heavily saturated as it reaches the Indian subcontinent. The Himalayas, rising spectacularly in the north, form a great barrier over which this moisture-laden air cannot climb. Building up against the mountains, the air is forced upwards into ever cooler zones. The water vapor now condenses, and it rains — or sometimes pours — on Nepal.

Rainfall in Nepal

The first major Himalayan range, the Mahabharat, receives a good share of the summer rain. Behind and lower than the Mahabharat, most of Midland Nepal (including Kathmandu) is less wet; for, once the clouds get over the Mahabharat, they travel straight across to confront the high Himalayas. At the base of these high peaks (at Pokhara, for instance) or at high altitudes, the summer rain or snowfall is intense. The Himalayas create an effective barrier to the rain clouds; immediately to the north, one finds desert conditions.

Nepal is fortunate to have the summer monsoon rain. Nonetheless, the rain can be damaging, especially where improper land use occurs. Because of deforestation and overgrazing, not only is soil

lost, but the water run-off is so rapid that very short but extremely high floods can develop. Previously immune cultivations and villages may suddenly be damaged or completely washed away. In a well forested watershed, water run-off is slow and prolonged; in a deforested one, it is rapid and intense.

5. Under suitable conditions the slopes of Midland Nepal develop a lush subtropical forest. Here one sees figs, laurels, and chilauni trees. In contrast to the oak-rhododendron forest, subtropical forests are not often enveloped in mist and clouds ; thus primitive plants such as fungi, mosses and ferns are reduced in number. Notice that very little moss is evident here ; for, except in the summer months, a great deal of sunlight reaches these subtropical forests. Gokarna forest, Kathmandu Valley, 1,300 m.

6. Fig trees are a common element in Midland Nepal subtropical forests where their fruit provides food for many birds. The adventitious roots hanging down and the roots spreading out on the ground are typical of many figs and help support the tree. Kathmandu Valley, 1,300 m.

Chapter Two

A Nepal Subtropical Forest

GODAVERI, a favorite picnic site for people of the Kathmandu Valley, has the clear air, tinkling brooks, and peaceful atmosphere that are just right for a relaxed holiday afternoon. Besides the food and company, though, what does one see when he visits Godaveri? To the casual observer, the whole area may be represented by a green blur — no species stand out in particular. A birdcall might be heard, or perhaps a wild flower noticed, but that is all. Others will see more but soon will forget details, for they do not know what species of trees, birds, or butterflies they are seeing.

A trained scientist, a field biologist, on the other hand, has a fascinating time. What will he notice? This is a difficult question to answer, but we can make a partial attempt. The only problem is that answering one question leads to asking several more. There are many questions at Godaveri yet to be asked and many solutions still awaiting discovery.

First of all, a trained person will see general patterns. An overall view of the landscape is important to him, for it shows things like slope steepness and exposure. One also can tell something about the density of the human population and how the countryside may have been altered by man. Climatic features, such as clouds clinging to the ridges, are observed with interest.

Secondly, as the field biologist approaches Godaveri, he can see details. He sees that the slopes of Pulchowki are not clothed uniformly with vegetation. Different shades of green emerge, indicating a variety of trees growing there. On this, his first visit, he will not know that the Godaveri forest is a remnant forest and one of the best examples left in Nepal of a once widespread Schima-Laurel-Chestnut subtropical type. Because of inexperience, the biologist will not appreciate the uniqueness of Godaveri. Nonetheless, he will note the vast array of plants and he might briefly review in his mind how important plants are to the ecology of man. He will also see many species of plants and animals living together in one limited

area and pause to consider how they all manage to survive within the competition of the forest. He will wonder what kinds of plants and animals are in these areas; what do they do during their daily cycles, or how do they survive in their environment? Let us examine some of these questions in light of our Nepal subtropical forest.

The Importance of Plants

Plants are important to man; indeed, they are vital. When we climb up and down the Nepal hillsides, we burn energy. From where does this energy come? The energy we use, to walk or to breathe, originally came from the sun. We ourselves are not able to transform the sun's radiant energy into stored (chemical) energy, but plants can. Through a complicated chemical process not yet fully understood or duplicated, plants combine water and carbon dioxide to form glucose (sugar) in which energy is stored. This energy then is passed on to us when we eat the plant (or eat animals that have eaten plants).

Besides providing food and energy for man, plants also supply shelter and fuel. Moreover, they are involved in moisture condensation and assist in controlling soil loss and erosion. The oxygen we breathe is produced by plants. Other plants are valuable for their medicinal properties; similarly, many are prized because of their colorful beauty and form.

Classification of Plants

Plants are arranged and grouped from what is thought to be primitive to the advanced. Nepal is rich in all levels of plant life. Flowering plants, the highest on the scale, grow profusely from the Nepal Lowlands up to above the treeline. Cone plants, or *gymnosperms*, are found primarily at temperate altitudes above 2,700 meters. Ferns, more primitive than the flowering plants, also are temperate; and one finds a great proliferation in the moist forests from 1,500 m. up to 4,000 m. Fern relatives (club mosses and selaginellas) are likewise abundant at these altitudes.

Of the lower plant forms, the mosses are perhaps most conspicuous at moderate elevations throughout Nepal; many forest trees and rocks are draped with them. Lichens also are seen in these forests, but are most obvious at high altitudes. Indeed, lichens live at elevations above almost all other plant forms. The fruiting

7. A forest trail above Toka, Kathmandu Valley. Just to the right of the trail grows Eupatorium adenophorum, *a plant that has recently come to Nepal from Central America. This plant is doing so well that one finds it very common in Midland Nepal from Ilam District to Baitadi, and there is some fear that it may be crowding out some of our native Himalayan plant species.*

capsules of another primitive group of plants, the fungi, sprout primarily in the moist summer months; they are the most colorful of the lower plants. Algae, primitive aquatic plants, are found in Midland Nepal ponds as well as glacier-fed lakes at high altitudes. We will consider these plant groups in more detail later.

The General Forest

Many introduced plants grow in Midland Nepal, and as one approaches Godaveri, he will see the hanging red flowers of the Bottlebrush Tree from Australia along with white-barked Eucalyptus trees also from Australia. These exotics (Exotics are plants not indigenous to the area) were planted here around the turn of the century. The last of the exotics is seen at the level of the St. Xavier's Boys School; once you climb up the valley behind the school you will find only indigenous Himalayan trees. Schima is common here along with numbers of Laurels and many Holly trees next to the path. Wild Apple also is common here, and its delightful white blossoms dot the landscape in spring.

Bushes at this altitude (1,600 m.) often are dominated by the Raspberry ("Ainsilo") whose delicious orange (Some species are black) berries are an important food item to numerous berry-eating birds, not to mention village children who venture into the forest. Also growing commonly along the roadside is an erect herb with a dark stem and broad leaves. This Eupatorium, an unattractive relative of the Ageratum, was introduced (Accidently, we presume) into South Asia from Central America, and is so prolific that there is some fear that indigenous Himalayan species might be crowded out.

Moving up in altitude to the next vegetation zone (at about 1,800 m.), we see Banj Oak appearing as a dominant tree on dry ridges. Black Bears are very fond of the acorns of this oak; and one can tell, at least in the wintertime, if there are bears about by examining the Banj trees to see if they have been damaged by climbing bears.

Above the Banj zone is yet another oak belt — this time the Khasru Oak appears. Mosses and other epiphytic plants festoon the branches of these trees, for clouds enshroud this forest level during much of the year. It is a delight, though, to visit here in February or early March, for the Tree Rhododendron or "Lal Guras" bursts

forth with crimson red blossoms, while at ground level a small bush with shiny, dark green leaves and white flowers scents the entire forest with exquisite perfume. This Daphne bush also has a remarkable bark from which the Nepal daphne (miscalled "rice paper") paper is made. Khasru Oaks grow in Midland Nepal from about 2,100 m. up to the top of Pulchowki (2,700 m.). Above this height the oak continues to grow, but in a mixture of conifers and rhododendrons and not usually as a pure forest type.

It might be mentioned, too, that in the oak forest there is a definite level at which Dwarf Bamboo grows profusely. This bamboo offers protective cover for several mammals and birds. Some species, the Red Panda or the Parrotbills are examples, have become so dependent on bamboo that they hardly ever leave the vicinity of these plants. This mixture of tropical elements (bamboos) and temperate (oaks) is a theme often found in Midland Nepal.

We have now glanced briefly at the general forests of the Nepal Midlands. One question certainly comes to mind regarding these forests — why are there so many species? Why is there not just one — the strongest — type of tree? Why the many kinds of butterflies; why not just the Himalayan Sailer? Do the animals here come and go as they wish? Certainly no one tells them, "You must do this," or "You must go there." Or, is it quite as simple as this?

Ecological Niches

We have pointed out how important the interrelatedness of living things is within an ecosystem, but one also should keep in mind that each individual, because of this interrelatedness, operates within many restrictions. A porcupine's movements, for example, are limited by his anatomy, social requirements, and physical surroundings. Thus, the porcupine has a specific place in nature which may be called his *ecological niche* (See Odum, 1966: 27–30).

A niche, then, is a small crack in the "great wheel" of nature into which a species, through adaptations, can fit. Not all available cracks necessarily must be filled, while it is possible that two species might be competing to fill another. In our study of Nepal, we are interested not only in the great wheel, but also in how each species fits into the cracks and what each contributes to the total makeup of the wheel.

Generally speaking, it is felt, especially by zoologists, that no two species can occupy the same ecological niche. If two species attempt

to do so, one through competition eventually will be eliminated. In Nepal we have many good examples of this mutual exclusion. There are numerous ways in which Nepalese animals have adapted themselves in order to maintain the necessary ecological separations.

It should be mentioned, too, that some botanists feel that in plant communities, ecological differences between plants may not be so distinct as in animals. Several dominant tree species, for instance, may exist in a single climax forest which offers relatively uniform ecological conditions.

Now let us examine some of the fauna in Nepal's subtropical forest to see how species maintain their ecological distinctiveness.

Magpies

A familiar sight to many people in Midland Nepal is the Redbilled Blue Magpie, " Lampuchare," sailing from one tree to another or crossing a deep valley with its long, white-tipped tail streaming out behind. These birds are common below Dandheldura and thence eastward to Godaveri; they are scarce toward the east of Nepal and seldom seen near Bhojpur or Ilam. One of the best places to see them is around the Royal Botanic Gardens, at Godaveri, where they feed together in fruiting trees or hop about the ground, their long tails arched upwards with just the white tips drooping.

This bird, with its bright orange bill and feet, combined with a lavender tinged breast, is wonderful to see, but it is not looked upon so kindly by other birds. Magpies are convicted nest robbers and will eat eggs as well as young of other birds. Consequently, when magpies venture too near a nest not their own, the threatened parents often scream and chase after the intruder.

Magpies are omnivorous; that is, they will eat most anything that is edible. They devour berries, catch insects and worms, and often are the first outsiders (besides carrion beetles and flies) to find the recently killed meal of a not-so-friendly leopard. If the killer is not present, the magpies may settle on the deer (or other animal) to rip and peck at its flesh. Recently a magpie was seen busily engaged in a forest tree with something that looked like a snake. Upon close examination, though, the " snake " turned into a section of intestine recently retrieved from somewhere in the neighborhood.

Now, if one thinks about the situation for a minute, he will realize that the habits and behavior of all birds are not exactly like the

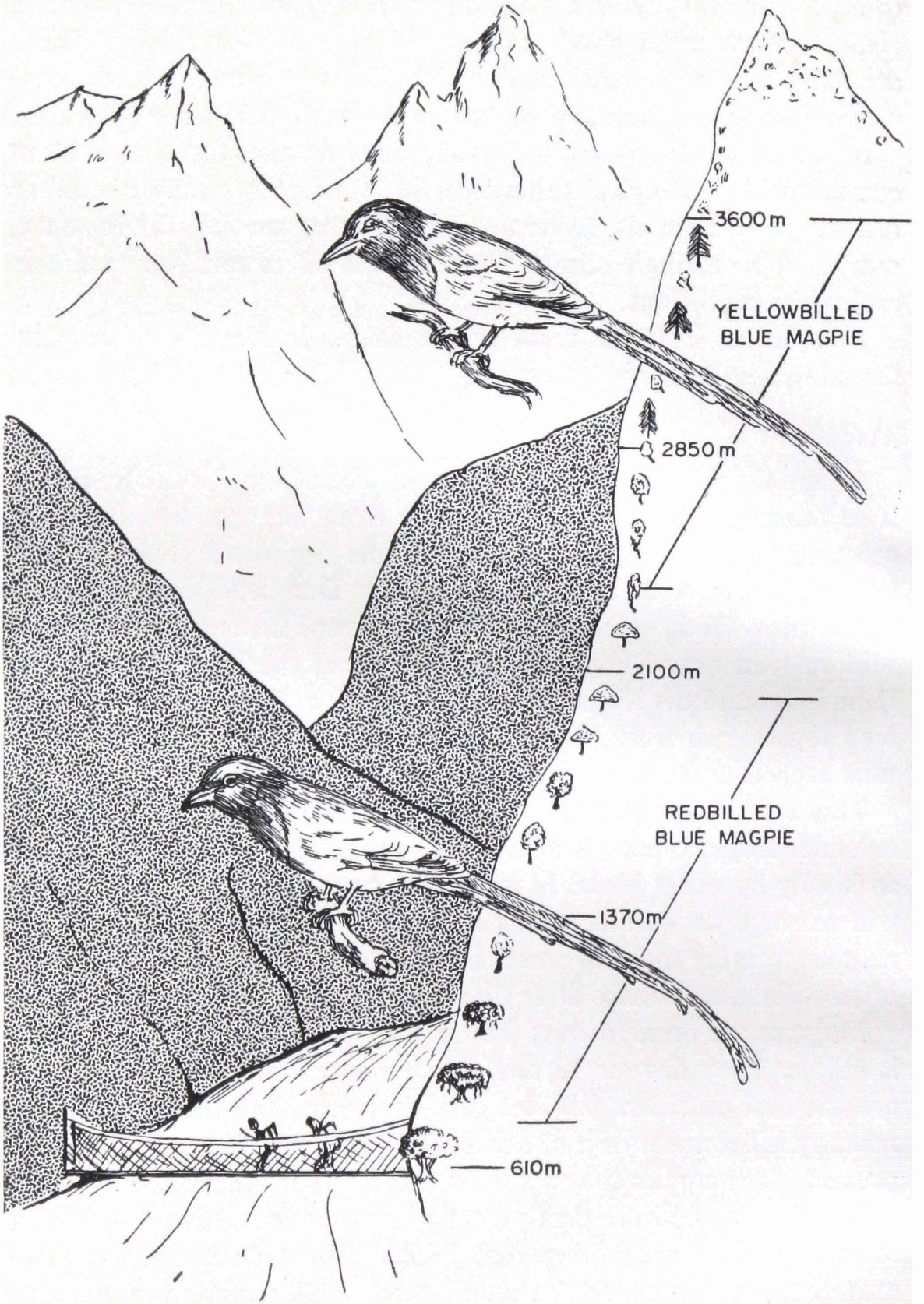


Fig. 3. Closely related birds are separated from one another in some ecological way. Nepal Magpies, the Yellowbilled and the Redbilled, look very much alike but live at different altitudes.

magpie — crows, mynas, and sparrows are all different. Thus the magpie lies in its own place in nature and would seem to be in little direct competition with other birds. Or is it?

If you look further, you will find that in Nepal there are two very similar species of magpies; both are about the same size and both have nearly identical habits. Then they must occupy the same niche? Or do they differ in some way? This question can be answered by taking field trips into the surrounding hills. First of all, what do we find below Dandeldhura or around Godaveri? The Redbilled species. Is the other species there too? No. The two varieties virtually are never found together. So, one must explore more forest to try to discover where the second — the Yellowbilled Magpie — lives. To find this second magpie, one must climb high into the cool oak forests of Pulchowki or other Midland Nepal hills, and here he will come upon his quarry. Thus, the two species are separated by space — altitude in this case — so they do not come into direct contact with each other. In Nepal, the Redbilled is a moderate altitude (1,500 m. to 2,200 m.) species while the Yellowbilled lives slightly higher (2,500 m. to 4,000 m.). There are no records in Nepal of the two species occurring together, although it would take only about ten minutes for a Yellowbilled bird to fly down to the level of the Redbilled. There are many examples of this altitude separation between similar species in Nepal. Perhaps you can discover others.

Flycatchers

Animals and plants are grouped in "families" of related species. You might ask the question, then, "Do all animals that are closely related, say in one family, live within the same narrow ecological limitations?"

To answer this question, let us look at a common family of birds in Midland Nepal. Flycatchers are agile little birds with wide mouths and prominent hairs or bristles around their bills. They live entirely on insects, most of which are caught on the wing. In the Kathmandu Valley alone, 21 flycatcher species have been discovered. Do they all act alike and do they live in the same areas? The fact that they all eat insects is a limiting factor that holds throughout the family. Therefore, these birds have to operate where insects are available. They cannot live, as choughs do, at 6,000 m. on Everest. But not only must insects be available, the conditions must be such that the

birds can catch the insects. For this reason, we find that almost all flycatchers are confined to forest areas where not only are flying insects abundant but also places from where the birds can view and launch their attacks.

Now, one must examine carefully each species of flycatcher in Midland Nepal, or at least in the Kathmandu Valley, to see if they differ in some way. After long study it will become apparent that, in reality, each species differs in some way from all the others. No two flycatcher species are found eating the same types of insects within the same altitude, forest, or level within the forest. Tables 1, 2, and 3 show these distinctions.

From Table 1, one can see that flycatchers are found at different altitudes; other species found at low levels are not included in this table. A major ecological difference in flycatchers, then, is that they live at different altitudes and would, of course, eat different species of insects. But even within the same altitude there are a variety of forest conditions. Table 2 gives the forest selections of birds living within 1,800 m. to 2,400 m. altitude. But even more specifically, there are different parts within the same forest type and birds choose different levels in which to live (See Table 3).

Starting with 21 species, we are now down to only two species that occupy similar niches — open areas near the ground in dense oak forests at 1,800 m. to 2,400 m. in summer. But then when you see these two species, it is quite obvious that they must, in part, eat different species of insects. This difference is noted because one flycatcher is only half the size of the other. So, no two flycatchers in Midland Nepal are ecologically identical.

Forktails

Habitat restrictions are noticed very easily in some birds. Some species are adapted to life along streams and are so confined to this habitat that they rarely stray elsewhere.

On most of the small streams of Midland Nepal, the stream above Sundarijal or the waterway near Dhankuta Bazaar are good examples, one may see (if he is quiet) a bird of spectacular form and pattern. This Spotted Forktail, a bird about the size of a myna, gives the appearance of being so delicate that a slight wind might blow it off the spray-soaked rock on which it stands. This creature is totally black and white, even down to *white* legs and feet, with a

TABLE 1

Altitude Distribution of Flycatchers in the Kathmandu Valley

Altitude	Summer Level	Winter Level
3,000–3,600 m.	Orange Gorgetted Yellowbellied Fantail	
2,400–3,000 m.	Sooty Rufoustailed Slaty Blue Ferruginous Rufousbellied Niltava Verditer Pigmy Blue	
1,800–2,400 m.	White Gorgetted Redbreasted Blue Little Pied Whitebrowed Large Niltava Whitethroated Fantail	Orange Gorgetted
1,200–1,800 m.	Brown Rustybreasted Blue Small Niltava Bluethroated Paradise Greyheaded	Pigmy Blue Rufousbellied Niltava White Gorgetted Whitethroated Fantail Yellowbellied Fantail Redbreasted

TABLE 2

Forest Type Selected by Flycatchers Living in the Kathmandu Valley Between 1,800 and 2,400 m.

Forest Type	Species
Unknown	White Gorgetted
Dense Oak Forest	Redbreasted Blue Large Niltava Whitethroated Fantail
Open Oak Forest	Little Pied Whitebrowed

TABLE 3

Feeding Zones of Flycatchers that Live in Dense Oak Forests in the Kathmandu Valley Between 1,800 and 2,400 m. Elevation

Feeding Zones	Species
Open Areas Near Ground	Redbreasted Blue Large Niltava
Within Bushes	Whitethroated Fantail

long, forked tail that bobs up and down while the bird searches the stream bed for insects.

Although visually attractive, the bird has virtually no song. Instead, it emits a high-pitched screech. Of what advantage is a screech? Interestingly, the Himalayan Whistling Thrush, which also lives along these streams, has an almost identical note. That these two birds have such similar calls reflects their similar environment. A soft, warbling song would be delightful to hear — but who could hear it above the noise of the mountain torrent? A shrill shriek, on the other hand, penetrates far up and down the stream and so is a useful contact note. The Spotted Forktail, then, is narrowly adapted to stream life; even its call is suited to its habitat. There are also dangers of becoming too specialized in habitat selection; for while it may be of advantage at first, if conditions upon which the species depends change, then the species may face extinction. This has happened often in the past, and will continue to do so.

Insects

Insects are another animal group that shows tremendous anatomical and ecological variations. Insects are well represented in Nepal; in fact they are so common we tend to overlook them. There are, it is said, some 1.5 million described insect species, with perhaps 10 million yet to be discovered (See Mani, 1968:4). The behavior and ecology of many insects is a most fascinating subject.

To begin with, though, we should know what an insect is. How does it differ from, say, a segmented worm? An insect is a mobile creature which has, in the adult form, six legs and three body

segments. Sensory antennae protrude from the head, while eyes, both simple and compound, located on the head, help receive visual images and detect lighting conditions. Young, or larval insects, the beetle grub for instance, may look like worms, except that worms do not have legs.

Insects breathe through a system of tubes into which gases diffuse. An insect can be suffocated if the openings, the spiracles, of these tubes are blocked. Internally, insect blood is kept circulating by weak contractions of enlarged portions of the circulatory vessels. Insect blood is hard to recognize at first, for it is pale yellowish-green and looks little like the red liquid we are used to, but nonetheless it serves the same function.

Insect muscles are tough. If man were able to lift as much as many insects do, then a 70 kg. person could easily move a car weighing some 1,400 kgs. and place it in the front room of some friend's house (provided he could get the car through the door). Some insects can lift even more (relatively speaking) than this (See Mani, 1968:38). How fast does an insect's wing beat is a fascinating question. The frequency of insect wing beats varies from about three per second of the Golden Birdwing butterfly of Godaveri and Nepal subtropical forests, to about 1,000 beats per second of the tiny midges that sometimes fly around your face. Ordinary House Flies move their wings at about 300 beats per second.

Insects are sensitive to a number of external stimuli. Eyes receive visual stimuli, and it is certain that some insects see color. Moreover, insects have a number of body hairs which assist in perceiving vibrations and touch sensations. On the antennae and also on the head are special sense endings for chemical analysis of the surrounding air (the sense of smell); and it is said that some insects are able to scent, depending on the wind, some objects a mile or more away. Other insects, such as butterflies, have smell and taste endings on their legs (See Wynter-Blyth, 1957:6).

Hearing is not well developed in most insects. Some, though, are very noisy, and it would logically follow that these species could receive and interpret sound. Cicadas, crickets, and grasshoppers certainly hear well. In these groups, the male attracts the female through these nuptial songs, or mating calls.

Insects, with their multitudinous variety, fill a great many positions within an ecosystem. They have adapted to an amazing number

of ecological niches and habitat types. Nepal insects, for example, live beneath the soil, on the surface of the ground, and many fly. Others are aquatic. Some are parasites; others predators. While many eat vegetable matter, some exist on decaying materials. Blood-sucking insects are well-known.

One major restrictive feature in insects is size. The exoskeleton of these animals is apparently limited by physical forces. You do not see gigantic beetles, for example. All large animals are ones with endoskeletons. This may be just as well, for it might be difficult to contend with a 50 kg. mosquito!

Insects provide food for a great many large animals — birds in particular. Few are eaten by man, although we do relish some insect products (honey). Economically, insects are important both as crop and garden pests and also as pollinators of important flowers. They also transmit several human diseases (malaria, plague, dengue fever, to name a few), and thus some species are very carefully watched.

Ants

Ants, "kamilo," are a good example of anatomical and ecological diversity within an insect family. Ants appear to be everywhere; often we pay little attention to them. In fact, outside of the protozoa, there are probably more ants, individually speaking, than any other animal on the earth (See Borror and Delong, 1964:575–576). Ants, when we do watch them, are fascinating creatures.

Ants are one of the most visibly industrious animal groups. You rarely see an ant just standing around, for they are always on the move from one place to the next. The speed at which ants first find food and then attempt to remove it is remarkable.

Ants are common in Nepal. Those of the Kathmandu Valley floor are terrestrial, with houses constructed in the soil. Others, at the edge of the Valley, build a conspicuous ball-shaped nest in small trees. One, a smallish dark-brown ant, lives in trees on Pulchowki and inflicts a nasty little bite. The infamous Red Ants, which so commonly build "paper" nests in trees in the Tarai, are not found in Kathmandu.

Ants can be the subject of several experiments in animal behavior and perception. One can ask: How do ants communicate? Or, how can they tell direction? How do they find their way back to a food source?

Ants communicate through tactile and chemical stimuli. One only has to see an ant stroke another with its antennae to realize that there must be sensitive chemical receptors in the antennae. The ant itself is marked with specific scents that other ants recognize; likewise, trails are dotted with easily-followed scent markers. It is hard for humans to detect the scent of any individual ant, but if you climbed an ant-infested oak tree on Pulchowki, you would be able to immediately pick out the scent of these insects.

Ant odor is also noticeable on the Rufous Woodpecker. This curious bird is strongly labelled with ant scent. Why? Strangely enough, this woodpecker lives right with the ant. In fact, its nest is built right into the ant colony. But how can this be, or why should it be? What is the advantage to the woodpecker? Or the ants? We do not know the answers to these questions. The birds are not stung, and the whole relationship of the woodpeckers to the ants is not well understood. Here is a fascinating research project for some zoologist in Nepal.

Other ants, too, have most unusual habits. One species in Nepal cuts leaves and carries them back to the colony. Once deep in the colony (which is underground), the leaves rot and on this base fungus grows. Ants eat the fungus and so could be called "Fungus Farmers." In other parts of the world, ants tend and then "milk" little aphids for tiny nectar droplets they produce. In Africa, certain ants are nomads; they never live long in one place. These ants, called "Army Ants," march in great numbers and devour any living thing in their path. They will also eat humans, except that humans can usually get out of their way. We do not have these army ants in Nepal.

Flies

Flies are another familiar insect order that has developed into a good many kinds of creatures occupying many ecological niches. We have a great many sizes, shapes, and colors of flies in Nepal. This insect group is of special interest to man because of its association with germ distribution; several are blood-sucking parasites of man and other mammals.

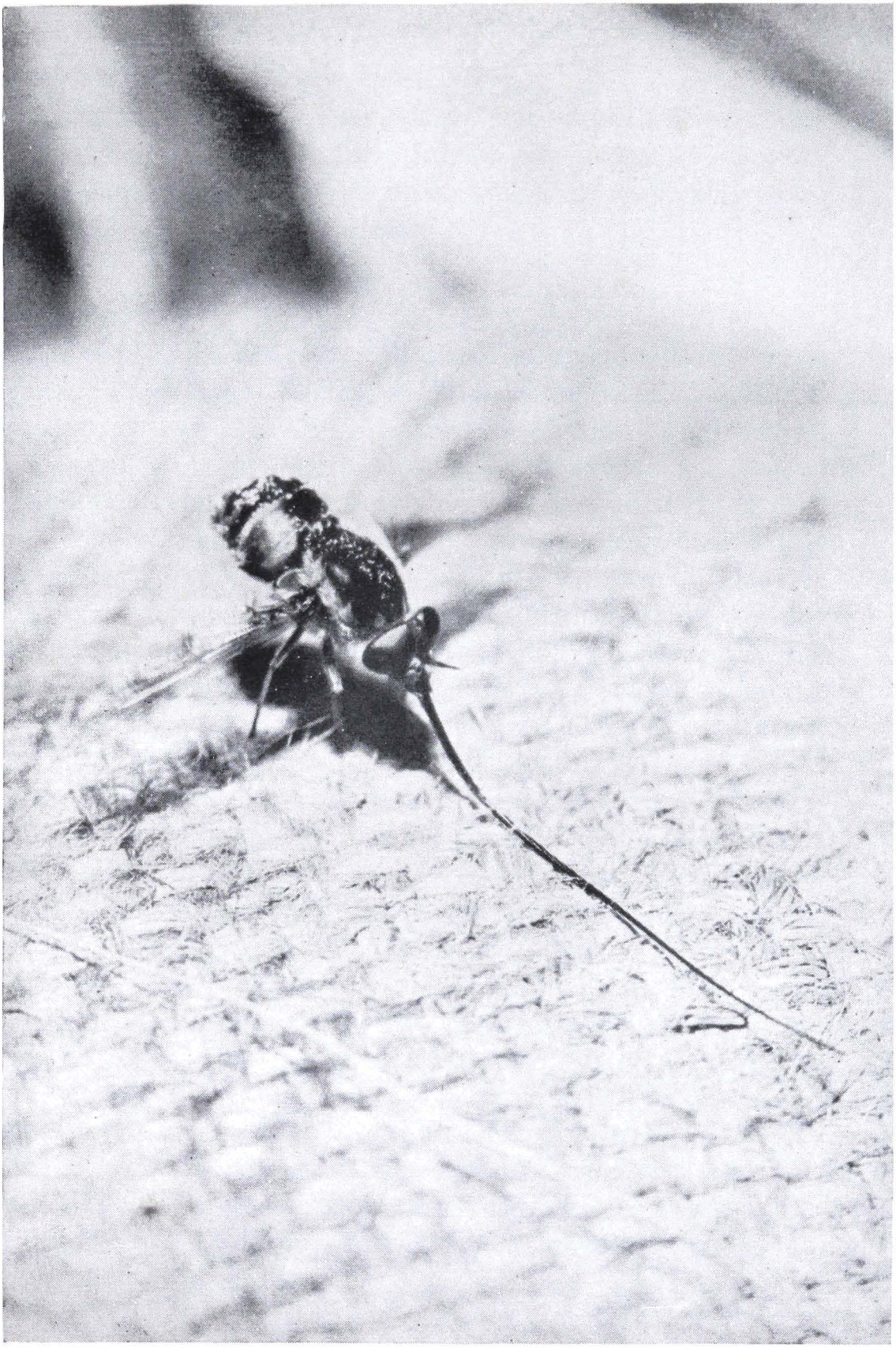
A House Fly illustrates the classic features of a fly: two strong wings, two wings reduced to halteres, well developed legs, eyes, and other sensory organs. The common House Fly is well-known

throughout the world. Unless one looks closely, though, he does not realize how interesting the fly actually is. The House Fly is quite a hairy beast. The hair is an important feature of the fly, for as the fly walks around (often on human dung), it picks up many bacteria and protozoans. Then, if the fly lands on some nutritious medium, the deposited bacteria and protozoa may multiply rapidly. Rice and vegetables are good bacterial culture media but old meat and milk are especially fine. If you then eat this stale and contaminated food, you may be in for serious intestinal trouble.

Flies develop rapidly and have a very short life cycle. Larvae hatch within 24 hours after the eggs are laid; from the larvae to sexually mature fly takes about 17 days. Consequently, under perfect conditions, a single fertilized female fly may lay 150 eggs, and then in 18 days 11,250 eggs are laid (assuming 75 females from the first laying). Astoundingly, in just over a month 843,750 eggs are being deposited, and in only seven weeks we would have a laying of over 63,000,000,000 eggs (See Majupuria, no date: 240–242). And remember, all this from just one fly! Fortunately, environmental conditions limit fly production, but this example does point out how rapidly some insects could reproduce and why so many individuals can occur even under far from optimum conditions.

Another fly found in Midland Nepal is the Sand Fly — a minute species with outsized wings. These wings are about four times the size of the body so that the animal seems to be all wings. This blood-sucking fly emerges during the warm weather, especially in the pre-monsoon period, and forages at night. Although nocturnal, it is attracted to lights burning in a room and can penetrate screens designed to keep out bigger insects. The bite of the Sand Fly is somewhat itchy to humans but not very painful. Sand Flies do transmit dengue fever, a malady common in South India, but so far not known in Midland Nepal.

Another spectacular fly of Kathmandu resembles a bee. Its bee-like body is orangy-brown and bee-shaped, but it has an extremely long proboscis that stretches fully three inches. This is the Pangonia Fly that lives on grassy hillsides and forest glades of Midland Nepal. Pangonias are related to the familiar Horse Fly. When attacking humans, the protruding proboscis is folded out of the way either by the feet, or by bending on the intended victim, and a short, spear-like proboscis penetrates the skin for a blood meal.



8. The Pangonia fly of Central Nepal has an amazingly long superficial proboscis. The piercing proboscis of this blood-sucking fly is quite short and lies underneath the long proboscis. This individual is searching fruitlessly for a meal from a bamboo mat. Altitude 2,300 meters.

Ecological Separation Through Time

Another way by which species of animals remain ecologically distinct is related to a time factor. Birds of prey are good examples of this phenomenon, for they are divided into the distinct daytime hawks, and the night-operating owls.

Owls

Nepal is richly supplied with owls; in Kathmandu Valley alone we have: the huge Forest Eagle Owl, Himalayan Wood Owl, Great Horned Owl, Brown Fish Owl; the medium-size Hawk Owl, Barn Owl; the small Collared Scops Owl, Spotted Scops Owl, Barred Owlet, Spotted Owlet, and the Pigmy Owlet.

One of the first night sounds a person in Nepal hears is a terrible screeching, crying, laughing, and yowling — all mixed into one sound. This noise comes from a remarkably small bird: the Spotted Owlet. This owl stays concealed in some hole in a tree or in a chimney during the day and ventures forth at dusk to search for insects and perhaps small frogs and other prey. Often Spotted Owls perch near lamp posts and burning lights.

Owls hunt by using their extremely keen night vision which is assisted by acute hearing. The eyes of owls are fixed in their sockets — they cannot be turned as we do our eyes. If an owl wishes to look behind him, he will turn his head completely around. The lack of eye mobility, then, is compensated for by an extremely flexible neck. (How convenient it would be for a teacher to have an "owl" neck, for then while writing on the blackboard, he could quickly swing his head around in order to keep an occasional eye on his students!) What advantage it is for an owl to be able to move only his head and not his eyes is not entirely clear. Visual acuity must be increased in the fixed eye position, one would suppose. Owls also have soft and fluffy feathers which enable them to swoop down noiselessly on unsuspecting prey. Owls are wonderfully adapted to their night-hunting ecological position.

Bats

Other creatures have adapted, also, to night flying and night feeding. Although bats fly and move about at night, they differ from owls in most respects.

Bats are the world's only flying mammals. In Nepal we have probably more than 30 species. They are found from the lowlands up to great heights (where the temperatures drop below freezing every night). There are many different kinds in Midland Nepal. If, as evening approaches, one happens to be strolling in downtown Kathmandu near the Annapurna Hotel, or near the main temple in Tansen, he may be startled by the sight of large, dark forms flying slowly past overhead. Are these nocturnal birds? No, they are Giant Fruit Bats.

During the day these Giant Fruit Bats sleep, fight, and move about in some large tree (often a mango). One can hear their chatter at considerable distances, and, if the wind is right, one can very definitely smell them! At dusk these bats suddenly fall silent and quietly leave their roosts to go in search of fruit or large flowers. A group can cause great damage to orchards of mangoes, peaches, papayas, and other fruit.

Actually, not much is known about the Giant Fruit Bat in Nepal. We do not know exactly what they eat, or in what proportions. How far do they fly at night? Do Kathmandu bats reach Gorkha; or do they fly, perhaps, to Chitwan? One day some biologist may wish to investigate these questions.

Many bats in Nepal eat insects rather than fruit. Insectivorous bats have a different tooth arrangement from the fruit-eating ones, and naturally are fairly small. It would be hard to sustain a large-bodied animal solely on flying insects. These bats are easy to find in Kathmandu for they come out each evening and circle around the lights on the Tundikhel. If you wish to see them during the daytime, you will have to find them at home — which could be in a hole in someone's house, or in a cave. The caves at Chobar are excellent for bats, and the floors of some are heaped with bat guano three and four feet deep. Bats probably have lived there for hundreds of years.

The noses and faces (with their folds and projections) of these insect-eating bats are most picturesque (also often called ugly). They are organs modified to receive sound signals and form a type of mobile "sound radar" station. Bats emit high squeaks which, when bounced off objects ahead, are detected by their sensitive receiving organs. In this way they can locate, in complete darkness, a flying insect and scoop it up.

9. During daylight hours, Giant Fruit Bats hang from trees in noisy colonies of three hundred or more individuals. At dusk, they fly noiselessly away to find fruit and flowers on which to feed. This is part of the colony that lives in downtown Kathmandu from early April to late December. How far they venture in quest of food is not known, but it is suspected that during a night they may journey as far as the Tarai.

Deep in their caves during the day and after they emerge into the night, bats are fairly safe from danger. However, they do get hungry and sometimes emerge early. You may have seen the first bats of the evening flying around 15 or more minutes before dark. It is during this dusky period that the bats are in great danger, for in Nepal there is a fast-flying bird — the Hobby Falcon — which catches and eats bats. The Hobby (we have two species here) feeds on such diverse things as butterflies, birds — and bats. The whole Shivapuri ridge, from Kakni to Mahadeothan, is favored by hobbies and occasionally, if you are in the right place at the right time, you may see a hobby flying off with a bat clutched in its talons.

Bats participate in the balance of nature in several different ways. Fruit bats destroy mango flowers in their search for nectar, but they assist in the pollination of others. Possibly, they help spread plant species by eating fruit and depositing seeds some distance away. Insect-eating bats help control invertebrate populations.

We have not mentioned the infamous vampire bats, for these blood-sucking species do not occur in Nepal. True vampires are confined to the tropical Americas. Although there are no vampires here, bats may sometimes bite humans and in this way transmit rabies. Cases of this type, fortunately, are extremely rare here.

Food Chains

As the field biologist walks through our Nepal subtropical forest, he knows that checks and balances in nature have developed into a complicated system of food chains and food pyramids. There are, in the animal world, plant-eating *primary consumers*, then *secondary consumers* that eat the plant-eaters, and even *tertiary consumers* that prey upon individuals of the second level. Thus there is a relationship in nature that might be called a "chain;" *i. e.*, "A" eats plants, "B" eats "A," and "C" eats "B."

Do animals in Nepal forests relate to one another in a chain? Yes, they do. Small insects eat plants, and birds eat the insects. The final link in a food chain is the *predator* — an animal that eats other animals. A leopard is a predator, for it eats animals from farther down the chain. Actually there are innumerable food chains in Nepal. *Ber* berries often are consumed by bulbuls, which in turn fall prey to falcons. A more complex food chain (but one that is quite implausible) might be from phytoplankton to small crustacean to small

A FOOD CHAIN IN NEPAL

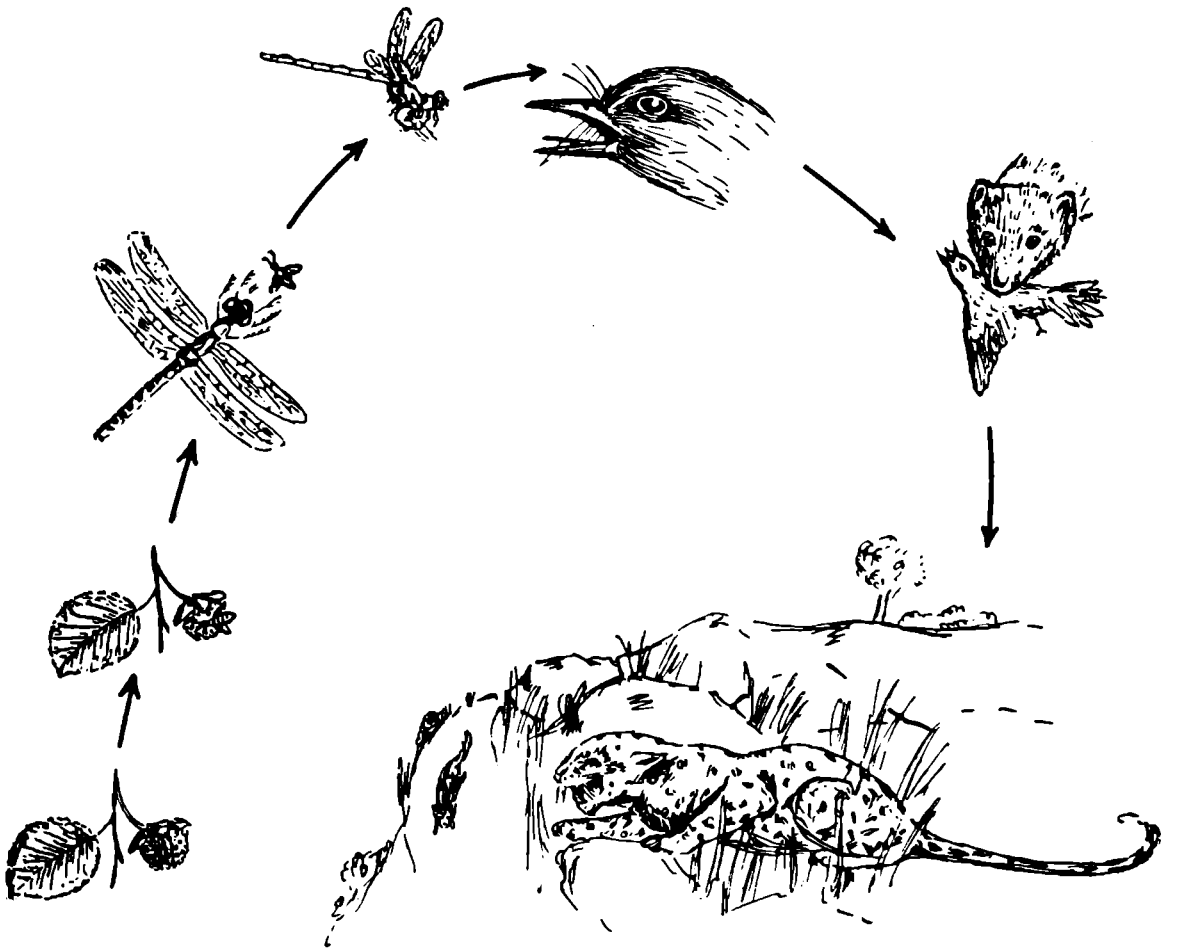


Fig. 4. Reading clockwise from the left, you see an insect eating vegetable material. The insect is then found by a dragonfly. The dragonfly may then be caught by a bird, which itself may fall prey to a Yellowthroated Marten. The Marten may possibly be pounced upon and eaten by a leopard. Eventually the leopard will die and, in decaying, will release minerals for further use in the ecosystem.

fish to large fish to egret to fox to leopard and then finally to a tiger. Divisions are not hard and fast though, and a species may fall into more than one level in a chain. Thus, a Himalayan Black Bear is both a top-level consumer while it eats a recently killed sheep, or a primary consumer while it feasts upon raspberries.

As has been mentioned, an important ecological theory states that, ideally, elements in nature are maintained in a state of balance. Populations are constantly fluctuating — rising and falling — so that although an overall balance is attained, things are never static. When one species becomes numerous, a second animal (a predator) usually will increase so that the first is kept in check. The predator is automatically reduced when its food supply dwindles.

Leopards

In Nepal, we have many predators. Probably the most spectacular in Midland Nepal is the Common Leopard (Tigers are generally confined to the Lowlands). Although a detailed study of the leopard in Nepal has not been made, they likely play an important role in limiting populations of large plant-eating animals such as the Barking Deer.

Leopards are fascinating animals partly because they are sometimes dangerous to man. They are amazing animals for they appear both bold and intelligent. A leopard has very keen hearing and good eyesight, but its power of smell is definitely inferior. Nonetheless, it learns to stalk prey from downwind so that animals are not frightened by leopard scent.

We still do not know very much about the family life or the behavior of leopards in the wild. Generally speaking, leopards do not attract attention to themselves, but walk and hunt quietly and try to make the least possible commotion. However, leopards do make noises and you may have heard these while visiting Godaveri or other Midland forests. The leopard's loud " sawing " call resembles the sound of a saw being drawn back and forth and probably is an advertising call during the mating season. This " song " is mostly heard, in Nepal, during the spring months. Another leopard noise resembles a human cough. This cough is given when the leopard is annoyed — if someone is near his food, for example.

Leopards constantly are on the move. This is only reasonable, for if a big cat stayed long in one patch of forest, all animals there would come to know this and would either move away or increase their vigilance. The leopard would then find it hard to catch any food at all. We do not know how many miles a leopard usually covers, but it appears they may follow a regular pattern; some are thought to cover their territories in about a month to six weeks. The famous Rudraprayag Maneater of Garhwal (to the west of Nepal) was reported by Corbett to cover 500 square miles in its search for food. The size of a leopard's territory would depend greatly on terrain and food availability. When assured of a good food supply (as near Tiger Tops Hotel in the Chitwan National Park), a leopard may move very little indeed. It would be fascinating to be able to follow a leopard around (now possible through radiotelemetry) to see how far it goes and what it does.

Leopards normally feed on deer, monkeys, pheasants, and other small prey; even frogs may be eaten. In scarce times (and even not so scarce seasons) they look longingly at domestic animals. Dogs are such a well-liked favorite that they may be stalked and eaten at any time. An interesting example of food preference was recently recorded. A badly mauled Barking Deer, obviously killed by a leopard, was found in an oak forest at 2,100 m. It appeared to have been dead for about three days. But why had the leopard not eaten the deer? It seemed strange. The answer, though, lay just 15 yards away. There under another bush were the scattered remains of a Langur Monkey. The monkey had been killed more recently than the deer and had been almost consumed while the deer lay, apparently, in reserve. Perhaps the monkey was considered better eating than the deer, at least by this particular leopard.

Sometimes, leopards turn to eating man. In 1964 and 1965, a man-eating leopard carried off and ate several people from Godaveri and Surya Binayak. Quite soon, though, this killer was tracked down and dispatched by Royal Shikaris. Aspects of man-eating often are related directly to the broad question of ecological balance. When the habitat is destroyed by man, the natural prey is reduced, and it is logical for the leopard to live off domestic livestock. Now the cat exposes itself to considerable contact with humans — and angry humans at that. Often the village hunter is improperly armed, or a poor shot; so when he shoots, he only wounds the animal. Gunshot wounds, accidents in the forest, and old-age are the usual reasons for cats' becoming man-eaters. Fortunately, most wounded or old animals do not grow into man-eaters, but once they do acquire the taste for human flesh, the leopard is much to be feared.

One question frequently asked is: What is the difference between spotted leopards and black panthers? In Nepal, black panthers are seen far less frequently than the spotted leopards; the black variety becomes more common towards Malaysia. Except for the pigment, there is essentially little difference between these two animals. In a litter of four cubs, one might be black and the other three spotted. Thus the black individual is a brother (or sister) of the spotted ones. The black condition is the result of a small change in the genes, a mutation, which causes the hair follicle to produce too much coloring. You may have seen albinos, a reverse condition in which there is a lack of pigment.

One might think that, because panthers or leopards hunt strictly at night, a black individual would have an advantage over its spotted brother. Is this true? If the black condition were very helpful to the cat, then one would expect the black ones to become more numerous than the spotted. But this is not the case in Nepal. Why? When stalking prey, color is only one factor. Size, agility, and ability also are important. Moreover, in forest regions, one rarely sees solid color patterns. A color scheme that breaks up the outline of an animal tends to camouflage it in the forest. When you look in the direction of such an animal, you have a difficult time making out its shape. Conversely, an animal of a solid color tends to stand out in a jungle area. Similarly, animals of the open plains are generally drab and uniform in color. This helps in camouflaging the creature for, if a wildly-colored animal with reds, purples, and whites were to walk along a grass slope above Jumla, for example, you can imagine how far away it could be seen.

Yellowthroated Martens

Predators are not all large, like the leopard. In fact, most of the animals that have developed into predators are small. Another mammal which is fairly common throughout Midland Nepal is a very efficient predator. This is the Yeliowthroated Marten. Martens belong to the weasel family, all of whom are carnivorous with voracious appetites.

Yellowthroated Martens are long-tailed and long-snouted animals which lope along the ground with their black tails slightly arched; they usually travel in pairs. Although often on the ground, they frequently climb high into tall trees where they may rest on a comfortable branch.

Because of the marten's small size, its diet differs greatly from that of a leopard. Birds are especially favoured, with the Kalij Pheasant a prime victim. The sense of smell appears well developed in martens; and in keeping with the behavior of birds, martens usually are abroad during the daylight hours. They also move at night, however, and often raid chicken pens at this time. Besides eating adult birds, martens will devour eggs and nestlings found in the forest.

Most predators will not kill more than their hunger requires. The martens are an exception for, when they get into a chicken pen, they

may kill every bird in the pen during their excited attacks. It is important in the balance of nature that " overkill " is infrequent. A leopard, for example, rarely kills more than it needs for the immediate future.

To see Yellowthroated Martens, you should visit places where there are a lot of birds. In and around the edges of Midland forests is where the martens are fairly plentiful. After reaching the appropriate habitat, one should then walk quietly along the path. Now, if you are lucky, you may hear a slight rustle in the leaves and the characteristic " grug, grug, grug " that is uttered softly by martens.

Several other kinds of martens and weasels live in Nepal. The beautiful golden Himalayan Weasel is found in the Midlands, but it is quite scarce. Martens assist in the ecological balance in nature by helping to maintain prey populations.

Spiders

Not all predators are mammals; in fact, most are not. We have in Nepal forests many predatory birds, snakes, and many invertebrates including spiders, dragonflies, and some worms.

Spiders are a fascinating group of animals; virtually all of them are predatory and eat insects. Spiders are common in Nepal and we see them in our gardens or forests.

Spiders, although closely related to insects, are not insects at all even though they are often thus called. Spiders have eight or ten legs; insects have only six. Spiders spin fine webs through spinnerets; insects do not have these. Most spiders have poison used to paralyze their prey. Once killed, the body fluids of the insect are sucked out (Often you see the insect " shell " in the webs). The action of spider poison on humans varies greatly. Man generally is not susceptible to much discomfort from spider bites. However, there are a few dangerous spiders in the world. The Black Widow Spider which lives in the Americas has such a virulent bite that children bitten by this spider may die. So far we have not heard of any such spider in Nepal. If any do exist here, they should be identified and publicized.

Large spiders, although fearsome to look at, are relatively harmless. Even the Hairy Tarantulas of the Amazon basin, with a leg span of five inches (11 cm.), are so mild-mannered that they can be kept as pets by those so inclined.

The family life of spiders is rather abrupt and harsh. The female is much larger (maybe 10 times or more) than the male, and it is she who builds the web and catches the food. The main function of the male, it appears, is to fertilize the eggs. After mating, he usually dies — either of exhaustion, or the female may eat him. Young spiders develop in an egg case which is carried on the abdomen of the female; often the egg case is a conspicuous white. When this case bursts, hundreds of tiny spiders come crawling out in every direction. Sometimes the young spiders spin a long thread, which when caught in a slight breeze, carries the spiders high above the earth. Some spiders have been collected at altitudes above 6,100 m.

Spiders are predators that capture prey in a way completely different from those considered so far. Leopards and martens stalk their prey; some spiders of Nepal do this too. Most spiders, though, build elaborate webs.

These webs are a marvel of natural architecture. They are strung between bushes, in trees and on the ground — anywhere that an insect might fly. Webs then ensnare unsuspecting insects which are promptly killed and eaten. Each species of spider builds its own type of web. Similar species usually construct similar webs. Within one species, there is not a great variety of architectural web types.

Spider silk is one of the most amazing substances created by the animal world, for although it is pliable, it is still many times stronger (comparing relative weights and sizes) than steel. Silk is produced in glands located on the abdomen from which it is exuded through spinnerets. As there are usually between four and eight spinnerets on one spider, the separate strands adhere together to form an ultra-strong thread. Silk is manufactured primarily from proteins obtained in the spider's food.

There are many varieties of spiders in Nepal. The large brown House Spider is familiar to people in Kathmandu and the middle hills. This spider rarely builds a web but is beneficial around the house, for it stalks and eats insects such as silver-fish (Silver-fish eat any sort of paper, like books or valuable pictures hanging on the wall). A fearsome-looking hairy, ten-legged spider lives around Godaveri. It is black and white and also does not build an elaborate web, preferring, instead, to stalk prey. It is relatively harmless to humans.

Spiders, then, form an important part of the Nepal subtropical forest where they assist in maintaining appropriate levels in insect populations. What, though, keeps the spiders in check? If one walks through the forest in the late monsoon, he would tend to say that spiders are not being kept in check, for there appear to be so many. The great populations of spiders at this time of year reflect the availability of food. But when the food is lessened, predator populations (such as spiders) also decline.

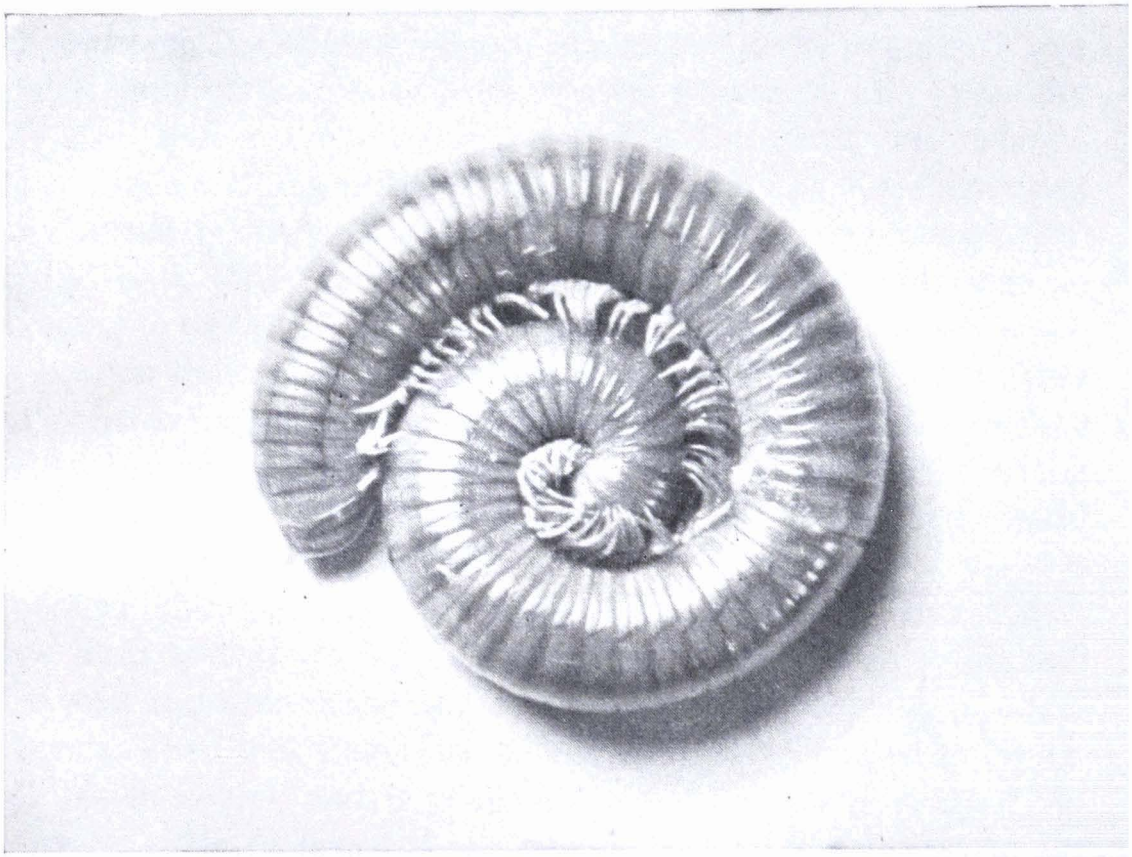
Centipedes

In Nepal, people are sometimes bitten by an unknown creature that leaves a narrow row of double puncture marks down an arm or leg. Bites of this type are from centipedes. Centipedes are nocturnal and normally shun light. At night they sometimes crawl onto a sleeping person, and unconsciously the person brushes at the intruder, thus exciting it into attacking. The venom of centipedes, unlike scorpions, is not dangerous to man, but can be painful and uncomfortable.

Centipedes are familiar invertebrate animals of Midland Nepal and are closely related to the Arthropods. They are long and slightly flattened with a pair of legs attached to each body segment. These animals live underneath stones or in soil where they move about looking for things to eat. As far as is known, they are entirely carnivorous and feed on beetle grubs, earthworms, and other invertebrates. Their special interest to man comes in the fact that their forward legs are modified into stinging organs with which they subdue their prey. When angered, centipedes may use their attacking legs defensively.

Centipedes range from a few centimeters to about 30 cm. in length. There is a large specimen, 20 cm. long, in the Anand Kuti Science College collection. Strangely, this individual was caught in the Physics Laboratory, not the Biology Laboratory.

Another animal, very like centipedes but with seemingly countless legs (actually only two pairs per body segment), is the millipede. These creatures are also nocturnal and are found commonly at night on Swayambhu Hill. They are harmless and can be easily handled. The wave-action of multitudinous legs working in sequence is a marvel of the animal world.



10. The Grey Millipede of Nepal curled in its defense posture. This creature does not sting nor bite so protects itself by showing enemies its hard shelled back. The Millipede is additionally protected by a foul-tasting fluid exuded when alarmed.

Eagles

Another form of predator is one that moves through the air. So far, we have considered those that live under rocks, on the ground, and others that climb trees. Eagles work in the air.

Hodgson's Hawk-Eagle, found throughout Nepal subtropical forests, is a powerful bird with long, strong legs and a long, pointed crest. This bird is almost always solitary and may be seen sitting motionlessly in a forest tree at the edge of an opening where food might emerge. The hunting style of this eagle is to lie in ambush and catch its prey with a sudden, swift dive. Pheasants and hares are main diet items. Occasionally, if one is fortunate, one may be startled while walking in the forest, by a screaming Kalij Pheasant diving vertically downhill with a Hodgson's Hawk-Eagle in pursuit. Usually, both birds vanish quickly behind a forest-clad ridge so the outcome of the chase is not known. But if the Kalij has much of a lead on the eagle, probably it will escape. At other times, Hodgson's Hawk-Eagles utter, every 20 seconds or so, a small rat-like squeak. The significance of this call is not clear. Is the bird trying to decoy out some other rat-eating animals which the eagle would then attack? We do not know.

Another common eagle of Midland Nepal is the Black Eagle. These birds sometimes are seen flying over towns such as Baitadi in the west and Ilam in the east, but usually they stay near the edges of forests. The Black Eagle is a mobile hunter (in contrast to Hodgson's Hawk-Eagle), and it glides effortlessly over the contours of the grassy ridge or forest slope, usually staying fairly close to the ground. The Black Eagle is a nest robber and will also eat many things such as snakes, lizards, and small mammals. Thus, the Black Eagle's diet differs greatly from that of Hodgson's Hawk-Eagle. No detailed investigation of eagle dietary habits has yet been undertaken in Nepal; when it is, some fascinating facets will emerge.

Food Pyramids

The weight of an animal is spoken of as its *biomass*. Plants also have measurable biomass. To support a primary consumer, it takes much more plant biomass than the weight of the animal involved. Thus, many plants are required to sustain one deer, and many deer for one tiger. The plant biomass is high, but decreases through each consumer level until at the top (the tiger), the biomass sustained is

relatively small. Put into geometrical form, this relationship appears as a pyramid with a wide base and a narrow apex. We have examined some of the pyramid's top-level occupants; now let us turn to the middle region.

Barking Deer

On an evening visit to Godaveri, the Barking Deer is one of the few creatures (outside of owls) you may hear in the stillness of the forest. This sharp bark — a single note repeated at intervals of a few seconds — is heard almost every night at Godaveri. What is the meaning of this bark?

Jungle animals, indeed all animals, have some means of communication. Highly developed animals can communicate the concept of danger. Almost every bird, for example, has its own distinctive "alarm" call. Similarly, mammals that are preyed upon by carnivores, also have their sounds. The bark that you hear, then, is the alarm call of the deer and signifies danger. In forests of Midland Nepal, this danger (at night) is usually leopards. But why call loudly when danger is sighted? Why not just creep quietly away? In nature, the survival of the population really is more crucial than the survival of one individual. An alarm call alerts the entire population within hearing and thus has its benefits despite the attention it draws upon the individual caller. Also, the call tells the leopard that the deer has spotted the danger and is alert to it. Leopards and tigers rely on surprise attack to catch their quarry, and once the element of surprise is removed, a leopard has a hard time capturing its food. Consequently, the alarm bark tells the leopard to look elsewhere. The calling individual is, of course, vulnerable and a human can stalk quite close to a Barking Deer when the deer is concentrating on danger in front. If leopards were able to take advantage of this and hunt in pairs, they might be the undoing of the little deer. Fortunately for the deer, leopards do not often work together (A mating pair may be together, but they rarely use combined strategy for catching food).

Thus, deer populations are limited not only by man's presence, availability of food and shelter, but also by predators. Nonetheless, the Barking Deer does quite well in Nepal, for it stays in dense thickets where it cannot be easily surprised. Barking Deer are common in Nepal as in most forested parts of the Oriental region.

11. The Barking Deer is a common mammal of Midland Nepal. It is a primary consumer, leaves and grass, and is in turn preyed upon by leopards and man.

Parasites

Animals have developed many kinds of feeding habits. We have noted species that actively stalk and catch their prey and others that lie in ambush. Let us now consider another form of animal — the parasite. Everyone in Nepal has seen parasites; they are common here.

A parasite is an animal (or plant) that lives on, or obtains food directly from, some other living thing (called the *host*). Naturally, a parasite is quite small compared to a host. Well-known parasites of Nepal are worms and blood-sucking insects like mosquitoes and lice.

The line between what is a predator and what is a parasite is sometimes hard to draw. As so often happens, categories do not accurately or completely describe the conditions found in nature. Thus, what is the familiar leech? Is it a parasite? Or is it perhaps a predator? After thinking about leeches for a while, perhaps you can decide.

Leeches

There are some 300 leech species in different parts of the world. Most of them are aquatic and live in either fresh or brackish water. Terrestrial leeches, on the other hand, are restricted to the warm, humid tropics or monsoon forests and, as you know, are common in suitable places throughout Midland Nepal.

In Nepal, terrestrial leeches emerge from underground burrows at the beginning of the wet season (in late May or early June), but some are seen as early as mid-April in the high hills. The leeches stay out until late September or early October.

If you look closely at a Godaveri Leech (Most people naturally do not wish to), you may see that it is divided into segments and has a light brown stripe running down both sides. Look more carefully and you may see a semi-circular row of black dots near the snout (on the top part of the head). These are simple eyes and numbered eight on specimens recently examined. The number of leech eyes varies from two to ten depending on the species.

A leech's mouth is uniquely adapted for securing a blood meal. While the suction section attaches to a tender spot on the victim's skin, three movable internal "lips," each of which has a median row of teeth, come into action to slice down through the tissue to a blood vessel. Meanwhile, a heparin anti-coagulant chemical is

secreted into the blood stream to keep the blood flowing. It is hard to imagine that a leech could attach to a person, saw through the skin and suck blood — all without the victim noticing anything. But they can! Most often, though, a sharp stab or sudden itching draws one's attention to the intruder before it feeds very long. Most animals (cows and deer for instance) are not able to do very much about a leech even though they feel it. This indicates that leeches are primarily adapted to feeding on animals other than man.

Besides being big digestive bags, leeches do have sexual parts — both male and female in the same animal. However, they cross-fertilize rather than self-fertilize.

Several methods of removing the biting leech exist. Some people say that you must burn off the leech with a match or cigarette; others say that you must use salt. After a casual study and several hundred bites, it appears that the simplest way of getting rid of the leech is just to pull it off. The head is *not* going to remain embedded in your leg, and the bleeding seems to be no more than with other techniques. Bleeding varies considerably from individual to individual and even from bite to bite. From recent experience, it seems that some of the longest bleeding times came from bites where satiated leeches had fallen off on their own.

Leeches are not known to transmit diseases, so there appears to be little danger from a bite. Secondary infection caused by scratching too much at the site of the bite may occur. On some people, bites regularly turn septic but this must be connected with the person's blood chemistry and physical condition, for it is by no means a universal problem.

Much needs still to be discovered regarding the behavior of Nepal terrestrial leeches. Do they invariably need a blood meal to survive? Or do they need the blood to reproduce satisfactorily? (A number of aquatic leeches are not even blood suckers.)

Is a leech, then, a parasite? Leeches actively seek out their victims (which predators do) but once the host is located, the "prey" is neither killed nor devoured. Thus a leech might be termed a parasite.

The position of leeches in the balance of nature is not clear. In what way do they contribute to the Nepal subtropical forest ecosystem? Superficially, at least, their effect on mammals is negative and one we could well do without. But is this really the case? Perhaps leeches work tunnels through the soil that would then allow

gases to reach plant roots. A detailed study of leeches would answer many questions.

Internal Parasites

A parasite, as has been mentioned, is a creature that depends upon another animal for its food and/or shelter. An "ideal parasite," if there be such a thing, is one which is adapted so entirely to the host that it can live there without disturbing the host too seriously. If a parasite becomes too numerous or affects the host too adversely, the host is likely to die, and along with it go the parasites. Most parasites have become very specialized and cannot live on many different types of hosts. Internally, some parasites are so specialized that they no longer have digestive tracts; food is absorbed directly through the body wall from the intestines of the host. The Common Tapeworm is a good example.

Common parasitic worms fall into three categories: 1 — Flatworms; 2 — Roundworms; and 3 — Segmented worms. Some flatworm parasites, which include the blood and liver flukes, are not common, apparently, in Nepal. Tapeworms, though, which are also flatworms, are frequently found here, especially in human populations at high altitudes.

Tapeworms

Tapeworms live in mammal intestines where they attach to the intestinal wall and absorb predigested food from the host. Tapeworm infestation is not particularly serious unless there are enough worms to block the intestine. One worm, though, can attain an immense length (28 feet in one case) so that if twisted and turned upon itself, it might just block the system. Adult worms deposit eggs which, after being excreted, may be ingested by scavengers or herbivorous animals. Once in the animal intestine, the eggs hatch into larvae which then burrow into the muscular tissue of this secondary host. If this muscle is eaten by one of the various meat-eating animals, the cysts reach the intestinal tract. Here, in the "primary host," the protective coat is digested off, and the young worms attach to the wall to begin their adult life.

In reality, the tapeworm is an egg factory. Each body section originates in the "neck" region, and each segment starts out as sexually immature, but gradually male parts develop in it. Soon after the mature male parts appear, they begin to degenerate and,

in the same capsule, the female organs develop. Other segments originate continuously at the neck so the worm is gradually lengthening. When the female parts have matured, the eggs are fertilized by male parts further forward on the same animal. At the end of the worm, the segments contain nothing but fertilized eggs. Sections then drop off and the eggs are excreted in the stool. If mature sacs do not detach as fast as new ones are being formed, then the worm lengthens and can attain incredible size.

Tapeworms enter the human picture when a person eats infested meat without cooking it first properly. Well-cooked meat is not dangerous. A secondary feature, fortunately not common, can be quite serious to human health. If one accidentally ingests the tapeworm eggs, through using unsanitary utensils or unclean hands, then the eggs hatch in the human intestine and the young larvae may burrow out through the tissues causing considerable damage before they finally encyst in some muscle.

Roundworms

Roundworm parasites are common in Nepal and can cause serious medical problems. The Hookworm is a good example of a dangerous worm in this group. Hookworms live in the intestines of humans. Eggs are deposited in the stool on soil; and if this soil happens to be both warm and moist (Along the edge of a river is ideal), then the eggs hatch into larvae. After the larvae go through several stages in the soil, they are ready to penetrate a host. Now, if a person comes along and touches the contaminated soil with bare skin (usually the feet), the larvae can work their way through the skin into the blood stream. The worms are so small that the person does not feel much except, perhaps, a little itching while the animals are digging through his skin. Once in the blood, the young worms are carried to the lungs where they are coughed up. If swallowed after being coughed up, the larvae reach the human intestine where they commence their adult life. Each worm does not consume much blood from the capillary lining of the intestine, but unfortunately the adult apparently shifts its position every two weeks or so. Thus it leaves behind a small bleeding wound. One individual would not cause much of a problem, but when there are thousands involved, anemia can become so severe that it results in death if not treated promptly.

There are many other types of internal parasites in Nepal. Filaria worms are minute creatures transmitted by the bites of mosquitoes. These worms live in the human blood stream and may become so numerous that lymph glands are blocked, thus causing the swollen extremities of elephantiasis. Filaria worms are all too common in Midland Nepal but, with modern diagnosis and treatment, are not so serious.

There are other forms of parasitic behavior also. Although not true parasites in the sense that food is obtained from the host, certain birds depend upon others to raise their young; they are called "social parasites." We have a number of these social parasites in Nepal.

Cuckoos

In Nepal, spring is the time of the cuckoo. On warm April afternoons, their notes throb from forest and hedgerow alike. The Indian Cuckoo has a familiar four-noted call: "Dee dah, dee day," the second couplet slightly lower in pitch than the first. This bird sings loudly when the Kyphal fruit hangs red on the forest trees; the Nepali name for this bird is "Kyphal Pakio."

The plumage of the Indian Cuckoo is not colorful but its habits certainly are! Upon arriving in the hill forests in the spring, the female cuckoo begins to hunt through the trees and bushes, watching other birds to see what they do. She may find several victims, usually warblers or small songbirds, building nests. In this case, she keeps the locations of the nests in mind; and as she is about to lay an egg, she hovers in the neighborhood of the intended nest target. When the true parents are away for a short spell, the cuckoo quickly flies to the nest and in an amazingly short time, lays an egg. The cuckoo's egg is small for the size of the bird and hatches quickly. The young cuckoo grows rapidly and soon it is strong enough to push the other, rightful nestlings out of the nest. In less than two weeks, the young cuckoo may be as big as the host parent; larger, within three weeks. Somehow the small warblers do not realize that this fledgling is not their own young, and they continue to feed a "youngster" more than twice their own size!

Another intriguing point is that the cuckoo egg often is similar in color to the host's eggs. Surprisingly, the Common Cuckoo, which has the familiar "koo koo" (the last note below the first) call, lays

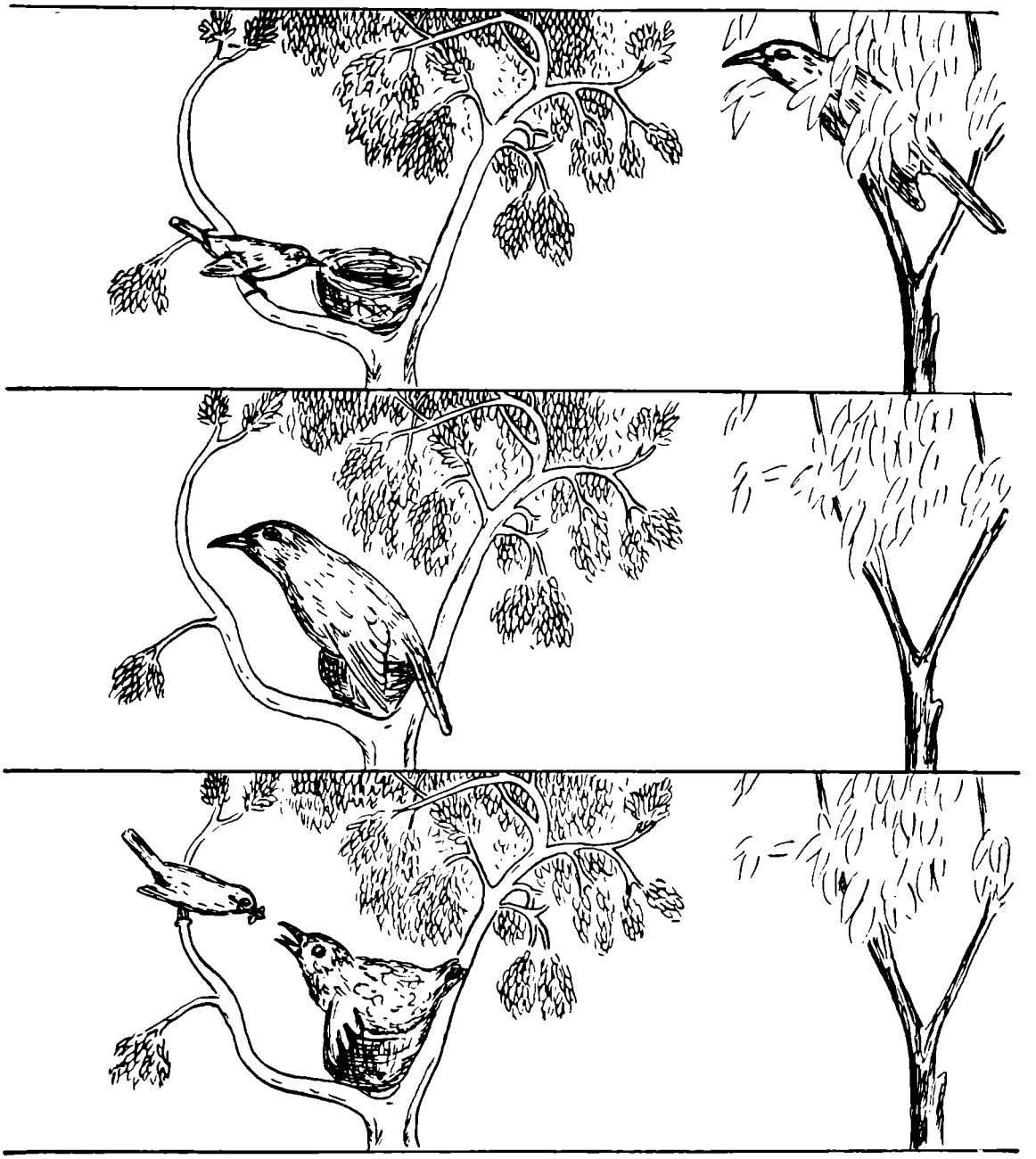


Fig. 5. Many Nepalese Cuckoos practice "social parasitism." The Cuckoo lays her eggs in the nests of other birds and the young cuckoos are then raised by their "foster parents."

several different color eggs in its Himalayan breeding range. In the western Himalayas, this Cuckoo often parasitizes laughing thrushes, whereas in the eastern Himalayas, warblers are often victims. Now, in the western Himalayas the Common Cuckoo lays a blue egg (similar to those of the laughing thrushes), while in the east their eggs are speckled red (See Baker, 1927: 137–140)! Common Cuckoos nest in Nepal, but we do not know yet what type of eggs they lay

here. Nepal falls along the center of the Himalayas; and, as both laughing thrushes and warblers are common here, perhaps the cuckoo's egg is blue and speckled. In Nepal, though, the cuckoo's egg is probably blue, for here the cuckoo breeds at altitudes above that of suitable warblers but at an altitude coincidental with laughing thrushes.

A cuckoo known to many people in Nepal is the Koel or Koeli. This shiny black creature (the female is speckled) is found in gardens and groves from the Tarai up to Kathmandu. Local tradition says that a Koeli is much more intelligent than a crow. The origin of this idea is not difficult to trace. Most cuckoos lay eggs in nests of birds smaller than they are, but not the Koel. The female Koel tries hard to find a crow's nest where she may, when the parents are away, slip in an egg. If all goes well, the young cuckoo is raised by the crows. Sometimes, though, the crows get suspicious and may build a new nest on top of the old one thus sealing off the eggs below. Both the Nepali and English names for this bird come from its call note of "Ko-el," the "ko" is low and the "el" rises in pitch.

The noisy "Brain-Fever" birds of the Tarai and Midland Hills also are cuckoos. You may have often heard their calls which seem to continue throughout the day — and most of the night, too! Actually, cuckoos often call at night which is unusual for daytime birds. The notes of the Tarai species rise in pitch with each "brain-fever," whereas the species in Midland Nepal call mostly on the same pitch.

The Honeyguide

The Yellowrumped Honeyguide is another fascinating bird of Nepal. It appears to be very rare here, though, so we unfortunately know very little about its habits and behavior. Honeyguides are primarily African; we have only one species in Asia. This bird has not been recorded from Kathmandu, although it should occasionally visit the Valley, for it is known from Dolakha District in the east and from Myagdi District in the west.

Eventually, we will know details about the Honeyguide in Nepal, but at the moment our information about this family comes from Africa. In Africa, honeyguides are known to purposely attract the attention of man or some animal such as a Honey Badger. The

birds do this by singing and jumping about on a branch. Once the honeyguide is sure that he has been noticed, he flies some distance, but not too far, and repeats the performance. In this manner the bird leads his "assistant" to a beehive. The helper then presumably breaks open the hive and takes what honey he wants before departing. Once the nest is exposed, the honeyguide can feed on the wax, bee larvae, and honey. These birds harbor colonies of amazing wax-digesting bacteria in their intestines so that the wax is broken down and used as a nourishing food for the bird. Candle wax would do just as well! Wax would not be a good food for humans, even if it were tasty, because we lack the necessary specialized bacteria (See Friedmann, 1955).

Honeyguides are included here, not because of their special wax-eating adaptation, but because they are social parasites. In Africa, the honeyguides victimize hole-nesting birds — often barbets. Once an egg is laid, the nestling hatches quickly. This youngster is equipped with a sharp and deadly point on its bill tip (This is something quite different from the cuckoos previously mentioned). When the young of the host birds hatch, they are quickly speared to death by the young honeyguide. Later this special tip on the bill drops off, and the honeyguide is raised unwittingly by its foster parents.

We have yet to discover if the life of the Nepal Honeyguide is similar to its African relatives. Not all honeyguides "guide," and our Nepalese species probably does not, else we would hear more about the bird. Nonetheless, they certainly eat wax, and they are found around cliffs festooned with beehives.

Plant Parasites

Despite the fact that many animals are parasitic, surprisingly few plants fall into this category. Around Kathmandu one may see tree branches supporting clumps of another small-leaved plant. This second plant is often a Mistletoe whose "roots" penetrate into and draw sustenance from the tree. Most secondary plants that you see growing on trees (such as ferns, mosses, and lichens) are not parasitic and use the tree branch merely as a resting place. Another parasitic plant, the Dodder, sends out yellowish stems that curl around over bushes like multitudinous vines. Dodder is very common along hedgerows in Midland Nepal.

12. Mistletoe, a parasitic plant, grows in clumps on branches of other trees. Pulchowki, 2,000 m. elevation.

13. This Mushroom is a fungus that grows from dead and rotting materials in the soil. Mushrooms assist in the breakdown of dead tissues and thus help to release minerals back into the soil. Nepal Midland forest, elevation 1,500 m.

Saprophytes

Besides parasites, the plant world has developed another category of feeding behavior — the saprophyte. Saprophytic plants live on dead and decaying material; thus, they are not parasites that require living tissues. There are no animal saprophytes. Oh, but you say, the leopard lives on dead (and decaying) animals. True, but there is a slight difference. The leopard attacks a living animal which dies in the process of being eaten (Capture is part of the feeding cycle). Well, what about vultures or carrion beetles? Surely they are saprophytes. Essentially they are similar. Saprophyte, though, refers strictly to plants; somewhat comparable animals are called scavengers.

Fungi

There are many saprophytes in Nepal. While walking in the Godaveri forest, one often sees fleshy plants that look like plates balanced on thick stalks. These are mushrooms and they form in colorful reds, yellows, purples, or browns.

Mushrooms are primitive plants. The part that you see in the forest is the reproductive section which has pushed its way above the soil; most of the mushroom body is composed of virtually transparent or opaque strands that intertwine through the soil and rotting vegetation on the forest floor. Mushrooms are only a part of a very widespread and diverse plant group known as the Fungi. Fungus species are usually very small, but mushrooms are an exception.

The spores of fungi are constantly in the air around us. When a spore lands on a suitable medium, transparent strands (hyphae) develop to form an intricate branching network called a mycelium pad. These are not easy to see with the naked eye for they usually occur beneath the surface of decaying tissues, the threads working their way into and between dead cells. Later the hyphae develop fruiting bodies which are erect stalks with a bulbous end. These appear above the surface, and we can see them easily. Mature spore capsules may vary in color and give a characteristic bluish, blackish, or even greenish tinge to the whole colony. When these capsules ripen, they break open, and spores are released into the air to continue the cycle.

Virtually everyone in Nepal has seen fungi. As fungi do not produce their own food, they obtain nourishment from dead and decaying materials. Consequently, we find them growing on almost

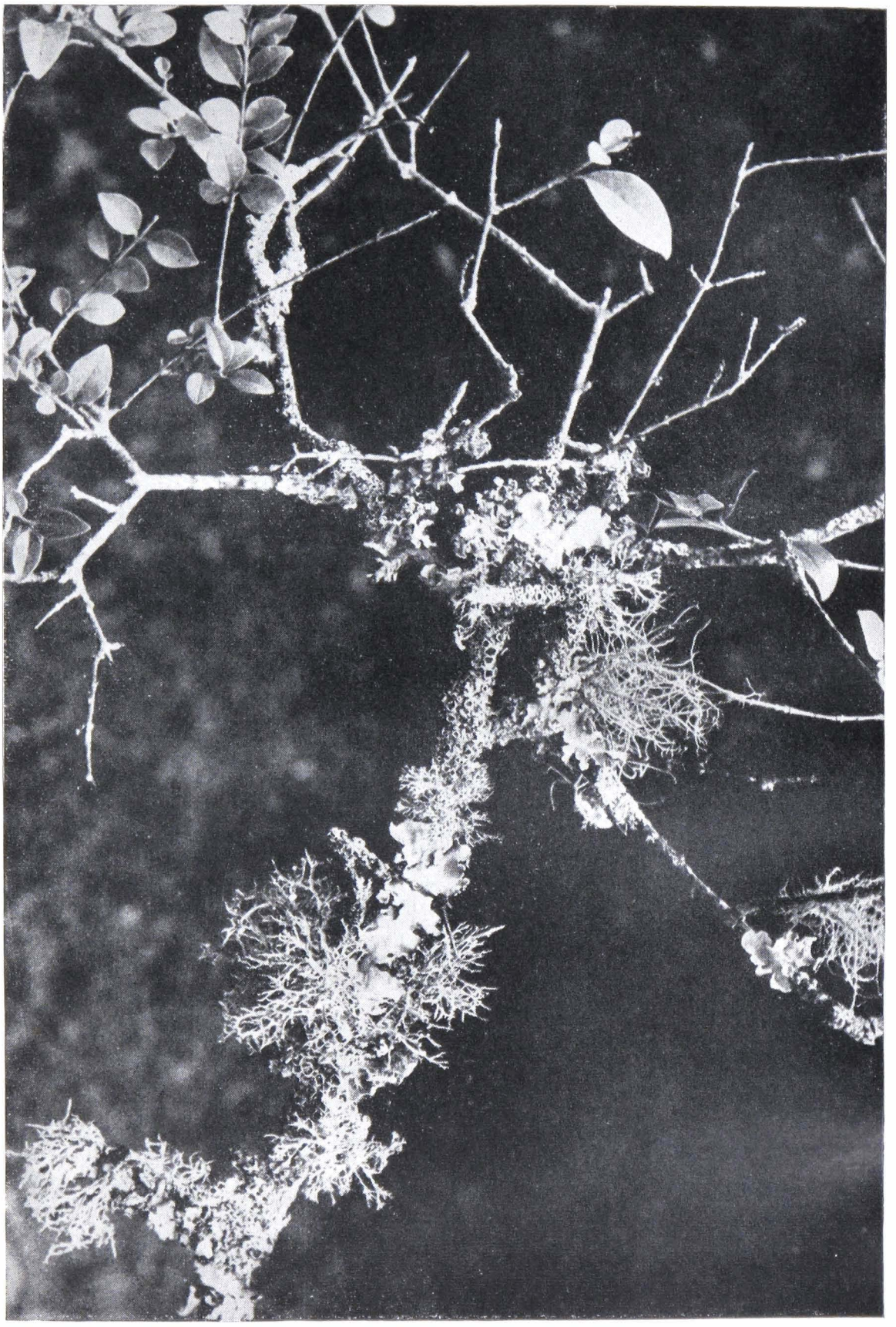
anything, from old chappaties to shoes stored in a closet. A number of fungi are serious agricultural pests. Wheat rust is a Basidiomycete that attacks the heads of wheat plants. The wheat rust life cycle is dependent not only on wheat but also on barberry bushes; if the barberry bushes near wheat fields are cleared, this disease is reduced considerably.

Mushrooms are perhaps the most spectacular form of fungi, and are often very specific about the medium in which they grow. Therefore, we find certain kinds growing on dung heaps in meadows while others are always on rotting logs. Still others grow on trees and can eventually damage tree cells. Mushrooms in Nepal can be divided into several types according to shape: Toadstools (that look like fleshy umbrellas), Groundstars (round balls that develop at the surface of the soil), and Shelf (that appear in shelf formations on tree trunks).

Mushrooms are eaten in Midland Nepal, as they are in other parts of the world. One has to be very careful, though, about consuming unknown types of fungi, because even closely related species vary greatly in their poisonous effect on man. It is best not to trust a species as edible until one looks into the matter very carefully. The poison of mushrooms acts on nerves and if much of a deadly kind is eaten, little can be done for the patient once the symptoms have set in. It has been discovered that the food value of mushrooms is minimal; their importance is one of taste and epicurean pleasure. Undoubtedly, there are numerous edible mushrooms in Nepal, but to date little research has been done on this aspect of the Nepal flora. We should know more soon, though, for fungi of Nepal are currently under study.

One or two curious facts about mushrooms have been observed in other parts of the world; probably they occur also in Nepal. Some mushrooms, for example, are luminescent; that is, they glow on their own (both at night and in the daylight). The function of this light is not understood and presents a question of considerable academic interest. In some places, woodsmen, it has been said, mark trails with bits of luminescent fungi.

Another phenomenon, observed in fungi that grow in meadows or grassy lawns, is that the mushrooms seem to be growing in a ring or circle. Just inside the ring the grass is very green, whereas in the center it is dead and brown. Formerly it was thought by



14. Lichens are a combination of two plants : algae and fungus. They grow on rocks or trunks and branches of trees. This bush is from a Midland Nepal forest at 1,500 m. altitude.

Europeans of the Middle Ages that fairies built these rings as places in which to dance; they are still known as Fairy Rings. The explanation of Fairy Rings is simple if one knows that the mushroom colony originated from a central point. As they grow, the mushrooms' hyphae gradually move outward and, at a fairly predictable point in their life cycles, develop fruiting bodies (the mushrooms we see). The rate of progression of hyphae is approximately steady in uniform soil so that after radiating from the center, they develop and age simultaneously. The fruiting bodies appear at about the same distance from the center, thus forming a ring. The hyphae help to dissolve nitrogen which is used by the grass; later, the dead hyphae kill the grass.

Other fungi attack human skin. The outside skin layer is composed of dead cells in which some fungi can live. Unfortunately, though, they also irritate the underlying layers and cause intense itching. Living cells also can be damaged. Ringworm and athlete's foot are two types of fungal infections. Once established, these infections are tenacious and difficult to dislodge, so they persist for a long time. Most infections of this sort are spread through direct contact or by using material (often shoes and socks, in the case of athlete's foot) infected by another person.

Besides knowing more about what species of fungi occur here, it would be good to investigate how they contribute to the Nepalese ecosystems. Fungi permeate the soil and so affect the growth of other plants. We have seen that this influence can be either positive or negative. Fungi may speed the breakdown of dead tissues and thus assist in releasing minerals to be used in rebuilding other tissues. Fungi are important food for some invertebrates, but not for large animals. Other fungi cause very serious plant diseases and are of great economic concern.

Lichens and Symbiosis

Closely related to fungi, and indeed, incorporating them, is a widespread group of plants called *lichens.* Lichens are fungi and algae living together; each appearing to help the other. When two such plants (or animals) live together with mutual benefit, the relationship is termed *symbiosis.*

It appears that the fungus protects the algae while the latter produces food through photosynthesis. Recent laboratory studies

show that component parts of some lichens may be able to live separately. Whether they can do so in nature is not yet known.

Everyone in Midland Nepal has seen or been near a lichen. They grow on exposed rocks or tree trunks, and branches are often festooned with weird-shaped cups and projections. Lichens are commonly grey, white, or light green; other colors are bright red and yellow. Lichens are common in Nepal for they are predominantly plants of cool regions. As one climbs upwards in the Himalayas, more lichens appear — up to the limits imposed by altitude and oxygen.

Lichens are important in the ecology of our planet, for their minute root-like system (hyphae) dig into the surface of rocks, thus hastening the breaking off of small sections which in turn form part of our soil. In other words, they assist in the formation of soil from the initial rock base. Lichens are eaten by Reindeer and other arctic animals and have been consumed by man, but how many of the high altitude animals in Nepal devour lichens is still to be determined.

Some work has been done on Nepalese lichens; as far as is known, most of our species are related primarily to those found in Europe and North Asia (See Asahina, 1955: 43–63). One spectacular Nepal lichen, *Usena*, is found growing on trees, usually above 3,000 m. altitude (but also around the Jumla area of Midland Nepal) where its long, trailing strands and whitish color remind one of some venerable man's beard.

Conclusion

The field biologist has now had a chance to glance at a Nepal subtropical forest and to briefly consider some of the many aspects of the vast activity that occurs here.

Much of Nepal, at least from the Karnali River eastward, was once covered by this subtropical forest from about 1,000 m. to 2,000 m. altitude. This elevation is also ideally suited, climatically, to humans and has been inhabited, probably, for centuries. Thus today, much of the original forest has been replaced by thousands upon thousands of terraced fields and many small villages. The total land mass, then, covered by Schima-Laurel-Castanopsis forest is really quite small; most of Midland Nepal is cultivated. The activities of man will be considered at the end of the next chapter.

15. A small village in Jumla District, W. Nepal. Terraced fields help to keep down erosion ; note also the deep erosion gullies to the sides of the fields. The flat roofs of the houses here are covered with about 15 cm. of dirt in which grass, vegetables and tobacco may be planted.

16. A small village in Mugu District of far N.W. Nepal. The fields around the village are not fully terraced, and from these one would expect to lose some topsoil. Although at only 2,200 m. elevation, the trees around this village are nearly all cone-bearing Blue Pines. This condition contrasts markedly with those at the same altitude around Kathmandu or in E. Nepal.

17. The Oak-Rhododendron forest of Midland Nepal as seen on a September morning. Altitude 2,000 meters.

Chapter Three The Oak-Rhododendron Forest

MUCH of Midland Nepal between 2,200 m. and 2,800 m. altitude was covered at one time with a climax oak-rhododendron forest. Although in some parts of Nepal most of this forest has been reduced to scrub, there are still good examples, especially in the western districts of Dandeldhura, Doti, and Bhajang; also on ridges around Kathmandu one finds good forest. Around the top of Shivapuri, hardly 10 miles from Kathmandu City, a virgin oak forest still remains.

The Nepal oak-rhododendron forest is an intriguing place. Here the oaks are interspersed with rhododendrons, maples, spindlewoods, and also magnolias and chestnuts in the eastern districts, and are covered with mosses. The ground likewise is strewn with ferns, mosses, and small flowering plants while the air resounds with the songs of birds — many of them unseen.

Climate is a major factor maintaining these forests. You will notice that clouds blanket the ridges of Midland Nepal for much of the year. Even in the "dry" winter months, clouds form over these ridges, and it may rain here by mid-afternoon. If you were to live in these forests during the monsoon, you would find that the clouds rarely lift, so that one may go two weeks or more without seeing the sun. These areas could also be termed "cloud forests," and it is quite an experience to walk quietly along between moss-draped oaks enveloped in a heavy, hanging mist.

Mosses

Mosses are an overwhelmingly dominant feature here. They grow nearly everywhere, covering tree trunks, branches, boulders, and parts of the ground. What space is not clothed in moss appears to be occupied by lichens.

Mosses are primitive plants found abundantly in Nepal in temperate regions of cool air and high humidity. As one descends toward the Tarai, mosses become much less evident, showing that they are not tropical plants. Mosses have chlorophyl, and thus make

their own food; they do not parasitize the trees upon which they grow. These small plants form a spore capsule upon a leafy stalk; and, except that they grow together in great clusters, they might not easily be noticed. Rain is important to the moss, not only from the moisture standpoint, but also because rainwater assists the movements of spores and thus the reproduction of mosses.

The ecological functions of moss are still somewhat unclear. In regions with nearly perpetual clouds, one finds moisture condensing on surfaces even though it is not raining. This happens constantly in the Nepal hills, and it is very likely that mosses add a considerable volume of water to the forest by presenting so much exposed surface on which moisture can condense. On a smooth-barked tree, the surface available for moisture condensation is limited. But imagine a tree covered with innumerable long strands of moss hanging from every branch and coating its trunk — how much surface area does it have!

Mosses have a profound effect on animals living in these forests. No detailed studies have been made yet, but it can be noted that almost every bird here uses moss either to actually build its nest or at least to camouflage it. Some birds (such as pheasants) eat moss, but it is not known how widespread this habit might be.

Ferns

Another conspicuous plant group here, which is remarkably similar in ecological requirements to the mosses, is the ferns. Where mosses are found, ferns usually grow too. Within the Kathmandu Valley, there are probably about 100 fern species; perhaps over 300 in all Nepal. They are more numerous in the East (Ilam) than in the West (Baitadi). Ferns also are temperate plants; only a few species are seen in the Tarai, whereas many grow up to 4,000 m. elevation in the mountains behind Kathmandu.

Ferns are semi-primitive plants that do not produce flowers. What you see on a walk through a Nepal oak-rhododendron forest are the spore fronds of the fern. If you look carefully on the underside of the frond, you may find a number of little dots or lines. These black or dark brown marks are often mistaken for some plant disease, but this is wrong for these are the *sori* — small capsules in which the spores are produced. Once the spores are liberated, they may settle down to form a new fern plant.

18. This Leucostegia fern grows on tree trunks in Midland Nepal. As all ferns, it is a free-living plant and is not a parasite of the tree. This mature spore-frond, which appears in June, turns yellow and falls off in the bright sunshine of October.

19. The small dots placed in regular lines along the leaflets of this Walnut fern show where the sori filled with spore capsules are located. In the oak-rhododendron forest at 2,400 m.

Ferns are classified according to their shape, root structure, spore and spore capsule anatomy. In Nepal, ferns range from the thumbnail size "naked line" to the tall "tree" fern. Some ferns are edible and make a rather tasty spinach that goes well with rice. Others are not palatable; none is yet known to be deadly poisonous. Fern fronds are eaten by certain birds such as the Crimsonhorned Pheasant, and also by larval stages of some insects. But by and large, the ecological value of ferns is still to be determined.

Some groups of plants and animals one sees in Nepal today were much more numerous thousands of years ago than they are now. With a little imagination, one can picture the countryside as it was when dinosaurs roamed the earth. The Himalayas did not exist then, but ferns did. In fact, ferns were quite tall (as told from today's fossils) and probably formed great forests. Today dinosaurs are gone — but ferns linger on. Tree ferns found in damp gullies in Midland Nepal are a reminder of past ages.

Biogeographical Classification

The majority of species found in the Nepal oak-rhododendron forest are Indochinese in distribution. In other words, they are found in Nepal eastwards through Sikkim, Bhutan, NEFA, and the mountains of western China and northern Indochina. This does not mean that any particular individual will move from Kathmandu eastward to Yunnan, but that the species is found from Nepal to Yunnan. Actually, most Indochinese species, especially speaking about birds, are fairly sedentary and do not move over long migratory paths.

In the Nepal oak-rhododendron forest there is one family of birds that is particularly conspicuous — the Timaliids. These are the laughing thrushes and babblers, and there are 36 representatives known from the Kathmandu Valley alone. These birds are noisy — you could tell that from their names. But they are also shy and thus are somewhat hard to see down among the thickets where they dwell. There are, of course, extroverted exceptions, and these are seen very easily as one strolls through the forest.

The Slenderbilled Scimitar-Babbler

Because of the secrecy of the babblers, new discoveries about their distribution and behavior are constantly occurring. Only recently, a peculiar trilling note was heard in the dense bamboo stand on the

north side of Shivapuri (near Kathmandu). The maker of the call was not discovered, however, for the bamboo was so dense it was hard to see into. Fortunately, the bird was heard calling again several days later — this time from a rhododendron tree. Then the bird was seen to be the size of a bulbul with a monstrously long and

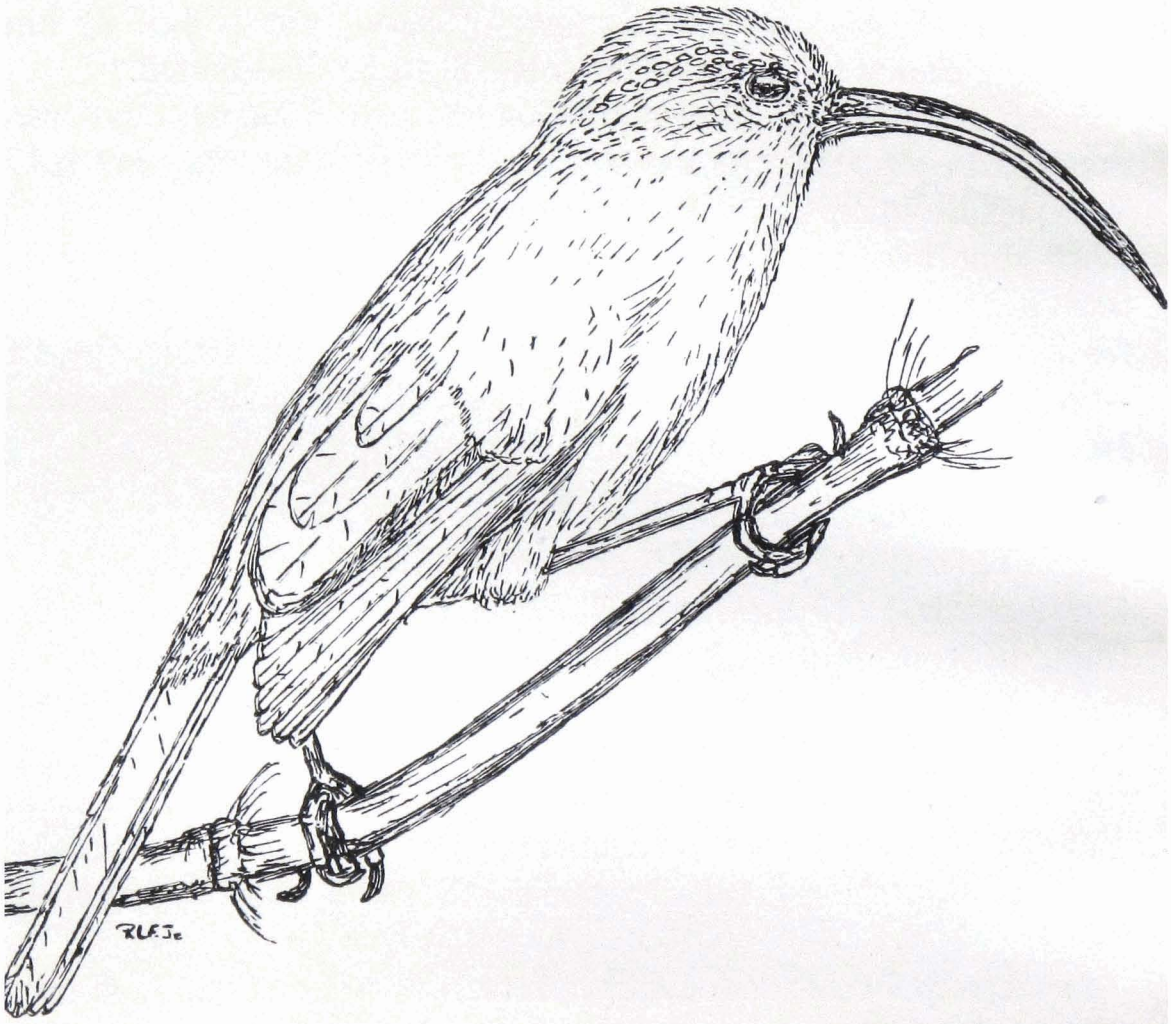


Fig. 7. The Slenderbilled Scimitar Babbler is a shy bird recently found for the first time in Central Nepal. It lives in stands of dwarf bamboo.

decurved bill. It was a Slenderbilled Scimitar-Babbler, a species known to live in Western China, west through Bhutan, and Sikkim to the Mai Valley of eastern Nepal, but not known from as far west as Kathmandu. Even more recently, the species has been sighted in the bamboo forests north of Pokhara.

The Blackcapped Sibia

A conspicuous, rather than secretive, bird in the Nepal oak-rhododendron forest is the Blackcapped Sibia. Its loud, ringing call

is heard almost constantly from early morning till dusk. Every area of the forest seems to have a resident population of sibias, and there appears to be little movement from winter to summer. In late winter and early spring, it is engaging to watch half a dozen sibias acrobatically drinking sap from the vertical trunks of giant oak trees. Over a dozen bird species, and also the Orangebellied Himalayan Squirrel, feed on this oak sap.

" Success " in Nature

The presence of sibias points out the fact that in any given region some species are numerous and others rare. Why is this? Obviously certain conditions are more suitable for some species than others. Food availability and the ability to procure it are vital. But this is not the whole answer, for as one walks through the forest he may see many food resources (berries, insects, and worms) not being eaten. In the case of birds, it is easy to see that food is a major limiting factor, but it must be remembered, also, that birds (as do other animals) have a life cycle which may be quite vulnerable at certain stages. For birds there is particular danger during the nesting stage. Thus the number of adult birds about may be controlled, in part, by how many nestlings are successfully raised.

"Success" in nature is spoken of in numbers. A prolific species with many individuals scattered about the countryside is spoken of as "successful." Numbers, too, are relative; and a "successful" bird will have many fewer individuals in the population than a "successful" bee.

In the case of the sibia, nesting probably has a great deal to do with its "success." Many birds nest rather casually and without much concern for camouflage; thus many nests are destroyed. In some places, more than half the number of nests are ruined. Not so with the sibia. The sibia builds its nest in a moss or fern clump high in a tall tree, usually toward the end of a branch. The nest is wonderfully hidden and is hard for even persistent humans to locate. The main dangers for nesting birds in Nepal are climate, snakes, lizards, man, and other egg-eating mammals (such as the Yellowthroated Marten). Now consider the sibia. It is fairly safe from man (not speaking of habitat destruction, of course), while there are virtually no tree-climbing snakes at these altitudes in Midland Nepal; and the marten, the most prominent danger, also seems to have difficulty

Fig. 6. The Blackcapped Sibia, a common bird of the Oak-Rhododendron forests, frequently drinks sap as it oozes from holes in oak trees.

in locating the nests. Although no study has been made, it would appear that the nesting success of these birds is very high, and this contributes to the abundance of sibias in the forest. Other species in these moss-covered forests (Chestnutheaded Tit-Babblers and Stripethroated Yuhinas, for instance) are also very numerous; they likewise build amazingly concealed nests.

The Nepal Cutia

Conversely, there are also rare species in the oak-rhododendron forests of Nepal. The Nepal Cutia is a rare bird. It is quite similar to the sibia in size and habits (they both drink sap oozing from tree trunks) and the two species are sometimes seen in the same tree. But one will see cutias perhaps a half dozen times a year, whereas thousands of sibias would be noted in the same time. What makes the cutia rare? We do not know. Food appears to be plentiful. The habitat in which it lives is still extensive, and its nest is probably not too vulnerable. In fact, it is so well concealed that the nest is yet to be discovered and described for the first time. Everything from the superficial point of view would lead one to think that the cutia should be common. But it is not; so there must be some as yet undiscovered ecological reasons or factors that limit the "success" of the cutia.

Feeding Levels within the Forest

Within the Nepal oak-rhododendron forest, various species of related birds are adapted to different feeding areas or levels. For example, there are two species of birds here that specialize in eating insects from trunks and large branches of trees. They can be seen crawling up tree trunks or scooting out on large branches. The Himalayan Nuthatch is blue-grey above and tannish underneath, with a strong, pointed bill, while the Sikkim Tree-Creeper is a long-tailed, brown bird with a long, slender, decurved bill.

Even though both birds find food among bark crevices and cracks, one would feel from looking at their bills that these birds differ in habits; and this is true. The nuthatch is prone to hammering and driving out insects. As it hunts, it clambers up and then scampers down the tree trunk. This differs from the tree-creeper, which uses its long bill for probing, not hammering, and for catching scurrying insects. Sometimes a tree-creeper will hop off the tree trunk and

chase an insect in flight. Also, a tree-creeper is built so that it can only go up a trunk; if it wants to go back down, it will flip off the trunk, drop vertically, and then land fluttering on the lower part of the tree. A further ecological difference between the two species is that the nuthatch moves up in the crown of the tree, using large branches as feeding tables, while the tree-creeper usually is seen on the lower two-thirds of the main tree and is not frequently found out on secondary branches. In this way, two ecologically similar species avoid each other.

East-West Variations in the Oak-Rhododendron Forest

The oak-rhododendron forests of Nepal are hardly uniform from east to west. Indeed, within the 800 km. span there are great differences in topography, soils, and man's encroachment. Much of the variation in species composition, though, is due to climate. The vegetation of East Nepal reflects a much wetter condition there than that found in West Nepal, although official average annual rainfall figures (as recorded by Baidya, 1970:6A) are 1,423 mm. for Ilam in the east and 1,519 mm. for Dandeldhura in the west. The forests in West Nepal tend toward homogenous oaks mixed with some pines and Tree Rhododendrons, whereas, at the same height in East Nepal, there is considerable variety with several species of rhododendrons plus laurels and chestnuts among the oaks.

The Kalij Pheasant

Even within one species, individuals living near Jhula Ghat in Baitadi District may differ markedly from those near Phidim in Panch Thar District. Take, for instance, the familiar Kalij Pheasant. In far West Nepal, this bird's crest is white and its rump feathers black, edged with white. Around Kathmandu, the same species has a black crest while the rump is still partly white. In East Nepal, though, not only is the crest black, but the rump also. The birds in East Nepal are slightly smaller than those in the West. This type of subspecific variation is common to many species through the hills of Nepal.

Mammals in the Oak-Rhododendron Forest

Because there are numerous birds in these forests, it would be natural to find many mammals here too. It is surprising, then, to

20 Forest on Hans Pokhari Danda of Ilam District. The numerous vines indicate high rainfall in this eastern region. Altitude 1,700 m., December.

21. The Karnali River Valley, Jumla and Achham District, W. Nepal. These valleys are usually hot and somewhat barren. There are few villages and cultivations here, but even so, the vegetation is confined primarily to the ridge tops, February.

22. A view in eastern Nepal showing vegetation between 1,000 m. and 2,300 m. elevation. Taplejung District, December.

23. Each winter, snow falls down to an elevation of about 2,000 m. in Midland Nepal forests. An oak forest at 2,200 m., January.

learn that mammals are relatively scarce. The ubiquitous Leopard and Barking Deer live here, as do Himalayan Black Bear and Wild Boar. There are few species, though, that are especially adapted and restricted to these forests.

The Giant Flying Squirrel

One mammal that does live here is the Giant Flying Squirrel, found from far West to far East Nepal. This big squirrel is reddish with a light orange underbelly and may reach a length of about three feet (including tail). They appear only at night; during the day they hide away in the hollows of trees. Their large eyes are adapted for night vision, but they can still see fairly well during the day. Their food consists of bark, acorns, berries, and tree leaves which they gnaw or pick off with sharp front (incisor) teeth.

The instincts of animals are amazing. No matter what noise or commotion, or how much light reaches these large squirrels during the day, they remain virtually immobile. A pet in Kathmandu slept peacefully, despite constant daytime noise and disturbance, to arise at dusk and dance about the house during the night hours. His instinct for night-time activity was so strong that even after two years of captivity, he had not changed his ways. This particular squirrel was very fond of Nepali biscuits, bark, and gaultheria berries. He did not care for any sort of nuts but relished mangoes and papayas.

Does the flying squirrel actually fly? Some people say it can. Actually it can only glide, so perhaps should be called a "Gliding Squirrel." These squirrels almost never come down to the ground but spend their lifetimes among the oaks of the Nepal forests. If they can only glide downhill and do not move about on the ground, then one supposes that all of the squirrels from the hills surrounding Kathmandu might end up on the Valley floor. This is clearly not the case; so what happens? What would you, as a glider, do if you could not touch ground but yet wanted to go uphill? Yes, you would probably do what the flying squirrel does. This animal finds moving uphill quite easy. First it climbs to the top of a tall tree. Now, seeing that the base of the next tree up the hill is actually below the squirrel, it merely takes a short glide and lands on the next tree. Then it scampers up this second tree and is in position to dive to the third.

Flying squirrels are not known to glide too far, but an unusually long glide recently was seen. One evening a squirrel was noticed poking his head out of a tree hole. The tree, an oak, was growing on a steep hillside at about 2,500 m. altitude. When the squirrel was disturbed, it did not hide back in the hole as was expected, but scrambled out and glided far down the hill. After covering about 150 m., the squirrel approached a large oak standing on a ridge top where it obviously would stop. But, instead of landing, it swooped upwards, pulling in its outstretched legs and shot right through an opening in the branches and disappeared down behind the far side of the ridge. How far it finally went is anyone's guess.

The Oaks

Oak trees are a dominant part of the vegetation between 2,130 m. and 2,740 m. elevation in Nepal. We have many different oaks here, although only the Khasru Oak is found commonly from far east to far west. The Banj and Moru Oaks are widespread in West Nepal but disappear in East Nepal. Instead, the Thickleaved Oak and the Laminated Oak compose much of the forest in East Nepal.

Oaks are flowering trees, but their blossoms, divided into male and female spikes, are inconspicuous. In some northern parts of the world, oaks lose their leaves as winter sets in, but Nepalese oaks do not, so hillsides covered with oaks retain their green tinge throughout the winter. Oak leaves are important in Nepal as a fodder material — especially for water buffalos. Trees near villages are heavily lopped; indeed, nowadays many oak forests below 2,240 m. elevation stand partly destroyed by this practice.

Although oak wood is tough and beautifully grained, it is not widely used in furniture because the growth is so gnarled and twisted that appropriate-sized oak boards are hard to get. Oak wood, in Nepal, is used mainly for burning. Acorns, though, are sought after by people as well as wild animals and birds. Both Himalayan Black Bears and the Himalayan Slatyheaded Parakeets are very fond of acorns.

Rhododendrons

Rhododendrons are a conspicuous plant genus in Nepal; 29 species have been discovered here so far (See Banerji, 1966:19). Rhododendrons are found in many parts of the world, but they reach their peak diversity in the Eastern Himalayas.

24. Much of the Oak-Rhododendron forest in Midland Nepal is draped with moss. Moss i

25. The Tree Rhododendron, Nepal's National Flower, is common in Midland Nepal. It is the world's tallest rhododendron species, with some trees reaching 60 feet (20 m.) in height. It blooms

The Tree Rhododendron (*Lal Guras*), the National Flower of Nepal, is found almost exclusively in the altitude belt under study here. In West and Central Nepal, it is the only rhododendron species in these forests. In East Nepal, though, others emerge, including epiphytic varieties (*R. lindleyi* and *R. dalhousiae*) that grow on other trees.

Rhododendrons are tough plants that can survive in cold conditions. Here in Nepal, they occur above 1,800 m. elevation. The higher one goes, the more rhododendrons he is likely to see (at least up to the treeline). At about 3,800 m., particularly in East Nepal, the dominant plants often are rhododendrons. Most species here have large and attractive flowers; a few are dwarf types but they remain colorful, nonetheless. The predominant colors of Nepalese rhododendrons are red, purple, pink, and white. There are also yellow kinds.

Tree Rhododendrons, perhaps the most famous species in the world, reach a height of nearly 60 feet here in Nepal, with trunks that measure over four feet in diameter in some big specimens. While the most familiar color for this species is red, there are also pink and white flowers (in the same species). Surprisingly, altitude plays a deciding role in the color determination, and if one climbs to about 2,400 m., he will likely see the pale-colored varieties. In the Kathmandu Valley it is possible, but not usual, to see all three color forms growing side by side. Any one individual tree sports only one color form; red, pink, and white flowers do not appear on the same tree.

Besides being colorful, rhododendron flowers attract a variety of insects that feed on the sweet nectar. Pursuing the insects, and also sipping nectar, are numbers of birds. If one has a chance to see Fire-tailed and Nepal Sunbirds accompanied by sibias, sivas, and yuhinas all flitting about a tree choked with scarlet blossoms, it is a sight not soon forgotten. For experiences like this, one should visit the Nepal forests in March or April.

Thus, rhododendrons contribute to the ecosystem by providing a food source for insects and birds. These animals, in turn, pollinate the flowers. Rhododendrons usually grow on exposed slopes and ridges, so help to maintain the soil on steep surfaces. Unfortunately, this is one of the first trees felled by woodcutters, as the wood is very soft and easy to chop. It is said to make good charcoal. The flower

petals can be cooked into a softly scented jelly. The leaves, though, are not safe to eat and apparently the bee honey from some rhododendron nectars is poisonous. Eaten in small quantities, the honey is reported to produce a not unpleasant lightheadedness!

Orchids

Another group of attractive flowers in these forests is the orchids. Orchids are free-living epiphytic or terrestrial plants with long fleshy leaves. Some have pseudo-bulbs at the base of the leaf and flower stalk. Because of their ornate and delicate flowers, which often are lightly scented, they are among the world's best known plants. Not all orchids, though, are colorful, and for every spectacular one, there is probably a drab variety. In Nepal we have both types, but we do not know for sure how many varieties of orchids are here. Judging from numbers in Kumaon and Sikkim, there are probably at least 250–300 species living within Nepal.

Around Kathmandu, and this holds true for much of Midland Nepal, orchids bloom at almost any time of year. They are found on rocks and trees on slopes around the Valley; there are not many on the Valley floor itself. The beautiful white orchid with a yellow center, *Coelogyne cristata*, blooms at Godaveri in the spring; a smaller white orchid with an orange center, *Dendrobium longicornu*, bursts forth in October on the Shivapuri ridge. Pale *Plione* orchids poke through a moss covering to blossom in March, while the Spider Orchids are seen in September. Bamboo Orchids come out in August on Nagarjung. The Satyrium Orchids dot grassy hillsides in July; Golden Orchids are out in May. Thus, in Nepal, one may find orchids blooming throughout the year. Each species is quite specific and usually blooms for only a limited period; one has to be constantly on the lookout in order to find different varieties (Also see HMG's Department of Medicinal Plants, Bulletin No. 2: "Flora of Phulchoki and Godawari").

Some orchids have attained a remarkable degree of anatomical specialization. Orchids are pollinated by insects; certain flowers, amazingly, have developed parts that resemble a female insect. Apparently a male insect, flying by, sees this "female" and stops to investigate. During his search, he is covered with pollen from the anthers of the flower. Finding no female, and quickly tiring of this flower, the insect is on his way only to be distracted, soon, by a

second flower. In this way he transports pollen from one flower to another. This high degree of specialization insures adequate pollination of the flower; but if some misfortune were to exterminate the insect in question, the orchid's future might also be affected.

Orchids are widely cultivated as an important economic industry in tropical places such as Hawaii and Singapore. In Nepal, we find that village women delight in ornamenting their hair with orchids, but otherwise the plants are not widely used. A type of *achar*, though, made from some *Coelogyne* pseudo-bulbs, is eaten in some parts of Nepal.

Orchids are thought of as tropical plants; so it is interesting to see in Nepal that orchids become more numerous as one moves from the Tarai up into the Mahabharat range (*i.e.*, away from the tropical areas). Orchids in Nepal are most prevalent in the moist foothill regions. Others are quite hardy, and it is startling for the uninitiated plant enthusiast to come upon *Plione* flowering on oak trees along the Symbhanjyang Pass (on the Tribhuvan Rajpath) in February when the orchid petals often are dusted with light snow. Similarly, Lady Slipper Orchids and Satyrium Orchids grow at heights of 3,500 m. to the north of Kathmandu.

The Influence of Man

Up to this point, we have been examining the subtropical and oak-rhododendron forests of Midland Nepal without much comment on man's activities. Humans, though, have had a profound influence on the landscape of Midland Nepal. Actually, most of Midland Nepal is covered with neatly carved terrace fields and small villages (and scrub plants on slopes too steep to be cultivated).

The story of man in Midland Nepal is bound to the story of soil. He has both wisely used and wastefully squandered this vital resource.

Importance of Minerals in the Ecosystem

As has been pointed out, minerals within an ecosystem are reused. Thus in Namura Ban, of Kabhre District, various compounds of phosphorus, calcium, carbon, and nitrogen are drawn up from the soil for use in plant bodies, but are again deposited there after the plant's death.

Nitrogen, for instance, is a vital element used in protein building and in energy transformations. Nitrogen forms about 79 per cent

of the air (by volume), and so it would seem to be readily available to plants. Or is it? Actually, gaseous nitrogen is in an unusable form. It diffuses into plant leaves through stomatal pores, but likewise filters right back out. Usable nitrogen comes from the soil. Air filters into the soil through natural cracks and openings made by the activities of animals such as earthworms and termites. Living within the soil are many microbes; some of these, especially nitrifying bacteria and nemotode worms, are capable of transforming the gaseous nitrogen into usable nitrates. These nitrates are then picked up by the root hairs and utilized in the plant body.

Once the plant dies and decays, the minerals contained therein are released into the soil where they can be picked up by the new-forming plants. Animals, too, may eat the plants and thus obtain essential minerals for the growth and life of their own bodies. Denitrifying bacteria also are present in the soil. They can reverse the process described above and reform gaseous nitrogen, thus maintaining a balance in the air.

So the growth, and indeed the life, of plants depends upon many things, including the conversion of nitrogen gas into nitrates. Should the converting micro-organisms be destroyed, nitrogen could no longer be fixed and the plants would die.

An important point in the concept of mineral cycling is that, should something disturb the ecosystem, valuable minerals may be lost. This does happen in Nepal when the soil is eroded away. Likewise, if plant tissues are taken away and do not have a chance to decay within the ecosystem, minerals are lost. Humans remove many plant tissues and quantities of minerals through agricultural harvesting. Consequently, man must replenish important elements through "fertilizing" the soil.

The picture that we find on Pulchowki and other Midland Nepal hills is of a virgin oak forest with rich soil and throbbing biotic activity. Man's presence in a forest can range from casual excursions, through selective exploitation, to complete destruction of the forest. In Midland Nepal and the Tarai, we have a tendency toward the last condition. Some species benefit (*i.e.*, increase) when man is around; others are harmed. Let us assume, then, that man arrives on Pulchowki and decides he needs the trees there for firewood and building. What happens then?

Soil, which is produced over thousands of years of climatic and biotic activity, is held on steep slopes by plant roots and friction. Other forest features also assist in retaining the soil. The vegetation canopy absorbs much of the shock of falling rain which would otherwise hammer at the soil. Creatures such as earthworms, beetles, and ants work through the soil, making it porous. This porosity allows water to be absorbed rather than letting it run off with considerable force. Thus in forests, soil layers are formed in which minerals can be retained.

Once the vegetation is cleared, creatures suited to forest life will adapt to the new conditions, move, or die. Most species cannot move to other forests (if the destruction is extensive), while adaptation takes many decades and is a slow process; so, the majority will die. Then laughing thrushes, orioles, leopards, barking deer, orchids, and rhododendrons no longer will be a part of the flora and fauna of Kathmandu. From an economic point of view, it may be argued, the loss of beautiful plants and animals is not important. Yet who can calculate the "economic benefit" of a relaxed afternoon beside a tinkling brook, enjoying the beauty of the flowers and butterflies and listening to the singing of melodious birds? After a relaxed picnic, the office worker may well return to his job with renewed vigor, not to mention new ideas. The importance of beauty cannot be quantified.

And on our "hypothetical Pulchowki," we now find exposed rocks, gullies, and inferior soil lodged in crevices or protected pockets. Well, you say, this picture is overdrawn and exaggerated. It may be. But on the other hand, it does not take long, while flying over Midland Nepal, to realize that there is little forest left at this altitude and that erosion is a serious problem. Much soil already has been lost.

Increased siltation levels, especially in relation to hydroelectric dams and barrages, is of simultaneous importance. A part of most hydroelectric schemes is to construct a reservoir above the dam from which water can be drawn at a constant rate. Flood control dams also need large artificial lakes in which to store water. High levels of siltation, though, may fill the reservoir so fast that the useful life of the project is severely curtailed. The Kosi River and projects along it are good examples of current problems faced in Nepal.

A great deal has been written about erosion and how to stabilize eroding soils. The best possible remedy for erosion is, of course, initial prevention through a thoughtful and ecologically sound exploitation of the forest. If some damage already has occurred, two major things can be done to prevent further loss. First, the force of the water runoff must be curtailed; the water must not be allowed to gain much momentum. And second, plants can be introduced to hold the remaining soil on the slope. Initially this is usually done with grasses.

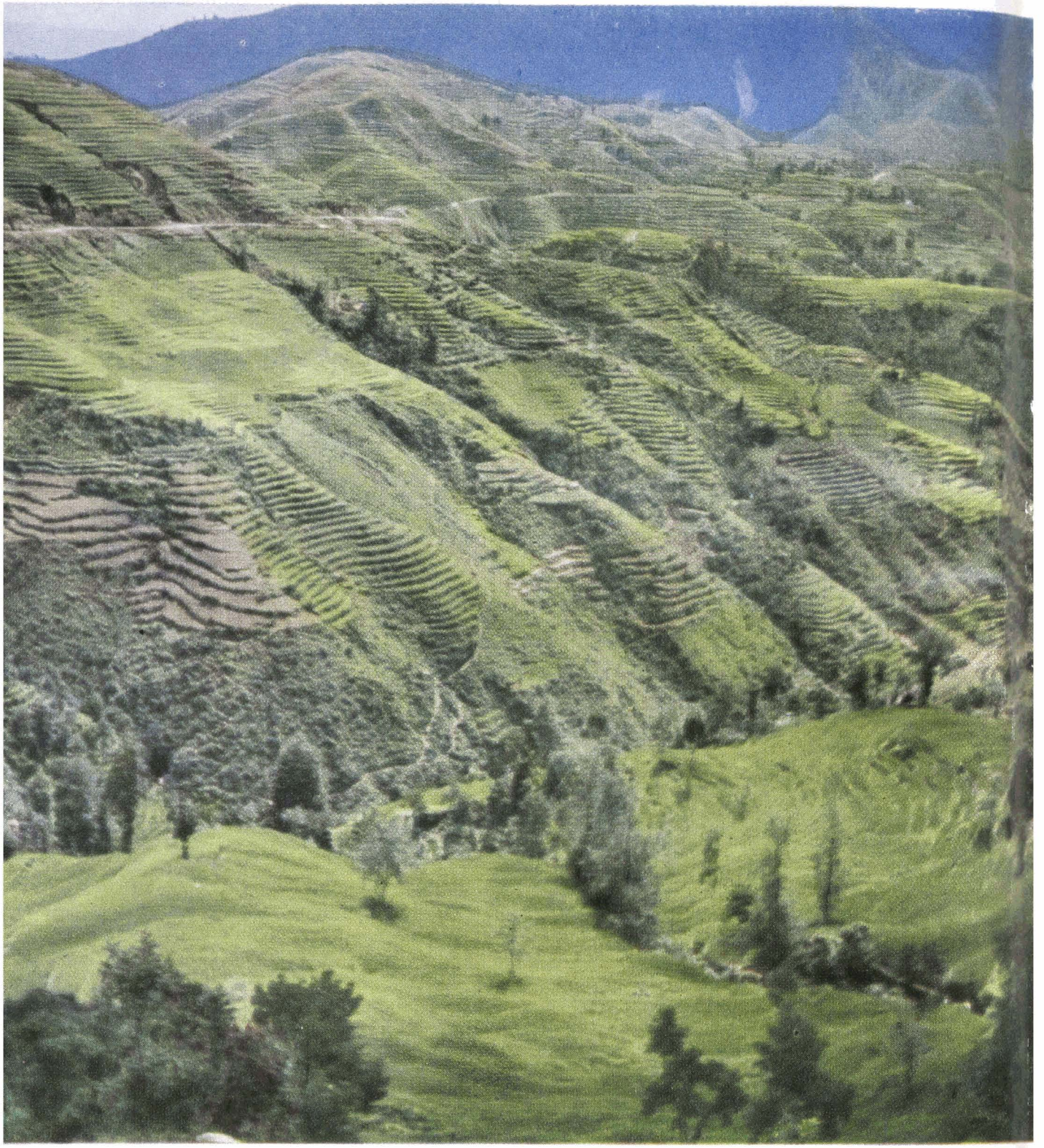
Grasses

Grasses are among the most important plant groups in Nepal, and indeed for most of the world. Grasses are plants with long, narrow leaves, obscure flowers, and usually extensive root systems. They are adapted to many different conditions from wet marshes to near desert-like areas. There are probably well over a hundred species in Nepal.

For erosion control purposes, grasses should be selected with a view to which species grow best at a given altitude. Certain species (*Imperata cylindrica*, for instance) have considerable soil binding capability; others are less effective. Grasses not only are important from an erosion point of view, but they are a crucial part of the world food production. Two of the world's most widespread crops — wheat and rice — are grasses. Likewise, corn and sugarcane fall in this category. Grasses are used widely for fodder, but it should be remembered that, under wilting conditions, a number of grasses are poisonous to eat. Other grasses are used in buildings and fences (bamboos), while some are woven into ropes and brooms. Thus, you can see why grasses make up one of the world's vital plant groups.

Extensive grass slopes now occur in Midland Nepal. Are these natural? Many are not, for they are maintained by a combination of overgrazing and fire. Other grass slopes, though, may well be a natural condition, given the slope angle and exposure. One finds that grasses usually occur on steep south-facing hillsides. It can be supposed that here the angle of the slope linked with the angle of the sun's rays produces a high transpiration-evaporation rate which then limits much plant growth. North-facing slopes (*i.e.*, facing somewhat away from the sun) are almost always bush- or tree-

26. Much of Midland Nepal is composed of terraced slopes and barren hillsides. Below the path and in the right foreground of the photograph is a grass-covered slope. The grass helps stabilize the hillside against erosion and soil loss. Grazing of domestic livestock is unrestricted above the path, and one can see the harmful effects of overgrazing in the erosion gullies and livestock " criss-cross " trails. Kabhre District, altitude about 1,300 m.



7. Most of Midland Nepal has been claimed for settlement and cultivation. Terracing helps reduce soil loss due to erosion. Nawakot District, altitude about 1,500 m.

covered. South-facing slopes near ridge tops also are often tree-covered because clouds develop here which reduce the radiation exposure. Southwestern faces are less affected by the sun than the southeastern, for in the mornings the sky often is clear while by mid-afternoon clouds have built up to obscure the sun.

Overgrazing

Overgrazing by domestic livestock is another factor directly related to erosion control. No matter how wonderful a theoretical erosion control program sounds, if nothing is done to reduce overgrazing by domestic animals, it will be ineffective. It is fascinating to travel in Midland Nepal and see slopes fenced off from domestic animals. Here luxuriant grass is grown, cut, and then used as roofing material. Immediately over the wall from the grass, the slope is virtually barren, the grass nibbled down to nearly nothing, and small erosion gullies are visible everywhere. Of the domestic animals in Nepal, the goat is perhaps the worst offender as it eats almost anything and everything. A rich grass stand can be reduced to a few scattered, unpalatable shrubs within a very few years by too many goats.

Terraces

Terrace fields are a conspicuous feature and a wonderful part of Nepal. Much of Midland Nepal is covered with terraces. Terraces, fortunately, are perhaps the best field type for steep mountain country. Although the terrace is one of the most difficult types of field to construct, many hundreds of people in past generations have expended countless hours in building them. Terraces hold the soil and help combat erosion. Thus, where these fields are well made, erosion is kept to a minimum (See Held, 1965: 64).

Travelling through Nepal now, one is sometimes alarmed at the new fields being prepared in marginal soil areas. One is not frightened so much at the fact that new fields are appearing, but that many of these fields are not being terraced. It is relatively easy, of course, merely to burn the brush and prepare the soil without bothering to build a terrace. With increasing pressure from an expanding population, signs of wasteful land use also are growing.

Population Pressures

The earth (and Nepal) can accommodate more people than it holds today — and it will be forced to do so. But there is a limit.

This is a natural conclusion, for there are just so many cubic centimeters of soil or air here. Space is simply limited; once that space is occupied, there is *no more*. Natural resources are limited; our ability to withstand crowding may be limited. Thus, unless there is some type of population growth stabilization, there can be little hope of either maintaining or improving the quality of our environment. Nepal has a population of about one crore. Now, consider what it would be like if 10 crore people lived here. For every 10 people you meet on the path now, then you would pass a 100. And for every 100 people you now see in Indrachowk, there would then be 1,000. Clearly, if future generations are to be able to live in Nepal, let alone enjoy living here, it is now time to act.

Pollution

The importance of man within the ecosystem cannot be overstressed. Man is the one species that can manipulate and drastically change natural ecosystems. Man already has altered much of Nepal, as he has natural systems throughout the world. Questions raised about our treatment of our environment transcend national and cultural boundaries; they affect us all. Thus, man, as a thinking creature, should pause from time to time to reconsider his actions in the light of increased knowledge and understanding of our world.

Pollution is a topic of ecological concern for everyone. Pollution is the contamination of water, soil, and air by waste products or foreign particles. Some pollutions can be in wave rather than particulate form. Recent attention has been focused on heavily industrialized sections of the world where pollution has reached crisis proportions, but it is not too early to consider the subject in relation to Nepal.

Many people living in Midland Nepal suffer from air pollution. But how can this be? Nepal is a land famous for sparklingly clear air. Coming from congested cities of the world, many people breathe a sigh of relief when they reach Nepal.

Speaking in overall terms, Nepal's air still is relatively clear, but throughout Midland Nepal there are thousands of small pockets of air that are thoroughly polluted. And it is here that the people concentrate. But where, you may ask, are these polluted pockets? In people's houses. Many houses in Nepal do not have adequate

28. Air pollution may become a serious problem for Kathmandu Valley in the future. The combination of the " basin effect " with the lack of much air movement in the Valley predisposes the region to trouble.

openings through which smoke from the cooking fires may escape. This trapped smoke, besides being uncomfortable, must certainly affect the health of the occupants — especially in regard to eye irritations and respiratory problems. A thoughtfully constructed stove, with a well designed smoke escape route, would do much to solve this air problem. One also can foresee the increased use of electricity in Nepal. Turning the energy liberated by water tumbling down mountain torrents into useful electricity would simultaneously relieve some pressure on the forests and reduce air pollution.

General air pollution is noticeable in Nepal in the late spring and early summer months. At this time, haze forms over Nepal through a combination of wind-blown dust from the Indian plains and the smoke of many grass and forest fires in both Lowland and Midland Nepal.

Kathmandu Valley would seem especially vulnerable to future air pollution problems. Given the Valley's bowl-like topography, combined with the lack of air movements and the constantly increasing number of polluting agents in the air, a serious problem could develop. Kathmandu Valley enveloped in a dirty-grey smog (familiar to many world cities) which stings the eyes, coats the buildings, induces plants to die, and obscures the rich panorama of the Himalayas would not be pleasant, either to the resident or to the visitor. One can foresee, without much difficulty, that enough improperly placed factories could contribute significantly to air pollution in Kathmandu which then could endanger Nepal's reputation as a beautiful mountain country and ultimately reduce her revenues.

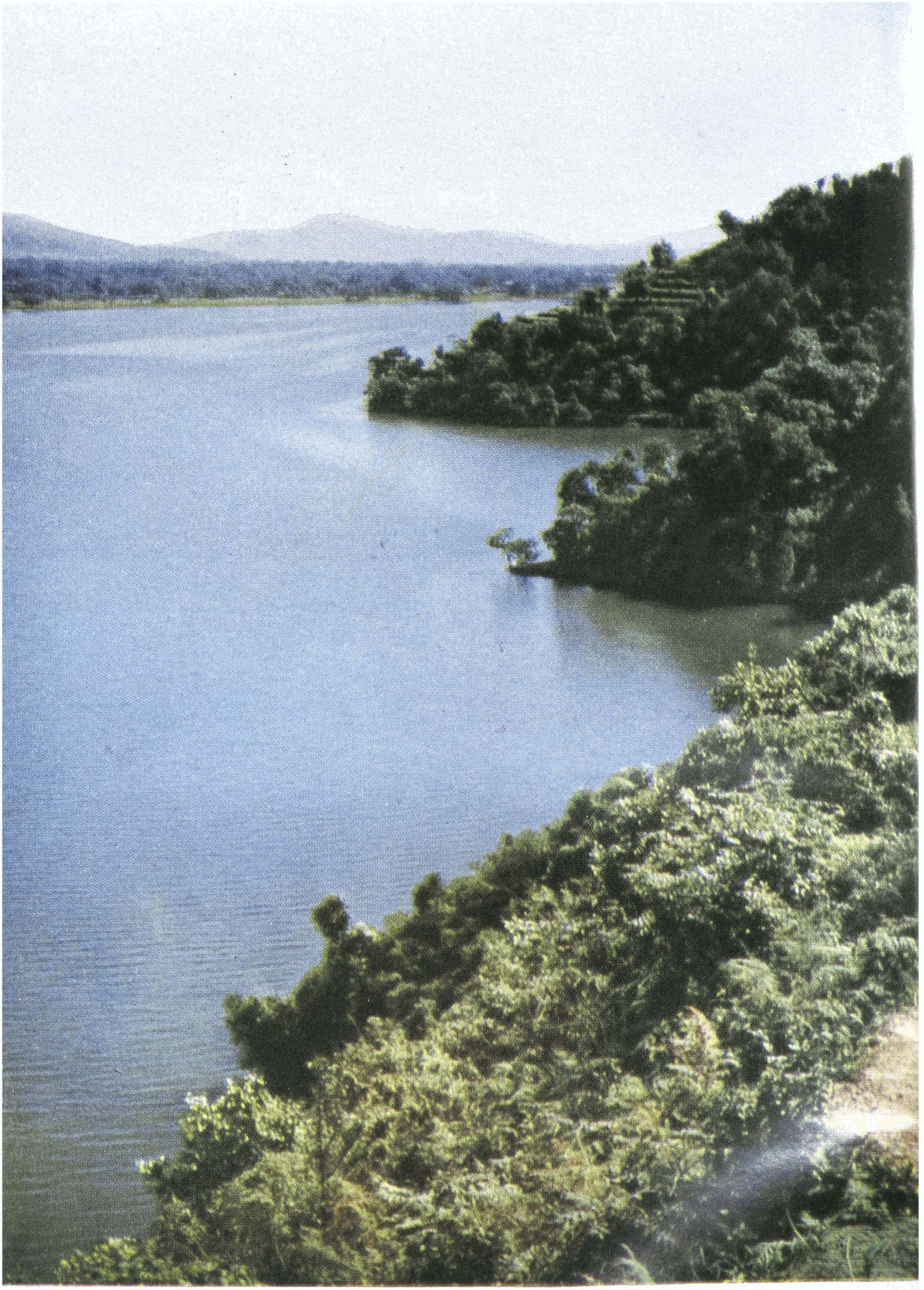
Wherever man exists, there will be some pollution. We will never be able to eliminate all pollution. Nonetheless, thoughtful control programs can do a great deal to keep down excess pollution.

Water pollution is of concern to people in Nepal. Soil particles and organic material washed into the waterways after rains are a natural form of pollution. This is a common phenomenon in Nepal and benefits areas and organisms in the Lowlands, but unfortunately man can increase natural pollution to unnatural levels. This is what has happened in some parts of Nepal: deforestation and overgrazing contribute to unnaturally high levels of silt in the Nepal rivers. To reverse the trend, one should consider restabilizing the soils throughout an entire watershed.

We are fortunate that chemical pollution of water is still at minimal levels in Nepal. Other countries are less lucky. Chemical pollutants in water come, partly, from factory wastes, fertilizers (when applied too liberally), and insecticides. Chemical pollution could become an irritating reality in the future; so we should act carefully here. When thinking about these conditions, the lakes of Nepal come to mind immediately. Most lakes in Nepal have slow water turnover rates which means that Phewa Tal in Pokhara, for example, could become badly polluted within a very short time if precautions in lakeside development are not taken.

29. Lily pads and other aquatic vegetation show that Begnas Tal, Pokhara, is biologic very active.

30. Land Crabs are found around most streams and pools up to about 1,900 meters in Mi



31. Phewa Tal, Pokhara, is biologically a fairly inactive lake. The clear water and lack of aquatic

Chapter Four Water in Nepal

Most of Midland Nepal is covered with land ecosystems, but there are some outstanding exceptions in the form of the Pokhara Valley lakes. Lake ecosystems, with their interacting plant and animal life, operate in much the same way as do land varieties. There are differences, though, especially in the inert factors of the aquatic environment.

We are fortunate in Pokhara to have not only magnificent views of the mountain peaks, but also two kinds of lakes. Phewa Tal, near the airport, is a deep lake with clear water, whereas Begnas Tal, 12 km. southeast of the airport, is shallow and has cloudy water.

Begnas Tal is biologically active; the shoreline is choked with aquatic vegetation while lily pads float on the water's surface. Frogs, fish, and birds abound. This is a good example of a productive lake. If one were to study Begnas, he would be concerned with several things including the oxygen content, temperature changes, and water movements at different levels. These would be directly related to lake depth, wind currents, and biotic activity.

Aquatic plants, especially the phytoplanktons which are microscopic plants such as bacteria and algae, are the mainstay of a lake ecosystem. These photosynthetic bodies provide food for innumerable microscopic animals including protozoa and crustaceans that in turn are fed upon by large creatures like fish, birds, and even man. In the shallowest parts of Begnas, lilies and other plants are able to take root and thus add to the activity of the lake. During the winter, numbers of ducks reside here, feeding mostly on the aquatic vegetation.

Phewa Tal, by contrast, is a deep, clear-water lake (except at a few points on the north and west shorelines). Aquatic vegetation is inconspicuous. This is not a productive lake, at least not in the same class as Begnas. This is not to say that nothing lives in Phewa — much does. If you examine the situation carefully, you will find that large fish lurk well down in the water. Little food for fish is

produced in the lake, but much nutrient material is washed into the water from the surrounding hills. The creatures, then, that live here are mostly scavengers, each searching the bottom for dead material drifting down from above. Because of this biological inactivity, wintering ducks cannot stay here for long as they find little to eat.

A lake is strictly a temporary phenomenon, for it is bound eventually to fill up or die through draining (This, of course, may take thousands of years for a large lake). In Nepal we have on display all stages in the "life cycles of a lake." Phewa Tal in Pokhara and Ringmo Tal of Dolpo District are in early stages which are biologically not very productive; Begnas and Mai Pokhari in Ilam District are intermediate and very active; while the Kathmandu Valley, a dried lake bed, is an example of what finally happens to all lakes (See Benton and Werner, 1966:198–247).

The Rice Field

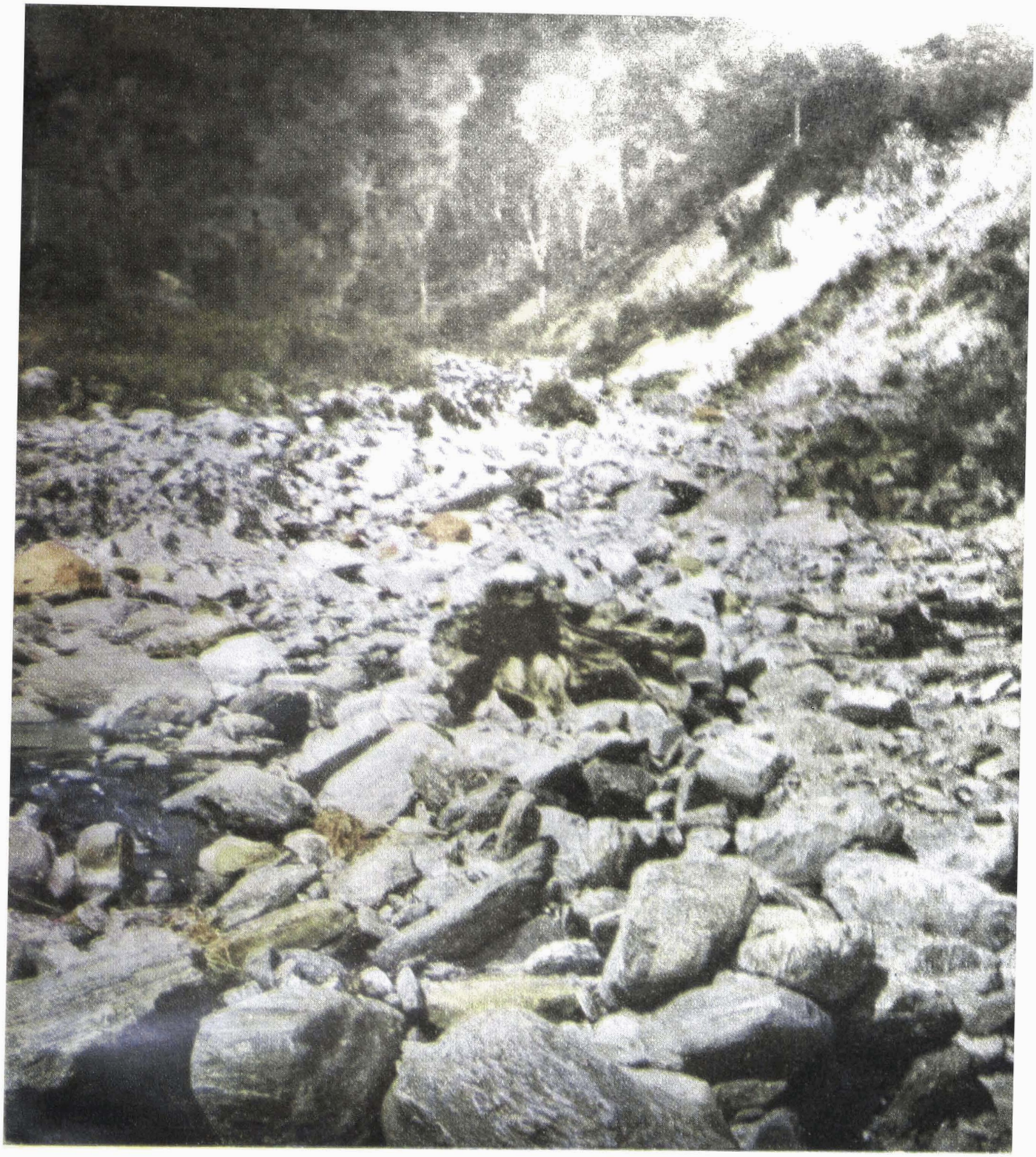
Another important aquatic ecosystem in Nepal is the rice field. Although strictly temporary, rice fields develop outstanding fauna which include fish, frogs, and insects (Larvae of mosquitoes are especially common). Although rice paddy fish cannot grow very large, often they are very numerous and can be most beneficial to man as a major source of protein. Fish cultures in paddy fields are being explored in detail in Southeast Asia, and this research may well be of great importance to Nepal.

From an ecological point of view, fish are important in insect population control. Many fish live primarily on mosquito and other insect larvae. One of the interesting fish found in Nepal rice fields has developed accessory breathing apparatuses which assist the fish to breathe when the water level is low. Further investigations of the rice field ecosystem in Nepal will be both stimulating and productive.

Streams

Mountain streams, another fascinating ecosystem type in Midland Nepal, are found within a few hours' walk of almost every village and town here. The Kathmandu Valley, although not well supplied with mountain streams, does have Sundarijal, where a fine stream flows down the mountainside.

The main feature of a mountain stream, as shown by the Bheri Khola that flows past Jajarkot, is the swift movement of water. This



32. The Tamai stream in Jhapa reflects natural erosion and the unstable geological condition the region. Heavy rains move tons upon tons of rocks and soil down these watercourses but a the winter, as shown here, little water flows. Hanspokhari Danda in the background.

33 *This hot spring at Syabrubesi, Rasuwa District, creates unusual conditions which favor the*

water also is shallow so that temperature change and other environmental fluctuations are felt quickly (as compared with most aquatic communities).

Aeration, of course, is excellent. Extreme turbidity, caused by great quantities of soil, boulders, plant parts including logs, and some animal materials, is characteristic of Nepal streams during the four-month summer monsoon period.

The main groups of animals in Nepal mountain streams are fish and insects. The latter usually are represented by their larval forms which can attach securely to rocks. Fish have narrow bodies adapted to reduce friction from water. In addition, they sport adhesive organs that allow them to cling to boulders. Not all fish manage to hang on during the monsoons, and some are washed into the plains of India (See Shrivastava, 1968: x). Considerable work is now being done on the special adaptations of Nepal mountain fishes by the Zoology Department, Tribhuvan University (See Majupuria and Shrestha, 1968).

Although we have been discussing a stream as a uniform phenomenon, one should remember that a stream really is quite varied. Semi-calm pools often form behind boulders lining the edge of the stream, and here other fauna, which might include Water Striders, can develop. Algae also may grow here and provide food for fish and other creatures. Small streams descending rapidly near their sources differ from the larger streams below. Similarly, glacial-fed streams, such as the Chilme Khola in Rasuwa District, differ from non-glacial streams like the Buri Ganga in Doti District.

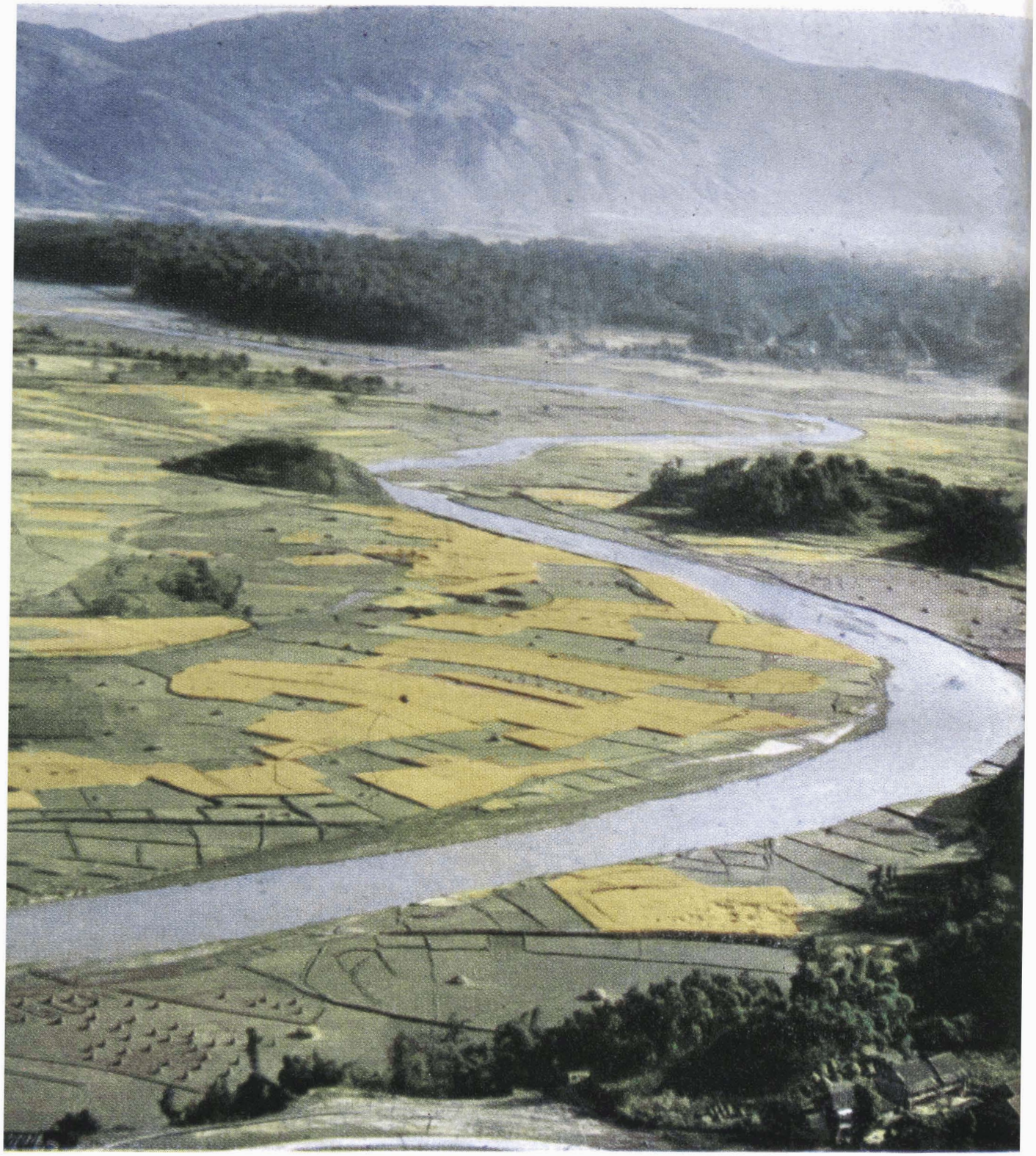
The mountain streams of Nepal are an important natural resource. Besides their potential for fish production, mountain streams can be used to generate electricity. Despite the huge initial cost of installing electrical systems, electricity will greatly benefit Nepal. One must consider too, though, the adverse ecological effects that hydroelectric dams may have on these streams and be aware of how to reduce damage to a minimum.

Hot Springs

Springs combining hot water with sulfur and iron compounds are found at several places in Nepal. Most hot springs seem to be along the edges of mountain rivers at altitudes of about 1,500 m. Tatopani on the Kali Gandaki in Myagdi District, Tatopani along the Sun

Kosi in Sindhu District, and the hot springs near Syabrubesi in Rasuwa District, are some of the best known.

Besides being of reputed medicinal value, the very specialized yet interesting ecosystem of a hot spring could form the basis of a fascinating study. Are there plants and animals adapted to living within the hot water? Does the presence of additional heat allow unusual species to live in an otherwise cool area? It has been noticed that peculiar algae grow near some Nepalese hot springs while little black frogs were seen around the Syabrubesi spring. Thus, hot springs do generate unusual conditions that should be more closely investigated.



34. The Kathmandu Valley was once filled with water, forming a lake. Over thousands of years, silt was deposited on the lake bed and these alluvial soils form the level surface you now see covered with rice fields. October.

Chapter Five

Man Living with Nature: The Kathmandu Valley

THE Kathmandu Valley today is cultivated or urbanized, although at one time most of the Valley, except the immediate river beds, was covered with forest. One might expect that, in a region of about 200 square miles where half a million people live, little would be left of faunal or floral interest. In some European and Asian countries, this would be true, but not in Kathmandu. In fact, here the tolerance of man towards nature makes this a fascinating place to observe intensive human activity mingled with the lives of many mammals, birds, insects, and plants.

The Kathmandu Valley floor, at about 1,370 m. altitude, is a fairly uniform place — at first glance. Actually there are a number of habitats here: city and village, field (wet and dry), hedgerow, forest (preserves), small lake, and river (including sand banks). The fields here are mostly terraces for rice in the summer and wheat in the winter. Vegetables and mustard (for oil) are also common. Bricks are a winter " crop " extracted from some fields.

Trees

As one walks or rides around the Valley, he often admires trees lining the roadsides. He may wonder what these trees are. Where are they from? Who planted them here? Upon further investigation, he will find that most trees along roadsides originally were from outside of Nepal; in fact, Kathmandu is a horticultural garden with trees from many parts of the world. The Bottlebrush tree is common along roadsides and has pendant red flowers that form a " bottle-brush " impression. Silver Oaks (not oaks at all, really) have frilly leaves with a silver-like sheen on the undersides. Their orange flowers open in the spring. Both these trees are from Australia. Eucalyptus, also Australian, was first introduced in the early 1900's and thrives on the road to Godaveri; a fine specimen stands in front of the General Post Office in Kathmandu. These trees have a very distinguished, smooth, white bark, and a faint aroma of eucalyptus oil permeates the air around them.

Sacred Fig trees (Pipals in particular) are scattered throughout the Valley. These trees are indigenous in Nepal (usually below 1,000 m. elevation). There are several Pipal trees along the Godaveri road and a favourite grows right in the center of town—just off Juddha Sadak and 50 m. east of former Prime Minister Juddha's statue.

A number of coniferous trees have been planted in Kathmandu. Conifers are those with needle-like leaves and seeds contained in "cones." The only conifer normally found at the level of Kathmandu is the Long-Needled Pine. These can be seen at Tripureshwar and Thapathali, to name only two places. They are common, also, on the road to Pharping and up to Tokha. The Deodar, one of the most stately Himalayan trees, is found on the grounds of Singha Durbar and Kaiser Mahal. This tree, a true cedar, is a West Himalayan species not normally found this far east (It grows naturally in Jumla and Tibrikot Districts). The Cryptomeria from Japan is also found in Kathmandu as is the funny-looking Monkey Puzzle tree (in Rani Bari, Rani Ban, and Kaiser Mahal grounds) from Australia.

Away from the main urban centers, one may find indigenous tree species such as the Willow trees along the streams. Generally speaking, though, local trees are best seen in the Valley's forest preserves.

Forest Preserves

There are four major forest preserves on the Valley floor: Rajnikunj, Rani Bari, Gauchar, and Chapagaon. The best known is Rajnikunj, or King's Forest, located beyond Baudha on the northern side of the Valley. Planes landing at the airport often approach over Rajnikunj. For those who do not have time to go farther afield, Rajnikunj is well worth a visit. Besides at least 232 species of plants (as listed in the "Notes of Flora of Rajnikunj" available from the HMG Ministry of Forests), there are many birds and numerous introduced deer.

The Rajnikunj, forest, much like other natural forests at this altitude in Nepal, is composed of three major vegetation layers or levels. A tall tree layer includes schimas, laurels, and chestnuts, while a small tree level consists of White Oaks among numerous relatives of the apple (Rosaceae). The shrub level also is composed

35. Many trees now growing in the Kathmandu Valley have been imported from distant lands. These white-barked Eucalyptus trees lining the road to Godaveri are from Australia.

36. Kathmandu Valley has a variety of habitats and ecological conditions. Here we see four habitat types : terraced wheat field, loosely-knit village, barren hillside and pine forest. The pine forest is a reforestation project and the Agave plants framing the picture are from Central America. Picture taken along the Godaveri road in March.

of many species including the daphne. The ground is carpeted with various ferns, mosses, and herbaceous flowering plants.

One of the main features of this forest is the extraordinary number of deer. The most prevalent species here is the Spotted Deer, which does not occur normally at this altitude in Nepal. These deer are lowland animals where they live in grasslands and along forest edges; they are a prime target for prowling tigers. The Spotted Deer appear to be doing fairly well in Rajnikunj although they are abnormally small (due to overcrowding, no doubt) but do seem a bit out of place to the ecologist who knows where they usually live. The little Barking Deer and the large Sambhar Deer also are in Rajnikunj and do not seem out of place, for they are found naturally in the Midland hills of Nepal.

The closest forest patch to downtown Kathmandu is Rani Bari, or " Queen's Garden." It only takes five minutes by car to reach Rani Bari from downtown Kathmandu. To get there, one should go along the Buddha Nilkantha road to Maharajgunj; and, as you start the climb up to Pani Pokhari, you will see the preserve just north of the pine-covered Indian Embassy grounds. This forest was said to have been established in the early 1600's for a Malla Queen. Some of the trees, especially the large fig at the north end of the preserve, are quite old. Over a 100 species of birds have been recorded from this little forest tract; large mammal species, though, are absent. Jungle cats and jackals sometimes are noted. The tall tree level is well developed (laurels, figs, schima, among others), but the bush and secondary levels are greatly disturbed by constant human interference.

The Gauchar forest between the airport and Pashupatinath has many tall trees but very few bushes and small plants. There is much disturbance in this forest, but Rhesus Monkeys are interesting to watch and draw one's attention. The Chapagaon forest, at the south edge of the Valley, has many exceptional trees and birds and is well worth a visit if one can negotiate the rather bumpy road. The Paradise Flycatcher, for example, is more common here than in any other part of the Valley. Occasionally, leopards wander into the preserve from the surrounding hills, but they are not common.

Birds

Although the Kathmandu Valley floor offers neither a wide range of altitudes nor many " natural " areas, it is still faunistically rich.

During the course of time, a number of animals have adapted to living in close proximity to man; birds are especially obvious in this respect. Of the vertebrate animals in Nepal, birds are probably by far the largest in number, both in individuals and species. There are, in fact, less than half as many mammalian species and an eighth as many fish here as birds.

Consequently, it is not surprising that people in Nepal notice birds immediately. In downtown Kathmandu we see Pigeons, House Crows, House Sparrows, Common Mynas, Common Swallows, and House Swifts. Night Herons perch on the fence of Rani Pokhari, white Cattle Egrets nest in the grounds of Kaiser Mahal. There are about 400 bird species in the Valley (See Fleming and Fleming, 1970), but one would not expect to see all of them on the Valley floor; nor are they all here at one time.

Some birds in Nepal are adapted to finding food in wet places and along streams. Others prefer fields, while some select the forest. In the Kathmandu Valley, one may locate mountain birds, plains birds, stream birds, and occasionally even desert birds. Naturally one does not see oceanic birds. But, wait a minute! Most birds of the ocean do not come to Kathmandu, even though some people consider Taudha Jheel fairly large; but some oceanic birds *do* visit Kathmandu for short periods. Recently, a Great Blackheaded Gull landed on the Bagmati near the University. This gull nests around the Caspian Sea, and in the winter it moves southward and eastward to as far as Singapore. On their way back to the Caspian, some individuals apparently follow along the Ganges River and then cross to the Arabian Sea. On such a journey, several regularly visit the Nepal Lowlands, and sometimes one or two stray into Kathmandu.

Crows

The common birds of the Valley floor, though, are usually resident species or birds that come here for the summer months. The House Crow, a black bird with a grey mantle, is common in Kathmandu City. This crow, abundant over the Indian Plains, is very much adapted to living near man. It is so attached to man and his urban centers that you could sit for years on the forest-covered ridge above Sundarijal before possibly seeing a stray House Crow. And yet, just a mile from where you sit, they are common! Why is this crow so closely tied to humans and their towns? The answer is not

entirely clear but must be related to food given or protection afforded. Anyhow, the crow definitely benefits man, for it assists in clearing away garbage and various dead animals.

The Jungle Crow of the Kathmandu Valley is completely black. It is larger than the House Crow and is more broadly adapted to Nepal than its smaller cousin. These crows dwell from the plains up into the high mountains. Even in winter, they circle up to at least 16,000 feet over slopes above Jomosom in Thakkhola, for example. Whereas the Jungle Crows are found near humans, they also reside in open country and in forests. In fact, this is one of the most widespread birds in all Nepal. While most birds are quite limited by diet, altitude, and habitat, Jungle Crows range freely. The major reason for this freedom is diet. The crow is omnivorous; it will eat anything, from scraps thrown out by a picnic party to dead animals and also berries and twigs. When a crow can, it will catch and eat small animals and rob birds' nests.

By human measurements, crows are considered intelligent when compared to many other birds. It is reliably said that they can recognize the difference between a walking stick and a gun (if they have had previous experience with both). Crows are very alert and remain suspicious, but they are also curious and often move into better positions to see what is going on. Play is part of their daily routine, and they seem to enjoy playing among themselves or teasing other birds or mammals (Monkeys are a favorite).

Jungle Crows are an example of an animal operating within an unusually broad ecological base. Here is a non-specialized, general animal that is a predator, forager, and scavenger. No wonder, then, that they are so widespread and numerous. As with all creatures, though, crows do have enemies; these might be listed as man (occasionally), nest-raiding mammals, koels (for raising young), and hawks. The crow's relationship to man is largely beneficial to both and is partly responsible for the size of the crow population.

House Sparrows

Another Valley floor species that is common here, but is not nearly as broad-based as the Jungle Crow, is the House Sparrow. These birds are grain and seed eaters; feed them only berries or meat scraps and they would likely die. Thus they cannot range about as crows do. But the sparrow is similar to the crow in that it

also lives in close proximity to man. When one examines the distribution of House Sparrows in Nepal, or in other parts of the world, he finds House Sparrows only where man lives. Why is this? What dependency on man does the sparrow have? Food is obvious. Were humans entirely carnivorous, without their extensive wheat and rice fields, sparrows could not exist in such numbers. The next point is less obvious. Apparently, houses of humans afford protected nesting sites for the sparrows. What benefit man derives from the sparrows is not clear.

The House Sparrow in Kathmandu is interesting from another point of view, too. If you look closely, you will see that there are actually *two* types of sparrows around the towns and villages of the Valley: the House Sparrow and the Tree Sparrow. The Tree Sparrow has a reddish-brown forehead and crown while the male House Sparrow has grey at these parts. Both of these birds dwell close to man, but rarely do they live right together as here in Kathmandu. As has been mentioned, an ecological theory states that no two species of animals can occupy exactly the same niche in nature — there must be some differences. If no differences exist, then, it is thought, the competition results in the defeat (extermination or shift) of one species. The question is, then: How do these sparrows differ?

The House Sparrow is widely distributed over Europe, North Africa, Central Asia, and India with recent introductions in North America and elsewhere. The Tree Sparrow, on the other hand, is found in Europe east through China and down into the Oriental Region (See Ripley, 1961:593–595). Nepal falls in the zone of overlap. Mussoorie in the Western Himalayas has only House Sparrows, Kathmandu both, and Darjeeling in the east only Tree Sparrows. Kathmandu, then, is a natural laboratory where one could study the difference between these birds. Is one species pushing the other out? You may notice in downtown Kathmandu that where people are most crowded, only House Sparrows live; toward the edge of Lalitpur, the proportion swings to about half and half. In outlying villages, Narayanthan, for example, there are only Tree Sparrows. Apparently the Tree Sparrow is still more of a field bird than the House Sparrow. What will the situation be here in 50 years? Only House Sparrows left? A study of population trends over a three- to five-year period would give some idea.

Common Mynas

Another creature closely associated with man is the Common Myna. This brownish bird with white wing patches occurs through the Kathmandu Valley, but as soon as one moves into the forests on Nagarjung, for example, there are none. Just what advantage it is for Common Mynas to live near humans again is not well understood; many other myna species have only a casual attachment to man. Like the crow, the Common Myna is practically omnivorous for it will eat scraps, berries, and insects; they will eat grain, also.

Common Mynas prefer to nest in the proximity of human dwellings; in fact, they often select holes up under the eaves of some house. Occasionally, people with myna nests in their houses are greatly distressed. Suddenly a wall near the nest may be covered with lice. Mynas carry great colonies of bird lice.

Almost any bird or mammal is the host for innumerable parasites, both internal and external. As mentioned earlier, some of these parasites become so specialized that they cannot live without one particular species of host. Fortunately, this is the case with myna lice for these small creatures are so narrowly adapted that they can live only on Common Mynas and closely related species. If myna lice crawl on you, you have no need to worry; they cannot possibly bite you or live very long on your "foreign" body (There are human lice too; these are so specialized that head lice cannot survive on other parts of the human body, whereas the body louse does not live on the human head). There are many different types of bird lice and each is specialized, so one can sometimes tell the relationships of the bird hosts by examining the similarities of the lice.

Snakes

Snakes are another type of animal that often live near or in human habitations. While it is sometimes hard to understand why some birds reside near humans, it is not so difficult to explain why some snakes do. Certain snakes such as the Common Dhaman (Rat Snake) feed on rats and mice. These mammals may dwell in far too great a number about villages and are naturally followed by rat snakes. This also shows why snake-eating snakes, cobras for example, haunt houses.

Snakes, as temperature-sensitive animals, are found primarily in tropical climates. Nonetheless, there are some varieties, one of

which is poisonous, that ascend the Himalayas to at least 3,300 m. elevation. During cold months, snakes usually are not about for they presumably undergo a long winter rest deep in an underground chamber.

Snakes are well-known reptiles of which there are about 2,800 kinds in the world (See Schmidt and Inger, 1957:69). In Nepal, we have probably about 70 varieties, although the total number may not be known for some time yet (See Swan and Leviton, 1962:139–142).

There are many superstitions about snakes. Snake charmers will tell you that the music of their flutes tames their specimens. This is a bit hard to understand from the scientific point of view for snakes do not have ears and cannot "hear" music. They are sensitive to vibrations, though, particularly those transmitted through the ground, so that as you walk along, the reptile can "hear" you through the vibrations in the ground.

Snakes can see fairly well — but only at a close range. Their eyes are not movable and are not equipped with focusing devices. Tasting and smelling organs are well developed in most snakes. In fact, if you watch a snake for any length of time, you will see its forked tongue flicking in and out. What is it doing? Some people think it is getting ready to sting with its poisonous tongue. This, of course, is nonsense as the tongue is not poisonous. The snake is actually picking up minute chemical particles on the tip of its tongue. The tongue is then inserted into a pocket in the roof of the mouth (palate) where there are a great number of super-sensitive chemical-sensing nerve endings. In this way it "tastes" the air and thus the snake knows what is happening around it.

A specialized sensing device is found in the pit viper group of snakes. We have several representatives of this family in Nepal, three in Kathmandu. Between the eye and nostril of a pit viper is a depression or "pit" which is a heat-sensing organ. With the use of this "pit," the pit viper can detect warm-blooded animals (which are its main food item) even in pitch darkness.

Some people think that *all* snakes — and lizards — are poisonous. This is not true. Poisonous snakes are in the minority in Nepal — and in most other parts of the world as well. A poisonous snake is one which has modified salivary glands that secrete poison through or around enlarged and modified teeth (called fangs). In Nepal, we

have two types of poisonous snakes: some have fixed fangs (*e.g.*, kraits, cobras, coral snakes); others (the vipers) have long fangs which fold back when the mouth is closed.

Poisonous Snakes of Kathmandu Valley

In Kathmandu there are at least four species of poisonous snakes: three pit vipers and one coral snake. None of these, fortunately, is common. The frequency of these snakes is not fully clarified, but data so far suggest you may see about 10 non-poisonous snakes to one poisonous one.

Pit Vipers

The commonest poisonous snake of Kathmandu, and Midland Nepal in general, is probably the Mountain Pit Viper. This creature is brown with mottled dark brown markings and has the usual triangular head of the vipers. The bite of this snake is not often fatal; in fact, the symptoms are generally mild. Very young children, though, could be seriously affected. The two other vipers are Green Pit Vipers, whose bites can be dangerous, but not necessarily fatal.

The Coral Snake

The really dangerous snake of Kathmandu, the Coral Snake, apparently is rare here. This slender creature may reach a length of about three feet, and its color pattern is somewhat variable. A fine specimen in the Anand Kuti Science College collection is maroon-red above with a black head bisected by a broad white line across the crown. The short tail has three black rings, and each vertebral scale has a black dot so that one sees a row of black dots right down the middle of the back.

Coral snakes are closely related to kraits and cobras. Their venom is primarily neurotoxic — it affects the nervous system of the victim. The vipers have a hemotoxic venom which affects the circulatory system. Some elements of both venom types are found in most snake poisons. Poison is primarily used to immobilize and help capture animals that the snakes eat; defense is a secondary benefit.

One intriguing situation in Kathmandu is that there are no cobras here (Apparently some cobras were introduced into the Balaju and Nagarjung region, but their continued presence remains to be

confirmed). Common Cobras are found up to at least 2,000 m. on the outer Himalayan slopes, so Kathmandu lies well within their altitudinal range. Why are there no cobras here? Perhaps it is because Kathmandu lies quite far back from the plains and the cobras have not managed to push past unfavorable ecological barriers. The King Cobra, a forest and hill species, occurs as high as 2,200 m., but even this snake has not been reported in hills surrounding Kathmandu.

One short note should be added before we move on to the non-poisonous snakes. In Rajendra Shrestha's snake collection at Anand Kuti Science College, there is a fine example of the deadly Lesser Black Krait. This specimen is uniform blackish and about two feet long. This animal is thought to have been found in the Swayambhu area but confirmation is needed (See Fleming, 1970:13).

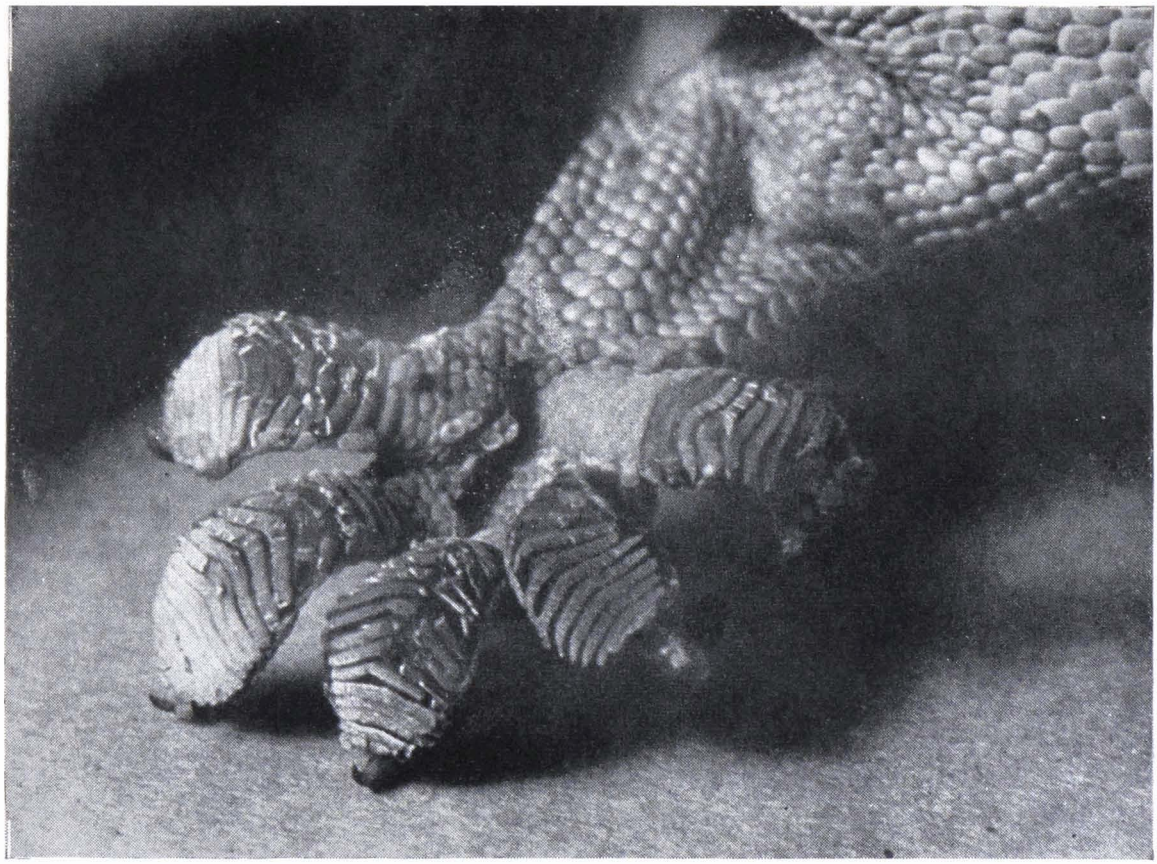
Non-Poisonous Snakes of the Kathmandu Valley

Several non-poisonous snakes are quite common in Kathmandu. Of these, you are most likely to see the Rat Snake (Dhaman), the Striped Keelback, or the Wolf Snake.

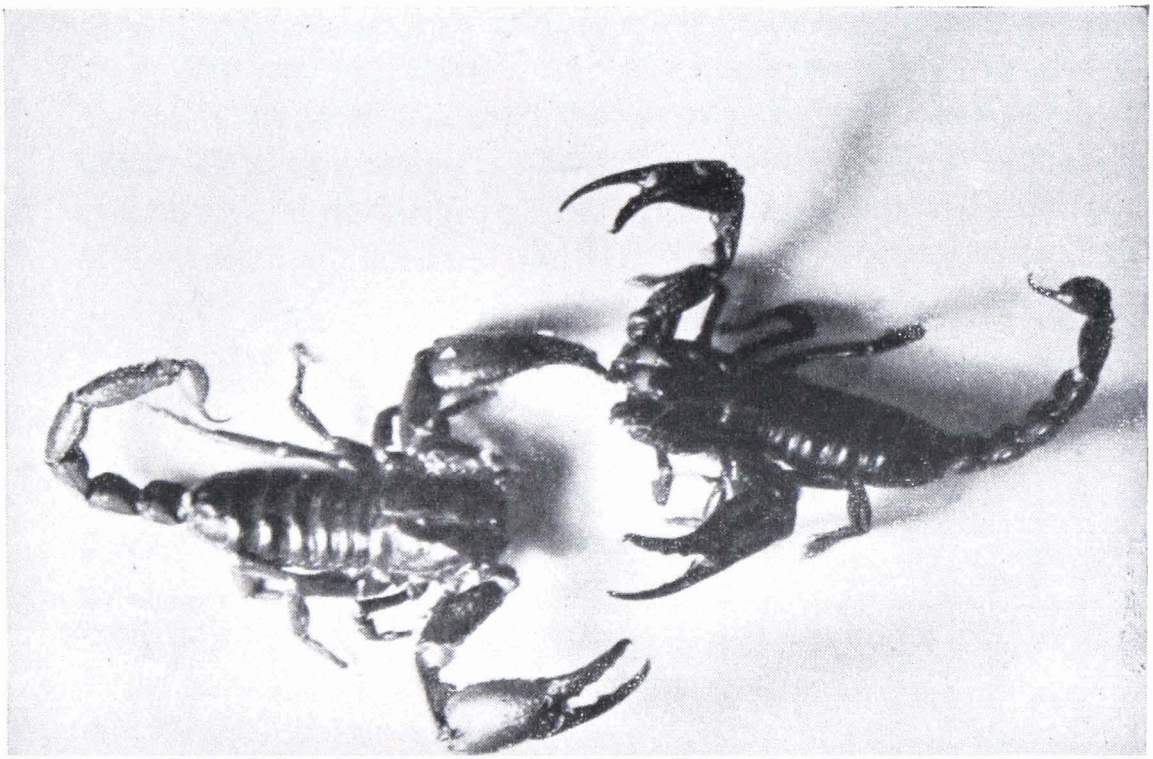
The Dhaman is a rat-eating snake that also pounces on frogs and toads. This creature can look quite frightening, for it may be two meters long and moves quite quickly. Old individuals are uniform black or dark grey above, and slightly lighter underneath. Young dhamans are greenish, then they change to grey, and eventually to black. Their coloration is uniform without any significant markings except several dark lines on the upper labials (lip scales). The shape of the dhaman head is not very distinctive and is certainly not triangular like the vipers. Some people judge that non-poisonous snakes have less distinctive heads than the poisonous types. This is a dangerous way to assess snakes, for some deadly Nepali snakes have heads that are not very distinctive.

The Keelback is a water snake with noticeable stripes down the sides. These stripes become more prominent toward the rear half of the body. These small snakes, which rarely reach over one meter in length, often are found in the grass at the edges of gardens. This is perhaps the most common snake of the Kathmandu Valley and Midland Nepal as a whole.

Wolf Snakes are distinctive creatures with bright yellow crossbars (They are sometimes cream-colored) on a brownish background.



37. A Gecko Lizard of Nepal, showing the amazingly rough pads on its feet. Note that there are no " suction cups " here. The lizard can climb walls because its pads adhere to uneven surfaces.



The bars are most visible on the forward half of the body and may become indistinct towards the tail. This harmless species appears to be addicted to the neighbourhood of people and often is found within houses. One was caught recently at Asan Tole in downtown Kathmandu. Wolf Snakes are thought to eat other small animals — mice, lizards, and possibly other snakes. The Wolf Snake is quite similar looking to the deadly Common Krait of the Tarai; Wolf Snakes often are mistaken for Common Kraits. The head of the Wolf Snake, though, is quite a bit broader than the neck, while the Common Krait's head is about as wide as the neck.

Lizards

A group of animals very closely related to snakes is the lizards. Lizards which do not have legs (One species may be found in the Eastern Tarai) look remarkably like snakes. We do have lizards, but not legless varieties, in the Kathmandu Valley. There are approximately 2,800 lizards in the world; so far only 13 have been found in Nepal. This shows that our lizard fauna is quite poor, but nonetheless there are representatives here of some interesting families.

Geckos

During the evening in Kathmandu, you may notice a small lizard running across the wall of your room. This animal seems to be attracted by light, for it rests near a burning light bulb. If it is attracted to light, though, why is it out at night? This is strange indeed! The answer is that the lizard is not especially addicted to light; but, since it eats insects which flock toward light, it too gravitates in that direction. The lizard we have been talking about, the House Gecko, is common in Kathmandu as well as over most of Lowland Nepal.

Geckos are a large group of lizards that possess specialized feet for climbing. You may have seen them climbing up a vertical glass window-pane. How can they do this? They must have suction cups on their feet! After close examination, you will find no cups at all. Instead, the pad is composed of innumerable lines. Each line has many little hook-like processes which are able to adhere to minute irregularities in a glass pane. On really smooth surfaces (like polished

Godaveri marble), a gecko will have a hard time. Thus you may marvel at how a gecko can travel across your smooth ceiling until you realize that the ceiling is really quite uneven and that the gecko's friction pads can take hold easily.

Reptiles are a strangely silent group. If you think over your experiences, can you remember hearing reptile noises? Birds, classed near reptiles, make multitudinous sounds. Then frogs (amphibians) fill the night with their love songs. But reptiles score a near-zero. One of the major exceptions to reptilian silence is the geckos: they make a variety of noises at night. Our House Gecko in Kathmandu has a soft *tok tok* call which does not disturb one's sleep, but the large geckos in Southeast Asia call so loudly as to frighten newly-arrived visitors.

Geckos are nocturnal and in this way differ from the majority of other lizards. The anatomy of the gecko clearly shows it is a nocturnal animal: it has large eyes. These eyes have transparent coverings but no real eyelids. The eyes are movable under the disks and are moistened in the usual manner through lizard tears.

The importance of geckos in the ecological balance of nature would appear to be one of insect population control. Like most lizards, geckos are predatory and carnivorous; so they stalk or lie in wait for their prey (Large lizards, such as the Varanus Monitor of South Nepal, eat mammals, birds, and whatever else they can catch).

Skinks

On walks and picnics around Kathmandu, one is apt to hear, especially at Balaju or on Nagarjung, a slight rustle and see a dark brown lizard dart beneath a stone or a leaf. This is a Common Skink.

From a distance, skinks appear to be shiny smooth, but on close examination, one can see that small scales evenly cover the body. Skinks are primarily subterranean animals, but here in Kathmandu they emerge to sun themselves on warm days.

Animals adapt to their environment. Since skinks live primarily underground, they have evolved certain modifications that assist in this form of life. The body, as has already been mentioned, is smooth; it is also long and thin. You can imagine a very fat, spiny creature trying to fight its way through a small tunnel. In many

skink species, the legs are severely reduced in size. Our Kathmandu skinks have fairly strong legs, as skinks go, which probably indicates they are not so completely subterranean as others.

Try to catch a skink some day and you may discover one of its interesting anatomical features. Down comes your hand as the skink is scurrying for a safe burrow, and you have it pinned by the tail! Suddenly the tail breaks off and the portion in your hand wriggles violently, distracting your attention for a moment while the skink makes good his getaway. Later, a new tail will grow (but it will not have vertebrae as the first tail did). Skinks are not the only lizards with this safety adaptation: Geckos are similarly equipped. Some skinks have carried this adaptation to the point where the tail is a bright color, contrasting to the rather dull body. When a bird pounces on an object, it will often strike for the brightest and most noticeable (*i.e.*, colored) part, and so hit the tail but miss the skink. Our Kathmandu skinks are not this specialized, although they do run considerable risk from meat-eating birds. Almost any carnivorous or omnivorous bird, including the little Pigmy Owlet, will catch skinks for food.

The eyelids of skinks show unsual features. As skinks are subterranean, their need for vision is reduced, and subsequently their eyes are modified. The lower eyelid is the main eyelid in skinks and variations are found in this organ. Some lower eyelids are "normal" (*i.e.*, When they are closed, the lizard cannot see). Other skinks have a small transparent window in the center of the lid so that they can see even with the eyelid closed. In some species, this transparent window is nearly the whole lower eyelid! A skink of this variety is found in the hills of Eastern Nepal; our skinks of Kathmandu are those with "normal" eyelids. Then there are completely blind skinks; but these are found only in Africa.

Fence Lizards

When most people think of lizards, they usually picture a familiar animal perched on a fence post or some warm rock. Our "typical lizards" are in the family Agamidae which is restricted to Africa and Asia. The lacertiids and iguanids are similar looking lizards found in Europe and the Americas.

The common garden lizard of the Valley, the Common Indian Bloodsucker or Fence Lizard, is an agamid. The English name

"bloodsucker" is an erroneous one, for this lizard pounces on insects and munches on plants and has nothing to do with blood. The English name comes from the bright red head and neck of the males which look as though they had been dipped in red paint or blood.

The red color shows primarily when the male is excited. What is the function of the color? You might think the red attracts the females, but a more likely explanation is that the bright colors and throat fanning are related to frightening off rival males. The Fence Lizard has an ability to change colors; in fact, most lizards can do this. Some people confuse all color-changing lizards with chameleons. True chameleons have most unusual, independently-working eyes, very slow movements, and a very long, sticky tongue. None have been recorded in Nepal, although they are found in parts of Central and South India.

Some people fear Fence Lizards because they are considered poisonous. This is nonsense. There are only two poisonous lizards in the world (the Gila Monster and Beaded Lizard of the Americas); all the rest are non-poisonous. This is not to say that lizards don't bite. They have many sharp teeth and can leave a nasty cut which may well become infected, but they are certainly not poisonous.

Snails

One of the conspicuous creatures around Kathmandu gardens during the wet summer months is the snail. Since snails are vegetarians, they can be serious pests in the garden and need to be "weeded" regularly. Snails are soft-bodied invertebrate animals which have the remarkable distinction of being able to carry their houses around with them. When danger appears, snails retreat into their calcium shells to await further developments. Slugs also are common in Kathmandu. They are essentially snails without shells. The breathing apparatus of snails and slugs requires moisture for the transfer of oxygen into the system, and this is one reason that you find these animals moving about extensively only in wet weather.

Snails, although abundant in Kathmandu, are not eaten here. In some places snails are relished as a delicacy. Thus, snails are not commercially important in Nepal; but they could form a constant supply of laboratory material that could be used for simple experiments relating to animal behavior.

Snails are preyed upon by other animals, and some snail predators have become so specialized as to exist almost entirely on snails. This narrow ecological limitation is dangerous to the species, though; for if the snails should disappear, the predatory species would be seriously threatened. Such is the current case in Florida, U. S. A., where a snail-eating hawk is now close to extinction due to the present lack of suitable snails. In Nepal, the Openbilled Stork of the Eastern Tarai eats quantities of snails — but its diet is not entirely restricted to that food item.

Snails are involved in some medical problems, for they are the intermediate hosts of a small bloodworm that causes the serious schistosomiasis disease. One finds this affliction prevalent in some African countries; fortunately, it does not occur, as far as is known, in Nepal.

Scorpions

The invertebrate fauna of the Kathmandu Valley and Midland Nepal is vast. We can touch on only a very few examples. One of the most talked about groups of invertebrates is the scorpion. They are found in gardens of Kathmandu, and sometimes wander into houses. Scorpions are hard-shelled arthropods, fairly closely related to spiders. Their menacing-looking pinchers are used for communicating, defense, and grasping prey to be stung. The stinging apparatus of scorpions consists of a sharp spine and a venom-forming bulbular gland located at the end of the tail. The poison is neurotoxic (nerve affecting) and thus resembles cobra venom.

Scorpion stings are very painful, but as far as is known, our Nepalese species do not often cause death. A virulent type found in North Africa, on the other hand, often is fatal. Nonetheless, stings could be dangerous to very young children or to someone who is allergic to the venom.

The typical Brown Scorpion found in the Valley is nocturnal, as are most scorpions, and moves about mainly in the wet season. During other times of the year, they curl up in crevices or under rocks. Scorpions are carnivorous and eat insects and other arthropods, so are just one of many predators that help in controlling populations.

Aerators of the Soil

In the Kathmandu Valley there is much activity within the soil. Many animals live their entire life cycle here; others may venture out from time to time. We are fortunate to have animals in the soil, for they perform a vital function by opening passageways through which air (and nitrogen) may diffuse. Any animal that resides in the soil may help, but especially important ones travel a great deal through the earth. Earthworms come to mind in this regard. Other animals such as roundworms, leeches, beetles, ants, termites, cicadas, and perhaps even mice are just a few of the great many animals that "open" the soil.

A pinkish worm you have seen commonly in your garden is very important from the ecological point of view. These creatures — the earthworms — actually "eat" soil from which they obtain digestible material. Thus they are continually burrowing through the soil, eating some of it as they pass. This opens the soil and allows, as has been mentioned, nitrogen-containing air to diffuse down to the nitrogen fixing organisms in the soil.

Besides being important in soil aeration, earthworms are valuable as a protein source for many birds, some mammals, and likely some snakes. Glowworms (actually beetles) in Kathmandu feast on earthworms. With the advent of DDT, feeding on earthworms has become dangerous for some species. It has been shown that earthworms are not very susceptible to DDT. As the earthworm crawls and eats its way through the soil, it naturally absorbs considerable quantities of this "insecticide" if it lives in a contaminated area. The DDT is stored in the body; and, later, a bird may catch the earthworm and so inadvertently ingest the dangerous poison. DDT from one earthworm would not be a serious problem. The unfortunate situation is that the DDT is now stored in the fatty tissues of birds (and man, for that matter) and so accumulates over a period of time (as the bird eats more earthworms). If DDT were excreted from the body, it would not be much of a problem; unfortunately it is not. When fat reserves are used, as on bird migration or during lean times, the poison is returned from the fat to other tissues of the body and the bird soon goes into convulsions and dies. The danger to humans is thus most apparent and warnings are now being heeded; the use of DDT has been banned in several parts of the world.

39. Earthworms at Godaveri. During heavy rains, these creatures are sometimes flooded ou their subterranean habitat and appear in hundreds along forest trails. August, altitude 1,700 r

Crabs are creatures dwelling in Kathmandu rice fields. They have a hard, shell-like body covering and front legs modified into large pinchers. Crabs are widely distributed throughout the world; most of them are found along the edges of the ocean or in fresh water. Land crabs, on the other hand, are seen only in South Asia and South America.

In Nepal, we have land crabs up to at least 1,500 m. elevation; they are common along the streams of the Kathmandu Valley. Crabs in the Nepal Lowlands attain a carapace size of 20 cms. across. Crab meat is considered delicious in many parts of the world; crabs are eaten in many Tarai villages.

Most farmers list crabs as villains. Why? Because crabs are thought to kill rice seedlings by damaging them at an underground level. Crabs certainly are constantly excavating and shifting about and it has been suggested (Goldman, *pers. com.*) that crabs may perform an important ecological function by opening up the soil. Likewise, they may push rich sub-surface soil upwards and this might help plants to grow. It can be said that we do not know, definitely, what the crabs do in the rice fields and this could lead to an interesting study for someone in the future.

Decomposers

Decomposers also live within the soil (Many, too, operate above soil level). These plants, such as bacteria and fungi along with animals like beetles, termites, and protozoa, are most important in a smoothly running ecosystem. What do decomposers do? They eat dead tissues. But why is this so important? To answer the question, let us look at some dead tissues (Let us take a dead tree, for example). The tree dies and lies on the ground. Now, if it were not acted upon by *any* plants or animals, what would happen? Very little. The dead tree would disintegrate very slowly. Weathering and climatic action would eventually wear down the tissues, but meanwhile all the minerals that went into building the tree are entrapped in the dead plant. They are not immediately reusable in the ecosystem to build new plants and so are temporarily "lost." If fungi and bacteria, along with termites and other animals, work rapidly on the dead tree, then you can see how quickly the minerals could be released and how valuable this is for the ecosystem as a whole. We have

already briefly glanced at fungi; now let us look for a moment at two groups of animal decomposers.

Termites are small social insects of great economic importance to man. They live primarily in the tropics, and we have a number of species in Nepal, although the termite fauna here has not been thoroughly studied as yet. Glancing casually around Kathmandu, one does not see any termite "mounds." Does this mean that there are no termites here? No. Many species do not build mounds; "moundless" termites are common in Kathmandu.

Termites in Kathmandu and Midland Nepal live in the soil or beneath the bark of trees. Several old buildings in Kathmandu are being undermined by termites. These insects invade houses through the mud plaster between the bricks and thus reach the wooden beams which they proceed to eat. Dead wood is their main food item and this is why they are important in the ecology of Nepal.

Termites have special digestive protozoans and bacteria in their intestinal tracts. Cellulose, widely used in construction of plant cells, is a most difficult material to digest. But these special animals and plants in the termites have no trouble at all with cellulose. Thus, the termites are valuable for their digestive abilities. Unfortunately, termites are not "well-trained" and to them dead wood, whether it be a beam in a house or a dead trunk lying in the forest, is food — and to be eaten. Thus termites, even when performing their natural function within the ecosystem, can be of great economic nuisance to humans.

The social structure of termite colonies is fascinating and differs somewhat from species to species. Generally, one finds reproductives, soldiers, and workers. The reproductives are sometimes divided into three or more levels, with the top or largest ones near the center of the colony. The soldiers, which can be either male or female, guard the colony. The Nasuta soldier is a specialized creature with a huge head (for blocking holes) on which a sticky substance is exuded. Workers bring in food and water.

The eyes of termites are poor and considerably reduced. As these animals are photosensitive, they stay away from the sun at all times. They are also extremely sensitive to temperature and moisture levels so have to construct extensive chambers both under and above ground in which they can control, to some degree, the humidity (For more information on termites, see Harris, 1961).

Beetles are by far the most numerous animal group on earth; over a quarter of a million are known already with many yet to be discovered. Beetles, unlike other insects, have hard, shell-like coverings over the wings and abdomen. In order to fly, these hard *elytra* are raised and the wings underneath extended.

Adult beetles come in many shapes and sizes and are among the most colorful of animal groups; some are brilliantly iridescent blue, green, purple, or bronze. The smallest adult beetles are about a millimeter long while the largest (found in South America) is about 125 mm. long. Our largest Nepali beetles run about 100 mm. in length. As colorful and remarkable as these adults are, they are not the most significant stage, from the ecologist's point of view, of beetle life. Then what is? The larvae.

Young, or larval, beetles are called grubs and frequently are mistaken for worms. Grubs may live for several years while they enlarge and mature into adults. Within this time span, they eat. They eat vegetable material — much of which is decaying. Thus, beetle larvae are decomposers. You may have seen a dead tree trunk riddled with passageways through which beetle larvae have traveled. "Woodworms" which you sometimes hear gnawing inside a piece of furniture are really beetle larvae.

Despite the fact that beetles assist in mineral turnover, they are not especially liked by agriculturalists. A few of the many thousands of beetles are quite harmful to several crop plants; others damage stored grain or injure forest trees. As far as is known, beetles do not assist in the spread of human diseases, but the same cannot be said for the dissemination of certain plant diseases.

Beetles are eaten by a variety of birds; grubs in particular are sought out by some birds. It is not known, though, how much effect birds have on beetle populations in Nepal. Other predatory controls, food, and living space also would be major limiting factors.

Conclusion

With the discussion of decomposers, we come full cycle in our considerations of the general ecology, fauna, and flora of Midland Nepal. As you can see, Nepal is a complex country; many exciting things are happening here. But we need to know more. We need to better understand nature and nature's interactions here in Nepal. The possible study subjects mentioned in the preceding pages are

but a few of the vast array waiting to be tackled by interested students.

Man is in the center of most ecosystems; he can utilize them thoughtfully or he may destroy them through misuse. Nepal is a land of great beauty, but she is faced with the modern-day twin pressures of population and pollution. How can Nepal maintain her beauty, retain the rich heritage given her by nature, and improve the quality of life for the people? This can be done, but only when planners give strong emphasis to economic development coordinated with the ecological realities under which we live.

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Appendix of Scientific Names

Apple, Wild	*Pyrus pashia*
Ants, Brown	Formicinae
Ants, Red	Formicinae
Ants, Army	Droylinae
Babblers	Timaliidae
Barbet, Bluethroated	*Megalaima asiatica*
Bamboo, Dwarf	*Arundinaria*
Bats, Giant Fruit	*Pteropus giganteus*
Bats, Insectivorous	Vespertilionidae
Bear, Himalayan Black	*Selenarctos thibetanus*
Beetles	Coleoptera
Boar, Wild	*Sus scrofa*
Bottlebrush Tree	*Callistemon lanceolatus*
Cat, Jungle	*Felix chaus*
Centipede	*Scolopendra*
Chestnut Trees	*Castanopsis tribuloides* and *Castanopsis indica*
Chilauni Tree	*Schima wallichii*
Crabs, Land	*Potamon sikkimense* and sp.
Crickets	Gryllidae
Crows, House	*Corvus splendens*
Crows, Jungle	*Corvus macrorhynchos*
Cryptomeria Tree	*Cryptomeria japonica*
Cuckoo, Brainfever	*Cuculus sparverioides*
Cuckoo, Brainfever (Tarai)	*Cuculus varius*
Cuckoo, Common	*Cuculus canorus*
Cuckoo, Indian	*Cuculus micropterus*
Cuckoo, Koel	*Eudynamys scolopacea*
Cutia, Nepal	*Cutia nipalensis*
Daphne Bush	*Daphne bholua*
Deer, Barking	*Muntiacus muntjak*
Sambhar	*Cervus unicolor*
Spotted	*Axis axis*
Deodar Tree	*Cedrus deodara*
Dodder	*Cuscuta reflexa*
Dogs, House	*Canis familiaris*
Eagle, Black	*Ictinaetus malayensis*
Hodgson's Hawk-	*Spizaetus nipalensis*
Earthworms	*Perionyx*
Egret, Cattle	*Bubulcus ibis*
Eucalyptus	*Eucalyptus* Species
Eupatorium	*Eupatorium adenophorum*
Falcon, Hobby	*Falco severus*
Figs, Pipal	*Ficus religiosa*
Fish, Paddyfield	*Channa gachua*
Fly, Bee	*Corizoneura longirostris*
House	*Musca domestica*
Sand	*Phlebotomus*

Flycatcher, Bluethroated	*Muscicapa rubeculoides*
Brown	*Muscicapa latirostris*
Ferruginous	*Muscicapa ferruginea*
Greyheaded	*Culicicapa ceylonensis*
Large Niltava	*Muscicapa grandis*
Little Pied	*Muscicapa westermanni*
Orange Gorgetted	*Muscicapa strophiata*
Paradise	*Terpsiphone paradisi*
Pigmy Blue	*Muscicapella hodgsoni*
Redbreasted	*Muscicapa parva*
Redbreasted Blue	*Muscicapa hyperythra*
Rufousbellied Niltava	*Muscicapa sundara*
Rufoustailed	*Muscicapa ruficauda*
Rustybreasted Blue	*Muscicapa hodgsonii*
Slaty Blue	*Muscicapa leucomelanura*
Small Niltava	*Muscicapa macgrigoriae*
Sooty	*Muscicapa sibirica*
Verditer	*Muscicapa thalassina*
Whitebrowed	*Muscicapa superciliaris*
White Gorgetted	*Muscicapa monileger*
Whitethroated Fantail	*Rhipidura albicollis*
Yellowbellied Fantail	*Rhipidura hypoxantha*
Forktail, Spotted	*Enicurus maculatus*
Grasshoppers	Acrididae
Gull, Great Blackheaded	*Larus ichthyaetus*
Holly Trees	*Ilex doniana* and sp.
Honeyguide, Yellowrumped	*Indicator xanthonotus*
Humans	*Homo sapiens*
Jackal	*Canis aureus*
Kite, Snail-Eating	*Rostrhamus sociabilis*
Laughing-Thrushes	*Garrulax*
Laurels	Lauraceae
Leech, Godaveri	Hirundinea
Leopard	*Panthera pardus*
Lice, Bird	Mallophaga
Lice, Human Body	*Pediculus humanus vestimentorum*
Lice, Human Head	*Pediculus humanus capitis*
Lizards, Beaded	*Heloderma horridum*
Lizards, Gila Monster	*Heloderma suspectum*
Lizards, House Gecko	*Cosymbotus platyurus*
Lizards, Fence	*Calotes versicolor*
Lizards, Legless	*Ophisaurus gracilis*
Lizards, Skink	*Leiolopisma sikkimense*
Lizards, Varanus	*Varanus monitor*
Magnolias	*Michelia*
Magpies, Redbilled Blue	*Kitta erythrorhyncha*
Magpies, Yellowbilled Blue	*Kitta flavirostris*
Maples	*Acer*
Marten, Yellowthroated	*Martes flavigula*
Mistletoe	*Loranthus* Species
Monkeys, Langur	*Presbytis entellus*
Monkeys, Rhesus	*Macaca mulatta*
Monkey-Puzzle Tree	*Arancaria*

Mustard	*Brassica rapa*
Myna, Common	*Acridotheres tristis*
Nuthatch, Himalayan	*Sitta himalayensis*
Oaks, Banj	*Quercus leuchotricophora*
Khasru	*Quercus semecarpifolia*
Laminated	*Quercus lamellosa*
Thickleaved	*Quercus pachyphylla*
White	*Quercus glauca*
Orchids, Bamboo	*Arundina graminifolia*
Bride-of-Heaven	*Coelogyne cristata*
Golden	*Dendrobium densiflorum*
Lady Slipper	*Cypripedium macranthum*
Long White	*Dendrobium longicornu*
Spider	*Dendrobium amplum*
Solitary Tree	*Pleione humilis*
Owls, Barn	*Tyto alba*
Barred	*Glaucidium cuculoides*
Brown Fish	*Bubo zeylonensis*
Collared Scops	*Otus bakkamoena*
Forest Eagle	*Bubo nipalensis*
Great Horned	*Bubo bubo*
Hawk	*Ninox scutulata*
Himalayan Wood	*Strix leptogrammica*
Pigmy Owlet	*Glaucidium brodiei*
Spotted Owlet	*Athene brama*
Spotted Scops	*Otus spilocephalus*
Panda	*Ailurus fulgens*
Panther	*Panthera pardus*
Parakeets, Slatyheaded	*Psittacula himalayana*
Parrotbills	*Paradoxornis* Species
Pheasant, Kalij	*Lophura leucomelana*
Pigeons	*Columba livia*
Raspberry, Black	*Rubus paniculatus*
Raspberry, Orange	*Rubus ellipticus*
Rhinoceros, Onehorned	*Rhinoceros unicornis*
Rhododendron Tree	*Rhododendron arboreum*
Sailer, Himalayan	*Neptis mahendra*
Schima Tree	*Schima wallichii*
Scimitar-Babbler, Slenderbilled	*Xiphirhynchus superciliaris*
Scorpion	*Scorpio*
Sibia, Blackcapped	*Heterophasia capistrata*
Silver " Oak "	*Grevillea robusta*
Slug	*Anadenus*
Snail	*Macrochlamys*
Snake, Rat (Dhaman)	*Ptyas mucosus*
Snake, Cobra	*Naja naja*
Snake, Common Krait	*Bungarus caeruleus*
Snake, Coral	*Calliophis macclellandi*
Snake, Green Pit Viper	*Trimeresurus stejnegeri*
Snake, Emerald Green Pit Viper	*Trimeresurus albolabris*
Snake, King Cobra	*Ophiophagus hannah*
Snake ,Lesser Black Krait	*Bungarus lividus*
Snake, Mountain Pit Viper	*Trimeresurus monticola*
Snake, Striped Keelback	*Natrix stolata*

Snake, Wolf	*Lycodon aulicus*
Sparrow, House	*Passer domesticus*
Sparrow, Tree	*Passer montanus*
Spider	Arachnidae
Spider, Black Widow	*Latrodectus mactans*
Spindlewood	*Euonymus tingens* and sp.
Squirrel, Giant Flying	*Petaurista petaurista*
Stork, Openbilled	*Anastomus oscitans*
Swallow, Common	*Hirundo rustica*
Swift, Nepal House	*Apus affinis*
Termites	Isoptera
Thrush, Whistling	*Myiophoneus caeruleus*
Thrush, Blackthroated	*Turdus atrogularis*
Tiger	*Panthera tigris*
Tit-Babbler, Chestnutheaded	*Alcippe castaneceps*
Tree-Creeper, Sikkim	*Certhia discolor*
Water Striders	Gerridae and Veliidae
Weasel, Himalayan	*Mustela sibirica*
Willow Tree	*Salix* Species
Worms, Earth	Annelida
Worms, Flat	Platyhelminthes
Worms, Filaria	*Filaria bancrofti*
Worms, Hook	*Necator*
Worms, Round	Nemathelminthes
Worms, Segmented	Annelida
Worms, Tape	*Taenia*
Woodpecker, Rufous	*Micropternus brachyurus*
Yuhina, Stripethroated	*Yuhina gularis*

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BHAGWANPUR DAM

mile 1 0 1 2 miles

SCALE

KEY

- Forest area
- 5000' Contour level
- Surface road
- Unsurface road
- Foot trail