भारतीय वन्यजीव संस्थान
Wildlife Institute of India
P.O. Box # 18, Chandrabani,
Dehradun (Uttarakhand) INDIA
Tel. : 0135 - 2640111-115 Fax : 0135-2640117
e-mail : wii@wii.gov.in
Website : www.wii.gov.in

A FIELD STUDY IN THE SHIVALIKS OF HIMACHAL PRADESH

TIGER BEETLES

V. P. Uniyal
Vinay Bhargav

Wildlife Wing
H.P. Forest Department

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V.P. Uniyal, Vinay Bhargav

PRINT VISION, 41-C Rajpur Road, Dehradun (Uttarakhand)
Tel. : +91 135 2741702, 6532172 Telefax : +91 135 2741702
e-mail : print_vision@yahoo.co.in, print_vision@vsnl.net

P.R. SINHA
Director
Wildlife Institute of India
P.B. # 18, Chandrabani,
Dehradun, Uttarakhand
Tel : +91-135-2640111 to 115;
Fax : +91-135-2640117
Email : dwii@wii.gov.in

Message

Insects form one of the vital components of biosphere. They are numerous, fascinating, varied and economically important. Knowledge about them is fundamental to studying the ecology and environment. Beetles constitute the largest order under class Insecta. Some common species of beetles are extremely sensitive to changes in nature and can therefore serve as convenient indicators of anthropogenic induced landscape modification. Therefore, knowledge of beetles is indispensable not only for professional zoologists, but also for agriculturists, ecologists and managers of protected areas. Tiger beetles (Cicindelidae) occur over a broad range of biotope types and geographical areas and they also exist in remnant patches of appropriate biotopes. Therefore on a small geographical scale, tiger beetles are useful as 'indicators' of biotope quality relative to disturbance. This field guide focuses primarily on tiger beetles, their basic ecology and the details of field level taxonomic identification. I feel that this guide will be useful for researchers, front line staff and field managers to identify major ecological stress like habitat degradation, habitat loss, or habitat fragmentation and to take appropriate management strategies to conserve the protected areas.

P.R.Sinha

VINAY TANDON, IFS
Addl. PCCF (Wildlife) &
Chief Wildlife Warden
Govt. of Himachal Pradesh
Talland, Shimla
Tel : + 91-177-2624193
Email : vtandy@gmail.com

Foreword

This pictorial guide focuses on one of the predatory groups of insects called tiger beetles, one of the most widely distributed in various habitats throughout the world. More than 2600 species are known worldwide, 200+ reported in India. In the guide the basic information about the morphology, ecology, and most emphasis is laid on the taxonomic identification of the species documented in various protected areas of Shivalik Landscape of Himachal Pradesh is provided. As far as insects are concerned the prime focus of forest officials remains on moths' caterpillars and beetles as the forest pests and their mitigation. Even many of local peoples are not aware of the wealth of beetles besides their role as “PESTS”. However, others, like the tiger beetles, which are known to be an important bioindicator for biodiversity and ecological monitoring, and can, serve well to identify the areas of high species richness, as there is a strong affinity of this group with many invertebrate and vertebrate taxa. Further, monitoring a few indicator species is a widely used method to measure the ecological sustainability and ecosystem health. The objective of the guide is to aware about these wonderful predators as one of the important taxa as indicator for biodiversity and ecological monitoring. This pictorial guide will be useful to frontline staff, researchers, and park officials in the field.

(Vinay Tandon)

Dr. AVV. FABIO CASSOLA, Ph.D.
(Specialist-Tiger Beetles of the World)

Via Fulvio Tomassuci, 12/20,
00144 Roma, Italy
Tel./Fax: +39-06-5200185
E-mail: FabioCassola@aliceposta.it

Preface

It is my great pleasure to review this field guide on tiger beetles of Shivalik Landscape of Himachal Pradesh. This guide takes the reader forwards better understanding about tiger beetles ecology, an updated taxonomy and distribution patterns in different protected areas in the landscape. The part on taxonomic identification even though elaborated is very amicably understandable even to the novices of the field and to a specialist too. The added note of glossary will help understanding of the technical terms involved in the taxonomic identification and in beetles in general. Further, the part on communal roosting is also interesting in a way as it has been observed by only few workers in entomology. However, a detailed assessment of this behaviour will strengthen our knowledge about eusociality in lower groups too. I hope that this guide will be helpful for management of protected areas using tiger beetles as ecological indicators.

(Fabio Cassola)

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We also thank the Science and Engineering Research Council (SERC), Department of Science and Technology (DST), Govt. of India, for providing necessary funds to undertake the research project on ecological study of tiger beetles in the Shivalik Landscape. Special thanks to Dr. B.P. Singh and Mr. Doyil T. Vengayil of SERC-DST for providing timely support to initiate the study.

We are grateful to Dr. David L. Pearson, Arizona State University, USA for spending precious time in the field for guiding precisely about the sampling techniques, field identification, and fruitful discussions about the ecology of tiger beetles. Prof. H. R. Pajni and Prof. (Mrs) P.K.Tewari, Department of Zoology, Punjab University, Chandigarh are acknowledged for identification of tiger beetles and providing relevant literature.

At Wildlife Institute of India, we are thankful to Mr. P.R. Sinha, Director; Prof. V.B.Mathur, Dean;

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V.P. Uniyal
Vinay K. Bhargav

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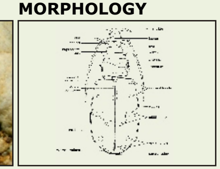

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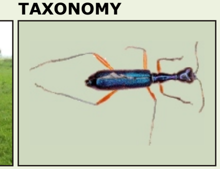


COLEOPTERA

The order Coleoptera (meaning "sheathed wing") includes the beetles, which has more described species in it than in any other order in the animal kingdom. The beetle's exoskeleton is made up of numerous plates called sclerites, separated by thin sutures. This design creates the armoured defenses of the beetle while maintaining flexibility. One of the most distinctive features of Coleoptera is the structure of the wings. Most have four wings; with the front pair thickened, leathery, hardened or brittle, called as *elytra* (sing. *elytron*) while the hind pair remain membranous. The elytra normally serve as protective sheaths while the hind wings are the only ones ordinarily used for flight. Hind wings are narrow usually longer than the fore wings when unfolded with fewer veins. Their antennae are generally with 11 or fewer segments. Their mouth parts are distinctly mandibulate, with opposable mandibles, spiracles usually present on the thorax and 8 abdominal segments, and their tarsi are with 1 or 2 claws. Beetles are the most diverse group of insects. Forty percent of all described insect species are beetles (about 350,000 species), and new species are regularly discovered. Estimates put the total number of species, described and undescribed, at between 5 and 8 millions.

They can be found in almost every type of habitat in which any insect can be found, but are not known to occur in the sea or in the Polar Regions. They feed on all sorts of plant and animal materials. Many are phytophagous; many are predaceous; some are scavengers; others feed on mold or fungi; and a very few are parasitic. Some are subterranean in habit; many are aquatic or semi-aquatic; and a few live as commensals in the nests of social insects. They impact the ecosystem in several ways as on one hand, the phytophagous species are free feeders on foliage; some bore into the woods and fruits, some are leaf miners; some attack the roots or feed on stored plant or animal products and eat other invertebrates. On the other hand, they are prey of various animals including birds and mammals.

Various species are agricultural pests, such as the red flour beetle *Tribolium castaneum*, the rice weevil *Sitophilus oryzae*, the Colorado potato beetle *Leptinotarsa decemlineata* or the mungbean beetle *Callosobruchus chinensis*, while others are important controls of agricultural pests like lady beetles (family Coccinellidae) consume aphids, scale insects, thrips, and other plant-sucking insects that damage crops. Various species are forest pests, such as *Hoplocerambyx spinicoris* on Sal (*Shorea robusta*), *Batocera rufomaculata* on mango (*Mangifera indica*), while others are biocontrol agents such as *six spotted* beetle *Anthia sexguttata*.

The life cycle varies in length from four generations a year to one generation in several years. Most species have one generation a year. The winter may be passed in any of the life stages, depending on the species. Many overwinter as partly grown larvae, or as pupae in chambers in soil or wood in protected situations.

The order Coleoptera includes more than 170 families in four sub orders *viz*., Archostemata (includes the primitive beetles), Myxophaga (includes tiny beetles occurring in water feeding on filamentous algae), Adephaga (includes the exclusive predatory/carnivorous beetles), and Polyphaga (beetles with varying feeding habits, different antennae and tarsal formula). Here, we describe the Adephaga to which the tiger beetles belong to.

ADEPHAGA

Adephaga (*Greek adephagos*, 'carnivorous, flesh-eating'), with more than 40,000 recorded species in 10 families, is a suborder of highly specialized beetles and the second largest suborder of the order Coleoptera. Members of this suborder are adephagans, a term which notably include ground beetles, tiger beetles, predaceous diving beetles, and whirligig beetles.

They are readily identified from other beetles by the first visible abdominal sternum which is completely divided by the hind coxae. So that the posterior margin of this sternum does not extend completely across the abdomen, but is interrupted by the hind coxae, nearly all have filiform antennae and 5-5-5 tarsi.

Habitat ranges from caves to rainforest canopy and alpine habitats. The body forms of some are structurally modified for adaptation to habitats. Members of the family Gyrinidae live at the air-water interface with continuous swimming in gyrations, Rhysodidae in heartwood, Paussine carabids in ant nests.

Most species are predators. Other less typical forms of feeding include algophagy (feeding on algae), Haliplidae; feeding on seeds, Harpaline carabids; mycophagy (feeding on fungi) Rhysodine carabids, and snail-feeding, Licinine and Cychrine carabids. Some species are ectoparasitoid of insects, Brachynine and Lebiine carabids or of millipedes, Peleciine carabids.

INTRODUCTION

INTRODUCTION

The tiger beetles (family Cicindelidae) are members of the suborder Adephaga within the order Coleoptera. Most adult tiger beetles are characterized by large, prominent compound eyes and eleven-segmented, filiform antennae. The antennae are inserted on the frons above the clypeus and below the eyes, and the labrum is as wide as the clypeus. The head, at the eyes, is wider than the pronotum (in most common genera of cicindelids). The tarsi are five-segmented.

Adult beetles of the families Cicindelidae (tiger beetles) and Carabidae (ground beetles) are quite similar morphologically, and indeed some authors place the tiger beetles in the subfamily Cicindelinae within the family Carabidae. The ground beetles differ in the following ways: antennae inserted above the mandibles to the side of the clypeus, and below the eyes and the labrum are narrower than the insertion of antennae. Most ground beetles have a head, at the eye, which is narrower than the pronotum (in most genera). The larvae of the tiger beetles are highly predaceous (like many larvae of the Carabidae), but are grub-like and do not hunt freely going around but stay in a special burrow in the ground, waiting for prey passing around. They have several unique characteristics which justify their separation from the Carabidae. There are over 2600 species of tiger beetles worldwide, 220 in India (with 114 or 51.8% endemics).

Tiger beetles are predatory insects that feed on small insects and other arthropods. The adults are active, mobile predators that search and hunt for prey. The larvae, however, are peculiar among beetles and, unlike the adults, are waiting (ambush)

Adult Tiger Beetle *Calomera chloris*

predators. A tiger beetle larva constructs a burrow and waits at the burrow's entrance, blocking the opening with its large, sclerotized head. When a suitable prey item passes close enough, the larva jumps out and grabs the prey with its long, sickle-shaped mandibles. Hooks on the dorsal surface of the fifth abdominal segment can dig into the side of the burrow, thus preventing the larva from being pulled out by large or particularly active prey. Larvae retreat down their burrows rapidly when disturbed, and can be quite a challenge to collect.

Tiger beetles exhibit two different general life cycles. There are spring/fall species and summer species. In spring/fall species, the adult beetles emerge from pupae in the autumn and are active for a few weeks or longer, depending on annual weather conditions. As frosts occur and the weather cools, the adults hibernate for the winter. They emerge from hibernation during the spring and mate and lay eggs. Adults then usually die off, and the newly hatched larvae develop burrows and hibernate for one or more winters. When the larvae are mature, they pupate during the summer and emerge as adults in the fall, thus completing the cycle. Depending on the species, the spring/fall life cycle generally takes 2 to 4 years to complete. In summer species, adults emerge from pupae in the early summer and are active during the summer months. They mate and lay eggs during this time. Larvae hatch in the fall, develop burrows, and hibernate for the winter. The summer life cycle generally takes 1 or 2 years to complete.

Mating tiger beetle couples are often seen (and for some reason, often photographed) while collecting. Male tiger beetles can be distinguished from females by the presence of dense, thick setae on the tarsi of the fore legs. According to some authors these setae are used to firmly grasp the female during copulation, but males of most species actually hold their fore legs out to the sides. Males grasp the females with their mandibles during copulation. Female tiger beetles bear grooves or coupling sulci, one sulcus on either side of the prothorax (on mesepisterna), that receives the male mandibles. Males do not possess coupling sulci. During copulation, sperm is passed from the male to the female via the aedeagus which is a sclerotized organ of the male reproductive system. The shape of the aedeagus is most often different from species to species and in other beetle groups, the shape of the aedeagus is used to separate species that closely resemble one another. The male everts the aedeagus and inserts it into the vagina or vestibule of the female. Sperm passes along the aedeagus, into the vestibule, and eventually reaches the spermatheca. The spermatheca is a special organ that stores the sperm until it is ready to be used for fertilization. During oviposition (egg-laying), the mature eggs pass from the ovaries down towards the vaginal opening. Along the way, the eggs pass the spermathecal duct and are fertilized before they pass out of the body. The eight and ninth abdominal segments of the female form a telescoping ovipositor that is everted from the body and used to deposit eggs one at a time into the ground. Different species prefer different soil substrates. Females are particularly choosy about their egg-laying sites because their newly hatched larvae cannot migrate to a new site if the substrate is unsuitable for them. After hatching, the larvae enlarge the chambers the female created during egg-laying and develop burrows. Tiger beetle larvae develop through 3 instars over a period of 1 to 4 years (depending on the species) before pupating.

Tiger beetle species differ greatly in habitat preference. Some prefer soils with high clay content while others prefer sandy soils. Some like moist environments while others like it dry, found along roads and open paths in moist deciduous woodlands where sunlight can penetrate. Temperature is very important to tiger beetles; they are most active (unlike Carabids) on warm, sunny days.

MORPHOLOGY

MORPHOLOGY

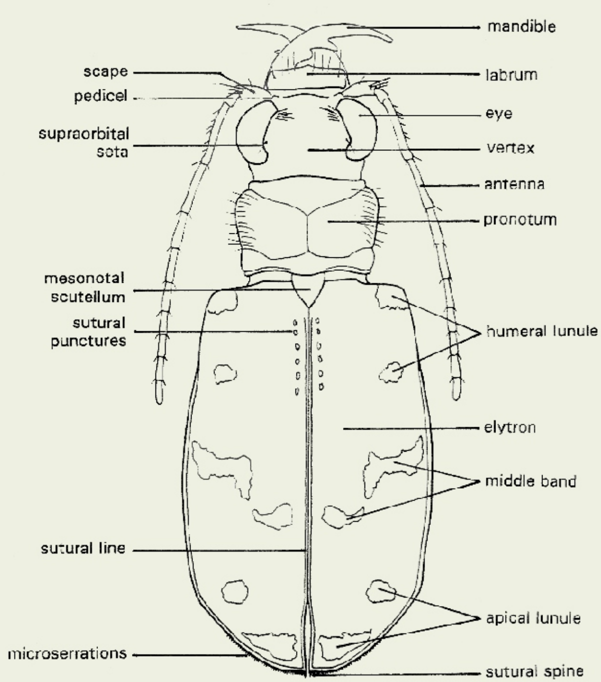
The most important characters for identifying tiger beetle species include the following. The first structures one notices on the head are the large, sickle-shaped mandibles. At the anterior (front) end of the head above the bases of the mandibles is the upper lip, or labrum, which in tiger beetles is characteristically as wide as the clypeus. Depending on the species, the distal end of the labrum may possess either one or three small projections called "teeth." A labrum with one tooth is referred to as unidentate and a labrum with three teeth is referred to as tridentate. Immediately posterior to the labrum is a thin, strap-like sclerite called the clypeus. The suture between the labrum and the clypeus, the clypeo-labral suture, is somewhat flexible and allows the labrum to move. Posterior to the clypeus is the front of the head, or frons. The suture between the clypeus and the frons is rigid and is called the fronto-clypeal suture.

On the frons just in front of each eye are the antennae. Each antenna has eleven segments. The first or basal most segment of the antenna is called the scape. At the tip of the scape are one or more sensory setae which are arranged in a single transverse row. Below the sensory setae are the accessory setae which appear scattered over the scape. On the frons above each compound eye is the supraorbital region (think of it as the eyebrow). Below each eye on the sides of the head are the cheeks, or genae (singular = gena).

Behind the head is the middle body region, or thorax. The thorax is divided into three parts: the front part is the prothorax, the middle part is the mesothorax, and the hindmost part is the

Taxonomic characters used in identification of Cicindelidae

(from Pearson and Vogler, 2001)



metathorax. Each thoracic segment bears one pair of legs. The legs of tiger beetles are quite long and adapted for running. In top or dorsal view, only the prothorax and a very small part of the mesothorax are visible. Sclerites of each thoracic segment are prefixed pro-, meso-or meta-, depending on the segment. The top sclerite of the prothorax is called the pronotum. The large sclerite on the side of the prothorax is called the proepisternum. The bottom or ventral sclerite surrounding the inner bases of the front legs is called the prosternum. If one looks closely just behind the pronotum along the midline of the body you will see the small, triangular mesoscutellum, which is part of the mesothorax.

Attached to mesothorax are the elytra (singular = elytron). The elytra are actually the modified forewings of beetles that enclose and protect the hind wings when not in use. Beetles belong to the order Coleoptera, which translates as "sheathed wings" (*coleo* = sheath, *ptera* = wings). The elytra are very important in tiger beetle identification. Many species have obvious markings called spots or maculations on the elytra. If the elytra have no markings, they are said to be immaculate. The anterior most marking (on the "shoulder") is the humeral lunule or spot. It is usually crescent shaped (hence the name "lunule" referring to a crescent moon). Along the lateral margin of each elytron is the marginal line. The middle band projects medially (towards the middle) from the median line. At the tip of each elytron is the apical lunule (sometimes interrupted and splitted in a sub-apical and an apical spots). Also, the apical border of the elytra may bear very small saw-like teeth. Such elytra are said to be serrulate. Moreover, there is usually a small but sharp sutural spine at the apex. The elytra may or may not have punctures.

Elytra with punctures are called punctate, and those without punctures are impunctate. The dorsal surface of the abdomen is hidden beneath the elytra, but the ventral surface is visible and is usually iridescent blue or green.

LIFE CYCLE

LIFE CYCLE

***Calomera chloris* in Copulation**

Two types of life cycle occur among the tiger beetles (and these are strongly allied to the concept of temporal segregation). Some tiger beetles are spring/fall species. The hibernating adults emerge in the spring, mature, mate, and oviposit.

These adults die off in the succeeding weeks. The new brood emerges in late summer or early fall. These beetles feed actively, but are not sexually mature. They hibernate for the winter and emerge the following spring. They reach sexual maturity shortly after emerging. Generally speaking these species are unable to tolerate the hot days of mid summer.

The other tiger beetles are summer species. They emerge from the pupal stage in the late spring and early summer, mate, oviposit, and die before the next winter. These species pass the winter in the larval, sometimes pupal, stage, but never as adults. No tiger beetles are known to have more than one generation per year, although some species may require additional seasons to complete their development.

ECOLOGY

- Habits of the adult
- Habits of the larvae
- Habits of the pupae
- Natural enemies
- Communal roosting

ECOLOGY

Habits of the Adult

Adult tiger beetles are (unlike Carabids) heliophilic insects, remaining inactive on cloudy, cool days. Activity of the adult beetles is regulated by air temperature, humidity (actual evaporation), light intensity, and wind. Most species do not become fully active until the air temperature reaches about 15° C. Contrary to first impression, the bright coloration and bold markings found on many of these beetles does not lead to their endangerment. Instead the colorful markings serve to disrupt the overall outline of the beetle and make it virtually unrecognizable against the substrate. It is usually the beetles' movement which reveals its position. There is undoubtedly considerable selective pressure to assure that individuals blend into the background. Those which do not are eliminated by predators. The dorsal surface of the abdomen is generally brightly colored in metallic or orange-red hues, although these colors are not visible because they are concealed by the folded elytra. However, when the beetle is disturbed and takes flight these bright colors are suddenly displayed and this serves to startle would-be predators.

Adults prefer to run, doing so in short zig-zag bursts. They usually fly only when disturbed by a larger animal or other moving object. Apparently the form and color of the threat is unimportant, for it is the size and motion that trigger the reaction to flight. To become airborne the beetle squats, leaps into the air, and then begins to fly. Most species fly in a relatively low (1 to 3 feet), level, straight path and land 5 to 20 feet away from the source of the disturbance. Some species are more

***Cosmodela intermedia* in camouflage**

"shy" than others and habitually fly further. On windy days beetles may be carried higher and farther than normal. It appears that the beetles land and face the direction of the approaching danger, and that they land facing into the wind. In cases where the habitat and "landing zone" is limited, beetles fly in a semicircular pattern and land. This is particularly common in areas of narrow habitats such as trails, roads, and beaches.

The adults of several species have been noted to produce defensive odors. These odors are produced by the anal, or pygidial, gland (which is poorly developed). These glands are rather poorly developed in comparison to the closely-related Carabidae because the tiger beetles have more advanced escape methods such as taking running, flight, and use of sharp mandibles. Adult tiger beetles also exude an unpleasantly scented, brownish fluid from the hypopharynx when captured. The function of this fluid is probably to predigest the prey when

***Calomera chloris* showing bluish iridescence**

feeding. It was noted "that where it comes in contact with the net, holes will appear sooner than elsewhere".

Adult tiger beetles are not completely free from predators like a dragonfly (*Aeschna interrupta interrupta* Walker), some species of robber flies (Diptera: Asilidae), species of amphibians and reptiles also feed on tiger beetles. Adult beetles burrow in the soil to pass the night and to escape unfavorable weather, either hot and dry or cold and wet. They also burrow rather deeply in preparation for winter diapause. Quite a few species of tiger beetles are attracted to light. Most experts feel that it is only the more "advanced" species that fly to light. Recently it has been suggested that the beetles actually come to the light to feed on other insects attracted to the light. In either case it is interesting to note how the beetles' behavior differs between daylight hours and night time. Many species that cannot be approached within 20 feet during the daylight hours are easily picked up by hand as they scurry about a light. Tiger beetles have very definite habitat preferences. Many species inhabit sandy areas such as sand dunes, sand pits, and sand "blowouts" (often far away from water).

Several species of tiger beetles may inhabit the same area. According to Gause's Law of Competitive Displacement species with identical ecological niches cannot coexist in the same habitat for a long period of time. But within a given area of macro habitat many species of tiger beetles do often coexist. However, they are spared from direct competition in two ways. First, many of them actually occupy different microhabitats (e.g., soils with different moisture levels, textures, salinity, and vegetation/plant cover). Secondly, many species are separated seasonally; that is the various beetle species have different times of emergence and peak populations. The combination of these two types of segregation provides for nearly complete separation among most species, and considerably reduces the competition among the rest. Selection of the breeding, or larval, habitat is a critical task left up to the adult female during oviposition. Because the larvae are relatively immobile and the habitat requirements are more circumscribed than that of adults the availability of larval habitat is often the limiting factor that controls the population levels of the beetles. When an area of larval habitat becomes endangered and disappears, so does the species it supports.

Copulation generally occurs on warm days with high humidity. After mating, the eggs are deposited singly in the soil, each in a small indentation created by the female's ovipositor. Part of the ninth and all of the tenth abdominal segments of the female are covered with hairs sensitive to conditions of soil moisture and structure. The female carefully selects the proper soil type

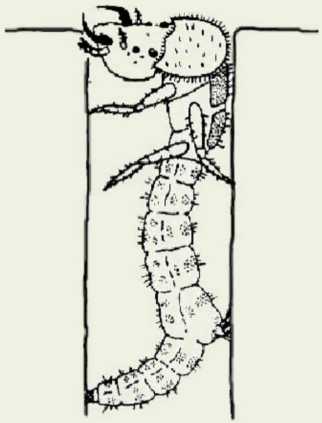
before finally ovipositing. Survival of the larva is dependent upon this choice.

HABITS OF THE LARVAE

Tiger beetles have three larval instars. Upon hatching from the egg the first instar larva proceeds to enlarge the impression made by the female's ovipositor into a burrow. As the larva grows the burrow is enlarged. Larval burrows of the tiger beetles are very characteristic. The entrance to the burrow is flush with the surface of the ground, and is clean and smooth. There is usually no "cone" of soil particles, as the larvae toss this material as far away from the burrow as possible. However, larvae of a few Indian species build a small "*turret*" above the ground. Most burrows are constructed so that they are perpendicular to the soil surface. However, there is considerable variation among individuals and species. The burrow depth varies greatly, although it does seem to be correlated to geographic location. Those in northern regions tend to be deeper. Most burrow construction takes place at night.

When first sighted the larval burrows appear to be unoccupied. Larvae are very wary and quickly drop to the bottom of the burrow. They are sensitive to motion, and possibly to vibration of the substrate, but are quite insensitive to sound. Larva also periodically plugs the entrance to their burrow with soil, especially after eating, during rainy weather, during droughts, before hibernation or aestivation, before molting, and before pupation. The larvae are elongate, cylindrical, and somewhat grub-like. The mandibles are powerful and curve upwards. The head and prothorax are fused and rounded, forming a circular plate. The head is held at nearly a right angle to the axis of the body. The fifth abdominal segment has a tergal hump bearing anteriorly curved spines.

Tiger Beetle Larva



The larvae wait at the burrow entrance and ambush passing prey. The rounded cephalo-pronotal plate helps disguise the larva's presence and hide the opening to the burrow. The larva employs the thoracic legs, tergal spines, and terminal spines to support themselves in the burrow by assuming an "s" shape and bracing themselves against the walls of the burrow. Tiger beetle larva feed on many types of small arthropods. Prey are generally consumed at the bottom of the burrow, unless too large. The tergal spines help keep the larva anchored in place when grabbing large prey. The first instar larva generally needs one good meal to store enough energy for its molt into the second instar. The second and third larval instars require at least several meals to survive and grow. The larvae may often have severe problems with competition for available food. However, long developmental periods and 24 hour feeding abilities are probably evolutionary attempts to overcome this problem. Given the precarious existence of the larvae, it is no wonder that the larval stage comprises the longest portion of the tiger beetle life cycle.

Larvae have few natural enemies. Some bee flies (Diptera: Bombyliidae) and small wasps (Hymenoptera: Tiphiidae) are parasites of larval tiger beetles. By far the greatest enemy that larval tiger beetles face is humans who destroy precious larval habitats through soil disturbances (construction, flooding, off road vehicles, etc.).

HABITS OF THE PUPAE

The third instar larva is responsible for construction of a special pupal chamber; usually off to one side of the larval burrow. The larvae plug the burrow with soil obtained from construction of the pupal chamber. The larva becomes quiescent, resting upon its dorsal surface. Within a period of time (one to three weeks) the larva is no longer able to move its appendages. The abdomen thickens and becomes a translucent, creamy-white color. Gradually the cuticle splits and body contortions are used to free the pupa from the old larval exoskeleton. The pupa then contracts to a slightly smaller size.

The first five abdominal segments of the pupa's abdomen bear a pair of dorsal tubercles, each with a ring of apical setae. These tubercles hold the pupa up off the substrate. The pupa gradually darkens, and the developing mandibles, tibia, tarsi and wing pads of the adult can be distinguished easily. The adult beetle emerges from the pupa via a dorsal split in the integument; this process takes about two hours to complete. The pupal period generally lasts for 18 to 24 days (unless over wintering in the pupal stage).

After emergence the cuticle of the new beetle begins to harden and darken. In an hour or two the elytral markings begin to show and the elytral tracheae are visible. Within ten hours the beetle is able to stand, and within 48 hours may become fully active. Some adult beetles may continue to change color long after emergence, and it has been shown by several researchers that the coloration varies according to environmental influences during pupation and subsequent emergence. Also, lipid deposits may stain and darken light-colored markings as the beetle ages.

NATURAL ENEMIES

Tiger beetles have a number of natural enemies. The adults are preyed on by various insect-eating animals, mainly insectivorous birds and larger insects (robber flies, dragonflies, etc.). Larvae are parasitized by larvae of certain bee flies (Bombyliidae) and some wasps (Tiphiidae). Probably man is their worst enemy, since they are readily killed by insecticides and such disturbances as dune buggies and dam building.

COMMUNAL ROOSTING

Communal roosting is one of the common social behaviours exhibited by many vertebrates especially birds typified by flocks of birds spending the night together. It is defined as an occurrence of numerous individuals of one or more species congregate in close proximity to one another for several hours. Such behaviour is also seen in insects too in Lepidoptera (butterflies and moths), Coleoptera (beetles), Diptera (true flies), Hymenoptera (ants, bees and wasps), and Odonata (dragon and damselflies). In case of tiger beetles, more than five thousand individuals of a particular species of tiger beetles were found to be involved in diurnal communal roosting behaviour with constant jostling and bustling. These roosts were found on two host plant species *viz*., Jamun (*Syzygium cumini*) and Karaunda (*Carissa carandus*) in the riverine area of the

Diurnal Roosting Tiger Beetles

Potential Riverine Habitat for Tiger Beetles

Aposematic Pattern of Assemblage

Simbalbara Wildlife Sanctuary of Himachal Pradesh, which is the most preferred habitat of these beetles. Sixteen species of tiger beetles have been reported from this sanctuary, and of these three of them *viz., Calomera plumigera Calomera angulata* and *Calomera chloris* were known to involve in communal roosting. It included dense aggregations of individuals in physical contact with each other.

Such roosts were found only during the months of monsoon (July and August) and disappeared soon in the late wet season, but isolated individuals could be still recorded till the onset of winter in the same habitat. The species, which were involved in roosts, include *Calomera plumigera* and *Calomera chloris*. Apparently, such roosts did not cause any damage to the host plant species owing to their predatory nature. But such roosts are usually not host plant specific as such roosts could also be seen on cut trees lying in the vicinity. However, as a rule they preferred the low height shrubs (<8 feet) with many branches to have more area for clustering and not tall trees. They tend to prefer the riverine habitat because of close proximity to water and food resources, and low human disturbance. These species exhibited high fidelity by returning to the same roost site year after year.

The functional and adaptive significance of communal roosting includes protection from predation due to enhanced aposematic (warning) pattern of assemblage, enhanced surveillance and some degree of cryptic (camouflaging) advantages, thermoregulation, and social function. Roosting tiger beetles also position themselves on twigs to expose their abdomen outwards thereby augmenting the effects of chemical defenses (benzaldehyde and benzoyl cyanide) against nocturnal

COLLECTION & PRESERVATION

Techniques

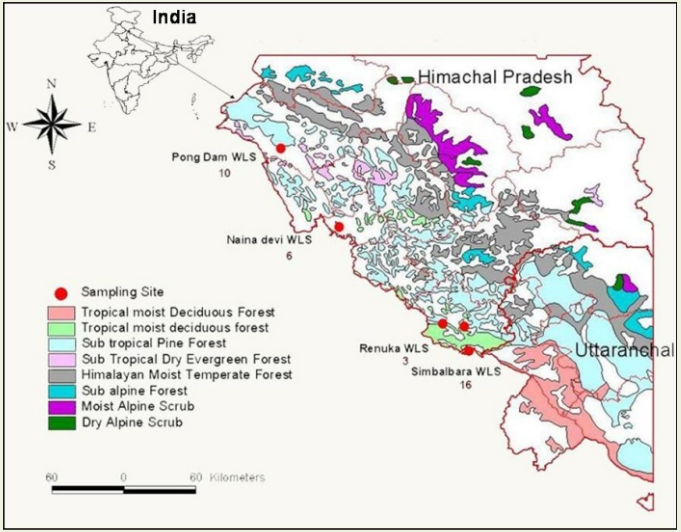
COLLECTION AND PRESERVATION

Techniques

The techniques for collecting adult tiger beetles vary by genus. Some are diurnal, while a few others are primarily nocturnal. The best time for collection is on warm (greater then 30 ºC), sunny days. The preferred habitats are variable and include riverine sandy areas, riverside forests, paths and trails, roadsides and agricultural fields. These beetles are very active runners and swift fliers and take some great skill, stalking and rapid use of the net to catch them. One has to carefully approach the beetle (with body as low to the ground as possible), once within the reach, slap the net quickly over the beetle. Quickly locate the beetle beneath the net and immobilize it as soon as possible in a killing bottle.

Collection Technique of Tiger Beetles

Digital Elevation Model (DEM) of Shivalik Landscape showing various protected areas and number of Tiger Beetles



As some species of tiger beetles are attracted to lights at night, so setting up a black light (or UV-light) or an incandescent portable lantern in an area of beetle habitat is appealing and worthwhile. At night, the beetles can actually be caught by hand as they sit calmly on the ground in the lighted area. Rarely some tiger beetle species can be caught in pitfall traps placed in their relevant habitats. Because these beetles have long legs they easily escape from simple pitfalls, hence it is necessary to use a two-cup trap system: a large outer cup sunk in the ground filled with a nested inner cup that has a 1/2 hole in the bottom along the outside edge. The beetles will go down the hole and are caught in the area between the two nested cups.

The preservation of tiger beetles follows usual procedures employed for preservation of any other insect. They are first immobilized using a suitable killing agent like benzene, ethyl acetate, or chloroform. Beetles are preserved pinned (through right elytron) followed by spreading of antennae and legs on a spread board. After some period of drying, the specimens are preserved dry in specially made airtight display boxes containing anti-bacterial and anti-fungal commonly available chemicals like naphthalene/moth balls and/or p-dichlorobenzene. In this state, they can be held for long time with occasional changing of anti-microbial chemicals.

Pong Dam Wetland Sanctuary

It occupies an area of 307 sq km. in Kangra district (31°50'-32°07' N and 75°58'-76°25' E) with a mean altitude of 335 m to 436 m above msl. The vegetation is mainly characterized by sub-tropical pine forests while the surrounding hillsides support some mixed deciduous and chir pine forests. The shoreline does not support emergent vegetation due to pronounced seasonal changes in the water level. The wild fauna includes the Indian wild boar, barking deer, blue bull, Indian red hare, and sambar. It also sustains migratory birds' population from Europe and Russia *viz*., red-necked grebe, Indian skimmer, black stork, bar-headed goose, pochards, mallards, coots, pintails, gadwalls etc. Amongst insects, 75 species of butterflies have been recorded.

Renuka Wetland Sanctuary

It is a small sanctuary occupying an area of 4 sq km. in Sirmaur district (30°35'58"-30°37'08" N to 77°26'34"-78°28'21" E) with a mean altitude of 220 m to 880 m above msl. The vegetation is mainly dry mixed deciduous forest and submerged aquatic vegetation. The wild fauna includes leopard, Himalayan black bear, jungle cat, goral and Himalayan palm civet. The sanctuary has about 48 species of butterflies.

Simbalbara Wildlife Sanctuary

It occupies an area of 19 sq km. in Sirmaur district (30°24'21"-30°28'13" N to 77°27'18"-77°31'26" E) with a mean altitude of 350 m to 700 m above msl. The vegetation is mainly moist sal (*Shorea robusta*) forest. The wild fauna includes leopard, leopard cat, sambar, goral, barking deer, Indian pangolin, jackal, and yellow-throated marten. It has also 126 bird species including white crested kalij, white-rumped shama, thrushes and flycatchers. About 74 species of butterflies augment the diversity of sanctuary.

Naina Devi Wildlife Sanctuary

It occupies an area of 123 sq km. in Bilaspur district (31°16'-31°24' N to 76°25'-76°35' E) with a mean altitude of 500 m to 1,000 m above msl. The vegetation is characterized by northern dry mixed deciduous and chir pine forest with dry bamboo patches. The wild fauna includes leopard, common langur, rhesus macaque, jungle cat, Bengal fox, Indian red hare, yellow-throated marten, mongoose, barking deer, goral, wild boar, sambar, Indian porcupine and common giant flying squirrel. In the sanctuary, 41 species of butterflies are also documented.

TAXONOMY

Cicindelidae
Collyrinae
Cicindelinae

TAXONOMY

Cicindelidae

Diagnostic characters

- Mostly 10-24 mm in length.
- Head, including eyes, usually (as wide as or) wider than pronotum.
- Antennae usually slender, arising from the front of the head above the mandibles, most segments longer than broad.
- Clypeus and labrum produced laterally beyond the bases of antennae.
- Mandibles long sickle-shaped, toothed.
- Elytra usually without grooves or rows of punctures.
- Metasternum usually with transverse suture just in front of hind coxae.
- Usually terrestrial beetles, hind legs not fringed or modified for swimming.

Subfamily *Collyrinae*

Diagnostic characters

- Abundantly distinct and almost entirely confined to India and Malayan region.
- Small and very slender insects, with the elytra usually of a bright blue colour, and more or less strongly punctured.
- Pronotum is generally more or less lagenoid or flask shaped, and is always contracted in front into a longer or shorter collum.
- Elytra very rarely connate, being usually quite free, and wings are always present.
- Legs are elongate and all the tarsi are strongly pubescent beneath with the fourth joint asymmetrically dilated.
- Species are (apparently) arboreal, to be found when sitting on large horizontal leaves, the dilated fourth joint of the tarsi is probably of use in clinging to foliage; their flight is short but very rapid.
- Sexes are very easily distinguished, the last abdominal tergite of the female on its posterior margin has six blunt, more or less hook-like processes and margin of last sternite has two sharp and straight short processes.

Neocollyris (*Neocollyris*) *bonellii* (Guérin-M.)

Diagnostic characters

- Length 8.8-13 mm
- Head is blue green, bright greenish or bluish-green colour, more of less coppery, narrow slightly impressed between eyes; antennae are long and slender, very slightly thickened, with the four basal joints deep blue and eyes are only moderately prominent.
- Pronotum is bluish green, elongate, slender, much constricted before base, elongate conical, with the pronotal collum almost or quite merged into the posterior portion.
- Elytra is bluish, long, narrow, parallel-sided, with the shoulders oblique, distinctly, closely, and regularly punctured, the punctures becoming finer at the apex which is dentate and somewhat excised near the suture.
- Legs with coxae blue-green with their apices black. Femora and trochanters are brick red coloured.
- In males, head is more ovate than in the female, the antennae longer, and the pronotum longer and more slender in front.

Neocollyris (*Neocollyris*) *saphyrina* (Chaudoir)

Diagnostic characters

- Length 13.5-17 mm
- It is of the same subgenus as *N. (N.) bonellii* in overall form but differs in having five intermediate teeth of the labrum strong and blunt.
- Head is bluish, a little longer, with the sides less rounded behind the eyes.
- Pronotum is short, bluish, elongate, slender, constricted before base as in *N. (N.) bonellii*; antennae variable in colour, terminal joints indistinctly dark at the apex.
- Elytra are more elongate, with the shoulders more obsolete, and the whole upper surface more finely and closely punctured.
- Legs with coxae blue-green and their apices are black, with black trochanters and femora brick red coloured.

Subfamily *Cicindelinae*

Diagnostic characters

- Head is large more or less excavate and always striated between the eyes, which are large and prominent; antennae are long, filiform, with the basal joints metallic and the apical joints dull.
- Mandibles are large and powerful with strong and sharp teeth.
- Pronotum is well developed, variably setose, and is usually quadrate or sub quadrate.
- Elytra are variable but always broader than the pronotum, with well marked shoulders.
- Males have first three joints of anterior tarsi dilated and pliose while in female they are simple.

Heptodonta pulchella (Hope)

Diagnostic characters

- Length 15-17 mm
- Head is large, brown coloured, striated between the eyes, without setae, lateral margins are metallic green and bluish; antennae are long, filiform pedicel is metallic coppery while the segments are dull brown coloured. Labrum with seven teeth in front.
- Pronotum is medium, dull red coloured, with rounded sides and without setae, margins are metallic green and bluish with some coppery tinge.
- Elytra are uniformly pitted, dull red brown coloured with mid lateral margins metallic green and bluish. It has no markings or any spots.
- Legs are with trochanters thickly setose brown coloured while rest of the segments are also red brown to brown coloured, tarsi ending in two claws.

Calochroa bicolor (Fabricius)

Diagnostic characters

- Length 15-17 mm
- Head is coppery and dark green, flat between eyes, front parts green, finely and rugosely sculptured; broad between the eyes; antennae metallic black with four basal segments greenish.
- Pronotum as long as head without the labrum with colour and sculpture similar to that of head, sides convex and narrow base.
- Elytra dark greenish, cyaneous or bluish with very fine sculpture, almost smooth and with two large yellow spots.
- Underside of the parts violaceous or partly green, abdomen dark, with the apex and the side margins reddish.
- Legs metallic, episterna of metasterna bare with a tuft of white hairs at inner posterior corner.

Calochroa flavomaculata (Hope)

Diagnostic characters

- Length 13.5-16 mm
- Moderate sized, dark velvety species, head and pronotum with very obscure metallic reflections, blue or green at the sides.
- Pronotum quadrangular, with the impressions and central line distinct, and with a bright metallic callosity at each end of the basal one.
- Elytra with the sides somewhat rounded, velvety with the sides and suture narrowly bright green or blue with three white or yellowish spots on each of about the same size, arranged in a line.
- Femora are metallic green or violet, tibiae and tarsi more or less pitchy; underside bright green or violaceous, sides of abdomen with scanty pubescence.

Calomera plumigera (Fabricius)

Diagnostic characters

- Length 10.5-14 mm
- Head dull coppery, brilliant bright and greenish, broad and flat between eyes, glabrous, very finely striated longitudinally between eyes. Pubescence coarser and thicker, hairs in front of the white labrum are also thicker, antennae black with four basal joints with blue or green reflection.
- Pronotum with colour similar to that of head, slightly rounded near apex, narrowed towards base, with impressions strongly marked, central line slightly marked. The margins of the elytra in the female are sometimes irregular and sinuate.
- Elytra with colour similar to head and pronotum, with greenish punctures and white markings, slightly widened in middle. White colour extends from the shoulders to the apex, with an interruption before the apical lunate patch;

- there is a transverse extension towards suture, a large inverted V- or S-shaped patch at middle extending backwards.
- Legs are greenish sometimes with coppery reflection.

Calomera angulata (Horn)

Diagnostic characters

- Length 12.5-16 mm
- Head is dark greenish and coppery, antennae black with four basal joints with purple reflection.
- Pronotum is contracted before the base with greenish central line and green punctures.
- Elytra are much broader than pronotum dark brown or olive green with elaborate or white testaceous markings. White colour extends from the shoulders to the apex, with an interruption before the apical lunate patch; there is a transverse extension towards suture, a large inverted V- or S-shaped patch at middle extending backwards.
- Legs are greenish and coppery with reddish trochanters.

Calomera chloris (Hope)

Diagnostic characters

- Length 11.5-12 mm
- Head is greenish with coppery and bluish reflection, broad slightly raised in middle between eyes, surface is finely striated; antennae with four basal segments green with coppery reflection, rest black.
- Pronotum green, with the sides and depressions blue or violaceous, slightly transverse.
- Elytra green to bluish green with blue punctures, much broader than pronotum, dull, granulose, at the margin about the middle there are two white spots joined by a thin line, before the apex a more or less comma-shaped spot.
- Legs metallic, underside green and violaceous, with the whole of the sides of the abdomen, the episterna and the genae thickly clothed with long white coarse pubescence.

Cosmodela intermedia (Chaudoir)

Diagnostic characters

- Length 14-15 mm
- Head greenish, coppery in middle, with two purple blue stripes in front of eyes, slightly raised in middle between eyes, glabrous; antennae with four basal segments greenish black and deep blue.
- Pronotum reddish coppery, with margins and impressions green and blue, with sides slightly rounded, narrowed towards base, with well marked impressions. Central line is moderately marked, rugose.
- Elytra much broader than the pronotum, with the sides being slightly rounded shoulders sub-rectangular, greenish and coppery. Each elytron has a white spot at the shoulder, and four others on each elytron, three in a longitudinal row near the margin (marginal spots), and a small one (humeral spot) just behind the middle one and near the suture.
- Underside shining green and deep blue, legs blue and black and trochanters are dark brownish-gray, femora metallic, tibiae and tarsi dark; genae with few white hairs.

***Lophyra* (*Spilodia*) *striolata* (Illiger)**

Diagnostic characters

- Length 10-15 mm
- Head is coppery, with greenish reflection, blue and green behind eyes aterally, slightly raised in middle between eyes; antennae with four basal segments metallic rest blackish and dull.
- Pronotum is with a more or less distinct coppery reflections, with the sides bright green and coppery, and with two short blue lines between the eyes, about as long as broad, with the sides more or less rounded with distinct short and scanty setae at the sides.
- Elytra with sides sub-parallel, velvety black, with a basal spot, two juxta-sutural spots, and a discal spot joined to a submarginal spot by a narrow line, and a subapical, usually interrupted lunule [extending up to middle band].
- Legs and underside metallic, coppery green and cyaneous.

***Jansenia crassipalpis* (Horn)**

Diagnostic characters

- Length 10-12 mm
- Head is predominantly green and violaceous with vertical striations, greenish reflection in front, and metallic green laterally and behind the eyes; eyes are prominent with metallic blue tinge; antennae with the first four basal segments with metallic greenish blue reflection, rest maroon red.
- Pronotum is bright green and metallic blue laterally, strongly rounded at base, constricted near apex and base with very little setae.
- Elytra are with brilliant blue margins and suture; maculations include two yellow spots on shoulder, two minute red spots near the margin in the middle, and three big, conspicuous yellow spots at the margin on each elytron, the surface being uniformly pitted with moderately deep punctures.
- Legs are black, with blue-green reflections, trochanters are red, and underside is brilliant blue with very little pubescence.

Jansenia chloropleura (Chaudoir)

Diagnostic characters

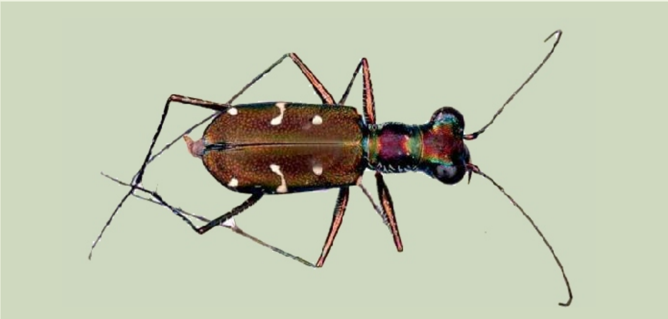
- Length 10-12 mm
- Head is predominantly coppery, with greenish reflection in front, green laterally behind the eyes, rather long, somewhat excavate and strongly striate between the eyes, which are moderately prominent; antennae with the first four basal segments black with greenish reflection, rest black.
- Pronotum is bright coppery, green and blue laterally, strongly rounded at base, constricted near apex and base.
- Elytra are dull coppery red or olivaceous with brilliant blue or green margins and suture, and with two white spots on each, just touching the marginal colour, one at middle and other at apex, surface with small moderately deep punctures.
- Legs are black, with coppery and greenish reflection, trohanters are red, and underside is brilliant green or deep blue with very little pubescence.

Cylindera (*Ifasina*) *bigemina* (Klug)

Diagnostic characters

- Length 9-10 mm
- Head is coppery, with green reflection and its surface is striated between eyes; antennae are black, four basal segments have greenish reflection. Genae and clypeus glabrous.
- Pronotum is coppery, slightly narrowed towards base, with straight sides. Female coupling sulci a broad shallow groove.
- Elytra with sides sub-parallel, shoulders sub-rectangular, extreme margins greenish- metallic dull, uniformly and thickly punctured. Each elytron has a whitish yellow spot at the shoulder, two on the disc and a sinuate middle band (acutely bent at middle), as well as an apical lunule.
- Legs are metallic, trochanters black; underside deep blue or greenish, coppery in front, with much thicker pubescence.

Cylindera (*Ifasina*) *subtilesignata* (Mandl)



Diagnostic characters

- Length 7-8 mm
- Head green, blue, coppery and golden, finely striated longitudinally between eyes, and finely rugose at other places, glabrous.
- Antenna with four basal segments greenish-black, rest pitchy; scape with one pre -apical seta.
- Pronotum coppery with margins green, sometimes entirely greenish, sub-quadrate, slightly narrowed towards base. Its surface is finely rugose (having wrinkles), covered with few white setae laterally.
- Elytra slightly widened behind basal one-fourth with shoulders sub-rectangular. Each elytron is coppery with a green strip extending marginally from shoulders to basal one-fourth and then sub-marginally up to basal three-fourth, suture and base green; markings whitish and comprise of a humeral spot, a discoidal spot and a small sub-marginal spot.

- Abdominal sternites dark blue green, six basal segments in ♂ while five in ♀
- Legs blue, green, and coppery, with trochanters reddish.

Cylindera (*Ifasina*) *spinolae* (Gestro)

Diagnostic characters

- Length 7-8 mm
- Head is small, black, striated between the eyes, glabrous (without setae); antennae with four basal segments metallic with red-green lustre, rest segments dull black coloured.
- Pronotum is small, with bluish margins, rugose, coppery, and transverse striations along median line.
- Elytra surface is uniformly pitted; brown coloured, shoulders are bluish green, coppery metallic. Each elytron with two conspicuous whitish yellow spots near the posterior half on the margin, and two minute yellowish spots roughly in the centre on either side of the elytra.
- Legs with trochanters are red-green metallic while rest segments are black dull, tarsi green ending in two claws.

Cylindera (*Ifasina*) *viduata* (Fabricius)

Diagnostic characters

- Length 7-8 mm
- Head is short, striated vertically between the eyes, coppery green; antennae with four basal segments with greenish red lusture, rest are dull black.
- Pronotum is short, elongated, coppery green, transversely striated, the apical sides are bluish green, feebly setose.
- Elytra with shoulders are flat, elytra is uniformly densely pitted. Each elytron with three whitish spots in lower half, one elongated at margin in the middle, one round spot near 2/3rd portion of body along mid-elytral suture, one at the lower end [is crecentric-like].
- Legs are with trochanters dull greenish coloured and tarsi are dull black.

Cylindera (*Eugrapha*) *grammophora* (Chaudoir)

Diagnostic characters

- Length 8-8.5 mm
- Head is blue, green, coppery and black, flat between the eyes, surface with broad and deep striations; antennae with four basal segments greenish, rest black.
- Pronotum coppery, greenish laterally, with sides straight and parallel surface is rugose covered with few white setae laterally.
- Elytra is dull, dark usually with more or less distinct greenish reflections at base, with sides sub-parallel, shoulders sub-rectangular, surface shallowly punctuate. Margins are mostly white testaceous, being interrupted before the basal and apical markings the white markings consist of a large crescent -shaped spot at the shoulders, central inverted V-shaped marking springing from the marginal patch, with the inner lines produced and dilated towards the suture.
- Legs metallic trochanters red, underside, head, and genae, thickly set with tomentose pubescence.

Cylindera (*Eugrapha*) *venosa* (Kollar)

Diagnostic characters

- Length 8-9 mm
- Head greenish and coppery, broad and slightly raised between eyes, with a small depression on each side of raised area, its surface glabrous, very finely striated between eyes and in front.
- Antennae with four basal segments greenish, rest black. Its scape is with one stout pre-apical seta.
- Pronotum greenish and coppery, transverse with sides straight and parallel, its surface are with transverse striations alongcentral line and almost smooth at other places, laterally covered with long white setae.
- Elytra slightly rounded at sides with shoulders slightly rounded, surface shallowly punctate with few basal punctures setigerous. Each elytron green and coppery with white maculation, which comprise of a complete white marginal line extending from shoulders to apex formed by fusion of a complete humeral and apical lunules and middle band.

- Abdominal sternites green, densely setose with glabrous areas in middle. Legs green with anterior and hind trochanters partially reddish.

Myriochila (_Myriochila_) _melancholica_ (Fabricius)

Diagnostic characters

- Length 10 mm
- Head is green and coppery, slightly raised between eyes, its surface is glabrous; antennae with four basal segments greenish black.
- Pronotum is coppery and green, sub-quadrate with sides slightly rounded, and narrowed at base.
- Elytra are slightly widened behind middle, with shoulders sub-rectangular, surface with few large deep punctures in middle near base. Margin of elytra broad and unevenly whitish testaceous; at the shoulders there is a crescent, produced behind into a sharp point, which almost joins a spot on the disc. A narrow band starts from the centre of margin and is strongly hooked ceases at the middle of the disc.Below the apex of this and near the suture is a white spot, the apical margin is white and produced at its upper end.
- Legs are reddish-testaceous with reddish trochanters.

Myriochila (*Myriochila*) *undulata* (Dejean)

Diagnostic characters

- Length 10-11 mm
- Head is small, dull coppery with the apex and basolateral portions being bluish green and coppery, feebly striated between the eyes and with no setae; antennae with the first segment metallic rest are dull brown coloured.
- Pronotum is more or less with parallel sides and lateral margins with setae the lateral sides of apex are bluish green while rest of the pronotum is dull coppery coloured
- Elytra are uniformly pitted expanded towards the base, the antero-lateral margins being bluish green while the rest of the elytra are dull coppery coloured. The markings include a crecentric-shaped patch running towards base, two prominent circular white spots near the base and the baso-lateral margins have the dull white marking running some way towards apex along the margins.
- Legs are with greenish trochanters, metallic, setose while rest of the segments are brownish, tarsi brown ending in two claws.

ROLE OF TIGER BEETLES AS BIOINDICATORS

Bioindicators are used to monitor the health of an environment or ecosystem. They are any biological species or group of species whose function, population, or status can be used to determine ecosystem level or environmental integrity. Such organisms are monitored for changes (chemical, physiological, or behavioural) that may indicate a problem within their ecosystem. An increase or decrease in an animal population may indicate damage to the ecosystem caused by an environmental stressor. For example, if pollution causes the depletion of important food sources, animal species dependent upon these food sources will also be reduced in number.

An insect taxon is used to identify the state or changes in the landscape or to find out how certain insect taxa are affected by a possible or an inevitable modification to the landscape. Insects in general are particularly suited for monitoring landscape change because of their abundances, species richness, ubiquitous occurrence and importance in the functioning of the natural ecosystems. In this regard, Pearson and Cassola have proposed the use of tiger beetles (Cicindelidae) as an indicator group for identifying areas for biodiversity conservation. Tiger beetles are well known, their biology well understood, occur over a broad range of biotope types and geographical areas and also exist in remnant patches of appropriate biotopes thus they are particularly useful as "fast bioindicators".

The family of tiger beetles (Cicindelidae) is an appropriate indicator taxon for determining regional patterns of biodiversity because (1) its taxonomy is stabilized; (2) its biology and general life history are well understood; (3) individuals are readily observed and manipulated in the field; (4) the family occurs world-wide and in a broad range of habitat types; (5) each species tends to be specialized within a narrow habitat; (6) patterns of species richness are highly correlated with those of other vertebrate and invertebrate taxa; and (7) the taxon includes species of potential economic importance. Logistical advantages provide some of the strongest arguments for selecting tiger beetles as an appropriate indicator taxon. Species numbers of tiger beetles are relatively well known for the various countries of the world. Eight countries alone account for more than half the world total of over 2600 known species. The tiger beetle species numbers can be reliably determined within fifty hours on a single site, compared to months or years for birds or butterflies, and the advantage of using tiger beetles in conservation biology is thus evident.

जैव-सूचकों के रूप में टाइगर बीटल्स की भूमिका

किसी पर्यावरण या पारितंत्र के स्वास्थ्य की निगरानी के लिये जैवसूचकों का उपयोग किया जाता है। वे जैवशास्त्रीय प्राणी जातियाँ या उन जातियों का समूह हैं, जिनका कार्य आबादी या स्थिति को पारितंत्र स्तर या पर्यावरणीय समग्रता का निर्धारण करने में उपयोग किया जा सकता है। ऐसे जीवों को परिवर्तनों (रासायनिक, शरीर-विज्ञान सम्बन्धी, या व्यवहार सम्बन्धी अध्ययन) के लिये मॉनीटर किया जाता है। एक प्राणी आबादी का घटना या बढ़ना किसी परितंत्र को प्रदूषण द्वारा हुए नुकसान को दर्शाता है। उदाहरण के लिये, यदि प्रदूषण के कारण महत्वपूर्ण भोजन स्त्रोतों में कमी आती है, तो उन भोजन स्त्रोतों पर निर्भर प्राणी जाति की संख्या में भी कमी आयेगी। एक कीट टैक्सान को भू-दृश्य में हुए परिवर्तनों या स्थिति को पहचानने में उपयोग किया जाता है या यह पता करने के लिये उपयोग किया जाता है कि भूदृश्य में अवश्यंभावी या संभावित होने वाले परिवर्तनों से कोई निश्चित टैक्सा किस प्रकार प्रभावित होता है। कीट सामान्यतः भूदृश्य परिवर्तन की निगरानी के लिये खासतौर पर उपयुक्त हैं क्योंकि ये प्रचुरता, प्रजाति सम्बद्धता, सर्वत्र उपस्थिति और प्राकृतिक पारितंत्र के क्रियाकलापों में महत्वपूर्ण हैं। इस संदर्भ में विश्व-विख्यात वैज्ञानिक पीयर्सन और केसोला ने टाइगर बीटल्स (*सिसिनडेलिडी*) का उपयोग एक सूचक के रूप में करने का प्रस्ताव दिया है, जिसे जैवविविधता संरक्षण के लिये उपयोग किया जाये। टाइगर बीटल्स अपने जीव विज्ञान के लिये जाने जाते है। ये बायोटाइप प्रकारों और भौगोलिक रूप से विस्तृत क्षेत्रों में पाये जाते हैं तथा उपयुक्त बायोटाइप के विभिन्न खण्डों में भी पाये जाते हैं। इस प्रकार वे ''तीव्र जैवसूचकों'' के तौर पर विशेष रूप से उपयोगी है।

जैवविविधता की क्षेत्रीय पद्धतियों के निर्धारण के लिये टाइगर बीटल्स (*सिसिनडेलिडी*) का कुल एक उपयुक्त सूचक टैक्सान है, क्योंकि (१) उसका वर्गीकरण विज्ञान स्थायी है, (२) उसका जीवविज्ञान और सामान्य जीवन इतिहास भली-भाँति समझा जा चुका है, (३) प्रत्येक का भलीभाँति निरीक्षण किया जाता है एवं क्षेत्र में कुशलता से प्रयोग किया जाता है, (४) इसका कुल, दुनिया भर में पाया जाता है व वासस्थल प्रकारों का एक विस्तृत क्षेत्र है, (५) प्रत्येक प्राणी जाति एक सीमित वासस्थल में भी विशेषता को इंगित करती है, (६) प्राणी जाति की सम्बद्धता की पद्धतियों अन्य मेरूदण्डीय टैक्सान से बहुत अधिक सह-सम्बद्ध होती है, (७) इस टैक्सान में संभावित आर्थिक महत्व की जातियाँ शामिल हैं। टाइगर बीटल्स को एक उपयुक्त सूचक टैक्सान के रूप में चयनित करने के लिये संभारतंत्रीय लाभ कुछ सशक्त तर्क प्रदान करते हैं। दुनिया के विभिन्न देशों में पाई जाने वाली टाइगर बीटल्स की कुल २६०० जातियों में से आधे से ज्यादा जातियाँ आठ देशों में ही पाई जाती हैं। किसी एक स्थल पर पचास घण्टों के भीतर टाइगर बीटल्स की जातियों को विश्वासपूर्वक निर्धारित किया जा सकता है, जबकि इनकी तुलना में पक्षियों या तितलियों के निर्धारण में महीनों या सालों लग सकते हैं। अतः जैवविविधता संरक्षण में टाइगर बीटल्स के उपयोग के लाभ बिल्कुल स्पष्ट हैं।

TIGER BEETLES ACROSS DIFFERENT PROTECTED AREAS IN SHIVALIKS

S. No.	Species	Simbalbara WLS	Pong Dam WLS	Naina Devi WLS	Renuka WLS	Nahan Reserve forest
1	*Calochroa bicolor*	+	-	-	-	-
2	*Calochroa flavomaculata*	-	+	-	-	-
3	*Calomera angulata*	+	+	-	-	-
4	*Calomera plumigera*	+	+	-	-	-
5	*Calomera chloris*	+	+	-	-	-
6	*Cosmodela intermedia*	+	+	+	+	-
7	*Cylindera spinolae*	+	-	+	-	+
8	*Cylindera bigemina*	+	-	+	-	-
9	*Cylindera grammophora*	+	+	-	-	+
10	*Cylindera subtilesignata*	+	-	+	+	-
11	*Cylindera venosa*	+	-	-	-	-
12	*Cylindera viduata*	+	-	-	-	-
13	*Heptodonta pulchella*	-	-	-	-	+
14	*Jansenia chloropleura*	+	-	+	-	-
15	*Jansenia crassipalpis*	-	+	-	-	-
16	*Lophyra striolata*	+	-	-	-	+
17	*Myriochila melancholica*	+	+	-	-	-
18	*Myriochila undulata*	-	-	-	-	+
19	*Neocollyris saphyrina*	+	+	+	+	-
20	*Neocollyris bonellii*	+	+	-	-	-
	Total	**16**	**10**	**6**	**3**	**5**

GLOSSARY

Aedeagus : The sclerotized terminal part of the male phallus used during copulation.

Antennae : Paired segmented appendages on either side of the head that function as sensory organs.

Clypeus : The part of the insect head anterior to the frons (front) to which the labrum is attached anteriorly.

Cupreous : Copper-colored.

Decumbent : Bending downward; bending downward at the tip from an erect base.

Elytra (sing. elytron) : The modified forewings of beetles serving as protective coverings for the hindwings.

Frons : The anterior portion of the insect head bounded in front by the clypeus.

Genae (sing. gena): The side of the insect head below the compound eye; the cheek region.

Glabrous : Without setae.

Hairs (sing. Hair) : Non-sensorial bristles.

Immaculate : Without any markings.

Impunctate : Not marked by punctures.

Instar : A larval growth stage between molts.

Integument : The multi-layered covering of the insect body.

Labrum : The uppermost and anterior most mouthpart ("upperlip") which covers the bases of the mandibles and is bounded posteriorly by the clypeus.

Maculae (sing. macula) or Spots or Maculations : Pale or colored elytral markings.

Mesad : Towards the midline of the body.

Mesonotum : The dorsal sclerite of the mesothorax.

Mesoscutellum : The visible triangular piece of the mesonotum between the bases of the elytra.

Mesothorax : The second thoracic segment bearing the second pair of legs and the elytra (forewings of beetles).

Metathorax : The third thoracic segment bearing the hind legs and the hind wings.

Proepisternum : The anterior most lateral sclerite of the prothorax.

Pronotum : The sclerite comprising the dorsal surface of the prothorax.

Prosternum : The ventral sclerite of the prothorax surrounding part or all of the leg bases.

Prothorax : The first thoracic segment bearing the first pair of legs.

Punctate : Marked by punctures or pits.

Scape : The basal antennal segment.

Sclerite : Hardened portions or plates of the insect integument separated from one another by membranes or sutures.

Sclerotin : A tough protein that is resistant to degradation and which forms the hardened parts of the insect integument.

Sclerotized : Hardened by deposition of the protein sclerotin.

Serrulate : Finely serrate; saw-like, with small teeth or notches.

Setae (sing. seta) : Sensorial bristles or hairs.

Spermatheca : A sac-like organ of the female reproductive system that receives and stores sperm.

Sulcus (pl. sulci) : A groove or depression

Supraorbital : Region of the insect head just above the margin of the compound eye.

Suture : An immovable seam between sclerites.

Tridentate : Possessing three teeth or tooth-like processes.

Unidentate : Possessing one tooth or tooth-like process.

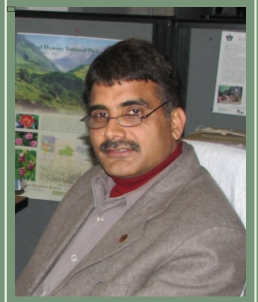
Vertex : The top of the head.

Vestibule : The space surrounding the ovipositor and formed by the walls of the surrounding abdominal segments.

♂ : Male

♀ : Female

About the Authors



He is a faculty member at the Department of Landscape Level Planning and Management, Wildlife Institute of India, Dehradun. He has been actively involved in the research on insect diversity, ecology and long term ecological monitoring in the protected areas of Himalayan region.

Dr. V.P. UNIYAL

He has completed his Master's from M.S.University, Vadodara. He is pursuing his Doctoral thesis on Coleoptera as bioindicators in the protected areas of Shivalik Landscape at the Wildlife Institute of India.

VINAY BHARGAV