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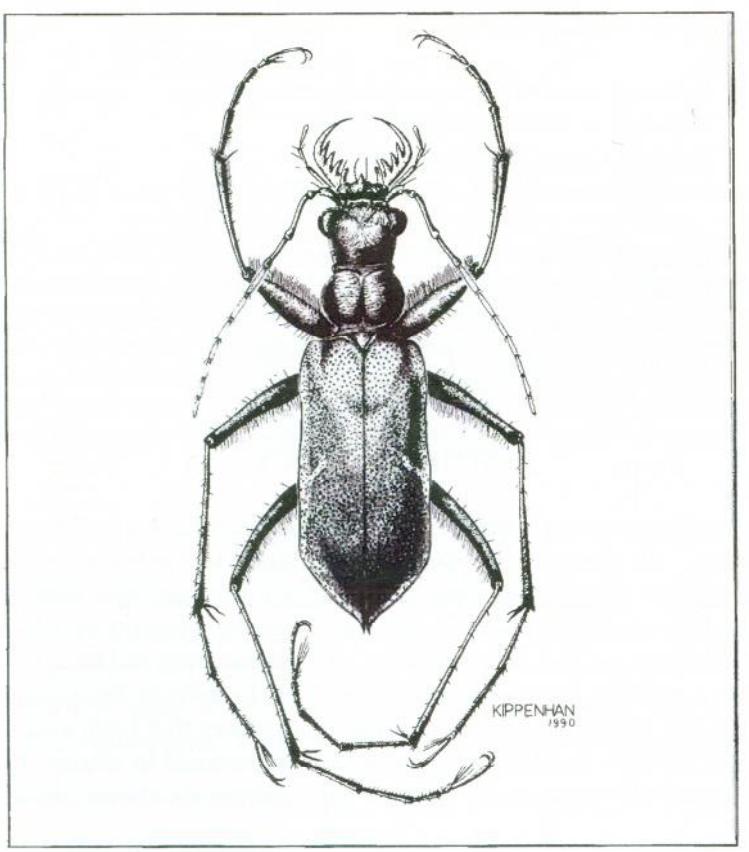

Holotype of *Oxygonia kondratieffi* Kippenhan, drawn from a male taken 29 June 1972, in Departamento Valle del Cauca, Colombia, 60 km NW of Cali.

COMMUNAL ROOSTING OF TIGER BEETLES (CICINDELIDAE: COLEOPTERA) IN THE SHIVALIK HILLS, HIMACHAL PRADESH, INDIA

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ABSTRACT: In the southern foothills of the Himalayas, communal roosts of three species of tiger beetles (*Calomera angulata* (Fabricius), *Calomera plumigera* W.Horn and *Calomera chloris* (Hope)) formed during the summer monsoon season. At the beginning and end of the monsoon, these congregations of roosting tiger beetles occurred primarily at night, but at the height of the monsoon, they became virtually permanent roosts day and night with up to 5000 individuals on a single low bush. The same few individual bushes were used each year. We hypothesize that these roosts may serve in protection from predators, escape from flooding, thermoregulation or reproductive synchronization.

INTRODUCTION

Communal roosting is defined as an occurrence of numerous individuals of one or more species that congregate in close proximity to one another for several hours. It is a common social behavior exhibited by many vertebrates but also seen in some insect groups, such as Lepidoptera, Diptera, Hymenoptera, and Odonata (Zahavi 2001).

Tiger beetles are normally considered asocial and tend to congregate only coincidentally for short periods around concentrated food sources or restricted shade sites (Pearson and Vogler 2001). However, several reports of seasonal communal roosts have been reported from Amazonian South America. These roosts form during the day for the nocturnally active *Cheiloxya binotata* (Laporte de Castelnau), and they involve up to 100 individuals found on low, shaded-stream vegetation (Pearson and Vogler 2001). Roosts of 10 to 15 individuals of several diurnally active species of the genera *Odontocheila* Laporte de Castelnau and *Pentacomia* Bates form at night in flood plain forest

undergrowth (Pearson and Anderson 1985, Knisley and Hoback 1994). These roosts appear to be most persistent in the early part of the rainy season. Here we report for the first time the observation of persistent tiger beetle communal roosts in Asia that involve thousands of individuals of three species.

STUDY AREA

The Simbalbara Wildlife Sanctuary (SWLS) (N: 30° 24' 21" and 30°27'33.8''; E: 77° 27' 18" and 77°32'05.6'') is situated in the foothills of the Shivalik Hills, in the state of Himachal Pradesh, India, (Fig.1) and lies in the confluence of the plains and the main Shivalik system. Thus, the flora, fauna and physical features show a mixture of affinities to the western Himalaya, Punjab plains and upper Gangetic plains (Biogeographic zones 2B, 4A and 7A respectively, Rodgers *et al* 2000). The mean altitudinal range is 350 m to 700 m above msl. It is a small protected area and spans over 19 sq. km. The hills are composed of unconsolidated sandstone and conglomerate that are extremely prone to erosion. The soil is extremely porous and thereby highly drained. However, in many low-lying areas springs emerge and create perennially moist riverine microhabitats appropriate for tiger beetles. The area receives a mean annual rainfall of about 1260 mm. The relative humidity varies from 100% during monsoon to 26% in summer (Pendharkar, 1993).

Moist forests dominated by dipterocarp tree species called Sal (*Shorea robusta*) and northern dry mixed deciduous forests characterize much of the sanctuary. In addition to these two major habitat types, there are mixed woodlands, riverine forests and small areas of eucalyptus plantations.

RESULTS

Seasonality, roost arrival and departure: During the early hot summer season when the daytime temperature rises to 42-45° C and relative humidity rarely rises above 36-40%, ground-dwelling tiger

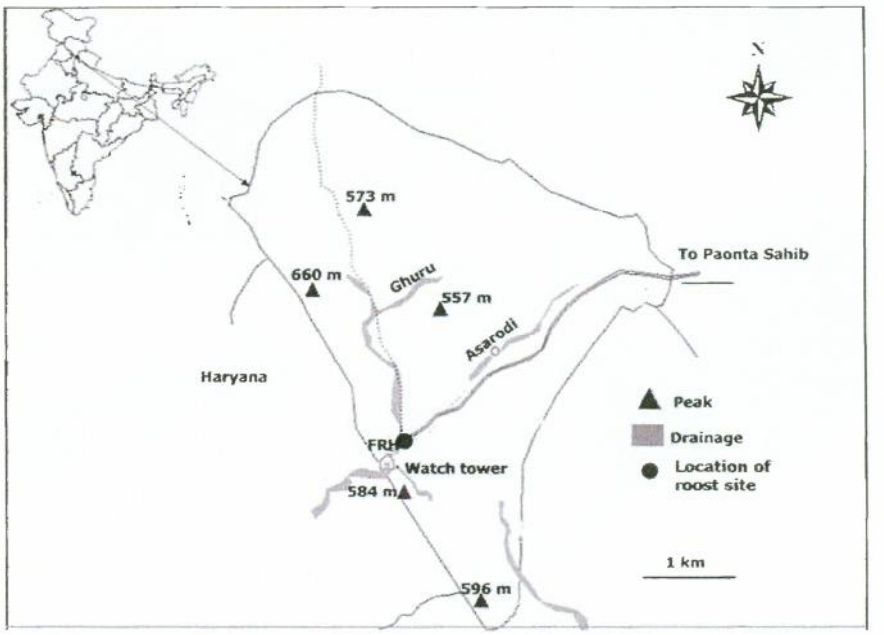

Fig. 1 Map of Simbalbara Wildlife Sanctuary, Himachal Pradesh, India

beetle species of the area rest for much of the midday on the ground in shady areas and rely upon catching prey by waiting and ambushing them. No communal roosting sites were used during this season either in the daytime or at night. However, with the onset of the heavy rains of the summer monsoon (July to September), a season associated with lower temperatures (24-28 ± 2.5° C) and higher humidity (80-100%), roosts started to form. Initially, after the first few showers in July when temperature was around 27-30° C and relative humidity was around 65-75 %, a few hundred individuals started clustering on the lower branches of a few low bushes. Nevertheless, at this point in time the roosts were not stable and were formed for only short periods during dawn and through the night (Fig. 2 and 3). However, as precipitation increased and temperatures decreased (24-27° C), the number of individual tiger beetles participating in communal roosts grew to thousands. The peak size of the roosts was attained during mid-August, a period of maximum precipitation (1360 mm). By the end of monsoon, in late September, the group size began to decrease to a few hundred individuals; few individuals were present in the roosts by the first week of October; and virtually all-communal roosting ceased after the wet season ended. However, isolated individual tiger beetles were still present on the riverbanks and other typical substrate habitats until the onset of winter.

Group size and mixed species congregates: These roosts involved more than 5000 individuals that assembled in close proximity with one another to rest for several hours. These aggregations were so dense that individuals were in close physical contact with each other and exhibited constant jostling and bustling (Fig. 4). Sixteen species of tiger beetles have been reported from this sanctuary (Uniyal and Bhargav, 2007), but we observed only three species, *Calomera angulata*, *Calomera plumigera* and *Calomera chloris* participating in the communal roosting. Approximately, seventy percent of the individuals were *C. angulata*, twenty-five percent *C. plumigera* and five percent *C. chloris*

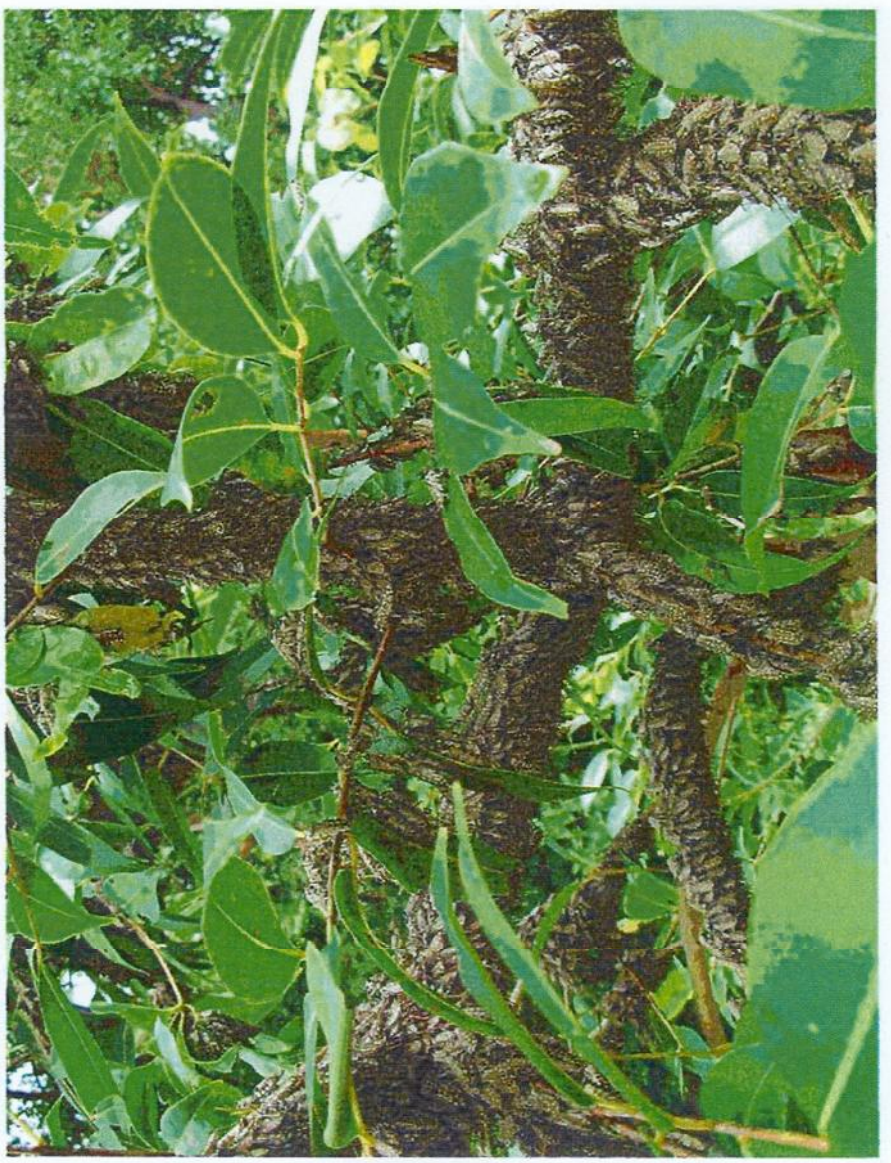

Fig. 2. Diurnal communal roosts of tiger beetles.

Fig. 3. Nocturnal communal roosts of tiger beetles.

Fig. 4. Crowded roosting behavior of tiger beetles.

Habitat Preference: These roosts were found in the most preferred habitat of tiger beetles *i.e.*, in the riverine area of the SWLS on two host plant species *viz.*, Jamun (*Syzygium cumini*) and Karaunda (*Carissa spinarum*). However, as a rule they preferred the low height shrubs (GBH girth at breast height = less than 10 cm) less than 8 feet as these shrubs provided many branches to have more area for clustering. Apparently, such roosts did not cause any damage to the host plant species owing to their predatory nature, and hence we speculate that such roosts are usually not host plant specific. Low height, less than 5 feet, shrub flora comprised of *Xanthium strumarium, Sida rhombifolia, Eupatorium adenophorum, Abutilon indicum, Crotolaria sericea, Caryopteris grata* etc. were also not inhabited. Tall trees more than 20 feet (GBH= more than 15 cm) in the vicinity comprised mainly of mixed riverine forest tree species *viz. Trewia nudiflora, Ehretia laevis, Acacia catehcu, Mallotus philippensis, Ougeinia oogenensis, Toona ciliata, Bauhinia malabarica, Litsea glutinosa* etc. were not at all preferred (Pearson and Anderson, 1985). They tend to prefer the riverine habitat because of close proximity to water and food resources, safety from predators, and reasonably low human disturbance.

Site fidelity: During the study period of three years (September 2004- August 2007), these species of tiger beetles also exhibited high site fidelity by returning to the same roost site of the same host plant species year after year in the monsoon season. Even though such moist riverine areas were found in other parts of SWLS, no aggregations of any kind were found.

Characteristics and activity patterns: Apart from accidental disturbances (by wild fauna, observer's presence) that caused some individuals to fly from the roost, most individuals maintained their place throughout the day and night. Occasionally a few individuals would leave spontaneously to hunt for prey along the river substrates, but they would later rejoin the group. There were also occasional sexual interfaces throughout the day and night among the adult beetles in the roost site.

Year round dynamics in riverine area: Of the sixteen species of tiger beetles recorded from the reserve, five common and regular species, *Calomera angulata*, *C. plumigera*, *C. chloris*, *Cylindera subtilesignata* (Mandl), and *C. venosa* (Kollar) inhabited open substrates in the riverine area. The other species were restricted mainly to upland areas of mixed forest and agricultural scape. In the riverine area, *Cosmodela intermedia* Chaudoir, typically a species more common in montane rocky streams, was found rarely during early sunset, and attracted to light traps set for nocturnal collection. While *C. angulata* and *C. plumigera* underwent hibernation during mid-October, isolated individuals of *C. chloris* could be observed on the moist riverbeds until mid-December only to re-emerge during mid-February. This latter species was found to be dominant throughout summer and some part of winter and were replaced by the other species involved in roosting during wet season.

Functional and adaptive significance: Several alternative hypotheses need to be tested eventually to sort out the function of the communal roosting behavior. The concentration of tiger beetle individuals and their movements could make them obvious to potential predators, such as Asilidae, Tiphiidae and Bombyliidae. If so, the grouping of tiger beetles in a stellate shape might produce a function of enhanced aposematic (warning) patterns (Fig. 5). These riverine species are known to produce defense chemicals such as benzaldehyde (Moore and Brown 1971) and benzyl cyanide (Blum *et al* 1981, Pearson *et al* 1988) from their posterior pygidial glands (Forsyth 1970). The typical posture in these roosts with their abdomens outwards might augment the effects of chemical defenses against predators (Calvert *et al* 1979).

Alternatively, there may also be some degree of cryptic (camouflaging) advantage against birds and other potential vertebrate predators. In addition, the possibility of thermoregulation cannot be ruled out, as these roosts were found concomitant to the low temperatures and ensuing rainfall. Often they dispersed post-rainfall only to reassemble later. Another possibility is that these roosts have a social function to synchronize reproduction and dispersal.

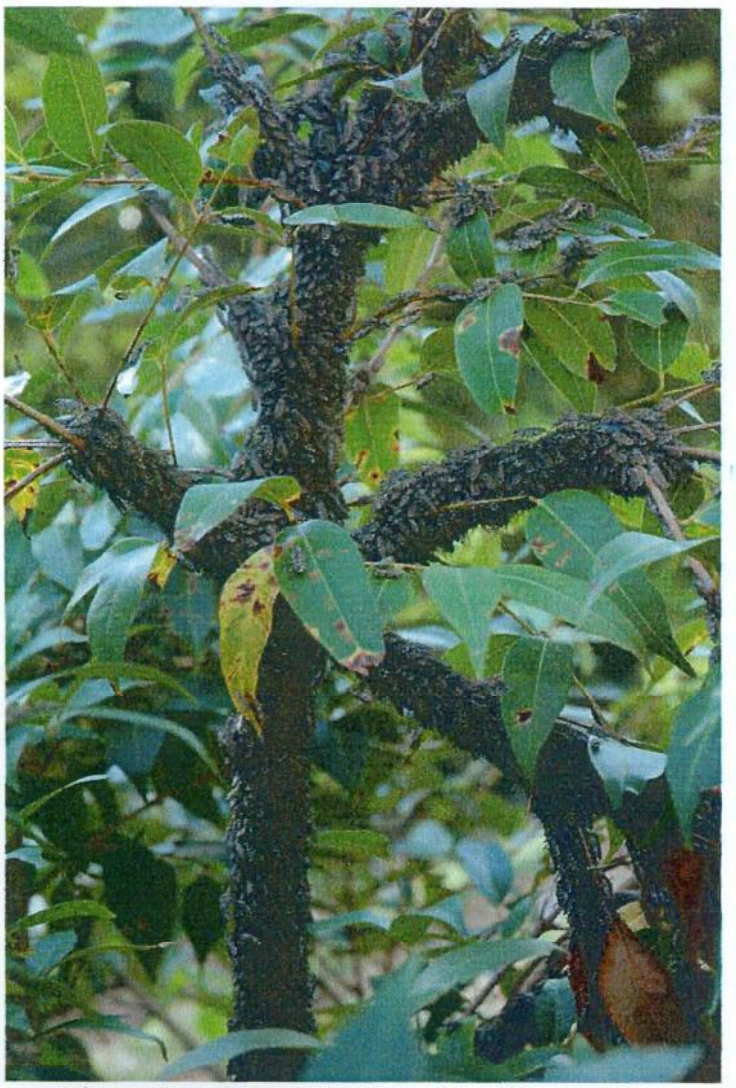

Fig. 5. Crowded roosting behavior of tiger beetles.

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CONTENTS

NOTICES;

The mailing date for *CICINDELA* 37(1-2), containing the description of *Ctenostoma (Procephalus) panamensis* Naviaux & Brzoska and *Ctenostoma (Neoprocephalus) hovorei* Naviaux & Brzoska, was 30 November 2005.

The mailing date for *CICINDELA* 39(1-2), containing the description of *Cicindela (Cylindera) terricola susanagreae* Kippenhan, was 17 September 2007.