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Species of Tari in Arunachal Pradesh: Morphology, Ecology and Toxicity of Entomophagy

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Abstract: Certain species of insects belonging to the genus Coridius (Hemiptera: Dinidoridae) are locally known as 'tari' (in dialect of Adi community) or 'paahu' (in dialect of Mishmi tribe) or 'gandhi puk' in Arunachal Pradesh. Many people in the region use these insects as food or condiment. The most abundant species of these insects are the *Coridius nepalensis* (West.) and *Coridius singhalanus* (Dist.). The less abundant is the *C. chinensis* (Dallas). People get intoxicated very often after its consumption. It may be due to inter-specific variation of the semiochemicals secreted from the metathoracic glands. Therefore, present work aimed to study the morpho-taxonomy of the most available species to avoid possible intoxication due to misidentification. As the ecology of these species is poorly known, secondary data on its summer habitat, site of oviposition, food resources were also collected from the villagers for further investigation, since detail ecology will be required for hygienic rearing and toxicological study of these species. Morphological study shows that C. *nepalensis* and *C. singhalanus* differ in body colour, body size, antennae, wing size and the length of the rostrum. Villagers identified two plants locally known as 'Adambo' and 'Ipheu' in Idu-Mishmi dialect to be their summer host. They also hinted about its phenotypic plasticity i.e. summer forms and winter forms. Many villagers informed that mating and oviposition occur in the summer habitat on their host plant before leaving for winter habitat. However, some people believe the winter habitat under the dry river bed stones as their mating and oviposition ground. Six percent of the interviewed people experienced intoxication from consumption of 'tari'. The intoxicated persons due to food poisoning tend to behave like 'tari'. They try to fly, want to pass through small hole, hide under carpet, misinterpret rope as snake etc. Physician pointed out respiratory tract and stomach to be the target system of the toxins of these insects. Nervous system is known to be affected in severe cases. The semiochemicals present in the metathoracic gland, associated microbial toxin or pesticide residues may be the active compound responsible for intoxication.

Key words: *Coridius spp.*, Entomophagy, Habitat, Host plant, Oviposition

Introduction

A number of native people in Arunachal Pradesh consume certain species of insects belonging to the genus Coridius Illiger, 1807 (Hemiptera: Dinidoridae) during winter as inherent food habit. These insects are known as 'tari' (in dialect of Adi community) or 'paahu' (in dialect of Mishmi tribe) or 'gandhi puk' in local dialect. These are very often sold in market for the purpose of consumption. It has been observed that these insects are collected mainly from dry river bed during winter season (November to February) or on the way to their winter destination. Choice of these insects as a source of food in north east India has been noted as early as beginning of 20th century (Distant, 1906). It is consumed either in roasted form

or making paste of pounded uncooked adult and rice (Maxwell-Lefroy, 1971). The legs, head and antennae are discarded at the time of preparation. It has been noted from the local people that very often person gets intoxicated after consumption of "tari". However, it is not clearly known whether the intoxication is due to intolerability to the semiochemicals secreted by metathoracic gland of the regularly consumed "tari" or consumption of certain other highly toxic species due to misidentification at the time of collection (Gogoi *et al*., 2013). "Tari" has been named to a group of morphologically similar species belonging to the genus Coridius. The species belonging to this genus recorded in India include *Coridius* (=*Aspongopus*) *nepalensis* (Westwood, 1837) (=*A. nigriventris* Westw, 1837)*; C. iaunus* (Fabricius, 1775); *C. brunneus* (Thunberg, 1783) (=*A. ochreus* Werstwood, 1837; *A. obscures* Fabricius,1794); *C. singhalanus* (Distant, 1900); *C. sanguinolentus* (Westwood, 1837); *C. fuscus* (Westw, 1837); *C. assamensis* (Distant, 1902)*; C. chinensis* (Dallas, 1851) and *C. nubilus* (Westwood, 1837) (Distant, 1906; Rolston *et al*., 1996).

To avoid possible intoxication due to misidentification, the present study was aimed to study the morpho-taxonomy of the most available species. Further, as the information about the ecology of these species is largely lacking in literature, preliminary data, mainly its summer habitat, site of oviposition, food resources were also collected from the villagers.

Materials and methods

Collection and morpho-taxonomic study

Coridius spp. were collected from Naharlagun market and their natural habitats in Arunachal Pradesh during winter season (October, 2016-March, 2017). Morphological measurements were recorded with vernier caliper. The species were identified on the basis of description presented by Distant (1900).

Ecology and toxicology

Data on the ecology of the species were collected through self observation and on the basis of the information provided by the villagers. For this, selected people were interviewed in the district Papum Pare, Upper Subansiri, Lower Subansiri, West Kameng, East Kameng and Lower Dibang Valley. Besides these, physicians were consulted for collection of information on intoxication due to 'tari' consumption. The survey work for collection of the ecological data was conducted from January, 2014 to June, 2017.

Results

The most abundant of the collected species were the *Coridius nepalensis* and *C. singhalanus*. The less abundant is the *C. chinensis.*

Morphotaxonomy

Coridius nepalensis is maroon in colour (Fig. 1 a, b). Extreme lateral margin of the pronotum black. Antennae black, apical annulus red-orange and narrowly black at the base (Fig. 2 a). Body beneath and legs more or less cupreous. Dorsal side of abdomen red.

Body of *C. singhalanus* is dark bronzy (Fig. 1 c, d). Antennae, eyes, rostrum and legs nearly black. Apical annuli of antennae (Fig. 2 b), base of rostrum and tarsi red-orange. Dorsal side of the body finely rugulose. Abdomen is reddish in colour above. Rostrum reaches about halfway between the anterior and intermediate coxae.

Body of *C. chinensis* is dark bronzy. Connexivum is black with transverse narrow dull reddish spots at the middle of the segments. Antennae are black. Apical annulus is redorange with black base (Fig. 1 e, f).

The branches of radius, cubitus vein and the radio-cubital cross-vein of the hind wing forms a trident like structure in these species (Fig. 3). The dark spots on the dorso-lateral side of the abdomen in females are nearly round in shape and that of the males are spindle shaped. Females of *C. nepalensis* and *C. singhalanus* are larger in terms of total body length. Tympanal organ is found on the inner side of the hind tibia (Fig. 3). Total body, wing and antennae size of *C. nepalensis* are larger in size than *C. singhalanus* (Table 1-3). Similarly, antennae of females are longer than that of the males (Table 2).

Table 1. Body size of *Coridius nepalensis* and *C. singhalanus*.

Species	Total length (mm) ± SD	Abdomen length (mm) ± SD	Breadth (mm) ± SD
Coridius nepalensis (male)	23.00 ± 0.26	16.23 ± 0.51	12.63 ± 0.47
Coridius nepalensis (female)	24.30 ± 0.33	17.57 ± 0.32	13.81 ± 0.21
Coridius singhalanus (male)	18.23 ± 0.82	13.02 ± 0.56	10.56 ± 0.51
Coridius singhalanus (female)	20.508 ± 0.28	14.72 ± 0.25	11.81 ± 0.06

Table 2. Antennae size of *Coridius nepalensis* and *C. singhalanus*.

Species	Length (mm) ± SD	Diameter (mm) ± SD
Coridius nepalensis (male)	11.77 ± 0.56	0.688 ± 0.09
Coridius nepalensis (female)	12.42 ± 0.40	0.62 ± 0.03
Coridius singhalanus (male)	9.19 ± 1.22	0.55 ± 0.08
Coridius singhalanus (female)	9.83 ± 0.23	0.59 ± 0.03

Table 3. Wing size of *Coridius nepalensis* and *C. singhalanus*.

Species	Forewing		Hindwing	
	Length (mm) ± SD	Breadth (mm) ± SD	Length (mm) ± SD	Breadth (mm) ± SD
Coridius nepalensis (male)	19.09 ± 0.21	7.17 ±0.19	15.52 ± 0.26	7.51 ± 0.25
Coridius nepalensis (female)	20.38 ± 0.59	7.55± 0.13	15.99 ± 0.37	7.74 ± 0.11
Coridius singhalanus (male)	15.18 ± 0.71	5.67 ± 0.29	12.11 ± 0.49	5.78 ±0.15
Coridius singhalanus (female)	17.69 ± 0.45	6.57 ± 0.19	14.12 ± 0.33	6.96 ± 0.24

Ecology

As per the information from the villagers, 'tari' exhibit phenotypic plasticity. The nymphs and adults are green in colour in summer. During winter season, they become dark brown or black in colour. The winter habitat is the dry stony river bed. Adults fly from their summer habitat to their winter destination during late October to November. This movement occurs in huge masses during clear weather condition at evening after sunset . They don't fly during cloudy or rainy day. Most of the villagers believe high altitude as their summer habitat. However, some others informed that they fly from their host plants in some distance away from their winter destination. In the winter habitat, they are found in aggregated mass of around 3 – 80 individuals under the same stone. However, the insects are not seen returning back towards high altitude again. They are presumed to rest there till end of their life.

Villagers identified two plants locally known as 'Adambo' and 'Ipheu' in Idu-Mishmi dialect to be their summer host before leaving for their winter destination. The leaves and twigs become whitish due to their sap sucking activity. Besides, some villagers also reported presence of the insect on pumpkin and bottle gourd plant during rainy season. On contrary, it is uncertain whether they feed in their winter destination or not. They may however derive their nutrition from rotten materials in the river bed. Certain local people reported the summer host plant as oviposition site which is used for egg laying before leaving to their winter destination. Another concept is the egg laying in the river bed during winter.

Toxicity

Intake of 'tari' bugs causes serious health dysfunction in many cases. Six percent of the people interviewed for this purpose, experienced intoxication from 'tari'. The inflicted person suffers from severe illness. Giddiness accompanied with vomiting sensation occurs as a result of food poisoning. Weakness is observed in most cases. Ingestion of these stink bugs also lead to psychiatric disorder, nailing down the person to a semi unconscious state. Affected person tends to behave like 'tari' in the language of local people, since the intoxicated people want to fly, tries to pass through small hole, hide under carpet, get feared believing rope as snake. Such behaviours are continued to exhibit up to six months or more if not treated properly. Physicians informed the occurrence of changes in respiratory and stomach physiology in such patients. Besides, disorders of neuronal function were also encountered by them in severe cases.

Some people experiencing intoxication believe strongly that person gets infected only when the dead insects are consumed. Most of the people however consider the strong chemicals released from the metathoracic gland of the insect as responsible ingredient of toxicity. The intoxication may vary with species to species. It is reported by the consumers that the burning taste of black tari (*C. singhalanus* and *C. chinesis*) is stronger than red tari (*C. nepalensis*).

Medical treatment

Patient needs immediate hospitalization if the symptoms are severe or persistent. Physicians prescribe drugs, after proper

Fig.1(a). Female *Coridius nepalensis* (Dorsal).

Fig.1(b). Female *Coridius nepalensis* (Ventral).

Fig.1(c). Female *Coridius singhalanus* (Dorsal).

Fig.1(d). Male *Coridius singhalanus* (Ventral).

Fig.1(e). Female *Coridius chinensis* (Dorsal).

Fig.1(f). Male *Coridius chinensis* (Ventral).

Fig.2(a). Antenna of *Coridius nepalensis*.

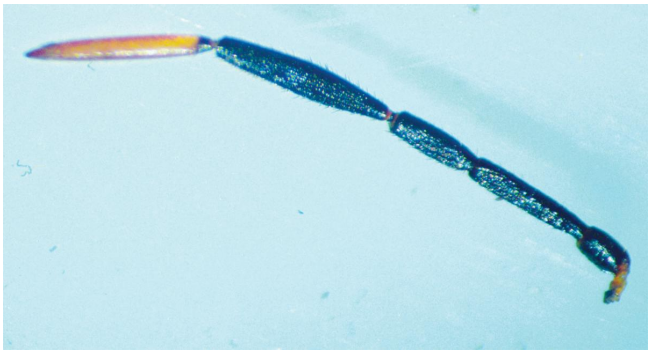

Fig.2(b). Antenna of *Coridius singhalanus*.

Fig. 3(a). Hind wing of *Coridius nepalensis*.

Fig. 3(b). Hind wing of *Coridius singhalanus*.

Fig. 4(a). Tympanal organ of *Coridius nepalensis.*

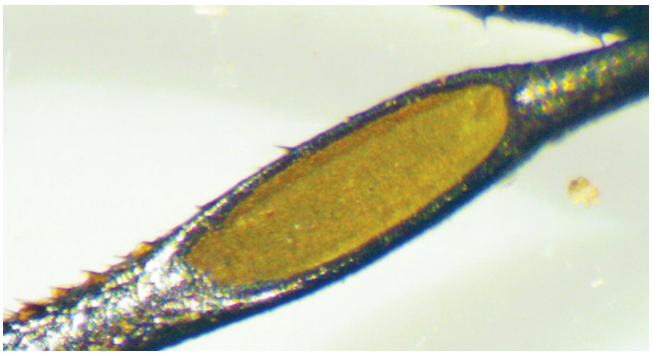

Fig. 4(b). Tympanal organ of *Coridius singhalanus.*

diagnosis. In case of severe weakness, patients are infused with saline solution depending on the health condition to maintain body homeostasis. Physicians are also known to recommend the tablet 'Avil®' (Pheniramine maleate), a group of anti-allergic medicines called 'antihistamines' which works by blocking the action of histamine (however, should not be used without consulting physicians).

Discussion

Morphology

Morphologically, the winter adult forms of C. *nepalensis* and *C. singhalanus* differs in body colour, body size, antennae, wing size, pronotum, connexivium and length of the rostrum, though they are known by the same common name 'tari'. However, literature regarding the nymphal stage and the summer forms are unknown. The conception of the local people regarding the phenotypic plasticity of these insects can't be nullified since temperature and other environmental factors including food plant availability plays a crucial role in polymorphism (Whitman and Agrawal, 2009).

Ecology

Host plants

Caryota sp. has been noted as host plant of *C. nepalensis*, *Morus alba* of *C. chinensis*, *Derris indica* of *C. brunneus* (Zhang, 1985; Schaefer and Ahmad, 1987; Meshram *et al.*, 1990; Zheng *et al.*, 2004; NDSU, 2008). Insects are known to be co-evolved with host-plants (Farrell and Mitter, 1990). Though plants from Cucurbitaceae, Fabaceae, Malvaceae, Asclepiadaceae, Pedaliaceae, Solanaceae are mentioned in literature as the host plant of the closely related species *Coridius viduatus* and *Coridius ianus,* the studied insects may not feed these plants due to adaptative evolution (NDSU, 2008; Tarla *et al.*, 2013). Instead, *C. nepalensis*, *C. singhalanus* and *C. chinensis* may feed on the plants closely related to them or their wild relatives.

Oviposition

Phytophagous insects usually oviposit on the host plant or nearby for food security and successful development of their offspring (Renwick, 1989). Since, the studied insects move in masses in the direction from summer habitat at higher altitude to winter river bed habitat at lower altitude and these insects don't undertake their return journey, it is evident that they lay eggs in their summer habitat. So, the information provided by the villagers of laying eggs in their summer host plant seems convincing. Reproductive system of the insects in winter habitat may provide further evidence in this regard.

Winter destination

The cause of their journey to the dry river bed is not known. From the period of the journey, it is however evident that they move under the influence of climatic condition to avoid harsh winter temperature. If it is like that, why they don't find out their winter habitat in forest areas? Migration of insects from higher altitude to lower altitude to avoid cold winter temperature is seen (Woyke *et al.*, 2003). But, in the case of 'tari', they are not seen returning and presume to die in the winter habitat. Further, they are not observed reproducing there. Therefore, choosing the habitat under stone which also gets cool during night is a mystery. It may be true

that they can find alternate food resource in the dry river bed what they don't find in other areas during this season.

Toxicity from entomophagy

Coridius nepalensis and *C. chinensis* are known to be used as food in many parts of north-east India since long (Distant, 1920; Strickland, 1932). Tribes reported to make use of them include the Miris, Mishmas, Abors and some Nagas. *Coridius nepalensis* is known to contain nutritionally relevant fatty acids and macro- and micronutrient (Chakravorty *et al*., 2011). However, it seems that people consume these insects as condiment rather than for nutritive value. People who consume these insects may possess inherent addiction for which they continue consuming still knowing that it causes intoxication. In certain cases, the people get paralysed and exhibit changes in motor coordination, abnormal movement and posture with ongoing performance after consumption of 'tari'. The behaviour exhibited after intoxication is an indication of neurotoxic effect (Schulze, 2002).

The stink bugs are known to produce blends of odoriferous compounds that serve mainly to deter predation, warn relatives of impending danger as alarm pheromone. The stink bugs produce these chemicals from two different types of glands depending on life stages (Aldrich, 1988). The adults produce these compounds in the metathoracic scent glands while the nymphs produce them in the dorsal abdominal scent glands. The dorsal abdominal scent glands can also be retained in some adults as functional gland (Aldrich, 1988; Aldrich *et al*., 1995).

Close relative *Coridius iaunas* is known to secrete 4,5-Dimethyl diazole; (E)-2-Hexenyl acetate; Iso-butenyl phenol; Undecane; Undecylamine; 1,12-Dodecan-diol and N-methyldodec-6,10-diene amine from metathoracic gland (Srinivasulu and Janaiah, 2011). Similar semiochemicals in the 'tari' are believed to be the bioactive compounds responsible for intoxication, for which it is sometimes advised to remove the red bi-lobed stink gland between the metathorax and abdomen. Stickland (1932) nullified paralysific effect from these chemicals. However, it is still can't be called safe to consume because tolerability varies from individual to individual. Moreover, these insects collected from natural habitat may be the source of microbial toxins. It may also be contaminated with toxic pesticide residues, which are the major drawbacks of entomophagy (Kourimska and Adamkova, 2016). Further, more toxic insect may be consumed due to misidentification.

From this study it is concluded that 'tari' contains a group of insect species mainly the *C. nepalensis*, *C. singhalanus* and *C. chinensis*. Though these are consumed since long, it is still not proved as fully safe for consumption unlike other conventional foods. Therefore, until it is being reared hygienically and known to be safe as per the food safety standards, it is better to discontinue its consumption. However, further study of its ecology is needed for its hygienic rearing and standardization of pre-processing handling protocol.

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