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Key to Identify Insects from Droppings of Some Insectivorous Bats of Nepal

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ABSTRACT

Food habit of insectivorous bats was studied using fecal analysis. The fresh bat dropping samples from Mahendra cave, Pokhara and Nagarjun cave, Kathmandu were collected in March and September 2011. Bat droppings were moistened in hot water, separated into fine pieces and observed under stereoscope. The recovered insects and insect parts were mounted in slide, photographed and identified up to Order and Family level. Altogether ten insect orders viz. Coleoptera, Diptera, Hemiptera, Homoptera, Odonata, Hymenoptera, Lepidoptera, Orthoptera, Trichoptera and Thysanoptera and 25 families were identified. In addition, spider and mites were also reported. The identification key to Order and Family level has been prepared based on the studied characters compared with taxonomic characters from literature.

Key words: Insects, identification key, bats, cave, order, family

INTRODUCTION

Bats are the unique mammals due to their webbed forelimbs making them the only mammals naturally capable of true and sustained flight like birds. They have been reported from all geographical areas of the world, except Arctic, Antarctic, extreme desert areas and a few isolated Oceanic Islands (Mickleburgh *et al.* 2002; Huston *et al.* 2001) occupying diverse niches in both natural and human modified ecosystems. Insectivorous bats eat flying insects such as flies, moths and others insects and play important role in natural ecosystem. Some bats also serve as pollinators and seed dispersion of many plants. Their population is one of the best natural indicators of the health of our environment, because bats flourish where an ecosystem is healthy and stable (Jones *et al.* 2009). There are 53 species of bats have been reported from Nepal with highest number of insectivorous bats (48 species) and small number of fruit eating bats (5 species) (Thapa, 2010). Some insectivorous bat species prefer particular insect groups (Ades, 1995).

Bat species of Nepal have been recently assessed and included in conservation priority and listed as Critically Endangered (*Ia io, Myotis csorbai*), Endangered (*Scotomanes ornatus*s), Vulnerable (*M. sicarius, Philetor brachypterus*), Near Threatened (*Hipposideros pomona, Murina aurata, Rhinolophus lepidus*) and 18 species are still with insufficient information and designated as Data Deficient (Jnawali *et al.* 2011).

Food habit study could be done either by direct observation or indirect observation techniques. Individuals have been killed to analyse eaten contents of bat species in direct method, which is not preferred due to conservation priority. Indirect method includes identification of undigested food remains of fecal matters (droppings) at reasonable label, at least to Order and often to Family (Whitaker *et al.* 1988). Although there are sufficient information on the food habits of bats for other countries (e.g. Ross, 1967; Kunz & Whitaker, 1983; Shiel *et al.* 1997; Whitaker & Tom-Tov, 2001; Perlik *et al.* 2012), diet analysis of insectivorous bats of Nepal is nearly at nix with exception (Malla, 2000), however studies on population, distribution, behavior and assessments have been done by Nepalese researchers (Acharya, 2006; Baral & Shah, 2008; Koju, 2008; SMCRF, 2010, Thapa, 2010; Jnawali *et al.* 2011). This work simply act as reference on the diet analysis of insectivorous bat of Nagarjun Cave (1609 m), Kathmandu and Mahendra Cave (962 m), Pokhara. Altogether eight species of insectivorous bats have been reported from these two caves including six species in *Rhinolophus affinis, R. pusillus, R. macrotis, Hipposideros armiger, Megaderma lyra* and *Miniopterus schreibersii* in Nagarjun Cave (Malla, 2000; SMCRF, 2010) and four species *R. affinis, R. ferrumequinum* and *H. armiger, H. pomona* (Giri, 2009; SMCRF, 2010) from Mahendra Cave.

This is the first attempt to identify insects from the insectivorous bat droppings of Nepal to fill the information gaps and provide reference materials for future researchers.

MATERIALS AND METHODS

Bat droppings were collected from Mahendra Cave, Pokhara and Nagarjun Cave, Kathmandu. The latitude and longitude of Mahendra and Nagarjun caves lie on the geographical coordinates of 28° 16' 19.6" N, 83° 58' 45.7" E and 27° 44' 43.7" N, 83° 17' 39.4" E respectively. Fresh bat droppings were collected two times by placing three white plastic sheets of 1 m × 1 m size under the roosting sites of the cave for 24 hrs within first and last week of each month of March and September, 2011. The fecal samples of each month were stored in air-tight container containing 70 percent ethanol and brought to the Central Department of Zoology, Tribhuvan University for further analysis.

Thirty dropping samples from each container were selected randomly. Samples were kept in a petri dish containing hot water and few drops of glycerol to ovoid evaporation of water vapours for 24 hours to soften the samples following the protocol (Kunz, 1988). The droppings were broken into fine pieces carefully with the help of fine dissecting needles under stereo-binocular microscope. The separated parts of insects were observed under microscope. Slides of the insect fragments viz. legs, wings, antenna, abdomen, mouth parts were prepared dehydrating samples in alcohol series and finally mounted in glycerinated gelatin or sometime in transparent nail polish. So, all together 120 pellets were analyzed from two caves of two season. The mounted parts in slides were photographed with PC-digital camera connected with computer. The slides were deposited at the Entomology Lab of the Central Department of Zoology, Tribhuvan University.

Structures and characters of recovered antennae, legs, wings, mouth parts, and other body parts of insects were studied and compared with available published papers (Ross, 1967; Kunz & Whitaker, 1983; Whitaker *et al.* 1988, Shiel *et al.* 1997; Whitaker & Tom-Tov, 2001) and textbooks (Vanemden, 1965; Bingham, 1975; Distant, 1977; Jacoby, 1975; Richards & Davies, 1977 and Borror *et al.* 1981). All parts were identified upto higher taxonomic category viz. order and family level and an identification key was prepared based on the characters noted from the samples.

RESULTS

Altogether nine insect orders viz. Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Orthoptera, Trichoptera and Thysanoptera representing 25 families were identified in the droppings of bats. In addition, other arthropod groups (spiders and mites) were also identified. Identification key based on the parts of insect orders and families recovered from bat droppings from Mahendra Cave, Pokhara and Nagarjun Cave, Kathmandu is represented in the following key.

Key to identify prey insects in bat droppings

Identification key is based on characters of insect parts recovered in bat droppings of Mahendra and Nagarjun caves. A dichotomous key to insect orders and families is represented as follows;

1. Body with 4 pairs of legs, legs hairy, wings absent… . ……………………………………………… …..…..2
   Body 3 pairs of legs, wings present…………………… ………………………………………………..…..3
2. Body oval, four pair of legs, anteriorly directed mouth parts (Fig. 1A, B)..Mites
   Leg long and hairy (Fig. 3F) …………………... ….………...Spider
3. Scales on wing present, fecal contents often contain mass of scales spread (Fig. 2B) ……………..…….Lepidoptera
   Scales on wings absent………………………………………………………………………………………4
4. Wing hard or leathery and colourful body……Coleoptera (Fig. 2L) or Heteroptera (Fig. 2K) ……............................5
   Body usually soft, wing membranous or fringed……………………………………………………………18
5. Tarsi with 4-5 segments, tarsal claws present (Figs. 3 J, P) without spine, antennae varied shaped viz. lamellate (Fig. 3 A, E), filiform, …...Coleoptera ……………………………………………………………………6
   Tarsi 2 or 3 segmented, hemelytra present, long hairy or spiny leg Hemiptera/Heteroptera ………..........................14

Coleoptera

6. Leg with notch……………………………………………………………………………………………...7
   Leg without notch…………………………………………………………………………………………8
7. Leg long and spiny (Fig. 3I), antennae long and composed of series of cylindrical segments ……..........Carabidae
8. Front tibia dilated…………………………………………………………………………………………..9
   Front tibia not dilated……………………………………………………………………………………..11
9. Antennae with plate like structure forming compound club (Figs. 3A, E)..…Scarabaeidae

Antennae without plate like structure……..10

10. Beetle often very heavy; elbowed antennae present (Fig. 3C)…….Curculionidae

11. Tarsal claw clefted with hair (Fig. 3O)……..Cerambycidae

Tarsal claw toothed at base……...Coccinelidae

Heteroptera

12. Hemelytra present, anterior portion of hemelytra contains two closed cells (Fig.1L)……Miridae

Without punctae on hemelytra…….13

13. Long hairy leg……..Pentatomidae

Leg with spine……Orthoptera….. 24, Homoptera…….14

14. Hind tibia with 1 or 2 rows of spines, hind coxae transverse…….Cicadellidae

15. With membranous or parchment- like wings…….16

Wing with comparatively less longitudinal veins……. 17

16. Wings with simple venation, few cross veins, can often distinguish parts of R, Cu, M or Oral veins (Figs. 2A, I,) ……...True flies……. (Diptera)

More complicated venation, often with numerous cross veins, more difficult to determine identification of specific veins (Fig. 2 F)…….Odonata

Diptera, Hymenoptera, Thysanoptera and Trichoptera

17. Anal vein straight gently curved; the anal cell closed at or before wing margin; hind tibia with or without apical spur; abdomen robust; eye usually bare; head somewhat triangular (Fig 1G)……..Tabanidae

Not as above…….18

18. Wings usually with fewer than seven longitudinal veins (Fig 2I)…….Cecidomyiidae

All veins equally heavy and more than 6-10 main veins…….19

19. Wings with scales and cross vein at about the middle, antennae pilose type, long slender, hairy leg (Figs. 2E, Fig. 3B) …….Culicidae

Wings without scale…….21

20. Housefly like (Fig.2G)…….Muscidae

Wings somewhat like Housefly but R and Cu veins structure differ, row of fine hairs on the costal margin present (Fig 2D)…….Calliphoroidae

Wings covered with relatively long hairs, cross veins absent, 10-11 veins run to the margin (Fig.2C)..Psychophidae

False margin…….21

21. Venation are sharply conspicuous and move more or less parallel with the border (Fig.2H)……Syrphidae

22. Wings with many fairly long hair attached along the veins .....Trichoptera

Abdomen is highly constricted (Fig. 1F), wings often with tiny hairs throughout membranes, stigma (dark spot on anterior part of front wing) often present on front win……..Hymenoptera…….23

Wings long and narrow, vein less or with only 1 or 2 veins and fringed with long hairs, minute insect (Fig.1C, E, Fig. 3C)……..Thysanoptera…….Thripidae

Hymenoptera

23. Wing with large cells, recurrent vein, abdomen constricted …….Ichenomonidae

Legs show pollen- transporting apparatus (Fig.3 H)…….Apidae

Orthoptera

24. Hind tibia with large spines at tip (Fig. 3M)…….Acrididae

Front femora with 2 or 3 apical spines, yellow brown wings, antenna Filiform (Fig.3G) .....Blattidae

25. Very less spines on dorsal surface of front tibia…….Tettigonidae

Spines on one side of leg (Fig. 3N)…….Gryllidae

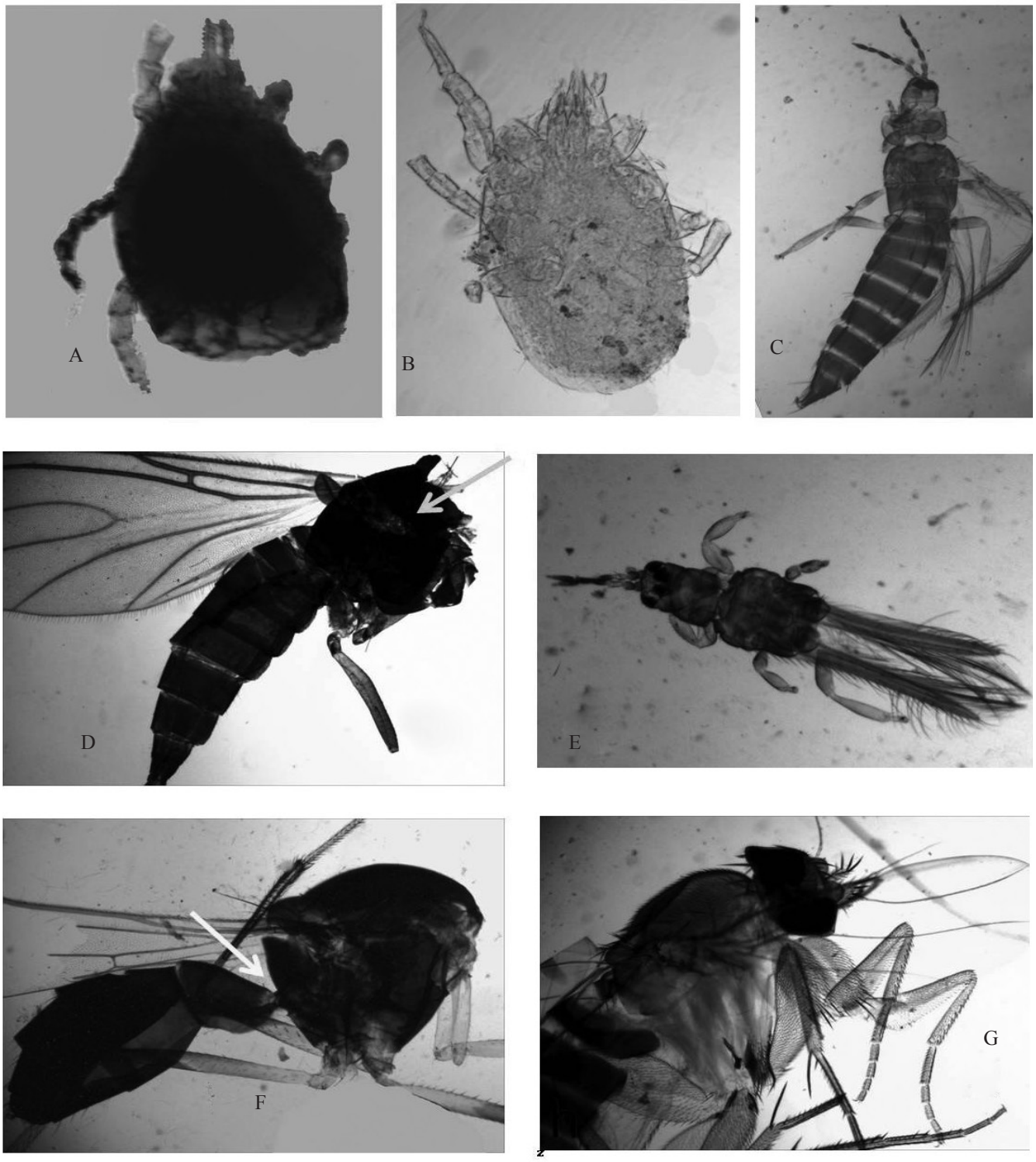

Fig. 1. Insects and Mites found in bat dropppings. A, B. Mites, C,E. Thrip, D. Cecidomyiidae, F. Ichnimonide, G. Tabanidae.

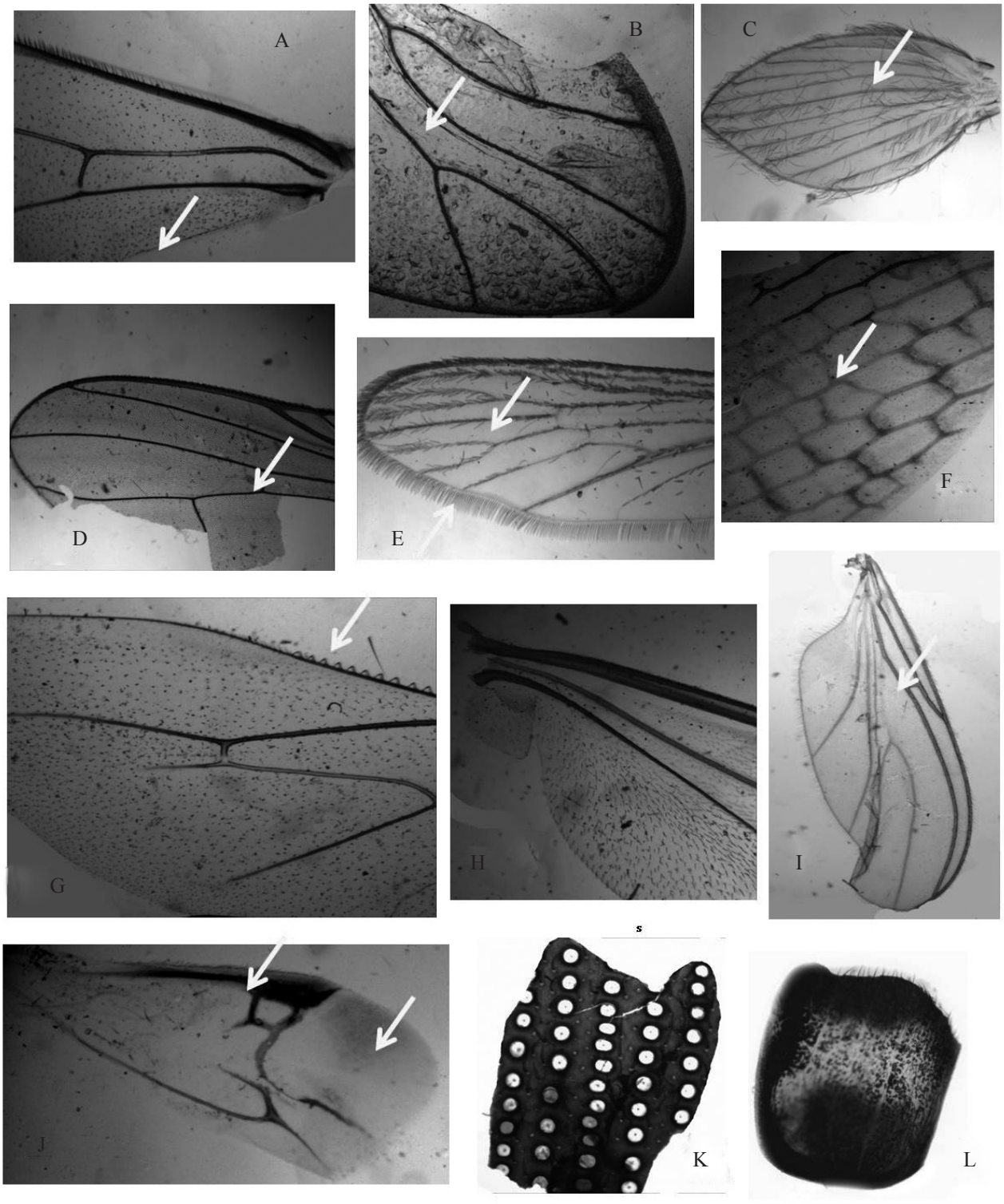

Fig. 2. Wings of insects recovered from bat droppings. A. Diptera, B. Lepidoptera, C. Psychophidae, D. Calliphoridae, E. Culicidae, F. Odonata G. Muscidae, H. Syrphidae, I. Cecidomyiidae J. Miridae, K., L. Beetle (Coleoptera)

Fig. 3. Antennae and legs of insects/spider collected from bat droppings. A, E. Antennae of Scarabaeidae, B. Antena and mouth parts of Culicidae, C. Antenna of Curculionidae, F. Leg of spider, G. Antennae of Trips (Thysanoptera), D. Filiform antenna of Cockroach (Blattidae), H. leg of Honey bee (Apidae), I. Leg of ground beetle (Carabidae), J, K, O, P. Tarsal segments of beetles (Coleoptera), L. Leg of mosquito (Culicidae), M, N. Leg of grasshoppers and crickets (Orthoptera).

DISCUSSION AND CONCLUSION

The dropping analyis of insectivorous bats represents a very good and reliable information on the insect diversity which can be identified at higher taxonomic categories viz. Order and Family level. Variety of food identified from two caves- Mahendra cave Pokhara and Nagarjun cave, Kathmandu there is considerable differnces in food types which might be due to difference of insect diversity around two caves, however beetels were the highest in an average in both caves. The environmental factors including temperature play a key role in regulating the insect abundance (Neuza *et al.* 2009). Some of the food items dominated by a single group of insects in particular season. Different authors published different results from different geographical areas (Kunz *et al.* 1995; Schulz & Wainer, 1997, Arlettary *et al.* 2000) with major proportion of species rich orders such as Coleoptera, Diptera, Hymenoptera, Orthoptera and Lepidoptera. But the present study represents very low number of Lepidoptera. Although insectivorous bats eat flying insects, few samples contained flightless arthropods such as mites and spiders. The former one may come along the insects infected with mites but spiders migth be picked up from the spiderweb during the flight which was also represented in significant number in some studies (Whitaker & Lawhead, 1992).

Although the diversity pattern of insect food items in both caves similar but the variety of insect food varies with changing geographical locations of two caves. It is obviously that the insect abundance and diversity varies according to elevation range in Nepal.

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