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Original article

Multivariate diversity analysis and systematics of hemipteran insects of family Reduviidae

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ABSTRACT

In current study, extensive field surveys are carried out to explore the fauna of assassin bugs of family Reduviidae, along with their habitats and prey records from different localities in the Pothohar region of Pakistan. The quantitative web structure is constructed for better understanding species habitat linkage and is represents a total of twelve different assassin bug species, of which five were identified as new country records i.e., *Tribelocephala indica* (Stal, 1853), *Coranus spiniscutis* (Reuter, 1881), *Oncocephalus schioedtei* (Reuter, 1882), *Scadra annulipes* (Reuter, 1881) and *Ectrychotes dispar* (Reuter, 1881). The result of diversity indices, Shannon-Weiner's and Simpson's index showed that Trail-5 (Islamabad), Taxilla (Rawalpindi), Sohawa (Jhelum) have maximum values (1.092, 0.662; 1.75, 0.82 and 1.69, 0.78) respectively. The assassin bug species i.e., *Rhynocoris marginatus* and *R. fuscipes* are found to predate maximum number of economically important pests of various crops. The diversity indexes of assassin bugs from the Pothohar region indicated that the species have uneven distribution in the five districts. The variation in richness of assassin bug population was recorded in the selected three districts of the Pothohar region. The species richness showed almost same pattern in Islamabad and Jhelum demonstrated by minute difference in Shannon's equitability index (0.65–0.929 and 0.77–0.87) respectively.

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1. Introduction

Diversity and abundance of insects varies according to geographic and temporal variability (Bashir *et al.* 2018; Khan *et al.* 2021). Reduviidae Latreille, 1802 (Cimicomorpha) is the most diversified family of order Hemiptera which represents a large number of terrestrial predators commonly known as assassin bugs (Schuh and Slater, 1995). Members of this group comprises of 25 sub-families and almost 7000 described species worldwide

(Weirauch et al., 2014). Assassin bugs have adapted to a wide array of terrestrial habitats stretching from burrows of mammal in the Sonoran Desert to the decomposed logs, in the Bornean rainforest in addition, they have broadened their prey preferences along with the development of a wide range of improved prey capturing strategies (Forero et al., 2011; Soley et al., 2011; Zhang and Weirauch, 2011). There are a large number of reduviid species that are either found in association by the bark of trees or the foliage of herbs, shrubs, and trees however, kissing bug (Triatominae) have adopted to live besides human habitat and feed on their blood (Radio, 1927; Miller, 1953; Louis, 1974) (Fig. 1).

Assassin bugs are larger in size than other predaceous species of true bugs and they consume not only more prey but also a wider array of prey (Schaefer, 1988). The predation behaviour of assassin bugs is used in biological control of many insect pests and there are almost 182 reduviid species in 69 genera and 10 subfamilies that can prey upon around 261 known forest and agriculture insect pests (Ambrose, 2006). There are several species that are used as the biological control agent, most importantly *Pristhesancus plagipennis* (Harpactorinae) as predator of stink bug and cotton bollworm (Grundy and Maelzer, 2000). Other species that are being explored for integrated pest management (IPM) includes species of *Zelus*, *Rhynocoris* and *Sinea* that feed, among others, on Lygus bugs, caterpillars and boll weevils (Cogni et al. 2002) (Fig. 2).

Members of subfamily Emesinae, commonly known as the thread-legged bugs, are known to prey on spider, also few species, are able to lure spiders using aggressive mimicry (Soley et al., 2011). The tribes of subfamily Harpactorinae i.e. Apiomerini, Ectinoderini and Diaspidiini have adapted to adhere plant resins on their fore legs with for capturing prey, whereas some members

of the tribe Harpactorini have developed their own sticky secretions to serve same purpose (Forero et al., 2011; Zhang and Weirauch, 2011). The subfamily, Holoptilinae that includes the feather-leg bugs can attract ant species to feed on the secretions which results in paralysis (Jacobson, 1911). The most notorious species of Reduviidae belongs to subfamily Triatominae i.e. the kissing bugs, which feeds on vertebrate blood including humans which enables them to vector i.e. *Trypanosoma cruzi* Chagas, the causal agent of Chagas disease (Lent and Wygodzinsky, 1979).

The family, Reduviidae is distributed worldwide however, level of diversity among species, and are clearly highest in the tropics of the Old and New Worlds. There are several subfamilies that are confined to specific biogeographic regions (Froeschner and Kormilev, 1989; Maldonado, 1990; Cassis and Gross, 1995). So far, the Indian assassin bug fauna is represented by 466 species in 15 families (Ambrose, 2007) and if compared with Pakistan, the number of assassin bugs is represented by only 41 species, which is far less and requires extensive exploration work (Afzal, 2005; Afzal and Ahmad, 2019; Shah et al., 2019). Therefore, an extensive field survey is carried out in different ecosystems from the Pothohar region (i.e. Islamabad, Chakwal, Jhelum, Attock and Rawalpindi) during 2017–2019. The present studies aimed to explore and identify reduviid species and to find out their biodiversity and relationship of habitats in various ecosystems.

2. Materials and methods

The study was conducted in the Pothohar region i.e. Rawalpindi, Jhelum and Chakwal Districts with Capital territory Islamabad of Pakistan. The data was collected from different habitats like forest,

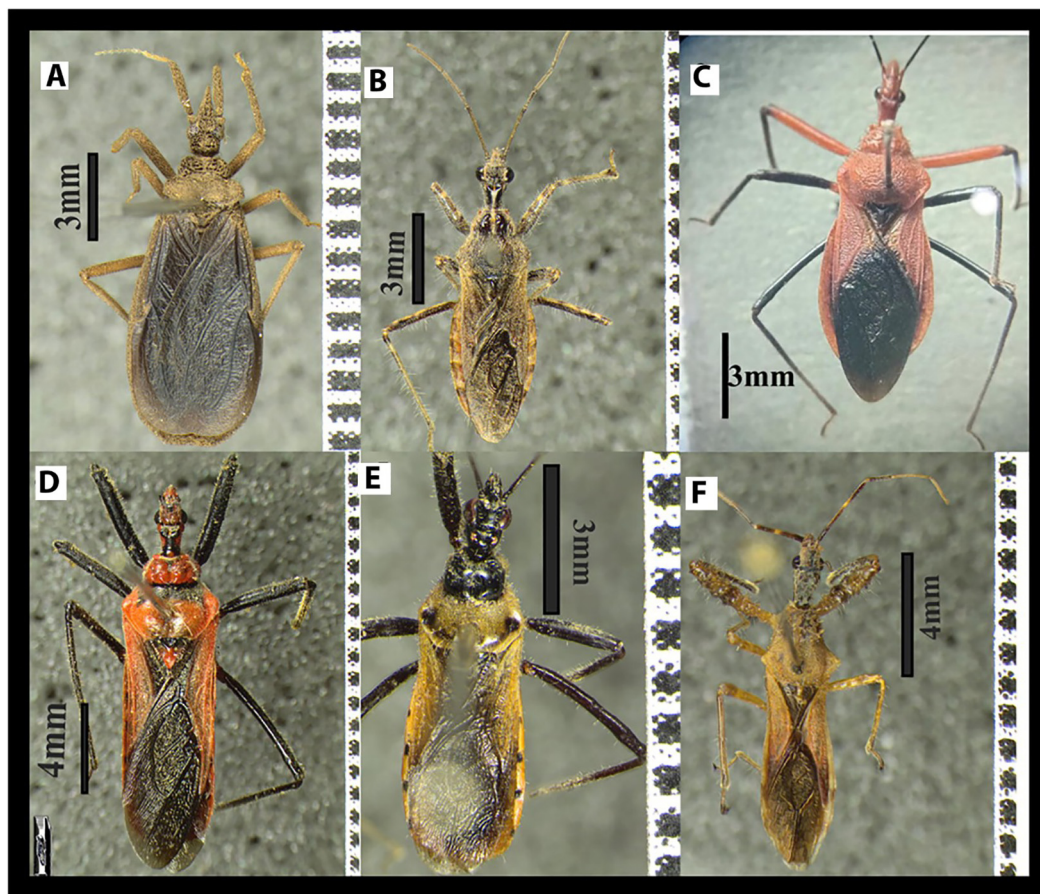


Fig. 1. Dorsal habitus of species 1: *Tribelocephala indica* 2: *Coranus spiniscutis* 3: *Rhynocoris marginatus* 4: *Rhynocoris fuscipes* 5: *Sphecanolestes faterculus* 6: *Sinea diadema*.

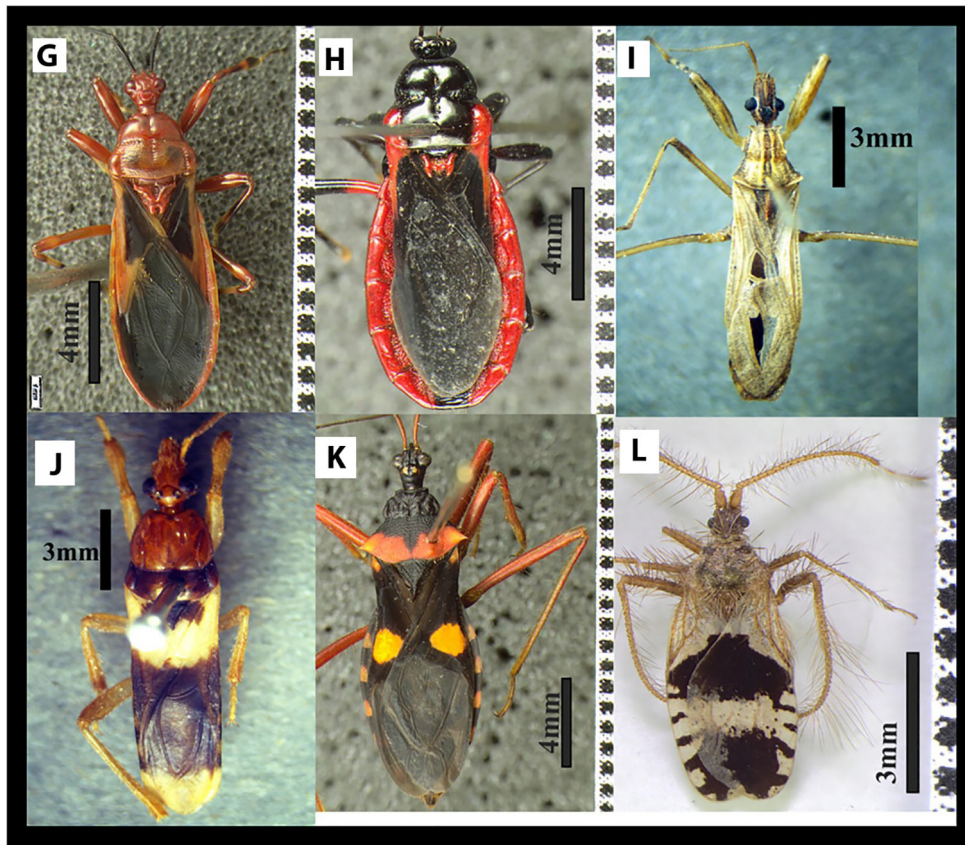


Fig. 2. Dorsal habitus of species 7: *Scadra annulipes* 8: *Ectrychotes dispar* 9: *Oncocephalus schioedtei* 10: *Sirthenea flavipes* 11: *Acanthaspis quinquespinosa* 12: *Holoptilus fasciatus*.

agricultural zones, hilly areas and grass lands in the peak months of pest pressure i.e. May to October during 2017–2019 by transect line methodology. The species distribution of family Reduviidae in each district was assessed by dividing the territory into a number of areas from where collection was done fortnightly (before and afternoon) with the help of sweeping net. These locations were selected in different latitudes of Islamabad, Rawalpindi and Jehlum as shown in Table 1.

In each location ten places were selected (10 replicated per locations) with three replicates per place. The ten places in each

Table 1
Geographical coordinates of the collection sites.

Districts	Sites selected	Latitude	Longitude
Islamabad	Said pur Village	33° 42' 9.72"	73° 7' 33.96"
	Phulgran Village	33° 45.0"	73° 13.0"
	F-9 Park	33° 42' 6.48"	73° 1' 22.08"
	Kachnar Park	33° 40' 12.72"	73° 4' 54.12"
	Trail # 1	33° 43' 57"	73° 02' 10"
Rawalpindi	Trail # 5	33° 45' 246"	73° 05' 147"
	Taxilla	33° 44' 46.68"	72° 50' 22.92"
	Kallar Syedan	33° 24' 45.72"	73° 29' 19.32"
	Nawaz-Sharif Park	33°38'54.96"	73°4'36.84"
	Ayyub National Park	33° 34' 18.84"	73° 4' 59.16"
Jhelum	Kuldana Forest	33° 55' 28.2"	73° 23' 58.56"
	Phagwari Forest	33° 58' 55.2"	73° 29' 51.36"
	Sohawa	33° 6' 46.44"	73° 24' 43.56"
	Dina	33° 1' 40.44"	73° 36' 4.32"
	Tainpura Dam	33° 03' 22"	73° 31' 15"
	Domeli Dam	33° 01' 28"	73° 21' 07"
	Lehri Park Forest	33° 8' 21.12"	73° 35' 9.24"
Bela Forest	32° 56. 0"	73° 44.0"	

location were at least twenty kilometer apart from each other (Zhao et al., 2020).

In order to remove the confounding effects of insect species habitat heterogeneity of the insect families the first hand sweep collected sample was at least 2 m apart from one another and in total, thirty (10 locations × 3 replicates) sampling points were covered. All the specimens were preserved as standard procedure, identified via recently published literature (Shah et al., 2019). The identified reduviid fauna is deposited in the Biosystematics laboratory of Pir Mehr Ali Shah- Arid Agriculture University, Rawalpindi, Pakistan. The morphological characters of specimens were observed with Olympus SZX7 stereo-microscope that has camera with Olympus Soft Imaging Solutions, GMBH (Model Olympus LC30).

The collected data was analyzed by paleontological statistics software package (PAST), which calculates the diversity indices including richness and evenness of the collected species (Hammer et al. 2001). Shannon-Weiner's and Simpson's index, Margalef's and Menhenick's index of different insect species were also calculated.

3. Results

3.1. Subfamily tribelocephalinae

3.1.1. Tribelocephala indica (Walker, 1873)

Opistoplatys indica Walker, 1873: 20; *Tribelocephala indica* Ambrose, 2006: 27.

Diagnostic characters: The body color ranges from chocolate-brown to piceous; tomentose heavily; legs and labium paler than dorsum; head and pronotum provided with granules; antennae

pilose; pronotum narrower behind mid, transverse; forewings bear membrane with darker veins; connexivum well exposed dorsally and legs pilose.

Morphological measurements (mm): Body length 10.725 mm, head length 2.46 mm, head width 1.24 mm, pronotal length 1.68 mm, pronotal width 2.48, scutellum length 0.64, scutellum width 1.26 mm, labium length 2.523 mm and antennae length 1.26 mm.

Distribution: India and Pakistan (Jhelum, **new country record**).

3.2. Subfamily Harpactorinae

3.2.1. *Coranus spiniscutis* (Reuter, 1881)

Coranus spiniscutis Reuter, 1881:275; *Coranus spiniscutis* Distant, 1904: 381.

Diagnostic characters: The body color is testaceous-fuscous to grayish; head brownish black, post-ocular region provided with central yellow brownish line; antennae 1st joint longest, 1st and 2nd joint base luteous; labial 1st joint less in length than 2nd, not reaching the pro-coxae; legs ochraceous, femoral annulations, tibial base and apex and apices of tarsi black, tibiae extreme base provided with pale annulation; forewing membrane bronzy-fuscous, slightly passing the abdominal apex; connexivum exposed and yellowish brown with black spots.

Measurements (mm): Body length 9.225; head length 1.95; head width 1.273; pronotal length 1.575; pronotal width 2.68; scutellum length 0.804; scutellum width 1.072; labium length: 2.485 and antennae length 4.55.

Distribution: India, Nepal, Myanmar and Sri Lanka.

3.2.2. *Sphedanolestes faterculus* (Bergroth, 1908)

Sphedanolestes faterculus Bergroth, 1908: 591; Distant, 1904: 264

Diagnostic characters: The head, pro-lobe of pronotum, labium, antennae, mid and hind sternal disks and the legs blackish in hue color; body ventrally and hind lobe of pronotum pale luteous, 2 black marks on hind pronotal lobes; post-ocular area little shorter than ante-ocular area; scutellum black with its apex luteous; corium dull or brownish ochraceous; antennal basal segment shorter than pro femora length; labial 1st joint reaching eyes; connexivum exposed considerably from dorsal view.

Measurements (mm): Total body length 9.63; head length 2.67; head width 1.53; pronotal length 2.18; pronotal width 2.71; scutellum length 0.77; scutellum width 1.12; labium length 2.35; antennae length 5.01.

Distribution: India and Pakistan (Jhelum, **new country record**).

3.2.3. *Rhynocoris marginatus* (Fabricius, 1794)

Reduvius marginatus Fabricius, 1794: 196; *Rhynocoris marginatus* Biswas and Bal, 2010: 260.

Diagnostic characters: The body color is sanguineous, setose; scutellum, eyes, antennae, inner region of corium, membrane and tibiae apical two-third violaceous black; antennae base and lateral abdominal margins blood-red in hue; corium wrinkled; sternal disk, trochanters, coxae and anterior pronotal lobe reddish-ochraceous; 1st labium joint apex reaching eyes; basal antennal joint somewhat equal in length to the anterior femora; pronotum posterior lobe and corium rugulose; membrane crossing the apical point of abdomen; connexivum exposed.

Measurements (mm): Total length 16.65 mm.

Distribution: China, India, Pakistan and Sri Lanka.

3.2.4. *Rhynocoris fuscipes* (Fabricius, 1787)

Reduvius fuscipes Fabricius, 1787: 312; *Rhynocoris fuscipes*: Ambrose, 2006: 11.

Diagnostic characters: The body color generally coral-red in hue; antennae, hind pronotal lobe interior region, legs, scutellum base, oblong mark between the antennae, pronotal 2 marks, black; labium with its basal joint coral-red while remaining joint blackish in hue; fore-lobe of pronotum sculptured, hind lobe medially little longitudinally impressed, hind margin of posterior lobe facing scutellum truncate.

Measurements (mm): Total length 17.05 mm.

Distribution: China India, Japan, Pakistan, Sri Lanka and Taiwan.

3.2.5. *Sinea diadema* (Fabricius, 1776)

Cimex multispinosus De-Geer, 1773: 348; *Sinea diadema* Stal, 1872b: 70.

Diagnostic characters: The body color is brownish ochraceous; head elongate supported with spines, ocelli yellowish, antennal basal joint longest; labial basal joint longest; pronotum more broad than its length, anterior pronotal lobe not sculptured, humeral angles sub-acute, lateral and postero-lateral margins sinuate; connexivum considerably exposed, membrane longer than the abdomen.

Measurements (mm): Total length 10.75 mm.

Distribution: England, Pakistan and North Mexico.

3.3. Subfamily stenopodainae

3.3.1. *Oncocephalus schioedtei* (Reuter, 1881)

Oncocephalus schioedtei Reuter, 1882: 702; *Oncocephalus schioedtei* Ambrose, 2006: 25.

Diagnostic characters: The body color is pale brownish; antennae with 1st segment fuscous biannulated, little longer than antero-ocular region; head disk with conspicuous mark behind the eyes, lateral regions fuscous; ante-ocular length almost 2 times the length of post-ocular area; pronotum bearing 2 middle longitudinal lines, merged at anterior lobe; scutellum black with middle pale reddish fascia; corium with sub-quadrate mark close to inner angle, elongate hinder subclaval mark, large elongate mark on membrane disk, dark brownish-black; labium 2nd segment except base, its apex, sub-basal, middle and apical annulation to pro-tibiae, meso and meta femur apices, sub-basal annulation to meso and meta tibiae, brownish-black; membrane little shorter than the abdominal apex.

Measurements (mm): Total body length 12.135; head length 2.25; head width 1.50; pronotal length 2.475; pronotal width 2.775; scutellum length 1.2; scutellum width 1.172; labium length 3.17; antennae length 6.448.

Distribution: India and Pakistan (Jhelum, **new country record**).

3.4. Subfamily ectrichodiinae

3.4.1. *Scadra annulipes* (Reuter, 1881)

Scadra annulipes (Reuter, 1881):309; *Scadra annulipes*: Ambrose, 2006: 4.

Diagnostic characters: The body color is reddish-brown; antennae strongly pilose, 2nd joint longest; labium with 1st joint longest, 3rd shortest; antennae, eyes, a mark on hind pronotal lobe each side, abdomen, triangular mark on anterior corial zone, hemelytral membrane, posterior-lateral rounded marks of venter, terminal ventral joint, tibial annulations, and tarsi apices, black; connexivum exposed and unspotted; hemelytral membrane little shorter in length than the abdominal apex.

Measurements (mm): Total body length 10.275; head length 1.34; head width 1.541; pronotal length, fore-lobe, 1.005 and hind lobe, 1.306; pronotal width 1.365; scutellum length 1.273; scutellum width 1.675; labium length 6.715; antennae length 6.633.

Distribution: Pakistan and India.

Table 2
Temporal Distribution of Assassin bugs along with their Host field & Prey records.

Sr. #.	Species	Host field	Prey record	Month	References
1	<i>Tribelocephala indica</i>	Dried leaves, Maize.	<i>S. litura</i>	June-Aug	Ambrose (1999)
2	<i>Coranus spiniscutis</i>	Brinjal, Okra, Sunflower	<i>H. armigera, S. litura, E. ventralis</i>	April-Oct	Claver and Reegan (2010)
3	<i>Rhynocoris marginatus</i>	Cabbage, Lady finger, Cucumber, Chilies.	<i>D. indicus, S. litura, D. cingulatus, E. vitella, O. laetus, H. armigera, G. servus, S. hospes, S. pandurus, R. linearis, N. inconspicuous</i>	May- July	Ambrose (2003, 2007)
4	<i>Rhynocoris fuscipes</i>	Cabbage, Lady finger, Cucumber, Chilies.	<i>D. indicus, S. litura, D. cingulatus, E. vitella, O. laetus, H. armigera, S. hospes, S. pandurus, R. linearis</i>	May- July	Ambrose and Claver (2001a), Nagarajan (2010)
5	<i>Sphedanolestes faterculus</i>	Parthenium, Brinjal	<i>C. obscura, caterpillars</i>	Mar-June	Rao et al., (1981)
6	<i>Sinea diadema</i>	Cabbage, Mungbean	Caterpillars in general, <i>C. biguttata, N. viridula</i>	May- Oct	Ambrose (1999)
7	<i>Oncocephalus schioedtei</i>	Peanut, Sunflower, fallen leaves	<i>N. inconspicuous, H. armigera, M. uniguttatus</i>	May- Oct	
8	<i>Scadra annulipes</i>	Cabbage, Lady finger, pumpkin	<i>A. ipsilon, Pieris rapae</i>	April-Oct	Singh and Gangrade (1975)
9	<i>Ectrychotes dispar</i>	Wild plants, millipede feeder.	Millipedes, <i>H. armigera</i>	Aug-Oct	Pawar et al. (1986)
10	<i>Sirthena flavipes</i>	Maize	<i>H. armigera</i>	May-July	Ambrose (2007)
11	<i>Acanthaspis quinquespinosa</i>	Ladyfinger	<i>D. koengii, H. armigera</i>	May-Aug	Sahayaraj (1991)
12	<i>Holoptilus fasciatus</i>	Peanut crop	<i>Cletus trigonus</i>	April-July	

3.4.2. Ectrychotes dispar (Reuter, 1881)

Ectrychotes dispar (Reuter, 1881): 304; *Ectrychotes dispar*: Ambrose, 2006: 2.

Diagnostic characters: The body color is black and reddish; antennae shiny black and moderately pilose; pronotum with posterior lobe lateral regions reddish, scutellum except base, coxae apices, trochanter, hind femur base, claval and corial bases, connexivum, tarsi bases, and abdomen blackish; abdominal apex ventrally piceous.

Measurements (mm): Total body length 12.85; head length 1.809; head width 1.809; pronotal length: fore-lobe, 1.608; hind lobe, 2.01; pronotal width (Pro lobe) 3.015; (hind lobe) 3.953; scutellum length 0.871; scutellum width 1.407; labium length 4.623; antennae length 5.259.

Distribution: India and Pakistan (Islamabad, Rawalpindi, **new country record**).

3.5. Subfamily Peiratinae

3.5.1. Sirthena flavipes (Stal, 1855)

Rasahus flavipes Stal, 1855: 187; *Sirthena flavipes*: Distant, 1904: 303; *Sirthena flavipes* Ambrose, 2006: 18.

Diagnostic characters: Head, pronotum with anterior lobe, abdominal disk beneath is castaneous; 1st antennae segment, legs, claval base and apical area, above and below marks to connexivum, apex of hemelytral membrane, abdominal spots, luteous; scutellum black; sub-basal mark to clavus and a mark in the middle of inner corial margins are piceous; head, antennae, legs, pronotum, abdomen beneath are pilose; 1st antennae joint little in length than the head apex, 2nd almost equal in length to the pre-ocular region; tarsi 3-segmented, 1st joint shortest, 2nd and 3rd sub-equal in length.

Measurements (mm): Total body length 15.75 mm.

Distribution: China, India, Japan, Sri Lanka and Philippines.

3.6. Subfamily reduviinae

3.6.1. Acanthaspis quinquespinosa (Fabricius, 1781)

Reduvius quinquespinosa Fabricius, 1781: 382; *Acanthaspis quinquespinosa*: Distant, 1904: 257.

Diagnostic characters: The body is generally black; head oblong, eyes well developed, furrow like longitudinal depression present between the eyes and ocelli; antennae 4 jointed, basal joint considerably crossing the head apex, and sparsely setose, others finely setose; labium reddish-brown, 3 segmented, terminal seg-

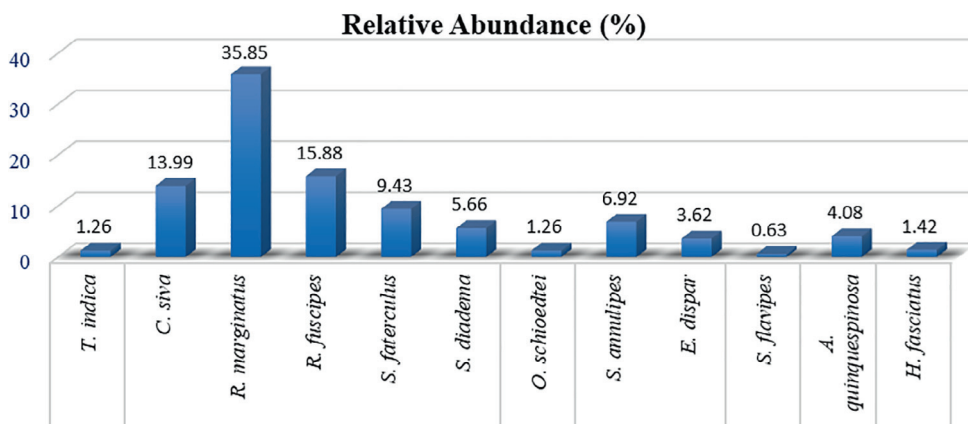


Fig. 3. Relative abundance of all the collected species of Reduviidae from the Pothohar areas.

Subfamilies relative abundance (%)

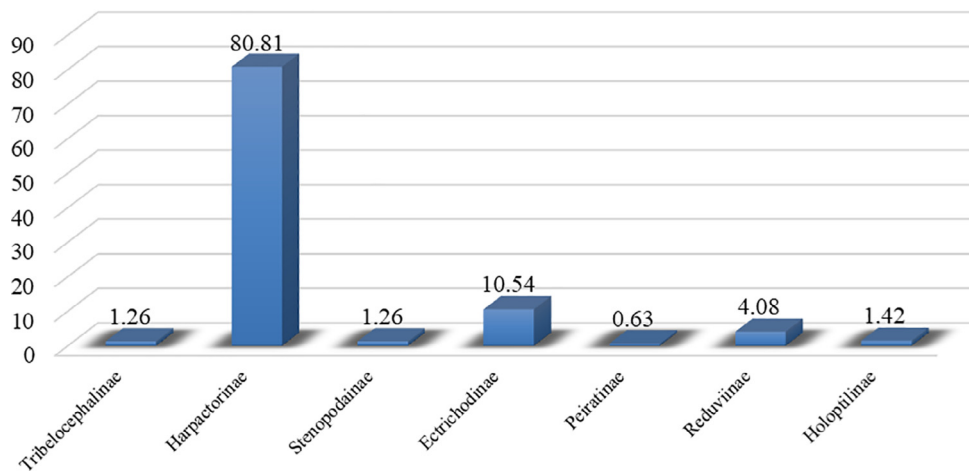


Fig. 4. Relative abundance of assassin bug subfamilies collected from 2017 to 2019.

ment the shortest, 1st and 2nd joint sub-equal; pronotal anterior lobe sculptured, pronotum with 2 discal and 2 lateral spines on posterior lobe, 2 sub-rounded marks on corium, and marks on and beneath connexivum, luteous; abdomen exposed; legs unicol-

orous and pilose; hinder tibiae much longer than the pro and meso tibiae.

Measurements (mm): Total body length 17.65 mm.

Distribution: Bangladesh, China, India, Myanmar and Pakistan.

Table 3

Collective rank list of all the collected assassin bug species from the selected sites of the Pothohar region.

Districts	Species	Abundance	Species					
			Saipur Village	Phulgran Village	Kachnar Park	Kachnar Park	Trail # 1	Trail # 5
Islamabad	<i>C. spiniscutis</i>	41	+	+	+	+	-	+
	<i>R. marginatus</i>	41	+	+	+	-	+	+
	<i>E. dispar</i>	15	-	-	-	+	+	+
	Total abundance	97	29	21	12	6	8	21
	Total # of Species		2	2	2	2	2	3
RAWALPINDI	Species	Abundance	Taxilla	Kallar Syedan	Nawaz Sharif Park	Ayub National Park	Kuldana Forest	Phagwari Forest
	<i>S. annulipes</i>	39	+	+	+	-	+	+
	<i>R. marginatus</i>	96	+	+	+	+	+	+
	<i>R. fuscipes</i>	35	+	+	-	+	-	-
	<i>E. dispar</i>	8	+	-	+	-	+	+
	<i>H. fasciatus</i>	9	+	+	-	-	+	-
	<i>C. spiniscutis</i>	27	+	+	+	-	+	-
	<i>S. faterculus</i>	23	+	+	-	-	+	+
	Total abundance	237	88	75	9	16	26	23
	Total # of Species		7	6	4	2	5	44
	JEHLUM	Species	Abundance	Sohawa site	Dina	Tainpura Dam	Domeli Dam	Lehri Park Forest
<i>R. marginatus</i>		45	+	+	+	+	+	-
<i>R. fuscipes</i>		31	+	+	+	-	-	-
<i>C. spiniscutis</i>		21	+	+	+	+	-	+
<i>S. faterculus</i>		37	+	+	-	+	+	+
<i>S. annulipes</i>		5	+	-	-	-	+	-
<i>S. diadema</i>		36	+	+	+	+	+	+
<i>A. quinquespinosa</i>		26	+	+	-	-	-	+
<i>T. indica</i>		8	-	-	-	-	+	+
<i>O. schioedtei</i>		8	+	+	-	-	+	-
<i>S. flavipes</i>		4	+	-	-	-	+	-
Total abundance		221	69	50	16	14	32	40
Total # of Species			9	7	-	-	6	6

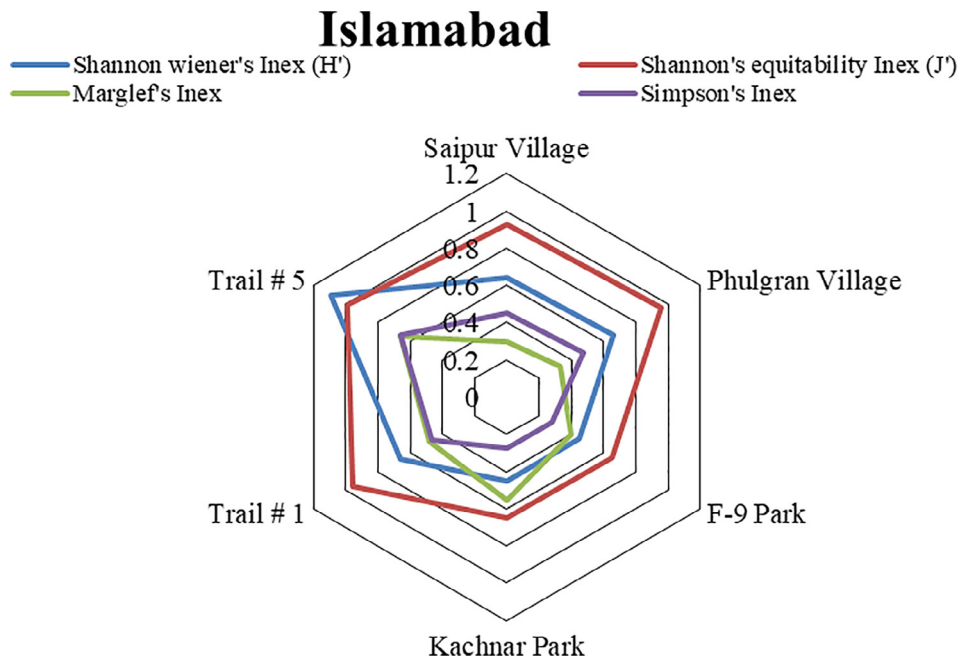


Fig. 5. Diversity indices values of Assassin bug species collected from different sites of Islamabad.

3.7. Subfamily Holoptilinae

3.7.1. *Holoptilus fasciatus* (Reuter, 1881)

Holoptilus fasciatus (Reuter, 1881): 272; *Holoptilus fasciatus* Lethierry & Severin, 1896: 94.

Diagnostic characters: The body is covered with elongate golden yellowish setae; head, antennae, pronotal margins, corial veins, legs and connexivum golden yellowish, antennae with long golden yellowish and piceously hued setae, head from beneath, coxae dark mustard in hue; pronotal pro lobe brownish, hind lobe

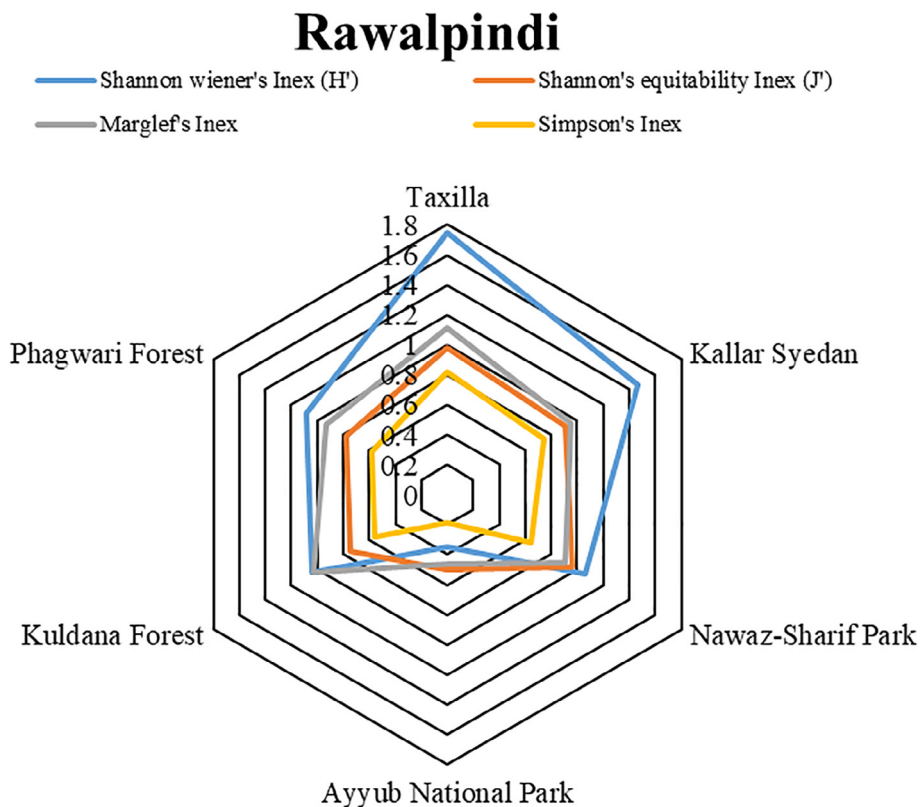


Fig. 6. Diversity indices values of Assassin bug species collected from different sites of Rawalpindi.

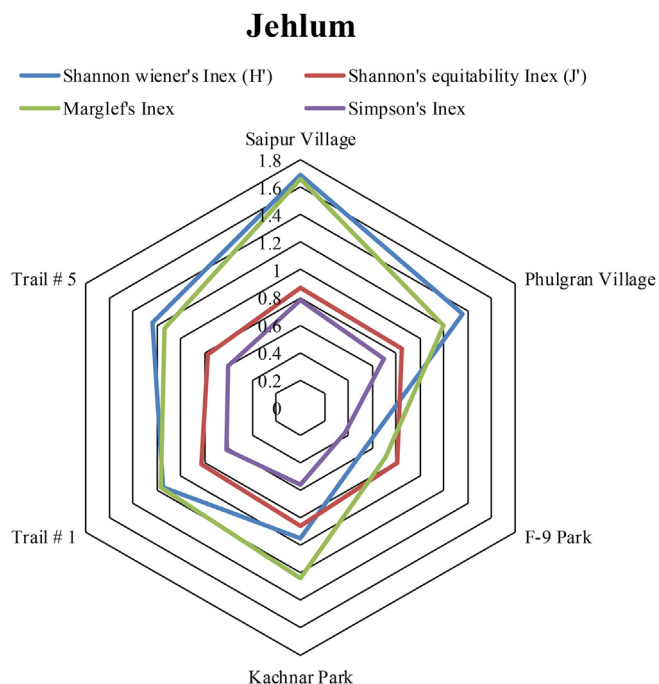


Fig. 7. Diversity indices values of Assassin bug species collected from different sites of Jehlum.

mustard; scutellum base piceous; corial and claval cells hyaline; hind femur robust, hind tibia long; abdomen oval round, covered with elongated setae, hemelytra passing abdominal apex.

Measurements (mm): Total body length 6.65 mm.

Distribution: India and Pakistan.

4. Discussion

Seasonal collection of various species of assassin bugs from the Pothohar region of Pakistan revealed (Table 2) that most of these were collected from May to October, particularly *R. marginatus* and *R. fuscipes*. Species *T. indica* has very narrow range of habitats and were only collected from the forest area while species of sub-family Harpactorinae, *R. marginatus* and *R. fuscipes*, were found from all the selected habitats. Moreover, species *R. marginatus* of subfamily Harpactorinae showed highest relative abundance (35.85%), whereas the species *T. indica* showed the least abundance i.e. 1.26% (Fig. 3). Among 7 assassin bugs subfamilies, Harpactorinae showed highest relative abundance (80.81) with maximum five species, while the Peiratinae recorded least relative abundance (0.63%) with only one species (Fig. 4).

From the selected sites of the Pothohar region of Punjab the site Sohawa of district Jehlum showed maximum species richness i.e. 9 species (Table 3). It has been noted that forest area of Islamabad territory exhibits maximum species richness while agricultural areas of District Rawalpindi and Jehlum are the most species rich sites with maximum abundance.

Diversity values, used for the evaluation of species richness and evenness of family Reduviidae from the selected sites of the Pothohar region (Figs. 5, 6 and 7) showed that Trail #5, Taxilla and Sohawa zones exhibited maximum values of Shannon wiener's index (1.092, 1.75 and 1.69 respectively), Simpson's index (0.662, 0.82 and 0.78 respectively) and Margle's index (0.656, 1.11 and 1.66 respectively).

The web structure represented that eleven species of assassin bugs were present in Agricultural and forest zone while the grassland zone is represented a total of 7 species. However, agricultural zone showed maximum abundance of species compared to forest zone, however, both the zones were represented by eleven species. Among different collected species *R. marginatus* belonging to sub-family Harpactorinae, is the most abundant species in all the

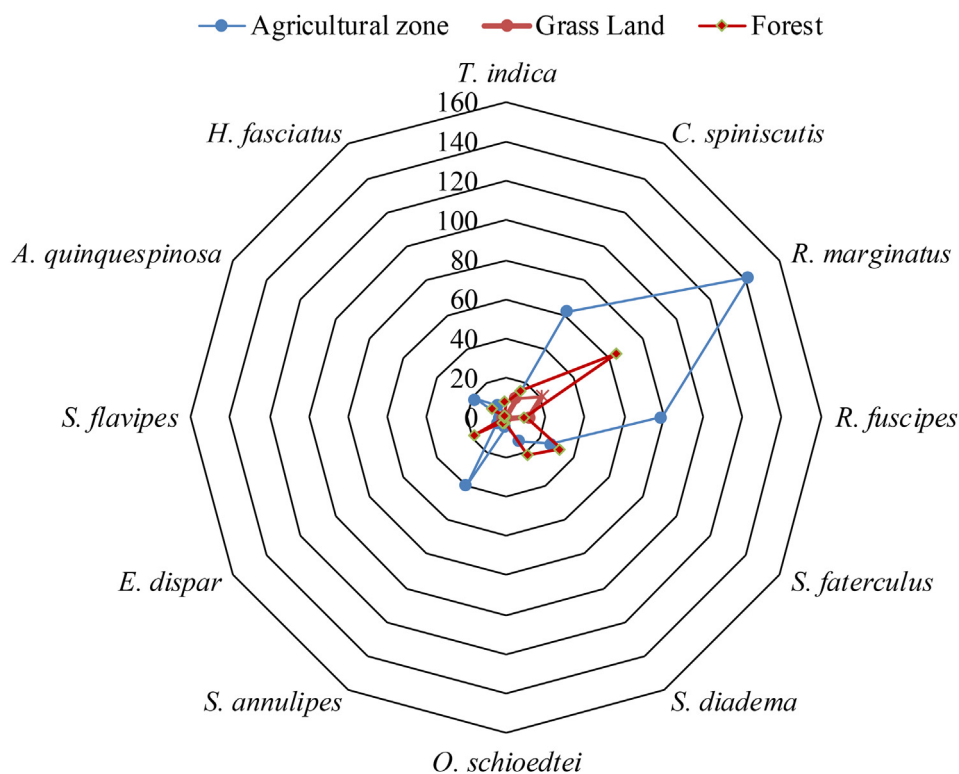


Fig. 8. Web structure showing number of species present in all the habitats and habitat abundance.

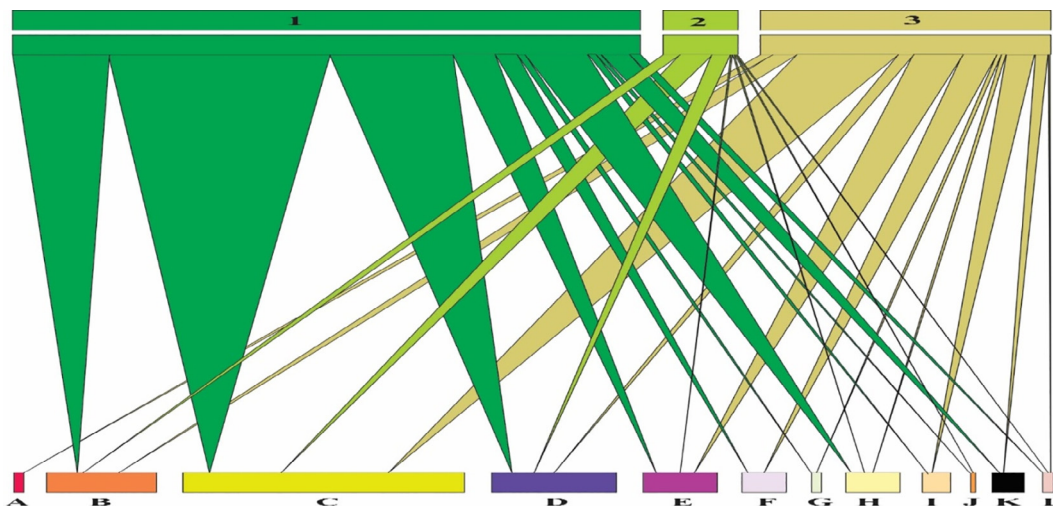


Fig. 9. Quantitative web structure of Reduviidae species linked with selected habitats. In above picture: 1 (Agriculture zone), 2 (Grass land) and 3 (Forest zone) are three different habitats. A = (*Tribelocephala indica*), B = (*Coranus spiniscutis*), C: *Rhynocoris marginatus*, D: *Rhynocoris fuscipes*, E: *Sphebanolestes faterculus*, F: *Sinea diadema*, G: *Oncocephalus schioedtei*, H: *Scadra annulipes*, I: *Ectrychotes dispar*, J: *Sirthena flavipes*, K: *Acanthaspis quinquespinosa*, L: *Holoptilus fasciatus*

selected habitats, especially in agricultural zone (Fig. 8). The quantitative web structure of twelve species of assassin bugs belonging to different genera, comprising of 636 specimens was presented. Almost all the species, except *T. indica* (absent in Agriculture and Grassland zones), *S. diadema*, *S. schioedtei*, *A. quinquespinosa* (absent in grassland) and *S. flavipes* (not present in forest) were present in all the selected habitats (Fig. 9).

5. Conclusion

A total of 12 species belonging to 11 genera under 7 subfamilies have been reported from the Pothohar region of Pakistan, which are quite less in number as compared to neighboring country; India 465 species. Species like *R. marginatus* and *R. fuscipes* were successfully utilized as bio control agents in economically important agricultural crops of India (Singh and Singh, 1987; Sahayaraj, 1995), *Coranus spiniscutis* (Jalali and Singh, 2002), *Acanthaspis quinquespinosa* (Das et al., 2010).

It can be concluded that the species of assassin bugs were not evenly scattered in all the selected sites of the Pothohar region. The variation in richness in the population of assassin bug was recorded in the selected three districts of the Pothohar region. The species richness recorded almost same pattern in Islamabad and Jehlum demonstrated by minute difference in Shannon's equitability index (0.65–0.929 and 0.77–0.87) respectively. But species richness of selected sites of district Rawalpindi was not same as demonstrated by a significant difference between the values of Shannon's equitability index (0.50–0.98) i.e. some sites were more species rich than the others. District wise maximum species have been found from Jehlum (10 species) followed by Rawalpindi and Islamabad (7 and 3 species, respectively). For the perspective researcher this study will provide a base line to study the assassin bugs ecology, biology and predatory potential against various insect pests. These findings will definitely prove handy in developing biocontrol strategies against various insect pests of different crops in plant protection programs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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