9. DISCUSSION

The present work deals with spiders of tea ecosystem of Dooars, West Bengal. The study area included 8 tea estates namely Shikarpur T. E., Kailashpur T. E., Meenglas T. E., Nepuchapur T. E., Nagrakata T. E., Bhogotpore T. E., Kurti T. E. and Dalgaon T. E.. All the tea estates are of conventional type. Of these the former 4 belongs to Western Dooars, while the rests are within the jurisdiction of Central Dooars. Among them Shikarpur T. E. and Kailashpur T. E. lie close to Baikunthapur forest division, while Meenglas T. E. lies close to Neora Valley National Park. Besides Nepuchapur T. E. and Nagrakata T. E. are somewhat close to or are in some way under the influence of Gorumara National Park and Chapramari Wildlife Sanctuary respectively. Again last 5 named tea estates experience high pesticides load as compared to the rests. The survey was conducted during the period of May, 2008 to October, 2011 in different sections of the referred tea estates in every month of any calendar year.

Spiders being ubiquitous and generalist predators are omnipresent. Therefore their presence in the tea ecosystem is nothing unusual. Like anywhere else, they occupy several trophic niches in the tea system too. Based on their habit and habitats, they are broadly classified into Web builders and Wanderers or Non-web builders. The web forming spiders may be Orb weavers, Foliage hunters, Sheet weavers and Space weavers. Non-web forming spiders include Stalkers, Ground dwellers, Trunk dwellers (Foliage hunters) and Ambushers. Thus there are 7 trophic niches. Orb weavers include members of the family Araneidae, Deinopidae, Eresidae, Nephilidae, Tetragnathidae and Uloboridae. Their preys are trapped in the viscid and elastic silk on the periphery of the web. Most araneids are typical Orb weavers and nocturnal. However, they are frequently found in the webs during the day time and adopt the spin wrap attack method to subdue their prey. Among them, Argiope pulchella Thorell is very much common in tea bush, rehabilitation crop and fencing trees. Cyclosa spp. remain in the web with food particles and feces. Neoscona spp. enjoy the foliages, weeds or sometimes the dry tea leaves, perfectly matching with the back ground. Dry leaf spider Acusilas coccineus Simon prefers the shade tree leaves of litter. Nephilids are the largest and golden Orb weavers. Nephila kuhlii C.L. Koch builds large web to the extent of 30ft. between two shade trees or between shade trees and tea bushes and thus maximizing trapping area. Unfortunately they are rare probably due to their intolerance to pesticides. Tetragnathids are long-jawed Orb weavers and therefore are good candidates of biological control. Leucauge decorata (Blackwall) is the dominant species. Tetragnatha spp. are prevalent in the moist places near drainage and shaded areas. Uloborids spin modified version of Orb webs, ranging from triangular to a single thread, consisting of viscid cribellate silk in low bushes or between objects near the ground. They prefer cool and shady places. Uloborus khasiensis Tikader is
the most frequent and typical in the tea ecosystem. None of the agronomic practices does affect the species, as they build their webs underside the tea leaves and tea bushes. **Foliage hunters** accommodate clubionids, herilids, miturgids, pisaurids and sparassids. Among them miturgids and clubionids construct white, flattened, tubular sac or retreat with silk usually in rolled up leaves, foliages, under loose bark of shade trees and sometimes under stone. Types of sacs vary depending upon their biological needs e.g. resting, mating and breeding. Their usual habit of capturing prey is by sudden jumping and seizing with stout chelicerae. They use their front legs to detect and grab the prey. *Dendrolycosa* sp. nr. *gitae* (Tikader), the only pisaurid, is predominant in the tea ecosystem. However not a single mature individual is collected during the period. Sparassids are usually found under the bark, in dry leaf litter and within folded leaves of tea bush and fencing trees. They do not spin webs, however make silken retreats. Linyphid ś spin flat, dome or hammock shaped **sheet webs** with isolated threads forming scaffolding. The spider hangs upside down under the sheet without any retreat. Prey is bitten from below through the sheet and pulled through it, before being consumed. *Linyphia nicobarensis* Tikader is the most widely encountered species. Most theridiids construct differently shaped 3D **space webs**, consisting of criss-cross viscid threads to catch flying insects. The threads break easily and glued prey becomes more entangled while trying to escape. Some species build special retreats within or out of the frame and use plant or soil particles to camouflage the web.

**Stalkers** consist of the members of the family Salticidae and Oxyopidae. Salticids, visually based stalking attackers, are frequent in tea trunk, both sides of leaves, fencing trees and shade trees. They are diurnal, typical non-weavers but make silken retreats in the form of a tube or sac fastened to various substrata to moult, sometimes to mate, egg laying or night shelter. Dominant species are *Hyllus semicupreus* Simon, *Phintella vittata* (C.L. Koch), *Plexippus paykullii* (Audouin), *Telamonia dimidiata* (Simon) and *Thiania bhamoensis* Thorell. Most oxyopids chase their prey with great rapidity over bush canopy, jumping in habit and usually hide from a flying insect until within stalking distance. Others lie in wait near flowers and spring upon insects that visit flowers. These diurnal hunting spiders make no web but quickly detect the prey with good vision and catch it with legs. They are often found in grass, weeds and fencing trees also. *Oxyopes shweta* Tikader, *O. kamalae* Gajbe, *O. matiensis* Barrion & Litsinger and *Hamataliwa reticulatus* (Biswas *et al.*) are the dominant species. **Ground dwellers** comprise the members of family Gnaphosidae, Lycosidae, Zodariidae and some members of Clubionidae. Lycosids are usually diurnal while some are nocturnal. They are typically non-weavers but make tunnels on cracks and crevices by weaving, usually found under stones or debris, at the plant base. Some prefer moist habitats. *Pardosa birmanica* Simon and *P. sumatrana* (Thorell) are most common in the tea ecosystem. Thomisids are **ambushers**. They are primarily diurnal, non-weaving; usually live
on plants and foliages and in winter hide in the cracks under stones and barks. On the bark, the body surface achieves a roughened texture to improve camouflage. They hunt by stealth and ambush with their powerful spinose legs and concealing colours. The decreasing order of niches (Fig. 630) are Orb weavers (41.74%) > Stalkers (27.82%) > Ground dwellers (8.70%) ≥ Foliage hunters (8.70%) > Ambushers (5.22%) ≥ Space weavers (5.22%) > Sheet weavers (2.61%). Their food spectrum includes several major tea pests such as Tea mosquito bug *Helopeltis theivora* Waterh., Red spider mite *Oligonychus coffeae* (Nietner), *Aphis gossypii* Glover, eggs and adults of *Hyposidra talaca* (Walker) and *H. infixaria* Walker, shade tree pests *Diacrissa obliqua* Walker, *Oxyrachis tarandus* (Fabricius), *Eurema hecabe* (L.) and many stray species.

Besides predation, spiders have specific adaptation to match with the background such as leaves, flowers, grass, twigs, bark and the ground. In some cases the crypsis is extraordinarily precise. For example, most thomisids mimic the colours of flower heads wonderfully and prey on pollinators that approach. *Deinopis goalparaensis* Tikader & Malhotra hang in a head down position in the web and at rest, their anterior legs remain extended forward while posterior backward. It seems like dry shoot or tea trunk. Such highly cryptic behaviour keeps them concealed in nature. Similar type of adaptation occurs in *Tetragnatha* spp. Some species of theridiids like *Theridion indicum* Tikader use plant or soil particles to camouflage the web. Nocturnal, grey brown and black sparassid spiders are often with enough mottling to provide camouflage. *Hersilia savignyi* Lucas usually inhabit the shade tree trunk where they mimic the dry bark and spread the silk over the nearby area. *Herennia multipuncta* (Doleschall) also inhabits the shade tree trunk and camouflages with the bark. Thus selection for crypsis in similar types of habitat has lead to the repeated evolution of similar colouration in unrelated species.

Spiders may gain some protection from predators through their resemblance with aggressive or unpalatable ants, a range of other organisms, alive or dead and inanimate objects. For example *Myrmarachne plataleoides* O. P.-Cambridge mimic with ants. Another interesting finding is the resurrection of a bird dung crab spider *Phrynarachne tuberosa* (Blackwall) almost after 150 years. The species remains in disguise as bird dung on the upper surface of tea leaves. They neither move nor spin web, probably depending on the red spider mite, another major tea pest. *Cyclosa* spp. construct vertical “sticks” of prey remains, within the web and leave a gap in the centre where it stays. In *Argiope pulchella* Thorell the visibility of both the contrastingly coloured ventral and the UV reflecting dorsal side of the opisthosoma may increase the prey traps in the web.

Spiders are always dioecious. Apart from a few exceptions, the females are always larger than males. Sexual dimorphism is especially obvious in many tropical Orb weavers such as *Nephila, Gasteracantha* etc., in which the males appear to be dwarf. Females of
*Nephila kuhlii* C.L. Koch are colourful, with size upto 5 cm, legs span upto 15 cm and build the largest orb web known, while males are many times smaller.

Cannibalism within spiders being a natural event, sociality is hardly expected. However present findings contain *Stegodyphus sarasinorum* Karsch, the only social Indian spider known. The species constructs very large webs in which hundreds of individuals live together and feed on the same prey and hence called social spiders. It is noteworthy to mention that actual number of social spiders is still unknown. Some theridiids of the genus *Argyrodes* Simon lead a kleptoparasitic life on the large webs of *Nephila* Leach and *Cyrtophora* Simon.

The survey yields a total of 115 species under 70 genera, distributed over 19 families (Fig. 632). The number of genera and species representing each family are given in Table: 2. Of these 8 species are recognized as new to science (Figs. 633 & 634).

Species:
Salticidae: *Cheliceroides brevipalpis* sp. nov.
Thomisidae: *Mastira septemapodemata* sp. nov.
Clubionidae: *Clubiona tridentata* sp.nov.
Oxyopidae: *Hamadraus baruni* sp. nov.
Linyphidae: *Linyphia bilobata* sp. nov.
Araneidae: *Chorizopes quadrituberculata* sp. nov.
*Cyrtophora bituberculata* sp. nov.
*Gibbaranea indiana* sp. nov.

Four genera and 12 species are new from the country (Figs. 633 & 634).

Genera:
Salticidae: *Cocalus* C. L. Koch

*Cheliceroides* Zabka
*Evarcha* Simon

Theridiidae: *Achaearyopa* Barrion & Litsinger and

Species:
Salticidae: *Cocalus murinus* Simon

*Euphrys frontalis* (Walckenaer)
*Evarcha flavocinta* (C. L. Koch)
*Phaeacius fimbriatus* Simon
*Telamonia festiva* Thorell

Clubionidae: *Clubiona rama* Dankittipakul & Singtripop

Theridiidae: *Achaearyopa pnaca* Barrion & Litsinger

Tetragnathidae: *Guizygeilla hungxiensis* (Zhu & Zhang)

Araneidae: *Acusilas coccineus* Simon
Four are new male morphs (Figs. 633 & 634).

Male morph:
Uloboridae: *Uloborus khasiensis* Tikader
Thomisidae: *Thomisus andamanensis* Tikader
Araneidae: *Cyclosa moondiensis* Tikader
*Cyclosa simoni* Tikader

Synonymies proposed are 2 (Fig. 633).

*Telamonia sikkimensis* (Tikader, 1967) as a junior synonym of *Telamonia festiva* Thorell, 1887 and *Oxyopes nalini* Gajbe, 1999 as a junior synonym of *Oxyopes matiensis* Barrion & Litsinger, 1995

Further, 19 more species are new records from the state of West Bengal (Fig. 633).

Species:
Deinopidae: *Deinopis goalparaensis* Tikader & Malhotra
Uloboridae: *Miagrammopes* sp. nr. *kirkeensis* Tikader
*Uloborus khasiensis* Tikader
Zodariidae: *Suffasia* sp. nr. *keralaensis* Sudhikumar et al.
Salticidae: *Carrhotus vidius* (C. L. Koch)
*Epocilla aurantiaca* Simon
*Menemerus brevibulbis* (Thorell)
Thomisidae: *Epidius bazarus* (Tikader)
*Phrynarchne tuberosa* (Blackwall)
Oxyopidae: *Oxyopes kamala* Gajbe
*Oxyopes matiensis* Barrion & Litsinger
Lycosidae: *Hippasa olivacea* (Thorell)
*Lycosa phipsoni* Tikader
Theridiidae: *Achaearanea budana* Tikader,
*Argyrodes gazedes* Tikader
Linyphiidae: *Lepthyphantes rudrai* Tikader
Tetragnathidae: *Tetragnatha maxillosa* Thorell
Nephilidae: *Herennia multipuncta* (Doleschall)
Araneidae: *Pasilobus kotigeharu* Tikader

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Out of 115 species, 30 species are recognized as endemic to India (Figs. 633 & 635), thus exhibiting high endemicity (26.08%). The generated data represents 6.82%, 15.98% and 31.67% of the Indian species, genera and family respectively (Fig. 636).

Seasonal distribution (Fig. 637) of spiders is maximum in Premonsoon (37%), followed by Postmonsoon (35%) and Monsoon (28%). Even though species richness is little higher during Premonsoon, always there remains a state of equilibrium throughout the seasons. Seasonal distribution also varies among the families (Fig. 638) viz. Araneidae and Salticidae are dominant during post monsoon, Oxyopidae and Lycosidae during pre monsoon and Tetragnathidae during monsoon, thus exhibiting a succession. Such heterogeneity is a welcome phenomenon not only from the stand point of biodiversity but also from the view point of tea pest management.

Analysis of Zoogeographical (Fig. 639) distribution reveals that the fauna is largely Oriental (100%), followed by Palaearctic (11.30%), Australian (10.43%), Ethiopian (5.22%), Nearctic (1.74%) and Neotropical (0.87%).

Number of recorded spider taxa (Fig. 640) from the study area shows that species diversity is maximum in Nepuchapur T. E. and minimum in Bhogotpore T. E.. Based on species diversity, the decreasing order of the tea estates are NTE (66.08%) > KTE (60%) > NATE (46.89%) > MTE (42.60%) > STE (39.13%) > DTE (34.78%) > KUTE (31.30%) > BTE (27.82%). This lead to infer ‘closer the forests or experiences less pesticides, higher the spider heterogeneity’. Again on an average, any of the tea estate harbours at least 50 spider species at any point of time.

In fine, the tea ecosystem (Fig. 641) is stable and typical due to its regular management practices and continuous influx of energy and nutrients. But being a monoculture crop, it can't favour diverse insect groups. On the contrary, it welcomes only few insect groups that are either pests or stray species. These species serve as a good food source to the inhabiting spiders. Study in the adjoining forests leads to guess that they opt ballooning as the means of movement ie. adjoining forests => tea gardens.

Therefore they may be identified as a potential regulatory factor to address the issue of pest problems in tea.

The management plan that can be suggested (Fig. 642) is simply to augment the diversity of spiders in tea field. This can be achieved by:

i) Creation of forest fringes
ii) Deposition of litters
iii) Addition of organic mulch and
iv) Manipulation of spacing distance
Fig. 630: Total no. of spider species trapped under different trophic niches from the Tea Estates of Dooars

- Ambushers: 10 species
- Ground dwellers: 10 species
- Stalkers: 32 species
- Space weavers: 6 species
- Sheet weavers: 3 species
- Foliage hunters: 10 species
- Orb weavers: 48 species

Fig. 631: Spider species trapped under different families from the Tea Estates of Dooars

- Deinopidae: 13 species
- Eresidae: 1 species
- Idiopidae: 1 species
- Salticidae: 1 species
- Sparassidae: 2 species
- Thomisidae: 2 species
- Theraphosidae: 4 species
- Miturgidae: 4 species
- Clubionidae: 2 species
- Anyphaenidae: 1 species
- Pisauridae: 1 species
- Theridiidae: 8 species
- Linyphiidae: 6 species
- Tegenariaidae: 8 species
- Nephilidae: 3 species
- Araneidae: 2 species

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Fig. 632: Total no. of spider taxa trapped from the Tea Estates of Dooars

Fig. 633: Highlights
Fig. 634: Spider families showing new findings

Fig. 635: Spider families representing no. of endemic species trapped from the Tea Estates of Dooars

Araneidae
Tetragnathidae
Linyphidae
Theridiidae
Lycosidae
Pisauridae
Oxyopidae
Gnaphosidae
Thomisidae
Salticidae
Uloboridae
Deinopidae

0 1 2 3 4 5 6
—i 2
J1
J1
-J 2
J 3
J 6
-J 5
368
Fig. 636: Comparison of the generated data as against global scenario 
(Platnick, 2013; Keswani et al., 2012; Biswas & Biswas, 1992)

Fig. 637: Seasonal distribution (%) of spider taxa trapped from the Tea Estates of Dooars, West Bengal
Fig. 638: Seasonal distribution (%) of spider families in the Tea Estates of Dooars, West Bengal

Fig. 639: Zoogeographical distribution (%) of spider taxa trapped from the Tea Estates of Dooars, West Bengal
Fig. 640: Comparative account of spider taxa trapped from the Tea Estates of Dooars
Fig. 641: Summary

- TEA GARDENS WITH LESS PESTICIDE LOAD
- ADJOINING FOREST
  - Ballooning
- TEA PESTS
  - DIVERSE INSECT GROUPS
    - Can't favour
  - Favour only
- FEW STRAY SPECIES
  - Good food source
- RESOURCE OF POPULATION GROWTH
  - More of 9s
  - 50 spider species
- TEA ECOSYSTEM STABLE & TYPICAL

- Regulatory factor
Fig. 642: Suggested Management Plan

Increase spider heterogeneity
Reduce PESTS PESTICIDAL LOAD
10. SUMMARY

Spiders are amongst the most omnipresent, numerous, generalist predators in both agricultural and natural ecosystems. They are nature’s master spinners of silken webs. They exert considerable top down effect and have the potential to both lower and stabilize pest population making themselves excellent biological pest management candidates. In their absence, the world of insect pests would run amok creating havoc of our health and food resources. India is the world’s 4th largest exporter of tea, a major, monoculture, permanently planted crop providing habitat continuity for many arthropod and nematode pests. Over the last few decades, India’s share in world tea export declined consistently for several reasons. One of the most important reasons is residual effect in made tea. On the contrary, recent agricultural practices towards reduced pesticide use and ecological sustainability have lead to increased interests in spiders as potential tool for IPM. As a consequence, the araneofauna of several cultivated crop systems eg. cotton, soybean, alfalfa, maize, orchards like citrus etc. are now well documented in some parts of the world.

Above prompted to study the spider species assemblage in tea ecosystem of Dooars, spread over an area of 1,18,701.6 hec.

The study area included 8 Tea Estates namely Shikarpur, Kailashpur, Meenglas, Nepuchapur, Nagrakata, Bhogotpore, Kurti and Dalgaon T. E.. Of these, the former 4 belong to Western Dooars while the rests are within the jurisdiction of Central Dooars.

Survey was conducted during the period, May, 2008 to October, 2011 in different sections of the referred estates in almost every month of any calendar year. Sampling was done by visual search, hand picking, foliage, trunk and branch scanning, pitfall and leaf litter extraction.

Generated data speaks of the existence of 115 species under 70 genera distributed over 19 families. These can broadly be divided in 7 trophic groups namely Orb weavers, Sheet weavers, Space weavers, Foliage hunters, Stalkers, Ground dwellers and Ambushers each enjoying their discrete niches. Recorded spiders include 8 species as new to the world, 4 genera & 12 species from the country while 19 more species from the state. In the process, a bird dung crab spider, *Phrynarachne tuberosa* (Blackwall, 1864) is resurrected; 4 recorded new male morphs are the members of Araneidae, Thomisidae and Uloboridae. Synonymies for the species *Telamonia sikkimensis* (Tikader) and *Oxyopes naliniuae* Gajbe are also proposed. Based on the species richness, the decreasing order of the tea estates are NTE> KTE> NATE> MTE> STE> DTE> KUTE> BTE. To infer, closer the forests, higher the spider heterogeneity. Araneids and salticids are the dominant groups.

Even though species richness is little higher during Premonsoon, always there remains a state of equilibrium throughout seasons. Oriental (100%), Palaearctic (11.3%).
Australian (10.43%) and Ethiopian (5.22%) elements are the major members. Diversity at the level of higher taxa is more in Indian context. Equally, the fauna exhibits high endemicity (26.08%).