1. INTRODUCTION

1.1. Background:

Invertebrate are most diverse and abundant animals in most natural ecosystem but their important in sustaining that system is commonly not appreciated (New, 1995). Determining the distribution of invertebrate is an integral part of assessing their conservation status and determines their possible management needs. Invertebrate and in particular insects, can therefore not be ignored in the assessment of biodiversity (Holloway and Stork, 1991).

The spider (Arachnida: Araneae) form a large distinct and wide spread group of mostly terrestrial arthropods. They are abundant in every type of climate and habitats. Spiders live anywhere, where they can find their food. They can be seen in field, wood, house and even in desert. And they prefer dark, humid and shaded location (Kaston, 1973). Diversity generally increase when a greater variety of habitat types are present (Ried and Miller, 1989). Structurally more complex shrubs can support a more diverse spider community (Uetz, 1991). Spiders are extremely sensitive to small change in the habitat structure; including habitat complexity, litter, depth and micro climate characteristics (Dowine *et al.,* 1999).

Spiders generally have humidity and temperature preference that limit them to areas within the range of their physiological tolerance which make them ideal candidates for land conservation studies (Riechert and Gillespie, 1986). Spiders are very considerable in size, shape and behavior. The basic characteristics shared them are; body divided into cephalothorax and abdomen, presence of eight legs (made up of seven segments each) and pedipalp, capacity to produce silk and possess no antenna. They are identified for their webs and web silks with future aspects. All spiders can make silk but they don't spin web, they may use the silk to wrap the prey to hang them and to make egg sacs and nests. They are ubiquitous in terrestrial ecosystem and abundant in both natural and agricultural habitats (Turn ball, 1973; Nyfell and Benz, 1987). They are one of the diverse and functionally important predators regulating the terrestrial arthropods population (Richertband and Bishop, 1990).

Spiders are chiefly terrestrial. They possess typical arachnid features with interesting modifications. Opisthosoma is unsegmented and connected to prosoma by a narrow pedicle. Pedipalps are small and leg-like. The chelicerae are provided with poison glands and the Pedipalps in male function as copulatory organ bearing the opening of sperm ducts. Respiration is by means of book-lungs, tracheae or both. The excretory organs are Malpighian tubules. The opisthosoma bears spinnerets for the production of silken threads which are put a variety of uses, such as construction of webs to trap insects, as guiding lines for males in finding mating partners, construction of egg-cases, etc. Most of the spiders are predaceous and nocturnal. They are mostly beneficial as they prey on harmful insects. Only few are dangerous to man such as black widows, trap doors, red backs and funnel webs. Mating is usually preceded by a more or less elaborate courtship in which

the male, always smaller than the female, is often eaten up by her after copulation (Kotpal, 2006).

They are sensitive to environmental alternation and as generalist predators, influence herbivore and detritivore population so their abundance and richness can reflect those of taxonomic group belonging to lower tropic levels (New, 1999). Moreover spider can explore a myriad of environment, occupy a key position in a variety of food webs and are ubiquitous and relatively easy to collect (Oliver and Beattie, 1993). Spider, which globally include about 44,000 described species in 114 families (Platnick, 2012) and are estimated to number 60,000-170,000 species (Oddington and Levi, 1991), comprise a significant portion of this terrestrial arthropod diversity. They employ a remarkable diversity of predation, strategies, occupy a wide array of spatial and temporal niches, and are characterized by high with in habitat taxonomic diversity, exhibit taxon and guild response to environmental change, extremely sensitive to small change in habitat structure, including vegetation complexity, litter depth and microclimate characteristics (Uetz, 1992). Spider responds distinctly to altered litter depth and structural complexity and nutrient content of litter (Uetz, 1991; Bultman and Uetz, 1982). Spiders employ a remarkable variety of predation strategies. As they are generalist predators, they are of immense economic importance to man because of their ability to suppress pest abundance in agrosystem. The population densities and species abundance of spider communities in agricultural field can be as high as that in natural ecosystems (Riechert, 1981; Tanaka, 1989).

Spiders are copious in both natural and cultivated environment, in which their annual abundance range from 50 to 150 individuals per square meter (Pearse, 1946; Duffey, 1962; Weideman, 1978; Nyffeler, 1982). Spiders are most dominant predators in any terrestrial community (Gertsch, 1949). They display a wide range of foraging methods and as such may reduce herbivore densities (Marc *et al.*, 1999; Schmit, 2008). One hundred forty four species of spiders are reported from Nepal (Basnet *et al.*, 2007). One of the most striking factors of spider to the human mind is its spinning habit. All spiders are predaceous and mostly feed on the insects which are generally harmful to man and livestock. The poison injected by the bite of spider kills the prey. Different spiders capture their prey in different ways, the wolf spider and jumping spiders forage for and pounce on their prey and crab spider wait for their prey on flowers. Majority of spiders capture their prey in webs and few spiders are commensals, living in the webs of larger spider and feed on small insects not eaten by larger one (Borrer and Delong, 1954).

About 45,144 valid species belonging to 3,935 genera and 144 families are known globally (World spider catalog, 2015), while Indian fauna consists of 1,686 valid species belonging to 438 genera and 60 families (Sebastian, 2009; Keswani *et al.*, 2012).

Thapa (1995) reported 144 species of spider belonging to 17 families. Some 109 species were new to science at the time of their identification in Nepal. Most have been collected from the high mountains and Mild Hills. The far western region and the entire lowland Terai and Siwalik Hills need further study, with the additional contribution of Thapa and Rana (2001), 175 species of spider have been identified. Panthi (2003) reported 39 species of spider under 15 families inside the Kathmandu Valley.

The aim of this study is to investigate the spider fauna in different habitats of University Campus area. Probably it is for the first time organized study is being carried out in this area to explore spider diversity.

1.2. Rationale

1.2.1. Justification of study

The proper exploratory work on the spiders has not yet been conducted inside T.U Campus area. Due to the different habitats, mild temperature, high moisture content in soil and pleasant climate, it is believed that University Campus area is rich in spider diversity.

1.2.2. Limitation of study

The study area was greatly influenced by human activities so it was difficult to collect samples in the field. The detail study was difficult to carry on due to limited budget and time frame. It was hard to identify all of the collected specimens due to the lack of sufficient literature and limited time. Mainly the limitation of available literature made the identification of spiders difficult.

1.3. Objectives

1.3.1. General objectives:

The general objective of the study was to explore spider diversity in Tribhuvan University Campus area, Kirtipur, Kathmandu, Nepal.

1.3.2. Specific objectives.

- To identify the specimens collected from forest, grassland, cultivated, and horticulture sampling sites.
- To prepare list of spiders and their ecological notes collected from different sampling sites.
- To compare the population level of different spiders genera during study period in different habitats.

2. LITERATURE REVIEW

2.1. In global context

The spider description in South Asia began in the late ''18th century'' with the first species described being *Gasteracantha geminata* by Fabricius (1798). However, before this period, there have been records of observation or collection of spider by Dutch Colonials in Srilanka. The earliest known formal illustration of a spider is of a Mygalomorph by Madam Maria Sibylla Merian in the Stopetersbug Academy of Science published, approximately, in 1700 AD. It was only in 1804 AD, that this species was formally described as *Mygale fasciata* by Latreille based on illustration published in Albertas Seba's Thesaurus, in 1734 (Smith, 2001). Most of the spiders described during the British period from South Asia were by foreigners based on the specimens deposited in different European Museums.

The oldest Spider described so far was from the Devonian period of North America (Selden *et al.,* 1991). Spiders are one of the most diverse groups of animals, which constitute the seventh largest order (Nyffeler and Benz, 1980; Wise 1993, Nyffeler, 2002). The distribution and diversity of spider has drawn attention of field workers in different parts of the world. These are often restricted by political boundaries and therefore often appear as studies on spider fauna of individual countries. Pioneering workers in spider taxonomy were Latreille (1804), Leech (1815), Koch (1846), Simon (1864) and Cambridge (1885). Thereafter, systematic studies on Spider develop rapidly with increasing knowledge. Petrunkeritch (1933) provide as inquiry into the natural classification of Spider based on their internal anatomy. Catalogues of Roewar (1942, 1954) and Bonnet (1945, 1957) gave an overview on the taxonomy of spiders. Lehtines (1967) prepared a comprehensive research on the araneo fauna of other countries have been conducted by many scientists. Studies on the spider of Taiwan by Lee (1966), Spider of Tokyo by Shinkai (1969), Spider of Australia by Mascord (1970), Malaysian spiders by Workman (1986), Spider of China by Feng (1990), Spider of Korea by Kim (1991) and Namkung (2003), Spider of Madagascar by Ono (1993), Spider of Bulgaria by Blagoev *et al*. (2002) and Spider of Vietnam by Tu and Li (2002) are notable contributions.

The works by Murphy (1986), Barrion and Litsinger (1995), Song *et al*. (1999), Koh (2002), Murphy and Murphy (2002) and Deeleman-Reinhold (2001) were valuable in identifying many species from South India.

The spider fauna of Indo- Pakistan subcontinent has been described by several workers. The contribution of Stoliczka (1869), Thorell (1895), Simon (1906), Pocock (1900), Gravel (1921; 1922; 1924; 1931; 1935), Deyal (1935), Sherriffs (1951; 1954), Sinha (1951; 1952) and Tikader (1987).

Brignoli (1983) gave a catalogues of Araneae, which provided a systematic list of about 7,000 species of spider from 1940 to 1981.

Tikade (1987) described 1,066 species of spider belonging to more than 43 families,

distributed throughout the country including Darjeeling, Ladakh, Madhya Pradesh, Andaman and Nicobar Island and Sikkim.

Platnick (1989) provided a bibliography of work relating to the taxonomy of Araneae published from 1981 to 1987.

Majumdae and Tikader (1991) studied the spider of family Clubionidae from India. They recorded 84 species belonging to 15 genera, of these 12 species in five genera were described as new to science.

Millidge and Russel- Smith (1992) described 27 species of the family Linyphidae from the forest of South East Asia.

Biswas and Biswas (1992) studied the spider fauna of west Bengal, India. They reported 213 species belonging to 70 genera under 20 families, of these 11 species in eight genera under six families were described as new to science.

Ghafoor and Beg (2002) surveyed the spider fauna of Vansda National Park, Gujrat. They reported 124 species from 67 genera under 22 families.

Biswas and Biswas (2003) studied the spider fauna of Skkim, India. A total of 91 species in 48 genera under 19 families were reported. Seventeen species under 13 genera and nine families were recorded for the first time in this state.

Silwal and Molour (2007) reported 2,299 spider species belonging to 552 genera and 67 families from South East Asia. Again, they reported about 1,830 species of spider are endemic to South Asia.

Sebastian and Peter (2009) reported 1,520 spider species belonging to 377 genera of 60 families in India.

Hore (2009) reported 186 species belonging to 77 genera and 27 families in Terai Conservation area in India.

Sebastian (2009) and Keswani *et al*., (2012) described 1,686 valid species belonging to 438 genera and 60 families in India.

2.2. In context of Nepal

Major R.W.G. Hingston first reported small immature Salticids spider on the rocky debris of the Mt. Everest, the region of 6,705 m (22,000 ft) in 1925 but the research of spider from Nepal was indeed started by B.K. Tikadar of the Zoological Survey of India (Calcutta) in 1961, who worked on spider collected during cho-oyu expedition.

Hubert (1973) described a new species *Nesticus nepalensis* (Nestidae) from Nepal. It had been collected from the range of 1,300 to 2,650 m.

Spider *Peculla martensi* (Pecullidae) from region of Himalaya region of Nepal was reported by Bringoli (1972).

Ono (1978) described the genus *Xysticus* from Nepal Himalayans, collected by Dr. Martens, in Thomisidae aus-dem Nepal Himalaya. Ono (1979) reported eight new species of the genus *Xysticus* from Nepal Himalayas, collected by Dr. Martens, in Thomisidae aus-dem Nepal Himalaya.

Ono (1979) reported eight new species of genus *Lysiteles* from Nepal Himalayas. It was one of the numerous monotypic genera and no collecting records had been published

since the Simon's original description of the type species *L. catalus, L. nigrifrms,* and *L. brunett* were described. Ono (1980) again described genus *Stiphropus,* which was one of the little known paleotropic thomsid, in Thomisidae aus dem Nepal Himalayan III. All Asian species of the genus so far known were revised and redescribed. Ono (1981) reported *Tetrablemma phulchoki,* belonging to the family Tetrablemmidae, from the Phulchoki region of Lalitpur, Nepal.

Bucher (1978) described first part of a morphological and systematic analysis of the family Lycosidae, collected by J. Martens, in Lycosidae aus dem Nepal Himalaya. A single species of *Acantholycosa* and a group (Southerlandi group) of closely related species of *Pardosa* were included.

Andrzej (1987) reported thirteen species of *Synagelides* of Salticidae from Nepal.

Bohdanowicz (1987) studies Salticidae of Nepal.

Martens (1987) comprised twenty-two species of *Lepthyphantes* (Linyphidae) from Nepal.

Thapa (1995) made an enumeration of spider on the basis of studies carried out in Nepal by J. Martens and other scientific communities since 1970, which was first overview of spider recorded for Nepal. He reported 144 species of spiders belonging to 17 families. Some 109 species were new to science at the time of their identification in Nepal. Most have been collected from the High Mountain and Mild Hills. The far western region and the entire lowland Terai and Siwalik Hills need further study. With the additional contribution of Thapa and Rana (2001), 175 species of spider have been identified.

Panthi (2003) reported 39 species of spider belonging to 15 families inside Kathmandu valley.

In Nepal 222 species of spider in 79 genera and 23 families have been reported (SAC, 2007).

Silwal and Molur (2007) reported four of 79 genera, endemic to Nepal and all of which only single genus, is monotypic. All of these 222 species, 176 are endemic to the country. They further reported, studies on spider were initiated in Mild ‘’20th century’’ and major contribution was done by Jagar (2000, 2001), who described 19 species, Bohdanowicz (1979, 1987) described 14 species and Bringoli (1972, 1973, 1976, 1978, 1983) described 12 species.

Jastrzerbski (2007) reported the medium-sized Salticids Spider genus *Epocilla praetextant* from Nepal.

Hore (2009) reported 186 species of spider belonging to 77 genera and 27 families in Terai coservation area near the border of Nepal and India.

Genus *Himalocoelotes* was found in Nepal (World spider catalogue, 2015).

Roessler (2016) described a colony Spider *Stegodyphus arasinorum* was found in thorny bushes in Nepal and other South East Asia countries. He further described tarantula Spider *Haplocosmia nepalensis* was native to Nepal. Again he reported Himalayan jumping Spider *Europhrys omnisuperstes,* as high as 6,700 feet above sea level on the Mount Everest.

3. MATERIALS AND METHODS

3.1. Study Area

Geographically Kirtipur is situated at 27̊ .67'' North Latitude, 85̊.28'' East longitude and 1,342 meters elevation above the sea level. T.U. is located on the north eastern facade of Kirtipur.

It is surrounded by the Bagmati River in the east. Tribhuvan University is located in the bottom of the hill. And it is rich in both flora and fauna. It constitutes forest, grasslands, horticulture and cultivated land. Cultivated land is an open field between Balkhu and T.U. Complex, where maize, wheat and paddy are cultivated at most during summer and monsoon. Grassland area is lowland north to the road and south to the nursery. The forest area is above the grassland having tall pine, Eucalyptus trees, Sumach, Chir Pine, Camphor laurel, Bead Plum, Sweet Gale, Golden Evergreen Raspberry, Crofton weed and Nilkada.

The area is slightly sloppy facing south-east and it receives the sun light directly whereas, grassland lie at the footage of this sloppy forest area and comparatively more damp and shaded by the trees of two sloppy sides. Climate of T .U. area is typical monsoon type with rainy summer and dry winter. Minimum temperature was recorded up to -4̊ C January and Maximum temperature was recorded up to 30̊.2 C (Thakuri, 2007).

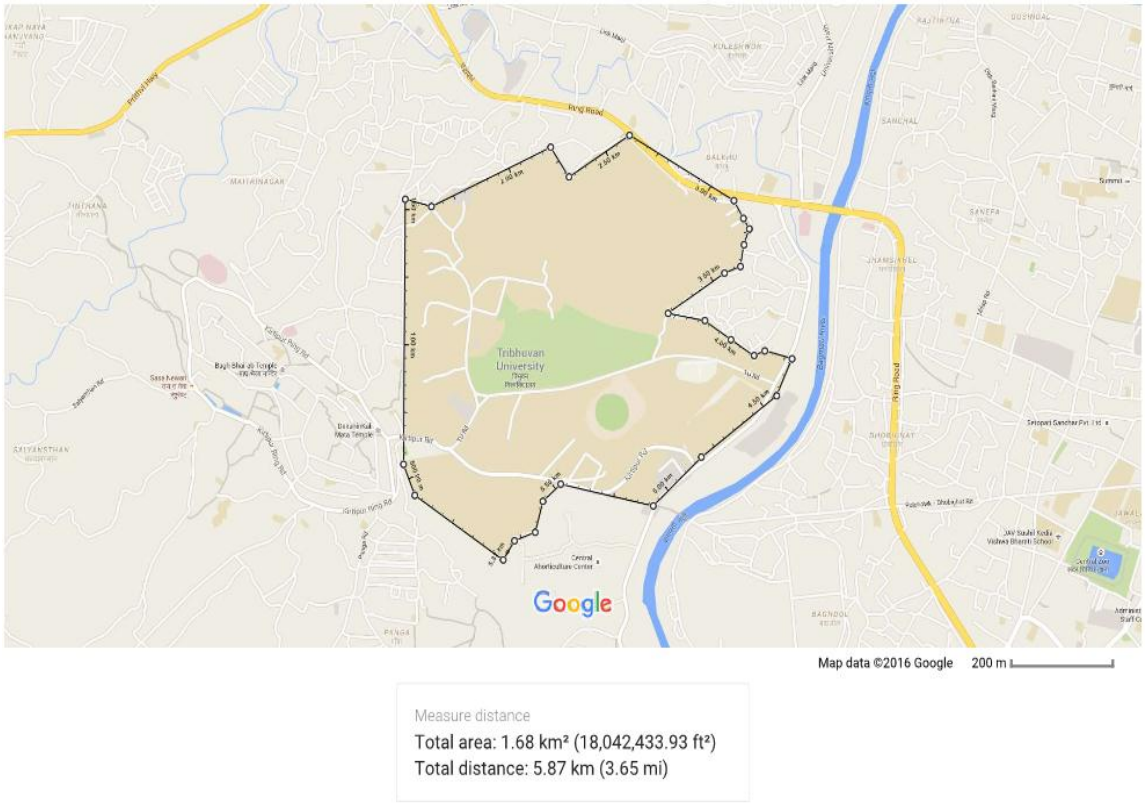

Fig.1. Map of study area (T.U.)

3.2. Materials

Equipment: Plastic mugs, spade, camera, vials, plastic bottles, forceps, brush, watch glass, glass slide, killing jar, microscope and gloves.
Chemicals: Alcohol, distilled water, commercial formalin.

3.3. Methods

Pitfall sampling method was used for the collection of ground dwelling spiders. This method is considered as one of the best techniques in collecting ground forms having nocturnal as well as diurnal habit (Kaston, 1972). Samples were collected twice a month from February 2016 to July 2016. Different habitat types including forest, grassland, cultivated and horticultural land were selected for sampling. Six traps were set in each habitat of the sampling sites. Traps were arranged randomly in six places. Each trap was four meter apart from each other. Pitfall trap consists of cylindrical plastic containers. These containers were set into the ground so that the top of containers laying at the ground level. These containers were filled with 400 ml. of 70% alcohol solution to kill and preserve (temporarily) the specimens that fall in (Kaston, 1972). Each trap was examined every 15 days and refilled.
The non-ground forms of spider were collected by active search, beating sheets, sticking and hand picking methods. All the collected spiders were preserved in 70% alcohol in separate small plastic bottles. The bottles were labeled with location site. Those collections were identified on morphological basis in entomology laboratory (CDZ) with the help of stereomicroscope.
The photographs of spiders were taken by using Canon digital Camera (5.0-40.0mm, 1:3.2-6.9). The species were deposited in entomology laboratory (CDZ).

3.4 Statistical Analysis

The abundance (%) and diversity indices were calculated from different habitats. Abundance was calculated as percentage of total collected genus. Shannon-Wiener diversity index (Shannon and Weiner, 1949) has been used to calculate the diversity of genera.

$$H' = -\sum [(pi) \times (In\ pi)]$$

$$(\therefore)\ Pi = ni/N$$

Where, $\sum$= summation
Pi = Proportion of total sample represented by species i (Divide no. of individuals of species i by total no of samples)

3.5. Identification of spiders

The collected specimens were identified following the standard keys formulated by Pocock (1972) in "Fauna of British India (Arachnida), Kaston (1972) in "How to know the spiders" and Tikadhar (1987) in "Hand book of Indian spiders".
The following key was prepared for the identification of spider on the basis of literatures mentioned above.

Keys for identification

1 (a) Chelicerae paraxial, Fangs are articulated in chelicerae so as to be movable in parallel plane of body……...
…….....Sub-order Orthognatha….2

2 (a) Posterior spinnerets shorter and thick, anal tubercle small, tarsi long and flexible, labium border than long; legs very long and slender…….
…….....Family Pholsidae
(b) Posterior spinnerets shorter and thick, anal tubercle small, labium longer than wide; legs not very long…….……3
.
3 (a) with eight eyes…….....4

4 (a) Eyes in three rows, front row more or less situated vertically median eyes enormously large ,second row of two eyes usually very small, often minute, third row of two eyes of medium size…….....Family Salticidae.

5 (a) Legs at least, I and II laterigrade, crab like in form…….....6

6 (a) First and second pairs of legs not much longer and not stouter than rest of the legs Apex of metatarsus provided with soft trilobate membrane. Lower margin of fang furrow of chelicerae distinct and armed with teeth, colulus absent…….....…….
……Family Sparassidae

7 (a) Eyes heterogynous, anterior spinnerets not conical, maxillae with a transverse oblique depression…….....8

8 (a) Eyes group hexagonal the posterior row procurved and anterior row recurved, with a clypeus high. Abdomen pointed beyond; legs with very conspicuous spines……Family Oxyopidae

(b) Eyes not forming a hexagon, clypeus much lower, abdomen not Pointed and legs without conspicuous spine…….....……..9

9 (a) Tarsi with trichobothria but irregularly distributed, all trochonters with a curved notch.....10

(b) Tarsi without trichobothria, clypeus lower than the height of the medium ocular area……11

11 (a) Posterior row of eyes strongly recurved that it may be considered too from two rows. Medium claws with a single tooth. Anterior piece of lorum rounded behind fitting into a notch of posterior pieces. Egg sac carried attached to the spinnerets and young carried on mother back……..Family Lycosidae

12 (a) Epigastric furrow between lungs slits procurved. No boss on chelicerae, chelicerae large and powerful…….....Family Tetragnathidae

(b) Epigastric furrow nearly straight. Boss present, chelicerae not very large…….....…….Family Argiopidae

The main identifying features of genus and species that gave the best clue for are mentioned below.

Sub-order Labiodognatha

Section Cribellatae

A. Family: Argiopidae

(a) Genus *Argiope*

Eyes of posterior line strongly procured, anterior lateral eyes are smaller than posterior laterals, anterior median eyes closer to each other, abdomen more than two times longer than the carapace.

(b) Genus *Nephila*

Labium longer than broad, abdomen more than two times longer than broad; the tarsus and metatarsus together of each leg longer than the tibia and patella together, ocular quadrangle slightly narrower in front legs very long spinulose.

N. clavata

Carapace with yellow patch behind head and yellow boarder, anterior legs with yellow band round femora and tibiae; palpi black at the tip, abdomen black below, varied with yellow lines and sports.
Upper side of abdomen yellow with indistinct transverse stripes

N. maculata

Carapace covered with silky yellow pubescence; abdomen olive brown, ornamented below with yellow spots and above with a pair of yellow longitudinal lines, a transverse yellow band in front, abdomen long; cephalothorax and its appendages black, legs long, coxae of legs and proximal half of palpus yellow.

(c) *Genus Cyrtophora*

Carapace flat with distinct thoracic furrow, abdomen anteriorly very high and provided with at least a pair of shoulder humps.

(d) Genus *Cyclosa*

Posterior median eyes very close, nearly touching, carapace provided with a 'V'– shaped junction between cephalic and thoracic region; lateral eyes closely situated.

(i) *C. bifida*

Abdomen posterior with a pair of spines lateral to the anal tubercle.

(d) Genus *Gasteracantha*

Carapace is dark brown, Cephalothorax as wide as long, spinnerets situated on an elevated circular space surrounded by a thick flange in the form of a ring.
Abdomen hard and provided with conical humps and spines

G. Mammaosa

Dark brown in color with black and slivery spots, the anterior part of abdomen consists of the black spots arranged in a concentric manner with two pairs of abdominal spines.

(e) Genus *Araneus*

Abdomen not flattened, highest at the front and widest anterior to the middle, median ocular area wider in front than behind; posterior medians not larger than anterior median eyes.

(f) Genus *Neoscona*

Anterior row of eyes are curved, carapace with no granules; Thoracic groove longitudinal, epigyne with unwrinkled scape and provided with pair of lateral lobes.

N. nautica

Color of the body dark brown, carapace yellowish, abdomen anteriorly high and darker than other pats

B. Family: Lycosidae:

Genus *Lycosa*

Carapace long, face vertical, four posterior eyes very large and arranged in a quadrangle which is wider behind; eyes and anterior line very small and straightly arranged, clypeus very low.

(i) *L. pseudoannulata*

Carapace long, black hairs on the ocular quadrangle, two rows spots on the abdomen from above, third leg smallest.

L. mahabaleshwarensis

Palpi long, mid pale line runs through the whole body extending from cephalothrax to the terminal part of abdomen. Lateral sides of carapace as well as abdomen whitish, legs orange brown.

(b) Genus *paradosa*

The legs relatively long, with the metatarsi and tarsi quite thin, spine of legs long, tibia first is provided with three pairs of spines, among which the distal pair is apical and shorter. The cephalothorax is highest in the head region, chelicerae small.

P. distincta

There is distinct pattern of light brown markings on a yellow background of carapace.

P. prativaga

Legs long with white and black spots randomly spread, carapace brown, body greenish white.

P. lugubus

Cephalothorax and abdomen both black from above, abdomen whitish below, Chelicerae and mandibles black.

(c) Genus *Pirata*

The member are easily recognized by the characteristic appearance of the carapace that a light yellow band extends from eye region back to the posterior edge, somewhat narrowed behind, enclosed in this light is dark 'V' shaped mark extending from between the rear eyes to the dorsal groove.

d) Genus *Hippasa*

Fairly large dark brown with two rows of white spots on its abdomen

C. Family: Pholicidae

Genus *Pholcus*

Legs very long, tarsi furnished with three claws, anterior median eyes very small and other eyes arranged in two triads.
Abdomen long more than twice as long as cephalothorax, femur I very long

P. phalangioides

Colour is pale yellow, a gray mark in the center of carapace.

E. Family: Salticidae

(a) Genus *Plexippus*

Anterior eye row not at all wider than posterior eye row
Sternum narrower in front than the base of labium, Leg III not longer than I

P. paykulli

The cephalic region is black, the thorax brown with a light median stripe
Abdomen is black with a yellow median line and white lateral lines

(b) Genus *Synemosyna*

Posterior portion of cephalothorax narrowed and with its sides more or less parallel thus adding to the apparent length of the pedicel, decidedly ant like in from, pedicle clearly visible.

S. formica

The cephalic part is separated from the thoracic by the deep groove, presence of a depression near the front of the abdomen, the abdomen is black.

E. Family: Oxyopidae

Genus *Oxyopes*

The posterior row of eyes strongly procurved, posterior lateral eyes about as far as from the anterior laterals as from the posterior medians retromargin of cheliceral fang furrow with a single tooth.

F. Family: Tetragnathidae

Genus *Leucauge*

Eyes of small size, legs long, front legs longest, black is sliver colored.
L. magnifica

Body somewhat oval, legs green, abdomen silvery with one median and two lateral black lines, black spots in the side median line.

4. RESULTS

During study period total 642 individuals were collected by pitfall traps, active search, beating sheet and hand pickling methods among them 55 individuals were collected from active search and hand pickling methods. Among them, 14 species covering 17 genera, six families of spiders were identified. The identified species with brief ecological notes are given below:

4.1. Ecological Notes on Identified specimens.

Sub-order Lebidognatha

(1) Family: Argiogiopidae

(i) *Argiope* spp. Audouin, 1827

Habitat: Cultivated land; on the branch of maize.
Remarks: Sternum with yellow median strip, Palpi yellow. Abdomen two time longer than the carapace.

(ii) *Nephila clavata* L. Koch, 1878

Habitat: Horticulture; near the green house.

Remarks: Carapace with yellow patch behind the head. Upper abdomen is yellow with indistinct transverse stripe. Mostly they are found in a large web on the tree. They are observed more on June and July.

(iii) *Nephlia maculata* Fabricues, 1793

Habitat: Forest, Inverted in a large web on the tree.
Remarks: Carapace covered with silky yellow pubescence; abdomen olive brown, ornamented below with yellow spots. They are found in a web in the tree. They are observed more on June and July.

(iv) *Cyclosa bifida* Doleschall, 1859

Habitat: Horticulture, in the bushes of Rose in a small web.
Remarks: Abdomen posteriorly with a pair of spines. Lateral to the anal tubercle. They are found in the bushes of Rose in a small web.

(v) *Neuscona nautica* L. Koch, 1875

Habitat: Forest, on the branch of *Schima wallichii*.

Remarks: Color of the body dark brown carapace yellowish. They are observed on May.

(vi) *Gastercantha mammosa* L. Koch, 1844

Habitat: Forest on the branch of tree.

Remarks: Dark brown in color with black and slivery spots. They are found on the branch of Pine.

(vii) *Cyrtophora* spp. Simon, 1864

Habitat: Forest

Remarks: Carapace flat with distinct thoracic furrow, abdomen anteriorly very high and provided with at least a pair of shoulder humps.

(viii) *Araneus* spp. Clerck, 1758

Habitat: Forest and Horticulture.

Remarks: Abdomen not flattened, highest at the front and widest anterior to the middle.

(2) Family: Lycosidae

(i) *Lycosa pseudoannulata* Fox, 1935

Habitat: Forest, Horticulture, Cultivated and Grassland.

Remarks: Carapace long, black hairs on the ocular quadrangle. Third leg smallest.

(ii) *Lycosa mahabaleswarensis* Tikader and Manhotra, 1980

Habitat: Forest, Horticulture, Cultivated and Grassland.

Remarks: Palpi long, lateral sides of carapace as well as abdomen whitish, legs orange brown.

(iii) *Pardosa distincta* Blackwall, 1846

Habitat: Forest, Horticulture, Cultivated and Grassland.

Remarks: There is a distinct pattern of light brown markings on a yellow background of carapace.

(iv) *Pardosa prativaga* L. Koch, 1870

Habitat: Forest, Horticulture, Cultivated and Grasslands.

Remarks: Legs long with white and black spots randomly spread, carapace brown, body greenish white.

(v) *Pardosa lugubus* Waclkenaer, 1802

Habitar: Forest, Horticulture, Cultivated and Grasslands.

Remarks: Cephalothorax and abdomen both black from above.

Abdomen is whitish below. Chelicera and mandible are black.

(vi) *Pirata* spp. Sundelvall, 1833

Habitat: Forest, Horticulture, Cultivated and Grassland.

Remarks: Dark V shaped mark extending from between the rear eyes to the dorsal groove. They are mostly found moist area.

(vii) *Hippasa* spp. Simon, 1884

Habitat: Grassland.

Remarks: Fairly large dark brown with two rows of white spots on its abdomen. They are observed more in moist area.

(3) Family: Pholcidae

(i) *Peholcus phalangiodes* Fuesslin, 1775

Habitat: Forest and Horticulture.

Remarks: Colour is pale yellow, gray marks in the center of the carapace.

(4) Family: Salticidae

(ii) *Plexippus paykulli* Savigny and Audouin, 1826

Habitat: Grassland and Cultivated.

Remarks: The cephalic region is black, the thorax brown with a light median strip.

(iii) *Synomosyna formica* Hentz, 1884

Habitat: Horticulture and Cultivated land.

Remarks: The cephalic part is separated from the thoracic by the deep groove. The abdomen is dark black. They are looked like ant. They are collected from pitfall traps.

(5) Family: Oxyopidae

(i) *Oxyopes* spp. Latreille, 1804

Habitat: Horticulture and Grassland.

Remarks: The posterior row of eyes strongly pro-curved, posterior lateral eyes about as far as from the anterior laterals as from the posterior medians. Mostly they are observed on the bushes.

(6) Family: Tetragnathidae

(i) *Leucage magnifica* White, 1841

Habitat: Forest, Horticulture and Cultivated.

Remarks: Body somewhat oval. Legs green in color. They are mostly observed on the bushes.

4.2. Population level of different spider genera

Three genera of ground dwelling forms were collected in significant numbers. They were *Pardosa*, *Pirata* and *Lycosa.* Some other genera of ground dwelling forms were collected in very few numbers and some of non- ground forms were collected, these all genera were categorized under the title 'Other'. Six hundred forty four specimens were collected during the whole study period. The genus *Pardosa* occupied the largest percentage of the total specimens i.e. 33.8 % (217), 30.22% (194) of the total collected specimens were covered by genus *Lycosa* while 27.1% (174) by the next genus *Pirata*. Other occupied remaining 8.88 %(57).

The others include *Hippsa, Oxyopes, Plaxippus, Synemosyna, Leucage, Argiope, Pholcus, Neoscana, Gastercantha, Cyrtophora* [Figure 2]

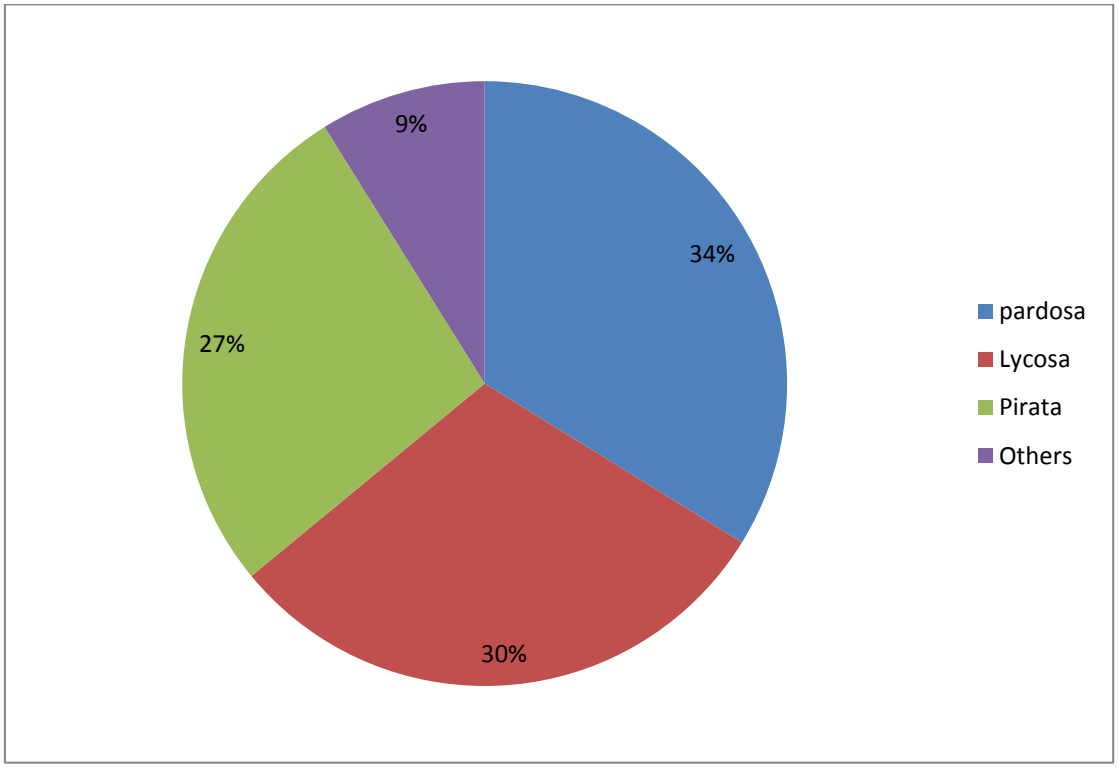

Figure 2 Abundance of different spider genera during study period

4.3. Population level of spider genera in different habitats

Regarding the habitats 184 spiders were caught from Grassland 136 spiders from cultivated land, 176 spiders from the Horticulture and 146 spiders from forest which constitute 28.7%, 21.22%, 27.4% and 22.7% of the total specimens respectively. [Figure 3]

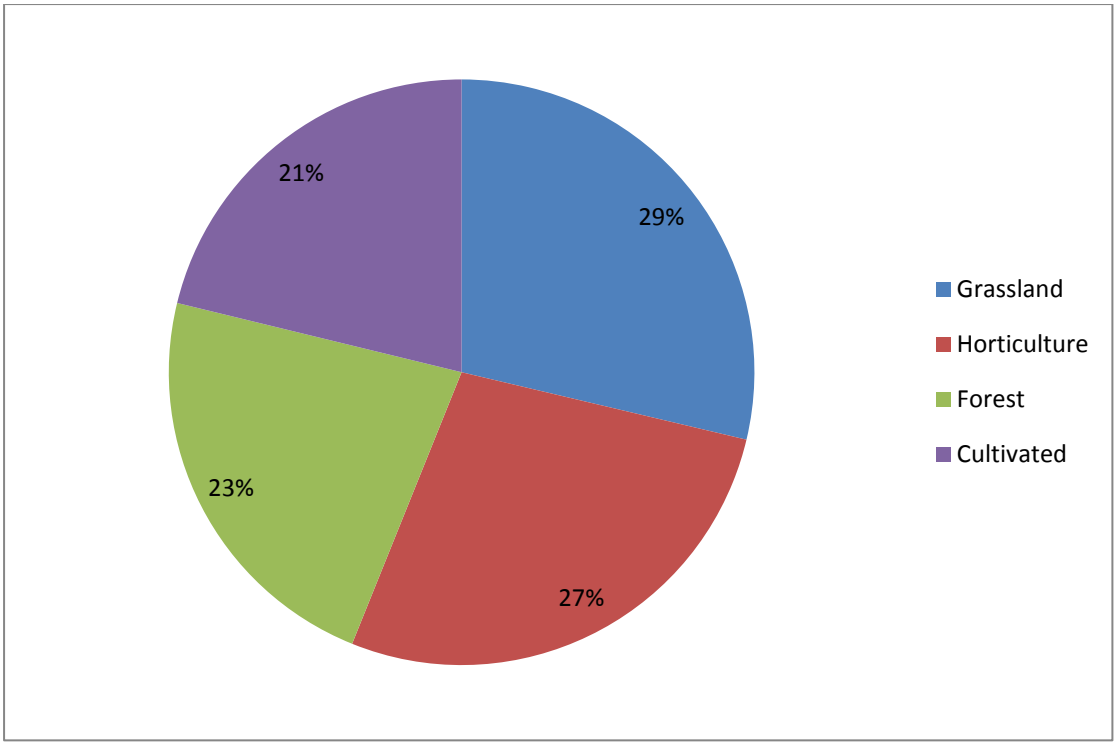

Figure 3 Abundance of spider genera in different habitats

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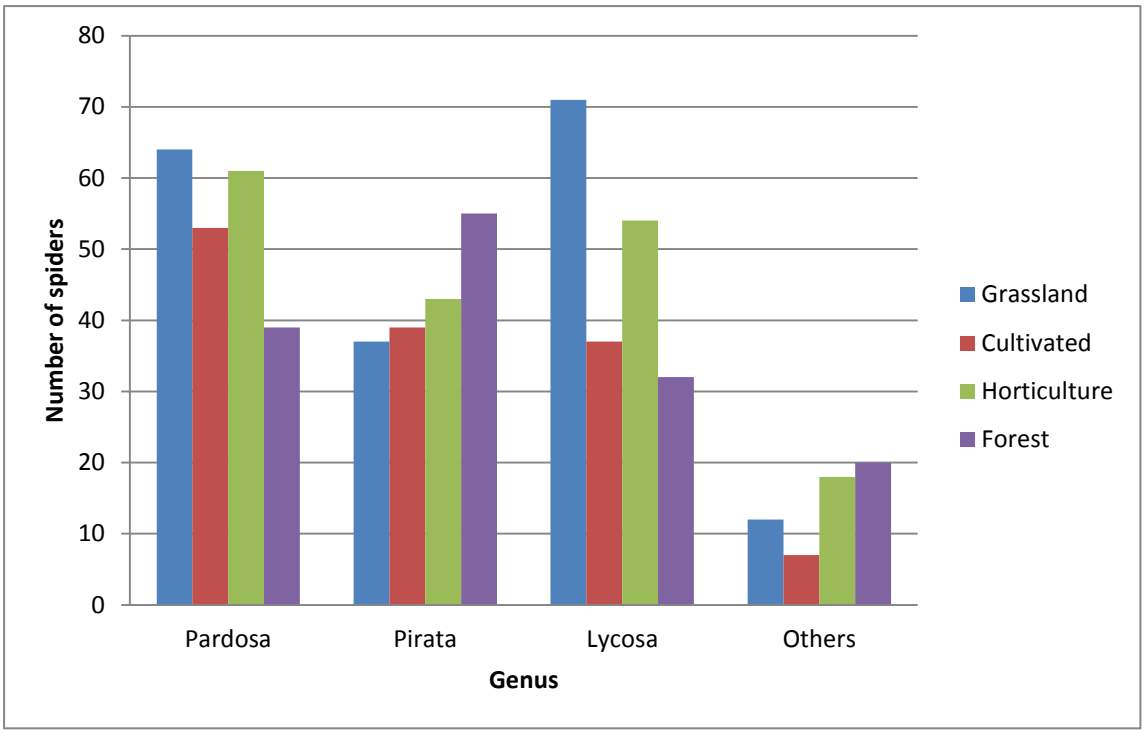

Figure 4 Spiders collected from different habitats

4.4. Diversity of spider genera in different habitats

The diversity index of the spider was found to be varied in different habitat. The highest diversity index value (H'= 1.557) was observed in forest land and the lowest value (H'=1.289) was observed in cultivated land and the value of diversity in Horticultural and Grassland were (H'=1.472) and (H'=1.315) respectively.

Table 1 Shannon-Wiener's genera diversity in various habitats

Habitat	H'= -∑ [(pi) × (In pi)]
Grassland	1.315
Cultivated	1.289
Horticulture	1.472
Forest	1.557

5. **DISCUSSION**

The aim of the study was to explore the spider fauna, their abundance and diversity. The spiders were collected for six months from February to July in four habitats.

A total of 642 specimens of spiders were collected during the study period from pitfall traps and active search method, among them 14 species under six families were identified. They are; *Nephlia clavata, N. maculata, Cyclosa bifida, Neoscona nautica, Gasterocantha mammosa, Argiope* spp., *Araneus* spp. (Argiopidae). *Lycosa pseudoannulata, L. mahabaleswarensis, pardosa prativaga, Pardosa distincta, Pardosa lugubus, Pirata* spp., *Hippasa* spp. (Lycosidae); *phocus phalangiodides* (Pholcidae); *Plexippus paykulli, Synemosyna formica* (Salticidae); *Oxyopes* spp. (Oxyopidae); *Leucage magnifica* (Tetragnathidae).

Panthi (2003) reported 39 species covering 15 families from Kathmandu valley. Six families are common with present study but others nine families were not reported in present study. The difference is because the previous report was confined with the collection made from different site of Kathmandu valley and study area of previous report was larger than that of present study. And he further reported 17 species covering 14 families from Kirtipur area. Ten species *Neoscona nautica, Lycosa pseudoannulata , Lycosa mahabaleswarensis, Pardosa distincta, P. prativaga, P. lugubus, Pholcus phalangiodies, Plexippus paykulli, Syanemosyna formica, Leucage magnifica)* are common with present study but seven species *(Atypus niger, Argiope arcuata, Cyclosa hexatubercutlata, Neoscona sylla, Lycosa phipsoni, Plator indicus, Mymarachne innermicheles)* are not reported in present study. Other four species *(Nephlia Clavata, Cyclosa bifida, N. maculata, Gassterocantha mammosa* are new in present study inside the study area.

Free State grassland consists of a high density of grasses and shrubs that create greater habitat complexity which means that there are many niches in which spider may live more than that of other habitats (Haddad, 2005).

The abundance of ground spider in grassland habitat was found highest (28.7%) and least in cultivated habitat (21.2%).

Genus *Pardosa* occupied the largest percentage of total collected specimens (33.8%).

Panthi (2003) also reported same type of result, he described the genus *Pardosa* occupied the largest percentage of the total specimens and grassland habitat had highest spider abundant than other cultivated and forest habitat in KTM valley.

There are many environmental factors that affect species diversity (Rosenzweig, 1995). Diversity generally increases when a greater variety of habitat types are present and that structurally more complex shrubs can support a denser diverse spider community (Ried and Miller, 1989).

The four habitats in TU campus area, Kirtipur showed not much considerable difference in the diversity of spiders. The forest land had the highest diverse spiders genera as indicated by (H'= 1.557) diversity index whereas cultivated land showed least diverse of spiders (H'= 1.289). In horticultural and grassland habitat had (H'=1.472) and (H'= 1.35).

No previous research on spider diversity has been carried out in this area and other area of

Nepal to compare the spider diversity. Cultivated land and grasslands area were a certain level of disturbance and vegetation structure of grassland was much simpler than that of forest and horticulture in study area.

Sobha (2014) recorded highest species diversity of spider in forest of Kerala in India.

Sudhikumar *et al.* (2005) also suggested that the species diversity of spider in forest habitat can be high diversity due to the high diversity of plants and other insects.

Kuan-chonchen and Imlu (2001) also suggested the low degree of species diversity in any area may be due to high degree of habitat destruction and human interference and other disturbance.

Halaj *et al.* (1998) reported that increase foliage complexity accounted for large percentage of species diversity. Wagler *et al*. (2003) found that species are more common in lower layers of thick litter. Uetz (1979) also described the spider diversity was highest in forest, which may be co-related with dense litter and generally moist ground surface. In present study diversity of spider were more in forest habitat than other habitats because, i observed more leaf litter, moisture present in forest habitat than that of other habitats.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the result throughout this study period, a total of 642 specimens were collected during the study period from pitfall traps and active search method, among them 14 species under six families were identified.

Genus *Parodsa* occupied the largest percentage of total collected specimens, which is followed by *Lycosa* and *Pirata*. The abundance of ground spider in grassland habitat was found highest and least in cultivated land.

The diversity index was recorded highest in forest (H'=1.557) and least in cultivated land (H'=1.289).The result of present study showed that variety of spiders exists in the study areas.

6.2 Recommendations

Based on this research following recommendations have been made:

- Spiders are important in maintaining the ecological balance, as they are chief pest control agents. So the strategy on the conservation of spider should be taken in consideration. Further works on taxonomy as well as on the potentiality of spider in pest control should be done.
- Further study is needed to identify more new species in the area.

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ANNEXES

ANNEXES I Photo plates of collected species

1. *Argiope* sp.

2. *Nephlia clavata*

3. *Nephlia maculata*

4. *Cyclosa bifida*

5. *Neuscona nautica*

6. *Gasteracantha mammosa*

7. *Cyrtophora* sp.

8. *Araneus* sp.

9. *Lycosa pseudoannulata*

10. *Lycosa mahabaleshwarensis*

11. *Pardosa distincta*

12. *Pardosa prativaga*

13. *Pardosa lugubus*

14. *Pirata* sp.

15. *Hippasa* sp.

16. *Pholcus phalangioider*

17. *Synomosyna formica*

18. *Oxyopes* sp.

19. *Leucauge magnifica*

20. *Plexxippus paykulli*

ANNEXES II photo of study site and sample collection

1 Grassland

2 Forest

3. Horticulture

4. Cultivated

5. Species collection from pitfall traps

6. Preserved species

7. Working at Entomology lab

8. Observation under microscope

ANNEXES III Data collection

Table: 1 Collection of Species in Grassland

Species	No. of individuals
Pardosa spp.	64
Pirata spp.	37
Lycosa spp.	71
Hippasa spp.	3
Oxyopes spp.	4
Plexxippus spp.	2
Synomosyna spp.	3

Table: 2 Collections of Species in Cultivated land

Species	No. of individuals
Pardosa spp.	53
Pirata spp.	39
Lycosa spp.	37
Leucauge spp.	1
Plexippus spp.	3
Argiope spp.	2
Synemosyna spp.	1

Table: 3 Collections of Species in Horticulture

Species	No. of individuals
Pardosa spp.	61
Pirata spp.	43
Lycosa spp.	54
Nephlia spp.	6
Cyclosa spp.	2
Oxyopes spp.	2
Araneus spp.	2
Pholcus spp.	3
Leucauge spp.	2

Table: 4 Collections of Species in Forest

Species	No of individuals
Pardosa spp.	39
Pirata spp.	55
Lycosa spp.	32
Cyrtophora spp.	6
Gasterocantha spp.	2
Neoscana spp.	2
Leucauge spp.	3
Nephlia spp.	3
Araneus spp.	3
Pholcus spp.	1