CHAPTER-1

INTRODUCTION

1.1 Arachnida: Araneae

Spiders are most diverse and dominant invertebrate animals on the earth. They always create confusion with insects but are different from insects as their body is divided into two parts i.e cephalothorax and abdomen, have four pairs of legs. Most of the spiders are having four pairs of eyes and some are having three pairs of eyes. Wings and antennae are absent in spiders. They are unique among other arachanids due to the presence of spinnerets, which produce silk. Spinnerets make them different among other Arachnids. They are having six types of silk producing glands at the end of abdomen.

They belongs to the class Arachnida order Araneae under Phylum Arthropoda, are an ancient group of invertebrate animals. The term Arachnidae was derived by Lamarck which comprises the other orders such as Scorpions (Scorpiones), Pseudoscorpions (Pseudo-scorpions), Whip scorpions (Amblypygi), Solifugae (Windscorpions), Palpigradi (Palpigrades), Ricinulei (Ricinuleids), Acari (Ticks and Mites), Opiliones (Daddy long legs) and Araneae (Spiders) (Sebastian & Peter, 2009).

Spiders are different from other Arachnids due to the presence of pedicel a narrow stalk which joins the cephalothorax and abdomen. The study of spiders is known as Arachnology. There are currently 48,182 described spider species belonging to 4,139 genera and 120 families (World Spider Catalog, 2019) in the world and there are many species yet to be discovered and described. Out of these, 1686 species belonging to 438 genera and 60 families have been reported from India (Keswani *et al*., 2012). From Gujarat 415 species belonging to 169 genera and 40 families were reported (Yadav *et al*., 2017). Out of these1074 species of spiders are endemic to India (Siliwal *et al.,* 2005).

1.2 Rationale of the Study

Biologists have identified India as one of the top twelve mega diversity countries of the world, sheltering of about 5, 00,000 of which some 10 to 30 million species of living organisms (Gadgil, 1996).There are many environmental factors that affect species diversity (Rosenzweig, 1995). Studies have demonstrated that a correlation exists between the structural complexity of habitats and species diversity (Hawksworth *et al.,* 1995). Diversity generally increases when a greater variety of habitat types are present (Ried & Miller, 1993).The present study was conducted in Champaner-Pavagadh Archaeological Park which is having dense forest, hill, garden and agricultural fields. This forest area is having large number of trees, climbers, shrubs and grasses. The forest floor has more litter as compared to other habitats which provides more shelter for ground spiders. This area is rich with flora and fauna which harbors rich diversity of invertebrates and vertebrates. This area has different type of habitats because of which it is rich in biodiversity, habitats and ecosystems. Despite its largely semi-arid and deciduous habitat, the area is rich in biodiversity. Therefore, it makes Champaner- Pavagadh Archeological Park a potential site to carry out studies on biodiversity. Further, the review of literature survey reveals that the study on diversity and ecology of spiders has been sporadic and restricted to few pockets in Gujarat. Hence, the study on diversity and ecology of spiders of Champaner- Pavagadh Archeological Park were studied during the present work.

1.3 Biological Role of Spiders

Spiders are the most-diverse and dominant invertebrate predators in terrestrial ecosystems (Nyffeler, 2000).They play an important role in controlling the insect pest population under control by feeding on insect pest such as thrips, caterpillars, aphids, plant bugs, leaf hoppers, flies, etc. (Nyffeler & Benz, 1987).Hence, spiders play an important role in reducing the usage of pesticidesin agriculture fields by eating harmful insects (Riechert , 1999). Spiders mostly feed on insect pest and are of economic value to human being due to their ability to reduce insect pest in agro ecosystems and in forests. They are sensitive to habitat structure including vegetation complexity, litter depth and micro-climate characteristics (Uetz, 1991; Churchill & Arthur, 1999). Spiders are considered as an ecological indicators and are diverse group of organisms for the study of ecosystem and

their sensitivity to environmental degradation caused by human or natural disturbances (Bowden & Buddle, 2010) Therefore, spider needs attention in research and conservation and have been recognized as excellent insect for research studies based on their diversity and ecological role. In the resent research most of studies have been done on application basedbenefits of spiders as bio control agents in agricultural fields. Hence spiders have been used in integrated pest management (IPM), due to their potential benefits as bio-controller of agricultural pests (Abrol, 2014). Thus spiders help in reducing pesticide in agriculture fields and increase significant economic values. Spider silk and venom are being used in medicinal research (stroke treatment) in pest control (pesticides) and in fiber technology.

1.4 Biology of Spiders

Spiders are mainly of two types Weavers and Non-Weavers (Tikader, 1987). Their life span is about one year but few live for 10 or 25 years (Smith, 1971; Vijayalakshmi and Preston, 1993). The life cycle of the spider consists of egg, spiderlings, and adult spiders.

Egg: Spiders are oviparous. Eggs are laid in large number in a protected silk shelter called eggcocoon or eggsac. The making of eggsac, shapes, and designs differ in different species of spiders. Eggsacs are laid on leaves and stems of plants and hidden in earth crevices, on the bark of trees (Figure 1) under stones or on walls or may even be kept strung in webs (Vijayalakshmi & Preston, 1993). The eggs and cocoons are of various shape e.g. tennis ball (viz. *Argyrodes* sp., *Pholcus* sp., *Scytodes* sp. etc.), spindle shape (like *Cyrtophora* sp.) (Figure 2), disc shape (e.g. members of family Lycosidae, Clubionidae, Salticidae), star shape like (*Uloborus* sp.), irregular shape like (*Argiope* sp.) or flat (like members of family Thomisidae). In few species, the eggsac is taken care of till the young spiderlings come out. Several species of female spiders carry the eggsac adhered to her spinnerets as in *Lycosa* (Lycosidae) or held by chelicerae as in case of *Pholcus* (Figure 3) or held under sternum as found in *Pisaurina* (Pisauridae). Few to several hundreds of eggs are present in an eggsac depending on the species. The hatching period ranges from 10 to 14 days.

Spiderlings (Young ones): Eggs hatch in 10 to 14 days and spiderling remains in the eggsac for 2 to 6 weeks, and leave the eggsac after the first moult. After emergence,

Spiderlings remain inactive for the initial phase whilst they are incapable of feeding or spinning. After a series of moults it attains maturity. Spiderling appears similar to their parents except in size (Figure 4). Initially, the spiderling is pale coloured and less thickly clothed with hair or spines. After the 2nd and 3rd moult they grow rapidly and attain its characteristic shape and markings. In the following moults very little alteration is observed, except for an increase in size. After final moult the spider becomes sexually mature. A male undergoes about 5 moults before becoming sexually mature while the female has to moult 7 or 8 times. The first moult takes place while the newly hatched spider is still with the rest of the brood either in or close to the cocoon. The later molts are generally accomplished by the spider where it attaches all its legs together with the silk of the web while its body hangs below. By a series of violent efforts, the old skin splits along the sides of body and wiggles itself free, leaving a complete cast (exuvia). The number of moults and intervals at which they occur vary from species to species. One or two days before moulting takes place the spider stops feeding. After moulting, it remains inactive for one hour. By this time the integument hardens. Many newly hatched spiderlings disperse by ballooning when they emerge from the eggsac. This is primarily to escape from the cannibalistic tendencies of their siblings and to seek new hunting grounds. Such an act also helps to avoid over crowding and sibling rivalries (Dean and Sterling, 1985). However, there are many spiders, which do not leave their nest for a week or more, even after the first moult.

Adults: Sexual dimorphism occurs in many species. Females normally being significantly larger than the males. The male spider can be distinguished by the swollen or knobbed tip of the palps**.** Most of the spiders are highly cannibalistic solitary creatures and practice bizarre courtship rituals. In many species of spiders, female kills the male for a handy source of protein for her newly fertilized eggs. Several species produce sound (acoustic communication) during courtship and agonistic displays (Rovner, 1975). For example, males of genus *Steatoda* (Theridiidae) produce sound by scraping together the elements of a stridulatory organ located on the posterior cephalothorax and anterior abdomen (Breene *et al.,* 1993).The male spider discharges a packet of sperm on a specially made web and absorbs the sperm into its pedipalps, which serve as the copulatory organs. Courtships in weavers and non-weavers are different. Male Orb-weavers and other web spiders with poor

vision announce their approach by plucking the strands of the female's web in a special way or drumming out a recognizable tattoo. Others stroke and tap the females cautiously.While non-weavers like wolf spider and jumping spiders dance and wave their legs before their mates. The Nursery web spider presents his mate with a fly to keep her occupied before mating. In some species, the male binds the female loosely with silk toimmobilize her before transferring sperms (Vijayalaxmi and Preston, 1993).

Males of some species die soon after mating. Spiders of many families show parental care. Female wolf spider (Family: Lycosidae) carries the cocoon attached beneath the abdomen or held by the jaws (Family Pholcidae). The females of family Theridiidae and Pholcidae (*Crossopnza* sp.) do not leave the cocoonun till the young ones hatch out. However, in Lycosidae, after the spiderlings hatch out, the brood continues to ride on the mother's back for about a week. A very few species of spiders are fatal to human being viz. Funnel-web Mygalomorph (Family: Dipluridae), *Phoneutriafera* (Family: Ctemidae), *Loxoscelesreclusa* (Family: Loxocelidae) and *Latrodectus* sp. (Family: Theridiidae). The condition caused by the bite of these spiders is called Arachnidism (Vijayalaxmi and Preston, 1993).

1.5 Morphology of Spiders

Spiders belong to the class Arachnida of the phylum Arthropoda that possess two main body parts, anterior prosoma or cephalothorax, and posterior opisthosoma or abdomen, joined by a narrow pedicel. They have four pairs of legs, six or eight eyes are present, wings and antenna are absent. They are unique arachnids as they have spinnerets located at the end of the abdomen which produces silk.

Cephalothorax

The cephalothorax consists of head and thorax which is fused into a single segment called cephalothorax. Dorsally covered by hard chitinis end plate, the carapace and ventrally by a similar one the sternum. The legs, maxillae, labium, palps, and chelicerae are articulated between these two plates (Figure 5). The anterior part of cephalothorax called cephalic region and a posterior part called as the thoracic region.

Abdomen: The abdomen is the largest and wide part of spider body with a remarkable variation in shape, size, coloration, markings and fine hairs. The abdomen is joined with cephalothorax by a narrow pedicel. Some spiders have hard sclerotized plate on the dorsal side called scutum and in some of the ventral side of the abdomen. In most of the spiders the transverse groove is present on the anterior half of the ventral surface called epigastric furrow (Figure 6).

Legs: On the lateral side of cephalothorax four pairs of legs are present I, II, III and IV respectively. Each leg has seven segments, viz, coxa, trochanter, femur, patella, tibia, metatarsus and tarsus with two or three tarsal claws (Figure 7). The upper pair of claws is called superior claw. The third claw is known as the inferior claw. The legs are mostly covered with different types of hairs, spines, bristles, spicules, etc. The spines on the dorsal surface of the legs are distinguished as dorsal spines and on the ventral side as ventral spines. Bristles on legs are used for taxonomic identification. Those spiders which capture their prey by active hunting are having two claws while the web builder spiders have three claws on their legs.

There is often depression in the middle of the thoracic region called thoracic groove or fovea which represents the cephalic region from the thoracic region of cephalothorax. Cephalothorax bears six pairs of appendages. The first pair is the chelicerae with a fang at the tip. The chelicerae are paraxial in primitive spiders (mygalomorphs) while in modern spiders (araneomorphs) it is diaxial. The second pair of appendages pedipalps are situated behind the mouth. These palps are divided into six segments, viz, coxa, trochanter, femur, patella, tibia, and tarsus. The basal segment, coxa, is directly associated with feeding and lies below the mouth. In most of the spiders, coxa is expanded to form a plate-like structure called maxilla. Between the maxillae a small criticized plate, the labium or lower lip, which attached to the sternum. The palps are different shape in male and female spiders. The tarsus in female spider is simple and may or may not be with a single claw. While in mature males the tarsus is usually prominently swollenat the apex and modified into a copulatory organ called palp organ to carry sperms (Figure 8).

Reproductive Organ of Male and Female Spiders

Pedipalps: In male spiders, one pair of palp organs are present in the last segment of pedipalps (Figure 9). Pedipalps are used for the transfer of sperms into the female. Palp organs are fully developed in mature male spiders. In most of the spider species, the bulbs have complex shapes and are important in taxonomic identification.

Epigyne: It is located above the mid epigastric furrow which is the female genital organ. The complexity of epigyne structure varies in different species and are one of the major identifying characters of female spiders to identify them upto species level (Figure 10).

Spinnerets: Spinnerets are six in numbers (three pairs) present below the anal tubercle which is present at the end of the abdomen. They are three pairs or six in number. The arrangement of spinnerets are termed as anterior pair of the spinneret, posterior pair of spinneret and median pair spinneret, but may be two pairs or even reduced to a single pair. The anterior spinnerets have two segments, median are unsegmented and the posterior spinnerets consist of 2 segments, but sometimes three or four segments are present (Figure 11).

Eyes: On the cephalic region six or eight simple eyes are present and their size and arrangements are different which are used for identification of spiders till family level. Two different types of eyes are known to exist i.e. diurnal and nocturnal eyes. When both types of eyes are present in a spider the condition is called a Heterogeneous condition where only one type of eyes is present the condition called as Homogenous condition. Eyes are usually arranged in two rows namely anterior row and posterior row each with four eyes. In some families, eyes are present in three rows. The rows are frequently curved. When curvature is such that the lateral eyes are further back than the medians, the row is recurved and when the curvature is such that the lateral eyes are further forward than the medians, the row is called procurved. On the base of their four pair of eye arrangement, they are termed as anteromedial (AME), posteromedial (PME), anterolateral (ALE) and the posterolateral (PLE). The arrangement of four median eyes is known as median ocular quadrangle (MOQ) or ocular quad and area enclosed by all eyes is termed as ocular area (Figure 12).

Figure 1

Eggsac fastened onto the bark of trees

Figure 2

Spindle shaped eggsac of *Cyrtophora sp* .on the web

Figure 3

Crossopriza lyoni carrying their eggs

Figure 4

Spiderlings of *Scytodes* sp.

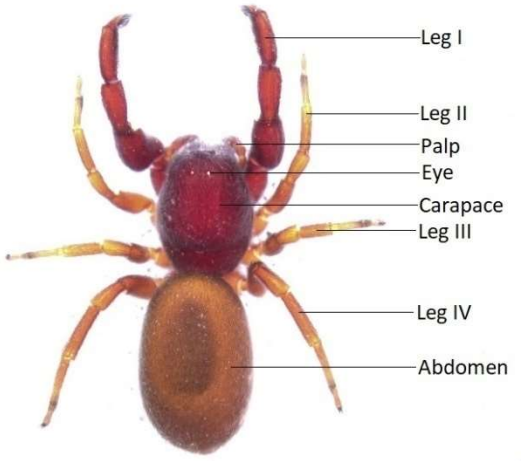

Figure 5

Dorsal view of female *Otiothops namratae*

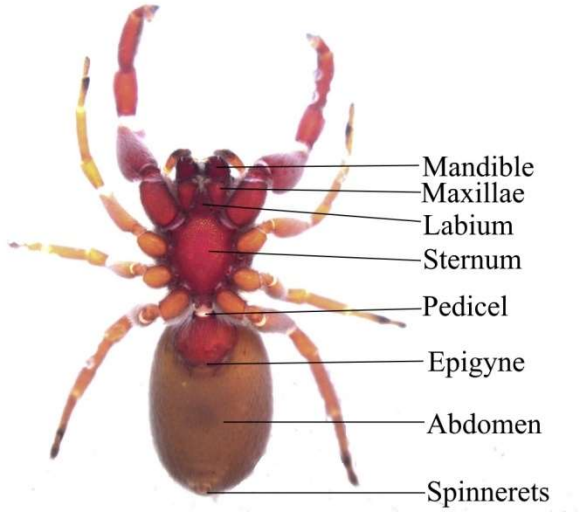

Figure 6

Ventral view of female *Otiothops namratae*

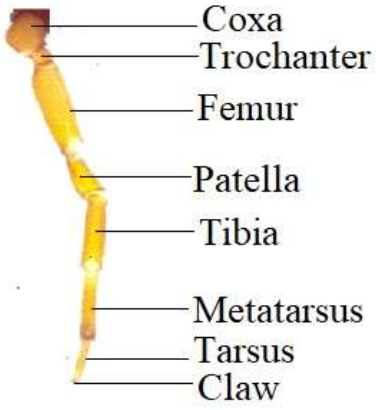

Figure 7

Lateral view of leg showing different segments

Figure 8

Dorsal view of male pedipalp of *Asceua* spider

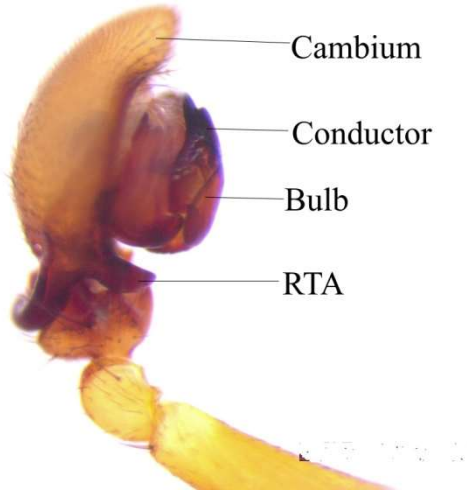

Figure 9

Enlarged view of male Pedipalp

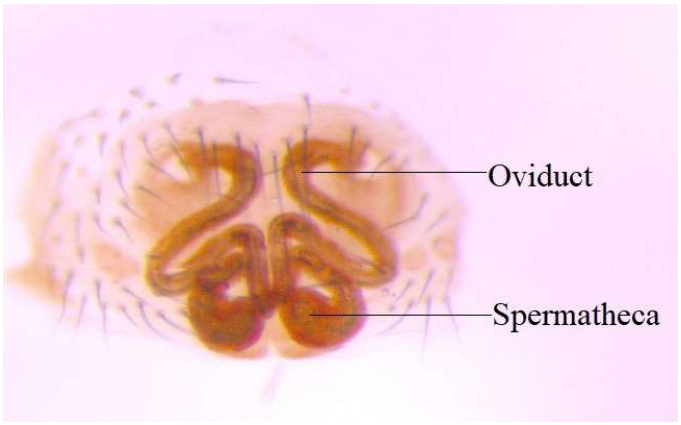

Figure 10
Enlarged view of female epigynum

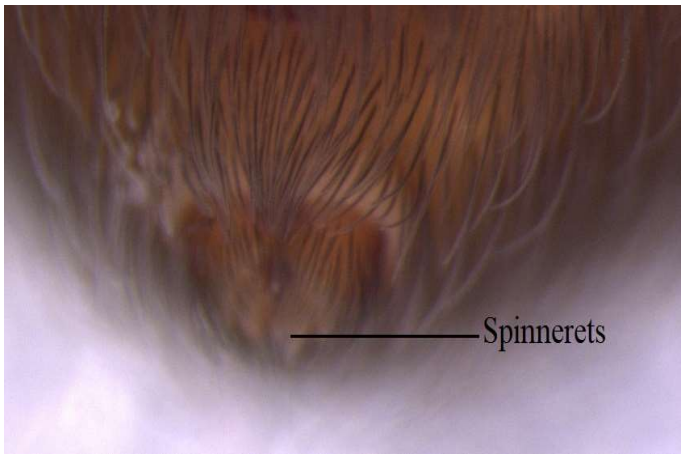

Figure 11
Ventral view of spinnerets

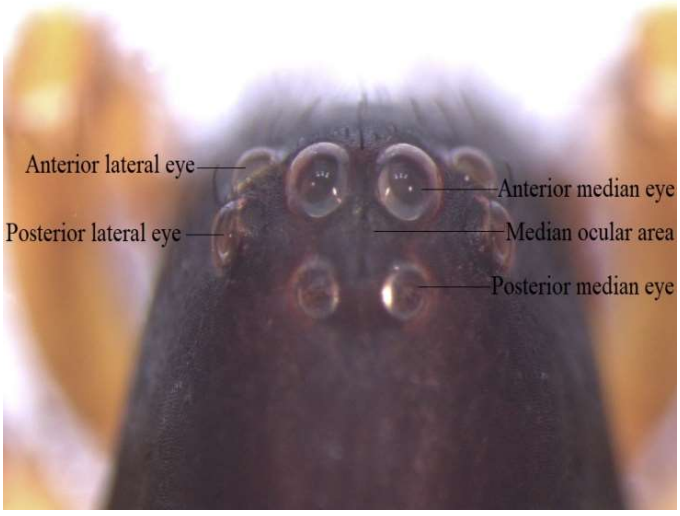

Figure 12
Eye arrangement of typical spider

1.6 Ecology and Diversity of Spiders

The present work deals with the diversity and ecology of spiders of Champaner- Pavagadh Archaeological Park. The study gives a detailed insight into the microhabitats, foraging strategies, guild structure, life cycle, web structure, food and feeding mechanism. As spiders species are poorly documented and no research has been done so far in Champaner-Pavagadh Archaeological Park. This work was undertaken Archaeological Parks have their own importance. It connects people to social values, beliefs, religion, and customs. They also provide unity and belonging within a group and allow us to understand better about previous generations and history. There is also a possibility of scientific finding at such sites and monuments.

This Particular Archaeological Park of Gujarat was announced as a World Heritage Site in the year 2004 by UNESCO. It was justified for inscription on the World Heritage List on the basis of four criteria adopted by the World Heritage. Ancient architecture, temples, and special water-retaining installations together with its religious, military and agricultural structures. This area represents a perfect blend of Hindu-Muslim architecture, mainly in the Great Mosque which was a model for later mosque architecture in India. It is also a place of worship and continuous pilgrimage for Hindu believers. Hence it is very important to know about its floral and faunal diversity.

Few studies on the flora of Champaner- Pavagadh Archeological Park have been conducted by the Department of Botany, The M.S. University of Baroda (Oza, 1961) and (Alpana, 2015) and geochemical stratigraphic and magmatic evolution studies have been done (Sheth & Melluso, 2008) from Department of Earth Sciences, IIT Mumbai.

Modi 2008 from heritage concern, Surat worked on managing and conserving of water in Champaner Pavagadh Archeological Park. A design approach study of Champaner Pavagadh was done from the University of Illinois, USA (Sinha, 2004). Forest Department of Godhra has also contributed in the form of reports where some plants and animals of Champaner-Pavagadh Archaeological Park have been mentioned (Table 1). But this important heritage site remains unexplored by taxonomists for various fauna. Hence there is a need to study various invertebrates and vertebrates of the Champaner-Pavagadh

Archaeological Park; spiders being one of them. Spiders are important creatures on the earth's biodiversity hence it is important to know which type of ecosystem is favorable for the survival of spider and thereby how to conserve them. After reviewing the literature, we hypothesized that such type of habitats like forest, agricultural fields, garden and the hilly area located in Champaner- Pavagadh Archeological Park will have a rich diversity of spiders.

Hence world heritage sites are visited by numerous tourists. Such sites should be maintained and studied for healthy ecosystems of flora and fauna. The site is unique; has a forest, agricultural fields, garden, monuments, temple and hill and a continuous pour of visitors. Forest area covered by 94% of the land has a mix type of vegetation like large number of trees, herbs, shrubs, climbers, and grasses. The major dominant plant species found in this forest area are *Tectona grandis, Writia tomentosa, W. tinctoria, Ziziphus mauritiana, Anogessus latifolia, Mitragyna parvifolia,* etc. Agriculture fields are present at the base of the hill which is a major source of livelihood for the locals. The major crops grown are pigeonpea, wheat, maize, and cotton. The community garden is present which is open for the public having ornamental plants like *Chrysanthemum, Creepers, Rosa chinensis, Ixora coccinea, Ocimum sanctum, Jasminum sambac, Vinca rosea, Nerium oleander*. This is a public place where people are frequently visiting. The monuments are located at the foothill or around the Pavagadh hill namely Saharki Masjid, Kevda mosque, Saat Kaman, Helical stepwell. At the foothill on South direction, some dilapidated house and the foundation of Jain Temples are present. The Pavagadh hill is about 11 km in length from North to South with a width of study area 6.4 kms (Alpana 2015). The altitude of the hill is 830 m from sea level. At the top of the hill, a famous Mahakali temple is located. The temple of Kalikamata at the top of the Pavagadh hill is valued enormously in the region. It is a very important shrine and is visited by lakhs of pilgrims throughout the year. It is an important religious center present in the state of Gujarat. This makes it not just an archaeological site but a living settlement and a thriving pilgrimage destination. This study is first of its kind on spider diversity, ecology and taxonomy and the first step towards conservation.

1.7 Objectives of the study

The study was carried out with the objective to document the spider diversity of Champaner-Pavagadh Archaeological Park which will fill the existing void of Arachnology literature for the state. In order to achieve the above goal, the following objectives were framed:

- To study the systematic and ecological distribution of spiders in Champaner Pavagadh Archaeological Park
- To explore diversity patterns of spiders along the slope of Pavagadh hill
- To analyze the guild structure of spider species obtained from the study area.
- To study the web structure of spiders found in Champaner-Pavagadh Archeological Park.

The study of Spiders of Gujarat is diverse but effective conservation has been impeded by lack of taxonomic knowledge. No work on spiders has been conducted in Champaner-Pavagadh Archaeological Park of Gujarat. Hence knowledge on ecology, diversity, taxonomy and conservation status of spiders is a must. Keeping this in mind the present study has been proposed. The aim of the present work is to make an inventory of the spider species in different habitats of Champaner-Pavagadh Archeological Park along with slope of Pavagadh hill.

> ***The next time you see a spider web, plea pause and look a little closer. You will be seeing one of the most high-performance materials known to man…….***
>
> Cheryl Hay