CHAPTER-3

MATERIALS AND METHODS

3.1 Study area

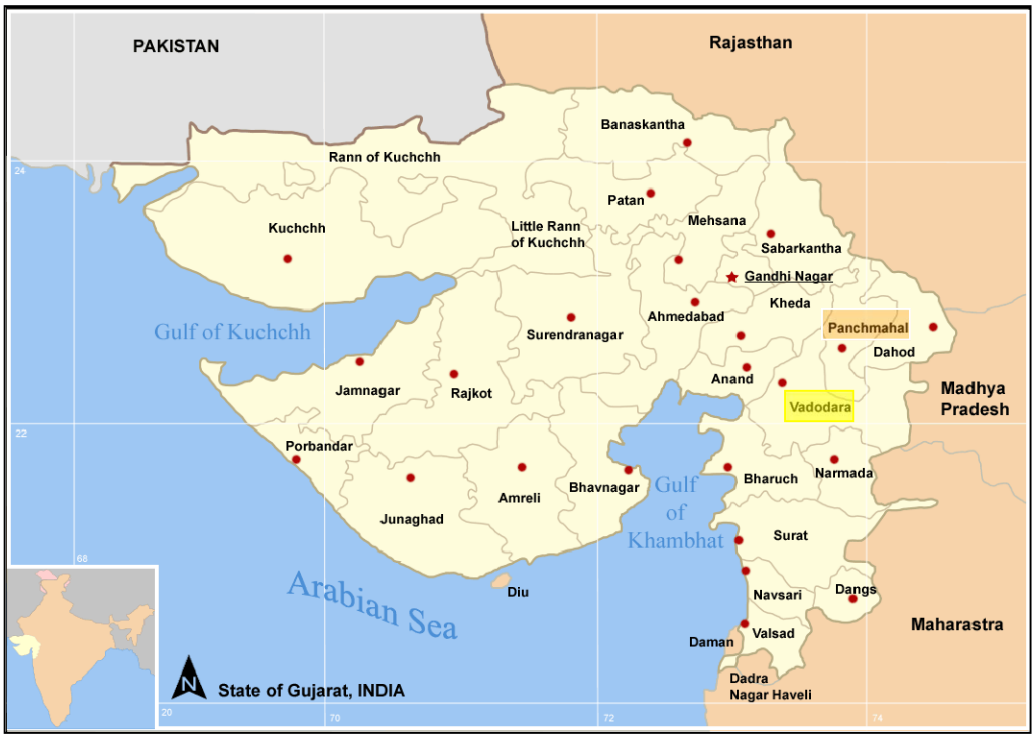
Champaner-Pavagadh Archaeological Park is amongst the 33 World Heritage Sites of India which has been inscribed by UNESCO on World Heritage list on 7th July 2004. This place is an example of very short living capital, making the best use of its topography and natural features.This area represents a perfect blend of Hindu-Muslim architecture. Champaner-Pavagadh Archaeological Park is the gateway to Panchmahal district of Gujarat India.

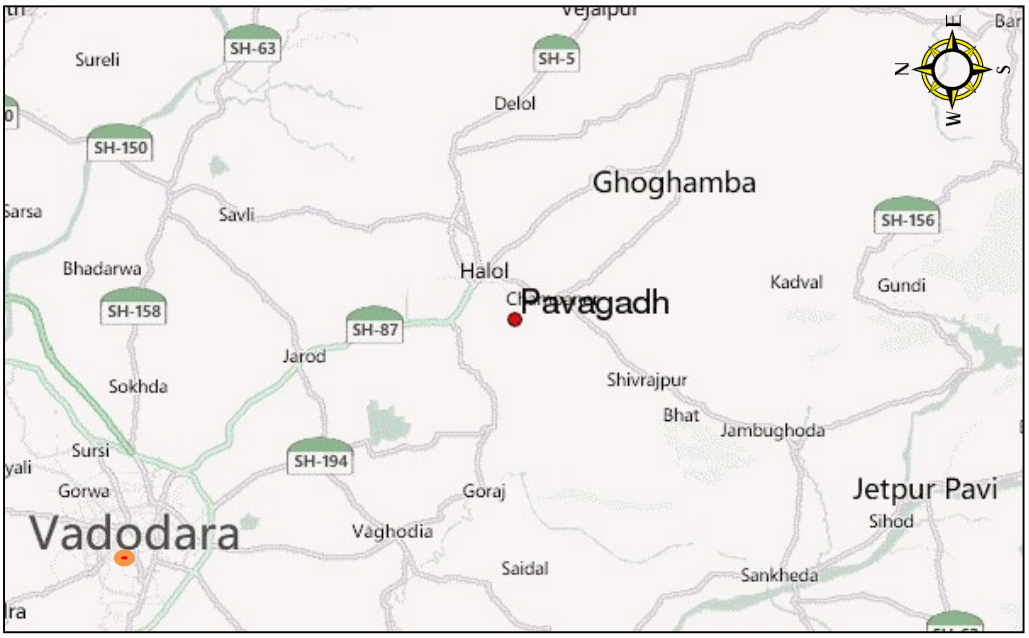
It is located at a distance of approximately 50 kms north-east of The M. S. University of Baroda, Vadodara and 45 km south of Godhra. The area is spread in 1,329 hectares.It is a place of historic importance having palaces, temples, mosques, arches, step wells, forest, agricultural fields, garden, concrete structure, residential area, and hills.

Pavagadh hill is the highest point in the district, rising to a height of 830 m from sea level. At the top of the hill a famous temple of Kalimata is situated, which is a famous religious destination visited by lakhs of pilgrims throughout the year. This area is also surrounded by several small hillocks ranging from 200m-300m in height. The hill has five successive plateaus viz., Naulakhi, Mauliya, Bhadrakali, Machi and Atak plateau.This area has seven major rivers, amongst that the Mahi river is the longest river. The river Vishwamitri originates from Pavagadh hill and flows through Halol before entering Vadodara district.

The climate of Champner-Pavagadh remains dry throughout the year except in the monsoon season. The mean annual temperature in the area is 20° C, with a maximum of 37º C and minimum of 18° C (Annexure 2.). The year may be divided into four seasons; Summer Season (March to Mid June), Monsoon Season (Mid June to September), Post-Monsoon (October to November), winter (December to February). Rainfall is very irregular and erratic. The average annual rainfall ranges between 700 mm to 1024 mm.The relative humidity is high during monsoon; in July reaches up to 50% to 80%.

Figure 13: Study Area of Champaner-Pavagadh Archaeological Park





Map Source: Google Map

In the month of January to May humidity is around 30- 40 %. Climatic conditions affect the diversity and ecology of spiders. The study of spider diversity and ecology helps us to know the environmental changes and any type of disturbances in study area.

The composition of the soil varies in Champaner- Pavagadh Archaeological Park. It is chiefly sandy loam and deep black to medium black. The study area generally has very shallow, poor and rocky soils at many places.

3.1.1 Study Period

The study was carried out for a period of 3 years i.e. December, 2015 to December, 2018 in all the four seasons of the year. Spiders are mostly found in all habitats like, forest, garden, agricultural fields, under stone, in leaf litters and are mostly found active in day time. Thus for collection of spiders day time has been considered .The sampling was done in the morning from 7 a.m. to 11 a.m. and 1 p.m. to 5 p.m. under suitable weather conditions.

3.1.2 Sampling Sites

For the convenience of spider diversity study in Champaner-Pavagadh Archaeological Park the entire area was divided into different sub-sites along with slope of Pavagadh hill based on their habitat structure and vegetation types.The coordinates and elevation of each site were taken with the help of the Global positioning system (GPS: Garmin Oregon 550).

The total area of Pavagadh is 6356.98ha, covered under forest which legally constitute reserve forest. It starts from foothill of pavagadh to the top of hill. The total 50 % flora of the study area has mix type of vegetation like climbers, herbs and shrubs (Table 1). The leaf litter layer present in the forest is estimated to be about 2-3 cm thick because many trees and climbers drop their leaves in floor.

Agricultural fields are present at the base of the hill which is a major source of livelihood for the district. In the present study four different agricultural fields were selected for spider study which are economically important crops of Gujarat viz. Pigeonpea, Maize, Cotton and Castor fields (Table 2). The agricultural fields at the base of hill mostly depend on rainy season. Some Portion of agricultural fields is irrigated by man made sources of irrigation.

The garden selected for the study purpose is large with different varieties of plants and shrubs. The area is having ornamental plants like *Chrysanthemum, Creepers Ixora*

coccinea, Ocimum sanctum, Jasminum sambac, Vinca rosea, Nerium oleander. It is also surrounded by forest and has monuments and mosques.

3.1.3 Hilly Areas

The study of spider diversity along slope is an interesting topic.

Related to spider diversity along altitude not many detailed studies have been carried out focusing the relationship between species diversity and the height. We have investigated the spider diversity along the slope of Pavagadh hill for three years. The hills were divided into three altitudes i.e. lower altitude (230m to 430m), Middle altitude (430 to 630 m) and higher altitude (630 m to 830m). Selected at a distance of 200 m each on the basis of vegetation, altitude and topographic context.

3.2 Collection Methods

Using single sampling method was not enough. Spiders are found in different habitats. They are foliage weavers, ground weavers, foliage hunters and ground hunters. Therefore a systematic collection was done using different sampling methods as employed in (Koh and Ming, 2013). They were Pitfall sampling, Sweep netting, Vegetation beating, Ground hand collection, Arial hand collection, and Leaf litter method. Sampling was done in the same way in all study sites in all the four seasons. All the methods were done twice in each month except for pitfall traps because pitfalls were not laid in monsoon season due to water flooding issues.

3.2.1 Pitfall Trapping

This method was used to collect ground-active, surface active, leaf litter inhabiting spiders. The pitfall trap was made up of round plastic cup of 10 cm diameter and 11cm depth. Traps were set in the field with ethylene glycol, which retained the spider specimens in good condition before laboratory processing and identification. Maximum 50 traps were placed in study area for 3-15 nights and monitored every 24 hours interval. Specimens were removed from trap after two days to maintain in a good condition. The importance of this method is it allow both diurnal and nocturnal species to be caught in the samples. Number of traps and days varied over the habitat and season.

3.2.2 Sweep-Netting

Sweep nets are mainly used in areas having long grasses, small shrubs, and low herbaceous

and shrubby vegetation. The net was emptied at regular intervals (after three to five sweeps) to avoid loss and destruction of the specimens. For sweep netting, a round sweep net was made of mosquito net (1.5 mm) having a diameter of 28 cm (aluminum ring) and 1 m long handle was used. Each area was sampled by 30-40 sweeps separated by 2 meter interval and the sampling time was kept as one hour for each area.

3.2.3 Vegetation Beating

This method was used for spiders living in the shrub, high herb vegetation, bushes and small trees and branches. Spiders were collected by tapping the vegetation with a heavy stick while holding an umbrella placed under the trees to catch the spiders which were unable to reach or seen hanging above.While on disturbance all the spiders will jump from the vegetation and can be collected in the umbrella. This method was used for 30 minutes at each area (vegetation). All the spiders on the umbrella were collected and transferred to the sampling vials.

3.2.4 Ground Hand Collection

This sampling method was used for collection of spiders which is inhibiting on ground like leaf litter, plant surface, forest floor debris, under logs of wood and stones that were below knee level. Small spiders were collected with the help of a brush dipped in alcohol. Spiders found on the leaf blades and those on the webs were caught in the vial by holding it open beneath them and by tapping the spiders into it with the lid. All the spiders visible on the ground i.e. below knee level were collected in the vial. This method was used for one hour in each area. Ground hand collection method is important sampling method for ground spider.

3.2.5 Arial Hand Collection

The method was targeted for collection of web-building spiders and free-living foliage dwellers.Whenever spiders were encountered, they were carefully picked without injuring them and transferred to plastic vials containing alcohol. It is a sub-type of hand collection method done with the help of forceps, brush and vial. A total of 40-50 samples were taken from each habitat.

3.2.6 Leaf litter Method

This method was employed for ground spiders. Leaf litter from one square meter area was

collected in a polythene bag and was dumped on a white surface to collect the spiders living in the microhabitat. In each habitat 10-15 times it was repeated from different areas. Leaf litter spiders were collected with paintbrush dipped in alcohol and the specimens were placed directly in 70% alcohol.

3.3 Guild Structure

Spider guild structure study was classified on the basis of their ecological characteristics associated with its foraging behavior, prey capturing behaviors, use of microhabitat and daily activity (Table 1). The guild classification of spider was done according to the behavior of collected families during the study period. Spider guild was designated on the basis of ecological characteristic of spiders as per Young & Edward, 1990.

3.4 Web Structure Study of Spiders

The web structure widely found in particular families of spiders was described by Lubin, 1978. The production of silk is a unique characteristic of spiders among other arachnids. Silk is produced from six silk glands which are located beneath the posterior part of abdomen. The web structures of spiders were different in different species to sustain in the environment. Most of the spiders make their web in the evening or at night for capturing their prey and consume their prey in the morning. At the time of collection of spiders the web patterns were also observed.

3.5 Specimen Preservation

After collection spider samples were brought to the laboratory for identification. The alcohol of the samples was changed to avoid contamination of microorganisms. All the samples were transferred to the glass petri plate with 70% alcohol and were sorted out with the help of paint brush and forceps. Spiders were then transferred to separate vial containing 70 % alcohol for further identification and measurements. The sample vials were labeled which includes the specific identity number, family, scientific name, sex, and date of collection, exact name of the habitat of collection and collector's name. All the specimens were deposited in the Entomology laboratory, of the Department of Zoology, Faculty of Science, The M. S. University of Baroda, Vadodara-390002 Gujarat.

3.6 Taxonomic Identification

Spider identification was done by observing specimens under stereo-zoom microscope (Leica MPS) with magnification from 20X to 75X in the lab. Spiders at all the stages were identified till genus level because their colour and abdomen patterns are almost same as adult. However species level identification was done in mature specimens because pedipalp and epigyne are well developed .In immature spiders epigyne and pedipalps were not well developed thus cannot be identified till species level. Mature pedipalp and epigyne structure are shown in Figure 10. All the mature female spider's epigynum were dissected and cleaned in lactic acid for 10–15 minutes. After that the structure of epigyne was compared with the available literature. These dissected epigyne were stored in 1 inch long glass microvials plugged with cotton and placed in the respective spider species vial number after identification.

Similarly in case of mature male spiders the pedipalp of left hand side were plucked and its structures were compared with the available literature. All the collected spider identification was done by me till species level and further confirmation was done by renowned Arachnologist Dr. Manju Siliwal, Women Scientist, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand. Standard literatures used for identification of spiders were:World Spider Catalog, 2019;Gajbe, 2008, 2007;Patel, 2003; Reddy & Patel, 1993 Majumdar & Tikader, 1991; Patel & Reddy, 1989; Sethi &Tikader, 1988; Tikader, 1982; Tikader& Biswas, 1981; 1980; Tikader& Patel, 1975;Tikader, 1974; Pocock, R. I., 1900; Pickard-Cambridge, 1870 and other relevant literature.

3.7 Photography

In field spider photography was done using Lumix Panasonic DMC- FZ60 with 24x optical zoom. In case of preserved specimens photography was done by SONY DSC-WX50 camera, which was attached to Stereomicroscope.

Table 1. Checklist of flora found in study sites of Champaner- Pavagadh Archaeological Park

Sr No.	Family	Botanical Name	Common Name
1	Apocynaceae	*Wrightia tinctoria* (Roxb.) R.Br.	Dyer's oleander
2	Apocynaceae	*Holarrhena antidysenterica* (L.) R.Br.	Coral Swirl
3	Annonaceae	*Miliusa tomentosa* (Roxb.) J. Sinclair	Hoom
4	Apocynaceae	*Wrightia tomentosa* Roem. & Schult.	Woolly Dyeing Rosebay
5	Capparaceae	*Capparis sepiara*	Wild Caper Bush
6	Apocynaceae	*Nerium oleander* L.	Oleander
7	Annonaceae	*Annona squamosa* L.	Sugar Apple
8	Moraceaea	*Ficus religiosa* L.	Sacred Fig
9	Euphorbiaceae	*Phyllanthus emblica* L.	Indian Gooseberry
10	Caesalpiniaceae	*Tamarindus indica* L.	Tamarind
11	Combretaceae	*Terminalia bellerica* (Gaertn.) Roxb.	Bedda Nut Tree
12	Verbenaceae	*Tectona grandis* L.f.	Teak Tree
13	Caesalpiniaceae	*Cassia fistula* L.	Golden Rain Tree
14	Alangiaceae	*Alangium salvifolium* Lamarck.	Sage Leaved Alangium
15	Rubiaceae	*Morinda tomentosa* (Heyne ex Roth) Hk. F.	Maddimara
16	Mimosaceae	*Albizia lebback* (L.) Bth	Lebbek Tree
17	Bombacaceae	*Bombax ceiba* L.	Indian Silk Cotton Tree
18	Celastraceae	*Maytenus emarginata* (Willd.) Ding Hou	Thorny Staff Tree
19	Ulmaceae	*Holoptelea integrifolia* (Roxb.) Planch.	Indian Elm
20	Caesalpiniaceae	*Cassia siamea* Lam.	Ironwood
21	Mimosaceae	*Pithocelobium dulce* C.E. P.Mart.	Manilla Tamarind
22	Rhamnaceae	*Zizhyphus mauritiana* Lamk.	Indian Jujube
23	Apocynaceae	*Carrisa congesta* Wight.	Bengal Currant
24	Myrtaceae	*Syzygium cumini* (L.) Skeels.	Java Plum
25	Combretaceae	*Anogeissus latifolia* Wall. Ex. Bedd.	Gatty Gum
26	Flacourtiaceae	*Flacourtia indica* (Burn.f.) Merr.	Madagascar Plum
27	Sterculiaceae	*Sterculia urens* Roxb.	Indian Tragacanth
28	Caesalpiniaceae	*Bauhinia racemosa* Lam.	Bidi Leaf Tree

29	Combretaceae	*Terminalia arjuna* (Roxb.) W. & A.	Arjun Tree
30	Ehretiaceaea	*Cordia dichotoma* Frost. F. Prodr.	Indian Cherry
31	Moraceae	*Ficus racemosa* L.	Cluster Fig
32	Mimosaceae	*Albizia odoratissima* (L. f.) Bth.	Black Siris
33	Verbenaceae	*Vitex negundo* L.	Nirgundi
34	Mimosaceae	*Acacia auriculiformis* A. Cunn.	Earleaf Acacia
35	Ulmaceae	*Trema orientalis* (L.) Bl.	Indian Charcoal Tree
36	Combretaceae	*Terminalia catappa* L.	Indian Almond
37	Moraceae	*Ficus benghalensis* L.	Banyan Tree
38	Caesalpiniaceae	*Peltophorum pterocaroum* (DC.) K. Heyne	Copperpod
39	Combretaceae	*Terminalia crenulata* Roth.	Asan
40	Ebenaceae	*Diospyros melanoxylon* Roxb.	Black Ebony
41	Burseraceae	*Garuga pinnata* Roxb.	Grey downy balsam
42	Meliaceae	*Azadirachta indica* A.Juss	Neem Tree
43	Rubiaceae	*Mitragyna parvifolia* (Roxb.) Korth.	Kaim
44	Anacardiaceae	*Buchanania lanzan* Spreng.	Almondette
45	Mimosaceae	*Acacia leucophloea* Willd.	White Bark Acacia
46	Meliaceae	*Soymida febrifuga* (Roxb.) A. Juss.	Indian Redwood
47	Mimosaceae	*Acacia nilotica* (L.) Del. Sub sp *indica*	Babul Bark
48	Verbenaceae	*Gmelina arborea* L.	Beechwood/ White Teak
49	Rhamnaceae	*Zizyphus xylopyra* (Retz.) Willd.	Jujab
50	Anacardiaceae	*Lannea coromandelica* (Houtt.) Herrill.	Indian Ash Tree
51	Rhamnaceae	*Zizyphus mauritiana* Lam.	Indian Jujube
52	Mimosaceae	*Acacia chundra* (Roxb. ExRottl.) Willd.	Cutch Tree
53	Sapotaceae	*Madhuca indica* J. F. Gmel	Indian Butter Tree
54	Rubiaceae	*Mitragyna parvifolia* (Roxb.) Korth.	Kaim
55	Papillionaceae	*Butea monosperma* (Lam.)	Flame of the Forest,
56	Bursuraceae	*Boswellia serrate* Triana & Planch.	Indian Olibanum
57	Caesalpiniaceae	*Parkinsonia aculeate* L.	Jerusalem Thorn
58	Mimosaceae	*Prosopis juliflora* Swartz. DC.	Algaroba
59	Myrtaceae	*Eucalyptus hybrid (*Cittidoraglobulus)	Eucalyptus

60	Rhamnaceae	*Zizyphus*	Jujube
61	Papillionaceae	*Pongamia pinnata*	Indian Beech Tree
62	Malvaceae	*Sida acuta* Burm.f.	Wireweed
63	Umbelifereae	*Trachyspermum stictocarpum* Wolff.	Bishop's Weed
64	Tiliaceae	*Triumfetta annua* L.Mant.	Bur Weed
65	Euphorbiaceae	*Acalypha indica* L.	Indian Copperleaf
66	Malvaceae	*Sida veronicaefolia* Lam.	Country Mallow
67	Malvaceae	*Sida orientalis* Cav.	Prickly Mallow
68	Asteraceae	*Eclipta prostrata* (L.)L.Mant.	False Daisy
69	Asteraceae	*Vernonia anthelmintica* (L.) Willd.	Purple fleabane
70	Caesalpiniaceae	*Cassia occidentalis* L.	Coffee Senna
71	Araceae	*Amorphophallus commutatus* (Schott)	Dragon Stalk Yam
72	Amaranthaceae	*Achyranthus aspera* L.	Prickly Chaff Flower
73	Euphorbiaceae	*Phyllanthus niruri* L.	Gulf Leaf-Flower
74	Asteraceae	*Blumea bifoliata* DC.	Blumea
75	Commelinaceae	*Commelina benghalensis* L.	Benghal Dayflower
76	Sterculiaceae	*Helictreres isora* L.	Indian Screw Tree
77	Caesalpiniaceae	*Cassia tora* (L.) Roxb.	Sickle Senna
78	Cucurbitaceae	*Cucumis setosus* Cogn.	Cucumber
79	Convolvulaceae	*Ipomea nil* (L.) Roth	Ivy Morning Glory
80	Combretaceae	*Combretum ovalifolium* Roxb.	Oval-leaved Wheel Creeper
81	Acanthaceae	*Hygrophylla auriculata* (Schumach.)	Marsh Barbel
82	Acanthaceae	*Carvia callosa* (Wall.) Bremek.	Karvi
83	Convolvulaceae	*Evolvulus alsinoides* (Linn.) Linn.	Slender Morning Glory
84	Musaceae	*Ensete superbum* Roxb.	Rock Banana/ Wild Plantain
85	Boraginaceae	*Trichodesma indicum* (L.) R.Br.	Indian Borage
86	Malvaceae	*Urena lobata* L.	Caesar Weed
87	Caesalpiniaceae	*Cassia auriculata* L.	Tanner's Cassia
88	Cucurbitaceae	*Luffa acutangula* (L.) Roxb.	Ridged Gourd

89	Poaceae	*Dendrocalamus strictus*	Calcutta Bamboo
90	Liliaceae	*Aloe vera* (L.) Burm.f.	Aloe Vera
91	Plumbaginaceae	*Plumbago zeylanica* Linn.	White leadwort
92	Euphorbiaceae	*Euphorbia hirta* L.	Asthma Weed
93	Poaceae	*Dicanthium annulatum* Forsk.	Marvel Grass
94	Asteraceae	*Sphaeranthus indicus* L.	Indian sphaeranthus
95	Acanthaceae	*Haplanthus verticillatus* Roxb.	Spiny Bottle Bush
96	Umbelifereae	*Pimpinella* sp.	Hairy Hogweed
97	Acanthaceae	*Barleria prionitis* L.	Porcupine Flower
98	Molluginaceae	*Glinus oppositifolius* (L.)Aug.DC.	Jima
99	Asteraceae	*Eclipta alba* (L.)Hassk.	False Daisy
100	Acanthaceae	*Senecio dalzellii* Cl.	Daisy

Source: Alpana, V. R. (2015)

Table 2 Major crops of the Agricultural fields

Name of the Crop	**Month of cultivation**	**Month of Harvesting**
Pigeonpea	June – October	November- March
Maize	June – July	September- October
Cotton	June – August	November- December
Castor	July - August	December -January

STUDY SITE

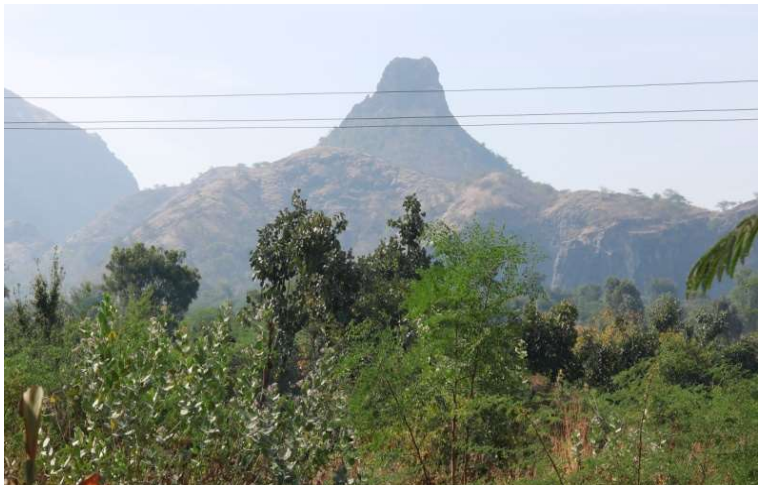


Figure 14
View of Pavagadh hill area

Figure 15
Pavagadh

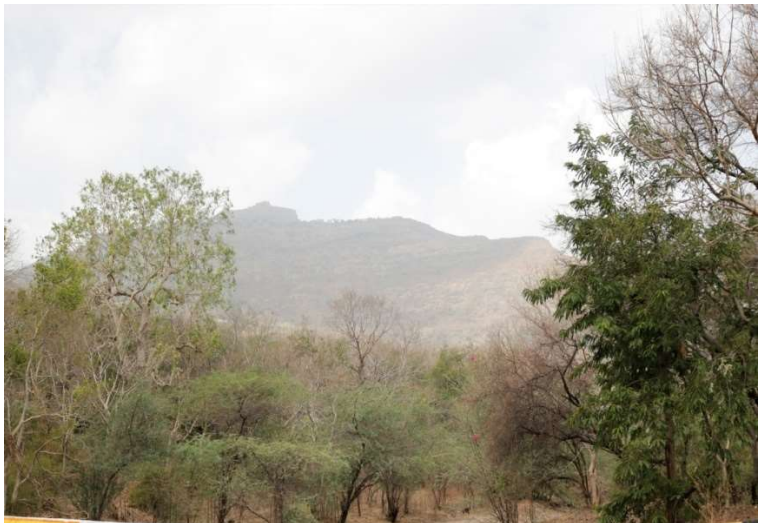


Figure 16
Pavagadh hill and forest area

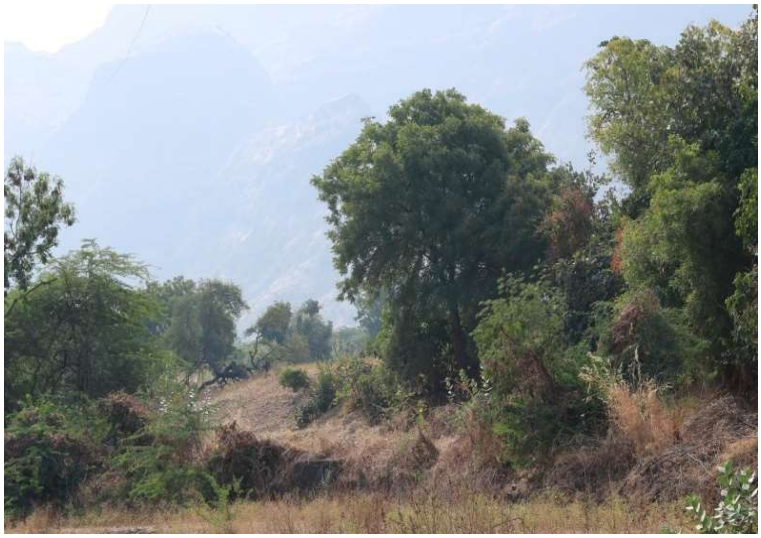


Figure 17
Forest area of Champaner-Pavagadh Archaeological Park

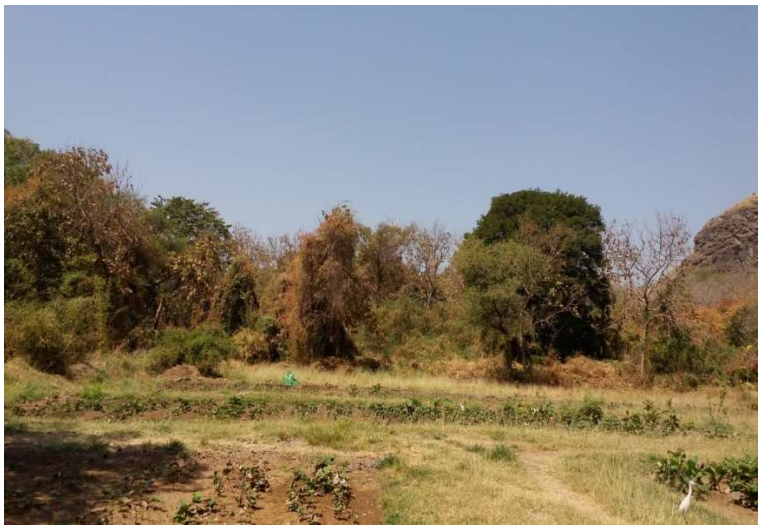


Figure 18
Thick vegetation in forest

Figure 19
Accumulation of leaf litters in the forest

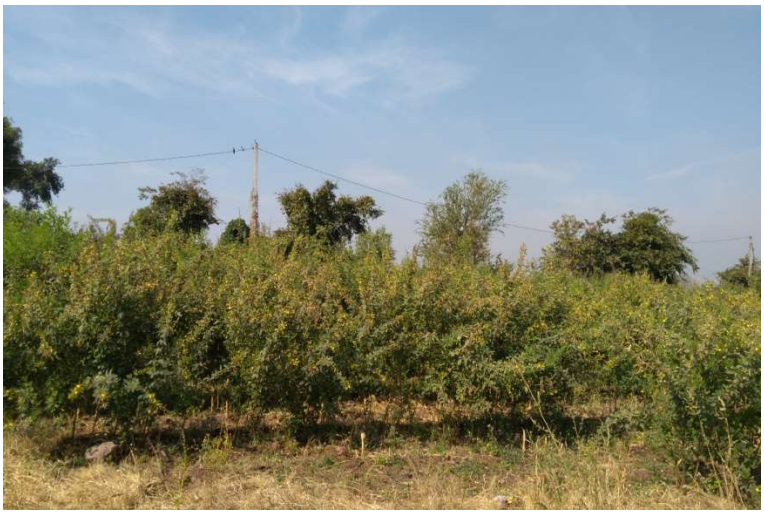


Figure 20
Pigeonpea agricultural field in Champaner-Pavagdh

Figure 21
Agricultural field in the forest area

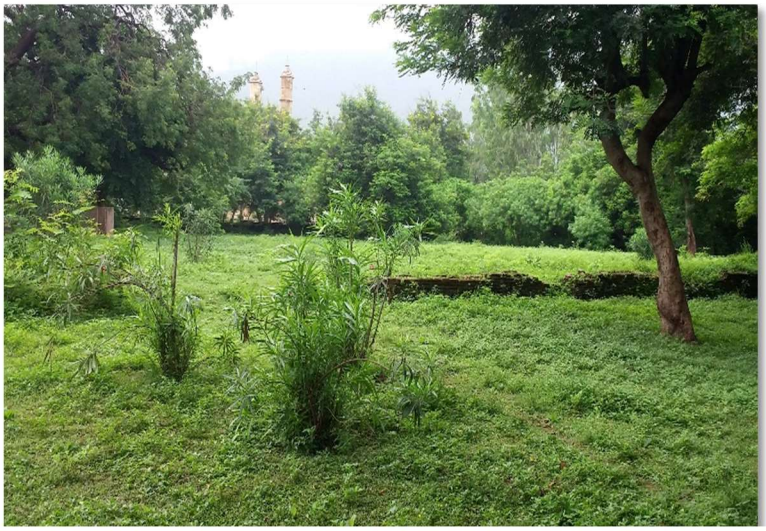


Figure 22
Garden in Pavagadh

COLLECTION METHODS

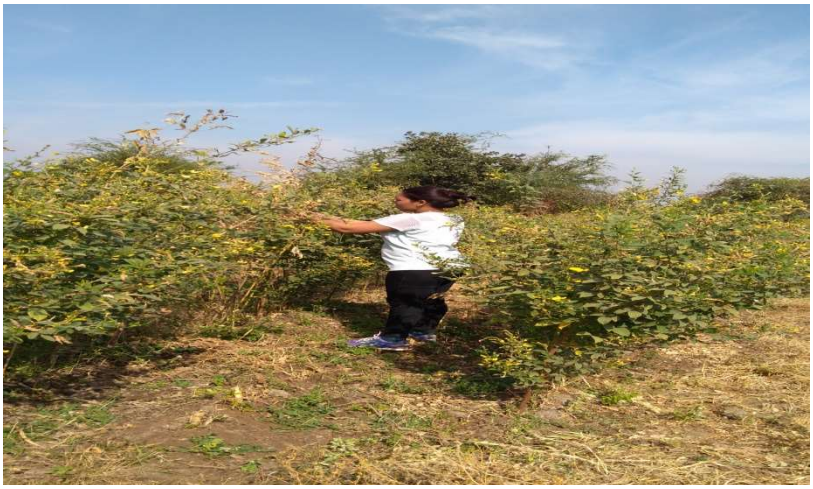


Figure 23
Active searching method

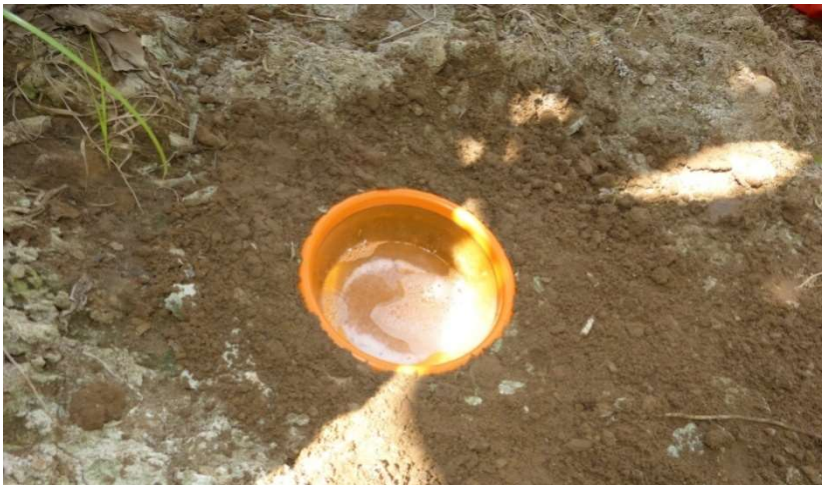


Figure 24
Pitfall trap method

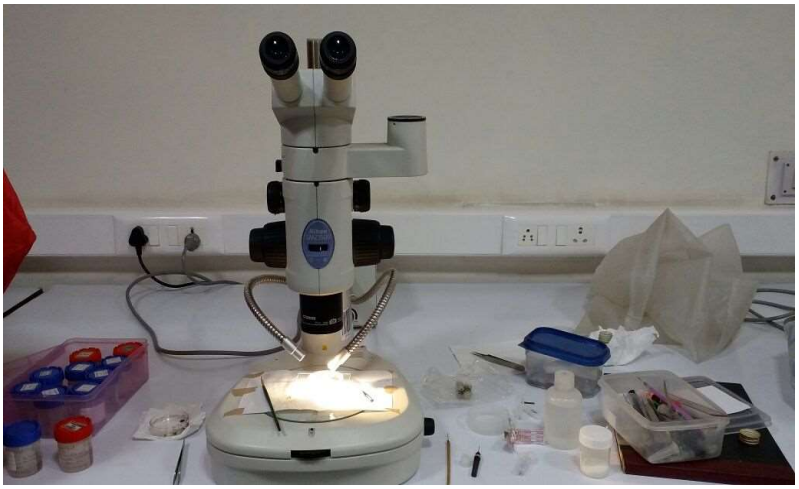


Figure 25
Stereo Microscope