



## Research Article

# Status and distribution of Red-backed Spider, *Latrodectus hasseltii* Thorell (Araneae: Theridiidae) in Gujarat state, Western India

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**ABSTRACT:** Specimens of *Latrodectus hasseltii* were collected from Gujarat State, Western India during 1970 to July 2015. All the records of its occurrence were placed together to establish its wide spread distribution and habitat association. It showed higher association with forest (36.6%) and wasteland (33.3%) habitats compared to agricultural (23.3%) and human residential (6.6%) habitats. *L. hasseltii* has been recorded from 11 forest areas, out of 13 forest areas surveyed intensively in Gujarat State. Out of nine crops studied in Gujarat state, *L. hasseltii* was recorded only from three crops (castor, cotton and lucerne).

**KEY WORDS:** Abundance, agricultural crops, distribution, Gujarat state, habitat association, *Latrodectus hasseltii*, red-back spider, Western India

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## INTRODUCTION

The widow spiders of the genus *Latrodectus* Walckenaer, 1805 (Theridiidae) are amongst the best known spiders on the earth. All members of this genus are believed to be deadly venomous and largest amongst the comb-footed spiders (Theridiidae) (Mc Crone, 1964). This genus is widely distributed throughout the drier parts of the tropics and warmer regions of the world (Murphy and Murphy, 2000).

The genus *Latrodectus* Walckenaer, 1805 is notorious over the world due to their mate feasting behavior by females and medical significance of the potent neurotoxin they possess (Mc Crone, 1964 Garb *et al.*, 2004). This genus is represented by 31 species globally, many of which are cosmopolitans occurring over many continents (Platnick, 2014). Considering medical significance of the genus *Latrodectus*, it is important that its distribution status is evaluated to check correlations with incidences of 'unknown insect bites', if any.

Till 2007, only *L. hasseltii* Thorell 1870 was known to occur in India (Pocock, 1900; Daniel and Soman, 1961; Tikader, 1987; Siliwal and Kumar, 2001; Siliwal and Molur, 2007; Hippargi *et al.*, 2012). In recent past *L. geometricus* Koch 1841, *L. elegans* Thorell 1898 (Kananbala *et al.*,

2012) and *L. erythromelas* Schmidt and Klaas 1991 (Srinivasulu *et al.*, 2013) have been added, making it a total of four species of widow spiders occurring in India. However, in Gujarat at least two species *viz.* *L. hasseltii* and *L. geometricus* are reported (Vasava *et al.*, 2015).

Red-backed Spider, *Latrodectus hasseltii* is distributed in South and South-east Asian countries including India (Pocock, 1900; Tikader, 1987; Murphy and Murphy 2000). It was initially reported from Karachi, Pakistan (Pocock, 1900) and India, including Pune (Simon, 1897; Pocock, 1900), Thane (Daniel and Soman, 1961) and Bhavnagar (Patel, 1971; Tikader, 1987). Its record from Vadodara district, Gujarat was considered as an additional record from Western India (Siliwal and Kumar, 2001). Later, this species was reported from Coimbatore, Tamil Nadu as range extension of the species to South India (Ganeshkumar and Siliwal, 2005), as published reports about its occurrence in India were very scanty (Siliwal and Kumar, 2001; Ganeshkumar and Siliwal, 2005). However, recently the species was also recorded from Great Indian Bustard Sanctuary, Nanaj, Solapur and Yedshi Ramling Wildlife Sanctuary, Osmanabad District (Hippargi *et al.*, 2012) and Melghat Tiger Reserve in Maharashtra (Rithe, 2012).

In India, *L. hasseltii* was considered to be a rare species when there were scanty published records. However that is not the case in Gujarat, as we have collected this species from entire Gujarat State, Western India and also published some information about its breeding behaviour (Patel and Pillai, 1987; Patel *et al.*, 1987) and occurrence (Patel and Vyas, 2001). Therefore, in this paper we present new information on the species distribution in Gujarat State, along with compilation of published records from Gujarat State, India.

## MATERIALS AND METHODS

The records of *L. hasseltii* reported here were largely made by the third author (BHP) during the survey of agricultural crops (Patel, 1987) and protected areas (Patel, 1999; Tatu *et al.*, 2001; Patel, 2002) from Gujarat State, Western India. Other records are either from unpublished thesis (Patel, 1971; Patel, 1985; Pillai, 1988; Sebastian, 1988; Pathan, 2003) or casual observations by co-authors made till July 2015.

Population dynamics of spider fauna was studied in the crops like cotton (*Gossypium hirsutum*), castor (*Ricinus communis*), groundnut (*Arachis hypogaea*), sugarcane (*Sacharum* sp.), bajra (*Pennisetum glaucum*), pigeon pea (*Cajanus cajan*) and fennel (*Foeniculum vulgare*) in nine districts of Saurashtra and north Gujarat during 1983 to 1986 (Patel, 1987). All the spiders encountered were collected manually from the crop canopy and using pit fall traps from the ground. In central Gujarat, Patel (2000) studied population dynamics of spider fauna in paddy crop (*Oryza sativa*) and Pathan (2003) did similar study in lucerne (*Medicago sativa*). Spider specimens were collected at weekly interval during the cropping period for two seasons (Parasharya and Pathan, 2013). In all the studies, relative abundance of all the species encountered was worked out.

Its closely related and similar looking species *L. erythromelas* Schmidt and Klaas (1991) was reported from Andhra Pradesh, India which is distinguished from *L. hasseltii* on the bases of absence of 'hour glass marking' on the ventral side (Srinivasulu *et al.*, 2013). Here, the dorsal and ventral view of the specimens showed species specific 'hour glass markings' which confirms their identity as *L. hasseltii*.

All the available Red-backed spiders specimens were closely examined with the help of literature (Tikader, 1987; Srinivasulu *et al.*, 2013), photographs were taken and a few of adults were kept alive for several days/months for studies before they were preserved.

## RESULTS AND DISCUSSION

### Confirmation of Identity

Female description (large adult): A jet black spider of *ca.* 11 mm length with long forelegs and prominent orange red/scarlet band on the dorsal side of the abdomen. Cephalothorax and abdomen black with a long longitudinal orange-red/scarlet band on the dorsum. Total length 10.80 mm, carapace 3.5 mm long, 3.35 mm wide; abdomen 7.25 mm long, 6.00 mm wide.

Abdomen: Black, globule, slightly narrowed on posterior side, slightly overlapping the posterior part of cephalothorax; dorsal side of abdomen ornamented with a broad longitudinal orange-red/scarlet band with uneven edges extending more than the posterior half of its length (Fig. 2), two brown oval spots on dorsum just anterior to the orange-red band. Ventral side with a small transverse reddish band in front of spinners.

Orange-red colour marking on ventral side was present in all the specimens, its size varied to some extent amongst the specimens. A broad transverse orange-red patch above the spinners was the prominent one. Two oblong red patches just below the Epigyne was second prominent red patch. Area on either side above the Epigyne was faint red (Fig. 4 and 6). All the specimens showed hourglass marking on the ventral side; the marking was more prominent in the freshly moulted adult females (Fig. 4, 5 and 6).

### Geographic distribution

Detailed information about the records of this species in Gujarat State, Western India is shown in Table 1 and Figure 1. The species was recorded from entire Gujarat State, except South Gujarat. The species have not been recorded from Bharuch, Surat, Tapi, Navsari, Dangs and Valsad districts of south Gujarat, in spite of intensive survey in Vansda National Park (Patel, 2000; 2003) and Purna Wildlife Sanctuary (Patel, 2004; Siliwal *et al.*, 2003) as Protected areas.

Over two decades study around Bhavnagar city, several specimens were collected from at least eight sites within 40 km radius of Bhavnagar city (Table 1, Sr. no. 1 to 4), which showed its wide spread distribution even within a district which was repeatedly surveyed for spider fauna. Looking at the distribution pattern recorded in the map (Fig. 1), it is clear that it has occurred at most of the protected areas which were intensively surveyed. Based on the present records, we conclude that the species is widely distributed at least in Gujarat State, Western India and may be distributed all over the state.

**Table 1. Chronological records of *Latrodactus hasseltii* from various localities of Gujarat State, Western India**

Sr. No.	Year	No. specimens	Habitat	Site of collection	Village/ District	Coordinates*	Reference
1	1970	1Female	Wasteland	Soil crevices, close to stream	Vartej, Bhavnagar	21°44'49.41"N 72° 3'10.38"E	Patel, 1971
2	1973-1993	Several	Wasteland	Soil crevices/ below stone	Akwada, Avania, Adhewada, Hathab, Talaja: Bhavnagar	21°42'40.57"N 72°12'29.92"E	BHP; Patel, 1985
3	1979	1 Female	Wasteland	Below stone, nr. Wetland	Sartapur, Ta. Talaja, Bhavnagar	21°18'35.32"N 72° 4'50.08"E	BMP
4	1979	Several	Forest	Below stone, nr. Wetland	Victoria Park (P.A.), Bhavnagar	21°44'50.81"N 72° 7'46.48"E	Patel & Pillai, 1987; Patel <i>et al.</i> , 1987
5	1983-1986	1 Female	Agriculture Cotton	Soil crevices	Rajkot; Rajkot	22°16'43.37"N 70°51'55.26"E	Patel, 1987; Pillai, 1988,
6	"	3 Female	Agriculture Cotton	Soil crevices	Vijapur; Mehsana	23°33'28.84"N 72°45'1.32"E	Patel, 1987; Sebastian, 1988
7	"	1 Female	Agriculture Castor	Soil crevices	Kadi; Mehsana	23°17'58.35"N 72°19'46.03"E	Patel, 1987; Sebastian, 1988
8	"	1 Female	Agriculture Castor	Soil crevices	Patan; Patan	23°51'2.91"N 72° 6'53.42"E	Patel, 1987; Sebastian, 1988
9	1996	2 Female	Forest	Below stone, close to wetland	Sukhi Dam, Pavi-Jetpur, Vadodara	22°17'54.37"N 73°54'55.39"E	RV
10	1998	1 Female	Forest	Below stone	Narielio, Hingolghadh WS(P.A.), Rajkot	22° 8'44.13"N 71°19'50.73"E	Patel, 1999; Patel & Vyas, 2001
11	1998	1 Female	Forest	Root base	Rampara WS (P.A.), Rajkot	22°37'14.01"N 70°56'33.49"E	BHP & RV
12	1999	1 Female	Forest	Below stone, near Canal bank	Jambughoda W.S. (P.A.), Panchmahal	22°21'58.15"N 73°42'36.85"E	RV& BMP
13	2000	1 Female	Forest	Below stone, close to water	Jambughoda W.S. (P.A.), Panchmahal	22°21'58.15"N 73°42'36.85"E	RV & BMP
14	1999	2 Female	Agriculture Cotton	Below Soil lump	Vadodara, Vadodara	22°18'21.59"N 73°11'13.59"E	Siliwal & Kumar, 2001
15	2000	1 Female	Forest	Below stone, on hillock	Udalmahuda,Ratanmahal W.S. (P.A.), Dahod		Patel, 2002
16	2001	1 Female	Forest	Below stone, on hillock	Landru point, Great Rann of Kachchh	23°50'9.32"N 69°55'59.09"E	RV & BHP
17	2002	1 Female	Agriculture Lucerne	Root base	Anand, Anand	22°32'11.32"N 72°58'56.07"E	Pathan, 2003
18	2002	1 Female	Forest	Base of wall,	Deri, Jessore S. B. S. (P.A.), Banaskantha	24°25'37.03"N 72°25'53.80"E	BHP
19	2004	1 Female		Nr. water pump			
19	2006	1 Female	Wasteland	Not known	Wankaner, Rajkot	22°37'14.01"N 70°56'33.49"E	Delvadia, 2007
20	2007	1 Female	Residential area	Below staircase	Bopal, Ahmedabad	23° 0'36.02"N 72°26'45.89"E	Santosh Gupta; personal communication
21	2007	2 Female	Wasteland	Below stone	Samot, Narmada	21°34'47.37"N 73°47'34.24"E	RV & BHP
22	2008	3 Female	Forest	Below stone	Samot, Narmada	21°34'47.37"N 73°47'34.24"E	RV & BHP
23	2008	2 Female	Wasteland	Below stone	Chotila, Surendranagar	22°25'33.34"N 71°11'16.67"E	Vishal Thoria, Shivbhadrasinh Jadeja, Chiku Vora; personal communication

24	2013	1 Female	Resident area	Below iron rack	Ahmedabad	23° 1' 36.62"N 72° 32' 41.19"E	Vishal Mistry, Prathmesh Patel, personal communication
25	2013	1 Female	Wasteland	Below stone, close to water	Vaso village, Kheda	22° 39' 41.69"N 72° 45' 30.88"E	Vishal Mistry, Prathmesh Patel, Personal Communication
26	2013	1 Female	Forest	Below stone, close to water	Targol dam, Jambughoda W.S.(P.A.) Vadodara	22° 20' 28.97"N 73° 39' 16.74"E	Kartik Upadhyay, Personal Communication
27	2014	1 Female & egg cocoon	Agricultural	Below stone	Nr. Narayan Sarovar, Kutch	23° 38' 55.07"N 68° 32' 49.61"E	RV
28	2015	1 Female & egg cocoon	Wasteland	Under the soil	Nr. Luvariya, Amareli	21° 36' 30.06"N 71° 23' 22.49"E	RV
29	2015	Several Juveniles	Wasteland	Below boulders	Tarkiya, Chotila, Surendranager	22° 29' 21.54"N 71° 9' 57.76"E	RV
30	2015	1 Juvenile	Wasteland	Below wooden log	Nr. Gunda, Rajkot	22° 16' 03.49"N 71° 7' 16.16"E	RV

(Abbreviations: PA = Protected Area; W.S. = Wildlife Sanctuary; Nr.= Near; In reference column, unpublished records by co-authors are abbreviated as follow: BHP = B. H. Patel; RV = Raju Vyas; BMP = B.M. Parasharya); \* Coordinates from Google Earth Maps, <http://www.googleearthmaps/>

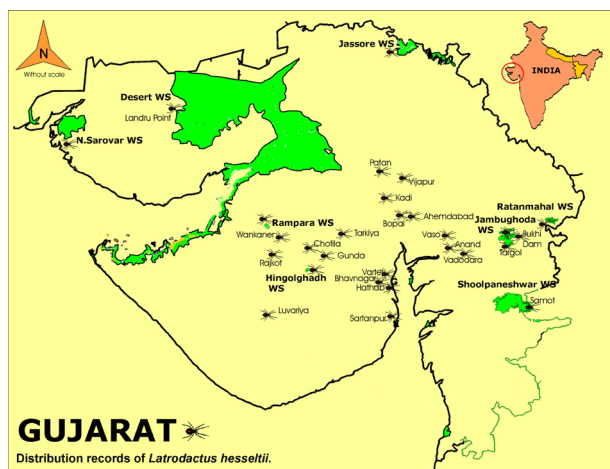
In spite of intensive survey of two forest areas of south Gujarat, particularly Vansda National Park (Patel, 2000) and Purna Wildlife Sanctuary (Siliwal *et al.*, 2003; Patel, 2004) the species was not recorded. These two Protected Areas are moist-deciduous Forests (Champion and Sheth, 1968) on the most northern end of Western Ghats. However, possibilities of its existence in these protected areas cannot be ruled out on the basis of habitat structures as some pockets of dry forest areas exists within the national park and sanctuary.

### Natural History

**Habitat:** Eleven (36.6 %) sightings were from forest area and ten (33.3 %) sightings from the wasteland. There were seven (23.3 %) records from the agricultural landscape. Two records (6.6%) from Ahmedabad were from the residential area; one from a building in middle of the city and other from outskirts of the city. Forest and wasteland (70.0% sightings) are relatively undisturbed habitats compared to agricultural landscape and residential area (30.0% sightings). Records of sightings in four habitats clearly showed habitat preference of *L. hasseltii*. Highest sightings were from forest area followed by wasteland. Forests and wastelands are natural habitats having minimum human disturbance to the spiders. On the other hand, there were seven (23.3%) sightings from agricultural landscape which has maximum human disturbance including pesticide applications which may cause heavy mortality of spiders and their insect preys.

Record of *L. hasseltii* in cotton field near Vadodara, Gujarat was considered as rare incidence (Siliwal & Ku-

mar, 2001) which may be a synchronized result of a few published references available. Moreover, record of a single specimen of *L. hasseltii* near Coimbatore, Tamil Nadu was considered as a distribution range extension (Ganeshkumar and Siliwal, 2005). In present study, repeated survey of a given area using appropriate sampling techniques helped to establish occurrence (in protected area) and abundance (in agricultural area) of *L. hasseltii*.



**Fig. 1.** Distribution records of *Latrodectus hasseltii* in Gujarat state, India.

**Sex Ratio:** Except for two records of males (Table 1), all sightings were of females. Males being much smaller in size remains unnoticed and also cannibalism is common in this group of spider, where female eat male after mating. These could be reasons for a few encounters of males than females. On the other hand, besides being larger, the females have jet black color with orange-red markings on

**Table 2. Relative abundance of *Latrodectus hasseltii* in some of the crops studied in Gujarat state**

Sr. No.	Crop	Year	Place of collection	No. of specimens collected & examined	No. <i>L. hasseltii</i>	% of <i>L. hasseltii</i>	Sources
1	Lucerne	2001-02	Anand	2943	1	0.033	Pathan, 2003; Parasharya & Pathan, 2013
2	Cotton	1983-86	Rajkot & Vijapur	11,686	4	0.034	Patel, 1987; Pillai, 1988; Sebastian, 1988
3	Castor	1983-86	Patan & Kadi	2754	2	0.072	Patel, 1987; Sebastian, 1988

the dorsal side of the abdomen (Fig. 2) and therefore easily noticed.

### Occurrence in Agricultural Crops

Published records about occurrence of a species in a given locality are largely qualitative. Such reports do not give information about relative abundance or frequency of sightings of the species in different habitats. However, quantitative studies in the agricultural landscape showed that relative abundance of *Latrodectus hasseltii* was very poor in the agricultural crops (Table 2). Out of nine crops studied in nine districts of Saurashtra and north Gujarat, *L. hasseltii* was recorded only from two crops. In cotton, it was recorded from Rajkot and Vijapur (Mehsana district) whereas in Castor it was recorded from Patan and Kadi (Mehsana district). Its relative abundance in cotton (0.034%) and castor (0.072%) crop was always low. The species was also recorded from lucerne crop with low abundance (0.033%) in Anand district, central Gujarat (Table 2). However, it was not encountered in the crops like groundnut, sugarcane, bajra, pigeon pea and fennel studied in nine districts of Saurashtra and north Gujarat (Patel, 1987) and in paddy crop in central Gujarat (Patel, 2000). Due to agricultural intensification, agro ecosystem is much more disturbed than natural habitats. Even within the agroecosystem, species richness and abundance of spiders was higher in the crops where tillage operations and pesticide applications were minimum (Sunderland and Samu, 2000). Amongst the crops, cotton consumes about 41.1 % of the total pesticides used in India (Vyas *et al.*, 1999). Naturally, the pesticides kill insect pests as well as their natural enemies. Hence, there are least chances of recording rare spiders in agricultural crops. In all the crops studied, its relative abundance was too low (Table 2). Lucerne is grown as a fodder crop and hence no pesticides are applied to it. As a result, the spider fauna survived well in Lucerne (Parasharya and Pathan, 2013). Castor and cotton crops in which *L. hasseltii* was recorded were very low input crops at that time; almost not receiving any pesticides. On the other hand, *L. hasseltii* has been recorded from 11 forest areas, out of 13 forest areas surveyed intensively in Gujarat State. Since it was repeatedly collected from the forested areas of Victoria Park, Bhavnagar, Jam-

bughoda Wildlife Sanctuary and Shoolpaneshwar Wildlife Sanctuary, it shows that this species prefers deciduous forest habitat. In Maharashtra, the species was also frequently encountered in the grassland of Nanaj Bustard Sanctuary (Hippargi *et al.*, 2012).



**Fig. 2. *Latrodectus hasseltii* female with dorsal large orange red patch, Chotila.**



**Fig. 3. *Latrodectus hasseltii* female with a faint hour-glass marking, Sagai.**

*Latrodectus hasseltii* is considered to be native of

Australia and later on spread to several countries in recent time. In India n sub continent, it was known to occur at least at Karachi and Poona (Simon, 1897; Pocock, 1900) in the 19<sup>th</sup> sanctuary. Present study shows that it is wide spread over larger area in Gujarat. As it is found in several remote areas, one wonders how its distribution might have been assisted by human being. In that case a comparison of mt DNA sequence with Australian specimens can throw light on genetic affinities between two populations. Hence, a study on genetic divergence of Indian *L. hasseltii* is urgently warranted.



Fig. 4. *Latrodectus hasseltii* female with a prominent hourglass marking, Ahmedabad.

We conclude that *L. hasseltii* is widely distributed in the natural habitats like forests and wastelands in Gujarat but occurs rarely in agroecosystem. Present findings show that *L. hasseltii* has continuous distribution right from Karachi (Pakistan) to Shoolpaneshwar Sanctuary in Gujarat and several parts of Maharashtra. It is likely that the species might occur between Nanaj (Maharashtra) and Coimbatore (Tamilnadu) if surveyed intensively.



Fig. 5. Freshly moulted *Latrodectus hasseltii* female showing side view of hourglass marking and reddish tinge on tarsus & metatarsus, Vaso.

Although experience show that *L. hasseltii* is non-aggressive, lactrodectism amongst humans due to black

widow spiders are severe (Brown *et al.*, 2008; Vetter and Isbister, 2008; Vetter *et al.*, 2012), its presence in the human dwellings and its probable dispersal to other parts of the country may pose a new health management issue which would require accurate data on status, distribution and behavior. Shukla and Broome (2007) suggested that, a study on the effect of spider bites and their antidote, pertaining to the Indian context is necessary. Considering medical importance of spiders, studies on spider diversity, in all areas of human dwelling is needed.



Fig. 6. Freshly moulted *Latrodectus hasseltii* female with prominent hourglass marking and reddish tinged on tarsus & metatarsus, Targol.



Fig. 7. Older *Latrodectus hasseltii* female with a faint hourglass marking and absence of reddish tinge on appendages, daughter of a female from Ahmedabad.

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## REFERENCES

- Brown KS, Nacaise JS, Goddard J. 2008. Additions to the known U.S. distribution of *Latrodectus geometricus* (Araneae: Theridiidae). *J Med Entomol.* **45**: 959–962.
- Champion HG, Sheth SK. 1968. *A revised survey of the forest types of India*. Government of India, Delhi.
- Daniel JC, Soman PW. 1961. Observations on the spider *Latrodectus hasseltii indicus* Simon with a note on arachnidism. *J Bombay Nat Hist Soc.* **58**(3): 823–826.
- Delvadia L. 2007. *Preliminary report of spiders of Morvi, Tankara and Wankaner*. M. Sc Thesis, Saurashtra University, Rajkot, Gujarat.
- Ganeshkumar G, Siliwal M. 2005. Range extension of *Latrodectus hasseltii* Thorell, 1870 (Araneae: Theridiidae). *Zoos' Print J.* **20**(11): 2072.
- Garb JE, González A, Gillespie RG. 2004. The black widow spider genus *Latrodectus* (Araneae: Theridiidae): phylogeny, biogeography, and invasion history. *Molecular Phylogenetic Evol.* **31**:1127–1142.
- Hippargi RV, Bolde PM, Manthen SV, Shaikh AR. 2012. Ecology of venomous spider *Latrodectus hasseltii* Thorell, 1870 (Araneae: Theridiidae) from Solapur and Osmanabad District, Maharashtra. *Indian J Arachnology* **1**(1): 169 – 174.
- Kananbala A, Manoj K, Bhubaneshwari M, Binarani A, Siliwal M. 2012. The first report of the widow spider *Latrodectus elegans* (Araneae: Theridiidae) from India. *J Threat Taxa.* **4**: 2718–2722, <<http://dx.doi.org/10.11609/JoTT.o3152.2718-22>>.
- Mc Crone JD. 1964. Comparative lethality of several *Latrodectus* venoms. *Toxicon.* **2**: 201–203.
- Murphy F, Murphy J. 2000. *An introduction to the spiders of South-East Asia*. Malaysian Nature Society, Kuala Lumpur.
- Parasharya BM, Pathan, VA. 2013. Diversity of spider fauna in Lucerne (*Medicago sativa* L.). *J Biol Control* **27**(4): 253–259.
- Patel BH, Pillai GK, Sebastian PA. 1987. Observation on cocoon spinning behavior and maternal care in *Latrodectus hasseltii* Thorell (Araneae: Theridiidae), pp. 41-49. In: Ismail SA, Alawdeen SS. (Eds.). *Aspects of Behaviour*. Department of Zoology, The New College, Madras, India.
- Patel BH, Pillai GK. 1987. Studies on sperm induction, courtship and mating behaviour of *Latrodectus hasseltii* Thorell (Araneae: Theridiidae), pp. 28-40. In: Ismail SA, Alawdeen SS. (Eds.). *Aspects of Behaviour*. Department of Zoology, The New College, Madras, India.
- Patel BH, Vyas R. 2001. Spiders of Hingolghadh Nature Education Sanctuary, Gujarat, India. *Zoos' Print J.* **16**(9): 589–590.
- Patel BH. 1971. *Studies on some spiders (Araneae: Arachnida) from Gujarat, India*. Ph D Thesis, Sardar Patel University, Vallabh Vidyanagar, Gujarat.
- Patel BH. 1987. Final Report of ICAR Research Scheme on Taxonomy, Biology, Ecology of spiders of Saurashtra and North Gujarat Regions. Department of Zoology, Sir P. P. Institute of Science, Bhavnagar University, Bhavnagar, Gujarat.
- Patel BH. 1999. Arachnida – Spiders, pp. 53-55. In: Singh HS. (Ed). *Biodiversity study on Hingolghadh Nature Education Sanctuary, Rajkot District, Gujarat State*. Gujarat Ecological Education and Research Foundation, Gandhinagar, Gujarat.
- Patel BH. 2000. Invertebrates: Spider fauna, pp. 71-78. In: Singh HS, Raval BR, Patel BH, Tatu K, Patel D, Vyas R, Patel BH. (Eds.). *Study on biodiversity on Vansda National Park*. Gujarat Ecological Education and Research Foundation, Gandhinagar, Gujarat.
- Patel BH. 2002. Invertebrates: Spiders, pp. 81-83, 193-196. In: Singh HS, Patel BH, Trivedi P, Raval DR, Pawar JS, Vyas RV, Patel BH. (Eds.), *Biodiversity study in Ratanmahals Wildlife Sanctuary*. Gujarat Ecological Education and Research Foundation, Gandhinagar, Gujarat.
- Patel BH. 2003. Fauna of Protected Areas in India - 1. Spiders of Vansda National Park, Gujarat. *Zoos' Print J.* **18**(4): 1079–1083.
- Patel BH. 2004. Spider fauna, pp. 57-62. In: Pandey CN, Patel SP, Chavan S, Salvi H, Patel BH, Vyas RV, Trivedi P, Jethva B, Aiyadurai A. (Eds.). *The status of biodiversity in Purna Wildlife Sanctuary*. Gujarat Ecological Education and Research Foundation, Gandhinagar, Gujarat.

- Patel DT. 2000. *Diversity, population dynamics, predatory potential and distribution of spiders in rice crop in Anand district, Gujarat*. M. Sc Thesis, Gujarat Agricultural University, Sardar Krushinagar, Gujarat.
- Patel SK. 1985. *Faunastic survey of spiders from Bhavnagar district, Gujarat State*. Ph. D Thesis, Bhavnagar University, Bhavnagar, Gujarat.
- Pathan VA. 2003. *Diversity, population dynamics and ground activity of the spiders in lucerne crop in Anand, Gujarat*. M. Sc Thesis, Gujarat Agricultural University, Sardar Krushinagar, Gujarat.
- Pillai GK. 1988. *Taxonomy and biology of some predaceous spiders from major agricultural crops of Saurashtra region, Gujarat*. Ph. D Thesis, Bhavnagar University, Bhavnagar, Gujarat.
- Platnick NI. 2014. *The world spider catalog*, version 15. American Museum of Natural History, online at <http://research.amnh.org/entomology/spiders/catalog/index.html> DOI: 10.5531/db.iz.0001
- Pocock RI. 1900. *Fauna of British India including Ceylon and Burma - Arachnida*. Taylor and Francis, London.
- Rithe K. 2012. Spider diversity from relocated area of Melghat Tiger Reserve. *Indian J Arachnology* **1**(2):92–105.
- Schmidt G, Klaas P. 1991. Eine neue *Latrodectus*-Spezies aus Sri Lanka (Araneida: Theridiidae). *Arachnologischer Anzeiger* **14**: 6–9.
- Sebastian PA. 1988. *Studies on the biology of some predaceous spiders on insect pests of some major crops of north Gujarat*. Ph. D Thesis, Bhavnagar University, Bhavnagar, Gujarat.
- Shukla S, Gour-Broome V. 2007. First report of the brown widow spider, *Latrodectus geometricus*. C. L. Koch, (Araneae: Theridiidae) from India. *Current Sci.* **93**: 775–777.
- Siliwal M, Kumar D. 2001. Rare sighting of poisonous spider *Latrodectus hasseltii indicus* Simon (Araneae: Theridiidae) in a cotton field in Baroda district, Gujarat. *Curr Sci.* **81**(9): 1170–1171.
- Siliwal M, Molur S. 2007. Checklist of spiders (Arachnida: Araneae) of South Asia including the 2006 update of Indian spider checklist. *Zoos' Print J.* **22**(2): 2551–2597.
- Siliwal M, Suresh B, Pilo B. 2003. Spiders of Purna Wildlife Sanctuary, Dangs, Gujarat. *Zoos' Print J.* **18**(1): 1259 – 1263.
- Simon E. 1897. Arachnides recueillis par M. M. Maindron a Mascate, en octobre 1896. *Bulletin du Museum (national) d'histoire naturelle. Paris*, 1897: 95–98.
- Srinivasulu C, Srinivasulu B, Javed SMM, Seetharamaraju M, Asha Jyothi S, Srinivasulu CA, Tampal F. 2013. Additions to the araneofauna of Andhra Pradesh, India - part II. Records of interesting species of the comb-footed genera *Latrodectus*, *Rhomphaea* and *Coleosoma* (Araneae: Theridiidae). *J Threat Taxa.* **5**(10): 4483–4491.
- Sunderland K, Samu F. 2000. Effect of agricultural diversification on the abundance, distribution and pest control potential of spiders: A review. *Entomol Exp Appl.* **95**: 1–13.
- Tatu K, Patel BH, Vyas R, Patel BH. 2001. *A study on bio-diversity in Kachchh desert wildlife sanctuary and its environs (Great Rann of Kachchh)*. (Preliminary Report), pp.165. Gujarat Ecological Education and Research Foundation, Gandhinagar, Gujarat.
- Tikader BK. 1987. *Handbook of Indian spiders*. Zoological Survey of India, Calcutta.
- Vasava AG, Patel M, Parasharya BM, Mistry V, Patel P, Mehta D, Patel D, Patel K. 2015. Records of brown widow spider, *Latrodectus geometricus* Koch 1841, (Araneae: Theridiidae) from Gujarat, western India with notes on its distribution, habitat and natural history. *Acta Arachnologica* **64**(1): 5–9.
- Vetter RS, Isbister GK. 2008. Medical aspects of spider bites. *Ann Rev Entomol.* **53**: 409–429.
- Vetter RS, Vincent LS, Danielsen DWR., Reinker KI, Clarke DE, Itnyre AA, Kabashima JN, Rust MK. 2012. The prevalence of brown widow and black widow spiders (Araneae: Theridiidae) in urban southern California. *J Med Entomol.* **49**: 947–951.
- Vyas AM, Pathak JS, Trivedi JR. 1999. *Pesticide industry: Yesterday, today and tomorrow*. Gujarat pesticides formulators association, Ahmedabad.