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ORIGINAL ARTICLE

ECOLOGY OF THE NILGIRI LARGE BURROWING SPIDER *HAPLOCLASTUS NILGIRINUS* POCOCK, 1899 (ARANEAE, THERAPHOSIDAE) OF NILGIRIS, INDIA

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ABSTRACT

The Nilgiri large burrowing spider, *Haploclastus nilgirinus* Pocock, 1899, an endemic tarantula in the Nilgiris Region of India, is critical for conservation yet poorly understood in terms of its ecology and habitat. This study addresses this gap by examining the nesting habits, tree-hole dynamics, and prey diversity of the species in Coonoor, The Nilgiris, specifically within tea plantations and fruit orchards. Observations focused on seven pear trees serving as nesting sites, with detailed measurements of nesting holes, including outer and inner circumference, depth, trunk base, ground-based height (gbh), and height from the ground. Data were collected over four consecutive months, both morning and evening. Insect diversity in the orchard was also assessed through counts and diversity indices, revealing variability among trees. The seventh tree had the highest spider population, with 13 spiders in 10 nests. Insect orders such as Blattodea, Orthoptera, Diptera, Hemiptera, and Lepidoptera were most prevalent around the seventh tree's nests. Across all trees, a total of 25 spiders in 21 nests were documented, with variations in hole size and other tree measurements. This research provides crucial insights into the nesting habits, tree-hole dynamics, and prey diversity of *this* species, informing conservation efforts for this vulnerable species. As *H. nilgirinus* faces threats from habitat destruction, climate change, and illegal trade, understanding its ecological needs is vital for developing effective conservation strategies and sustaining ecosystem health.

Keywords: Arachnid, Coexistence, Conservation, Microhylid, Western Ghats habitat.

INTRODUCTION

Haploclastus nilgirinus Pocock, 1899, belong to the family Theraphosidae (Order, Araneae), which is endemic to India. The genus *Haploclastus* Simon, 1892, consists of seven valid species: *H. tenebrosus* Gravely, 1935; *H. cervinus* Simon, 1892; *H. validus* (Pocock, 1899); *H. nilgirinus* Pocock, 1899; *H. kayi* Gravely, 1915; *H. satyanus* Barman, 1978; and *H. devamatha* Prasanth and Jose, 2014 (World Spider Catalogue, 2022). Previously, there were eight species within *Haploclastus*, but recently, *Haploclastus himalayensis* Tikader, 1977, was transferred to the genus *Chilobrachys* Karsch 1892, based on generic characteristics

(Siliwal and Raven, 2010). *H. nilgirinus* is found predominantly in the Nilgiris, enclave, under holes in tree trunks. Compared to the burrows of other mygalomorph groups, theraphosids are comparatively easy to find since they have open entrances (Siliwal *et al*., 2013).The ecology and habitat of this species have not been extensively studied; there is a need to test the hypotheses about the underlying mechanisms of syntopy and sympatry which may be applicable to tarantulas which is lacking due to the dearth of ecological studies on these populations (Lapinski, 2020).

Spiders can serve as biological markers of natural ecosystems and provide information on how communities respond to environmental disturbances or changes (Marc and Canard, 1997). South and Central American theraphosid spiders, also known as bird-eating spiders, are very common in the pet trade (Molur and Siliwal, 2004). *Thrigmopoeus psychedelicus* (Sanap and Mirza, 2014), is the most strikingly colored tarantula species from India, likely to be in high demand as a pet, that may have a negative impact on the wild population (Sanap and Mirza, 2014). This study is a brief framework on *H. nilgirinus* ecology that is aided for tarantula conservation. Tarantulas are vulnerable groups which may face extinction due to habitat destruction, climate change, and illegal trade.

We studied the habitat ecology of *H. nilgirinus* from Coonoor, The Nilgiris, as well as the tree burrow characteristics of the species in order to understand the microhabitat characteristics and preference. This study examined the diversity of the spiders and the insects at the sampling sites, as well as the prey choice of the spiders, also provided some notes on the diet, sympatric species, coexistence, and egg sacs of this species. Thereby, the study was developed to understand the ecology of the lesser known *H. nilgirinus* focusing on its future conservation.

MATERIALS AND METHODS

Study area and specimens collection: The research was undertaken at Coonoor (11°20'52.4"N 76°47'23.6"E), The Nilgiris from during the year November 2022 to February 2023. The specimen was identified using Moinudheen *et al*. (2017). The study area consisted of tea plantations and fruits orchards. *H. nilgirinus* nesting holes were investigated in 7 pear trees. Measurements of the nesting holes (Tab.1) were taken separately for all the trees, along with the distance between the trees. Trees bore at least one hole that was occupied by *H. nilgirinus* of different age classes; thus, measurements were systematically taken for all the occupied tree holes along with their age class through visual comparison. A total of 21 tree holes were investigated from tree 1 to tree 7. Trees 1, 2 and 3 had one hole each. Tree 4 had two holes, tree 5 and 6 had three holes each, and tree 7 had ten holes. Theraphosids are known to be nocturnal, sit-and-wait predators. Males are often observed roving, looking for females at certain times during the morning hours (Costa and Pérez-Miles, 2002).

Micro and macro habitat data were taken from the orchard. The research was conducted in the morning from 8.30 a.m to 9.30 a.m and in the evening from 8.30 p.m to 9.30 p.m on the same day. The study was conducted over four consecutive months. Standard measurement tools were used. Photographs were taken using a Nikon P900 camera fitted with an 83x optical zoom lens. Temperature and rainfall for the four months were taken consecutively. The geo locations of the trees were taken and mapped using Qgis Software, Ver 3.1(QGIS Development Team, 2019). The raster file of the sampling area was extracted from Google Earth Engine and worked in Qgis software. The nesting trees were marked in the raster file using the geo coordinates.

Calculation method: The numbers of spiders were counted, the sizes of the spider holes and the height of the trees were taken, and the statistics were computed using descriptive statistics that summarized the data. The data summary includes the mean, median, mode, standard deviation, maximum value, minimum value, and variance (Borkar and Seth, 2020).The prediction interval was calculated with an interval in which subsequent observations would fall with a specific probability using the observed sample statistics of mean and standard deviation (Penell *et al*., 2018). Number of insect on individual trees and the diversity of insects in and around the trees was calculated.

The data were collected to understand the diet of *H. nilgirinus* and the sympatric association with other species. The study also focused on estimating the species diversity of insects, reptiles, and amphibians in the vicinity of nesting trees. The diversity of insects was high, and therefore various diversity indices like Shannon-Weiner index (H'), Simpson diversity index (D), Margalef index (Dmg), Pielou Evenness (J'), and Berger-Parker dominance index were used for analyses ($p < 0.05$).

Map (1): Showing the sampling sites.

RESULTS

Insect diversity: Insects were identified according to order. The quantifications of spider nests included the number of tree holes in individual trees, age class of spider, outer circumference of holes, inner circumference of holes, hole depth, tree trunk base, girth at breast height (GBH), and height from ground. Diversity quantifications are tabulated in Table (1), and presented visually in Diagram (1).There are a total of 25 spiders that inhabit the tree holes. We have classified the spiders as large, medium, small, based on their sizes. In the orchard, there were a total of 25 spiders in 21 nests in 7 trees.

More spiders and nests were located in the seventh tree. The seventh tree housed 13 spiders under 10 nests, which comprised 4 adults, 5 juveniles, 2 sub adults, and 2 sub juveniles. Three nests, each with an adult, a sub adult, and a sub juvenile were located in the sixth tree at a much lower level in comparison with the other six trees. Insects from a total of 11 orders were studied: Blattodea, Coleoptera, Dermaptera, Diptera, Hemiptera, Neuroptera, Orthoptera, Phasmatodea, Polydesmida, Lepidoptera, and Hymenoptera. Orthoptera 1.381, Diptera order 1.378, Hemiptera 1.373 and Blattodea 1.364 make up the majority of the insect orders in the garden. The insect order with the least number is Phasmatodea, followed by Coleoptera (1.305), Dermaptera (1.354), Neuroptera (1.355), Polydesmidae (1.352), Lepidoptera (1.355), and Hymenoptera (1.376). Insects were found to be visible around the nesting trees during the nocturnal hours while surveying for *H.nilgirinus*. The order Blattodea (Cokcroaches), Orthoptera (Grasshoppers, Crickets, Treehoppers), Coleoptera (June Beetles, Flower Chafers), Lepidoptera (Moths), and Hemiptera (Bugs) were the most common insects found in the area around the spider nests in the 7th tree. The most frequent orders in the fifth tree were Blattodea, Diptera, Orthoptera, and Hemiptera; the most numerous orders in the fourth tree were Blattodea, Orthoptera, and Diptera; and the most frequent insect orders in the third tree were Blattodea, Orthopera, Diptera, and Coleoptera.

The orders of insects that were prey to *H. nilgirinus* included: Blattodea, Orthoptera, and Lepidoptera. The location and tree with the most insects and holes was tree number seven. This tree had the greatest number of insects. *H. nilgirinus* primarily consumes katydids, cockroaches, and grasshoppers. *H. nilgirinus* has pedipalps, which were used to sense the prey and drag it with its claw (Quade *et al*., 2019). All theraposid spiders have scopulae and claw tufts, which are sticky and used for prey capture and mobility, primarily when climbing (Pérez-Miles, 2020).

Table (1): Insect Diversity from the sampling sites.

S. No.	Order	Simpson_1-D	Shannon_H	Evenness_e^ H/S	Margalef	Berger-Parker
1	Blattodea	0.7391	1.364	0.9783	0.5066	0.319
2	Coleoptera	0.7116	1.305	0.9216	0.5009	0.3534
3	Dermaptera	0.7328	1.354	0.9679	0.6635	0.3587
4	Diptera	0.746	1.378	0.9918	0.4081	0.2871
5	Hemiptera	0.7436	1.373	0.9867	0.4679	0.2906
6	Neuroptera	0.734	1.355	0.9694	0.6558	0.3505
7	Orthoptera	0.7472	1.381	0.9946	0.4152	0.296
8	Phasmatodea	0.6328	1.143	0.7843	1.0820	0.500
9	Polydesmida	0.7341	1.352	0.9663	0.6846	0.325
10	Lepidoptera	0.7345	1.355	0.9687	0.4485	0.3238
11	Hymenoptera	0.7448	1.376	0.9895	0.4657	0.2994

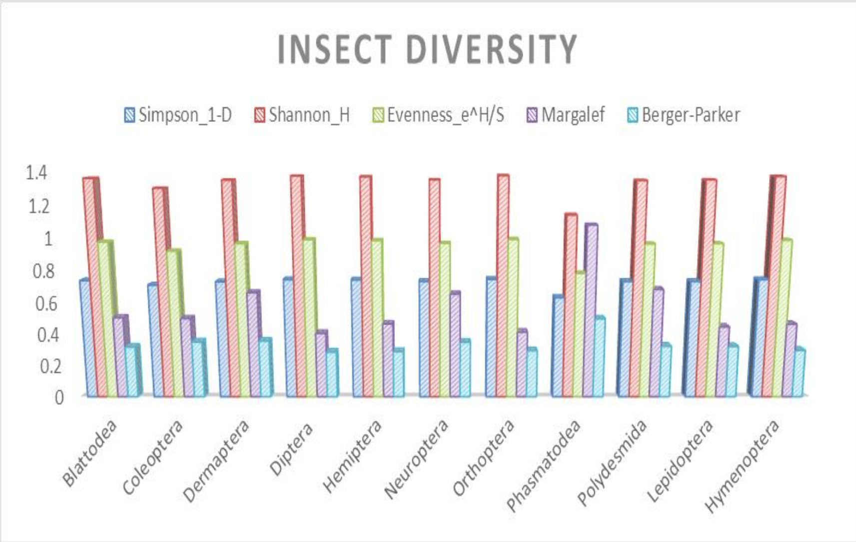

Diagram (1): Histogram of the Insect Diversity from the sampling sites.

Tree-hole dynamics: There were a total of 25 individuals under 21 burrows of *H. nilgirinus*. All the burrows were found only in trees. The outer circumference of the occupied tree holes was a minimum of 2 cm, and a maximum of 90 cm, with an average of 23.5 cm. The inner circumference of the occupied tree holes was a minimum of 1.5 cm, a maximum of 120 cm, and an average of 22.3 cm. The depth of the tree holes was a minimum of 1.5 cm, maximum of 15 cm, and 6 cm, on average. The trunk base size was a minimum of 65cm, a maximum of 210 cm, and an average of 122 cm. The GBH had a minimum value of 60 cm, a maximum of 97 cm, and an average of 73 cm.

The tree hole occupancy of individuals was observed to be greater the size more than the number of individuals. In a total of 7 trees, *H. nilgirinus* was found to range from a minimum of one individual to a maximum of 10 individuals. Tree 1, 2, and 3 had only one individual each hole. The average values of tree hole size for the three trees are as follows, outer circumference: 14 cm, inner circumference: 7.1 cm, and depth: 6.8 cm. Tree 4 had two holes with three individuals. The first hole occupied two individuals, whereas the second hole occupied one individual. The first hole: outer circumference: 90cm, an inner circumference: 120 cm, and depth: 10 cm whereas the second hole: outer circumference: 5 cm, inner circumference: 3 cm, and a depth: 3 cm.

Trees 5 and 6 had three holes, each having one individual with an average value of outer circumference: 15.9 cm, inner circumference: 12.9 cm, depth: 7.01 cm. Tree 7 had a total of 12 individuals of various sizes that may have represented various age classes under ten tree holes. The tree holes supported a minimum of 1 and a maximum of 3 individuals. The maximum number of individuals was found to be smaller, where the tree hole had a measurement of outer circumference: 80 cm, inner circumference: 110 cm, depth: 4 cm. The average value for all the tree holes of tree 7 were, outer circumference: 26.2 cm, inner circumference: 24.7 cm, depth: 5.6 cm.

The occupancy of tree holes by more than one individual, as in the case of Tree 4 and Tree 7 can be attributed to their tree hole size. The average value for individual smaller ones was compared with the multiple ones as aforementioned, which showed a considerable difference as, outer circumference: 18.65 cm vs 90 cm, inner circumference: 13.95 cm, vs 90 cm, depth: 7.02 vs 9.6 cm. The results show that the hole size had a positive relationship with the number of individuals. Nevertheless, larger individuals who were suspected to be adults were known to be solitary and were also known to inhabit larger tree holes; outer circumference: 26.6 cm, inner circumference: 24.3 cm, depth: 6.75 cm.

The overall analysis of the data indicates that the number of occupied tree holes increases as the trees become larger. The size of the hole showed a negative correlation with the height of the variable (r= -0.025) (Diag. 2), thus there was no height preference between the animal sizes. The spiders of different sizes, which are assumed to be of different age classes, might have just filled the niche according to the availability of tree holes and size irrespective of tree height.

The highest variance was seen with the height from ground variable, followed by trunk base, inner circumference, outer circumference, GBH, and depth (Tab.2). This denotes that the trees were of different sizes, and thus there was more variance with the trunk base too. The least variance was observed in the depth, which shows the preference of spiders (Tab.2). Although there are many holes found in the tree, the spiders prefer tree-holes according to their age classes.

Table (2): Quantification of tree hole dynamics.

Value	Outer (cm)	Inner (cm)	Depth (cm)	Trunk base (cm)	Gbh	Height from ground
Mean	23.54286	22.34286	6.266667	122.381	73.90476	242.1429
Median	12	8	5	90	77	210
Mode	7	4	4	90	77	300
SD	24.75966	33.59757	3.854002	47.08023	12.26746	131.9615
Maximum	90	120	15	210	97	500
Minimum	2	1.5	1.5	65	60	65
Range	88	118.5	13.5	145	37	435
Variance	613.0406	1128.797	14.85333	2216.548	150.4905	17413.83

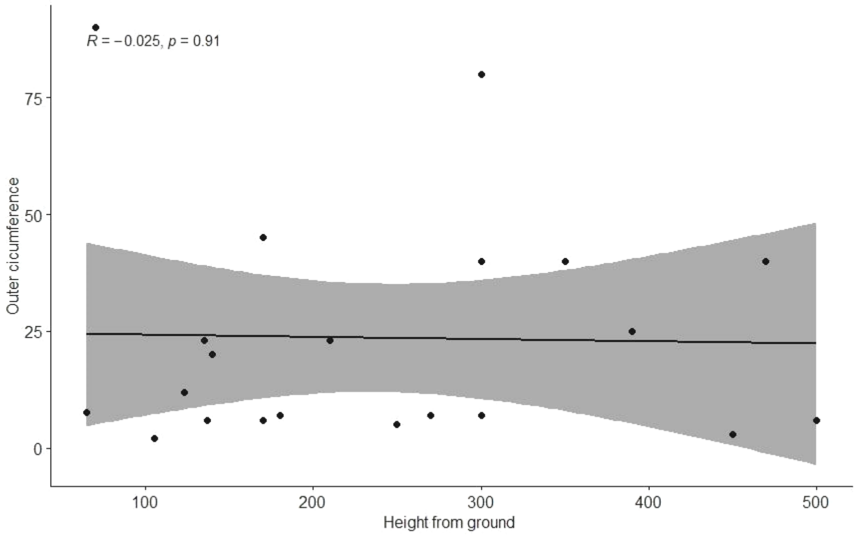

Diagram (2): Pearson correlation showing negative correlation between height from ground and outer tree-hole circumference.

Commensalism: The commensalism of spiders is a significant phenomenon since spiders and amphibians have mostly experienced this trait in various ecosystems. Commensalism is an interaction where one species benefits while the other species neither benefits nor receives harm (Siliwal and Ravichandran, 2008). In this study, we have been examining commensalism between *H. nilgirinus* and Traingular spotted frog *Uperodon triangularis* (Günther, 1876) for 4 months. They coexisted in the same nest without interfering with one another (Pl. 1). This observation thus accounts for sympatric and syntopic relationships. They were found to co-occur next to each other without any disturbance. Both species were found active during the night times sitting on the edge of the tree-hole, while during diurnal hours they spent their time inside the holes. There have been a few species of theraphosid spiders and microhylid frogs that are known to exhibit commensalism (Bascoulès *et al*., 2021). Population interactions within a community determine the community structure, variety, and how food webs are shaped. Competition, predation and other interactions can be both beneficial and detrimental (Steffenson, 2014). The observation is however, novel in terms of the species *H. nilgirinus*.

Plate (1): *H. nilgirinus* and *Uperodon triangularis* coexisted in the same nest without interfering with one another.

This study was conducted to understand the ecology of the poorly studied *H. nilgirinus* from an orchard of the Nilgiris. In the present study, the tree-hole dynamics of the spider and the diversity of insects at the sampling sites were recorded. There were a total of 18 trees, but the spiders were seen only in the pear trees which included 7 trees in total. The pear trees in the orchard naturally had holes in the tree crevices. The spider which occupied tree-holes were arranged in such a way that sunlight did not enter, but one hole was positioned in a direction where sunlight directly entered through it, but it seemed that the spider had plugged the hole using prey debris and its own exuviae. However, this artificial facade was absent in other trees (Pl. 2).

Spider web dynamics: In this study, we do not discuss reproduction; however, we have already witnessed this spider's courtship rituals. The male spider vibrated his body similarly to the female spider when they were together, close to the third spider web, but the female spider did not possess the same. There was a possibility for seismic signals to be the primary communication route used by burrowing tarantulas, especially during courting, given the benefits of seismic signals and the frequent occurrences of vibration activity in theraphosids (Ferretti, 2020).

Sympatry: We encountered *Cnemaspis* sp. and *Dravidogecko* sp. geckos in the same trees, along with the spiders, during nocturnal hours of the field work. While looking for tiny insects in the fifth tree, an adult *H. nilgirinus* approached the edge of the hole, and caught the *Cnemaspis* sp., and then entered back into the hole. Their primary sources of food were insects, spiders, and worms, but they also consumed a variety of other taxa including fish, mammals, birds, reptiles, and even extremely poisonous poison dart frogs (Hénaut and Machkour-M'Rabet, 2020). The majority of the time, these spiders would hunts at night. Usually, a few spiders emerged from the hole and waited for food 10 cm away. In every circumstance, these spiders relied on the hole (Pl. 3). It would drag itself inside the nest as soon as it received food.

***Haploclastus nilgirinus* egg sac:** In our study, we had the opportunity to observe the egg sac of *H. nilgirinus* (Pl.4). Remarkably, the size of the egg sac measured an impressive 4.2 cm. This spider's egg sac fell while cutting down a tree. Mirza *et al*. (2011) reported that the eggs of *H. validus* Pocock, 1899 were laid post winter or in the onset of summer. Likewise, in the study *H. nilgirinus* was observed to lay eggs during the winter season. During the breeding period, we made an intriguing observation regarding the behaviour of *H. nilgirinus*. We found that these fascinating creatures exhibited a unique mating ritual, where they would close their nests tightly with mud. This behaviour serves as an exceptional adaptation, providing a protective enclosure for their eggs and ensuring the safety of their offspring. By including these remarkable findings in our research article, we shed light on the reproductive strategies of *H. nilgirinus.*

Plate (2): Plugged hole entrance with prey debris and exuviae.

Plate (3): *Haploclastus nilgirinus* rely on the hole.

Plate (4): Egg sac of *H. nilgirinus*.

DISCUSSION

H. nilgirinus is a nocturnal tarantula that has a complex ecology due to its ambush and secretive lifestyle. The study found that they were arboreal and semi arboreal by nature. The occupied tree-hole dynamics reveal some important key points, such as, the age based preference upon depth variable and the negative correlation between height from ground and outer circumference, which explains filling the niche. The study also found that other than depth, and size of individual there was no variable that is found to influence the nesting ecology of *H. nilgirinus*.

The habitat of *H. nilgirinus* was found to inhabit pear trees that had also been represented by a variety of insect species of different orders. Theraphosidae can feed mostly on insects, including Lepidoptera (particularly Saturniidae and Sphingidae), Hymenoptera, ants, beetles, cicadas, grasshoppers, crickets, and termites (Baerg, 1958; De Wet, 1991; Pérez-Miles *et al*., 2004). *T. vagans* also preys on larger, more energetic prey, such as cockroaches, more frequently than other forms of species (Dor and Hénaut, 2013). In one study, coleopterans from the genus of *Eleodes* Eschscholtz, 1829 are found to be captured less frequently than inoffensive prey like crickets, despite the fact that chemical may be collected and eaten but only make up a very minor fraction of their diet (Minch, 1978).

The observation of other insects shows their diversity and importance, which thereby appears to influence the foraging ecology of *Haploclastus nilgirinus*. During the study, we found that the nocturnally active species such as *Dravidogecko* sp., *H. nilgirinus*, and *Uperodon triangularis* in the study area were found to be very sensitive to artificial light at night. Along with *H. nilgirinus* the *Dravidogecko* sp was found to be strictly nocturnal and thus was found to be disturbed under ALAN (Artificial Light at Night). This study is a base line study initiated to understand the nesting ecology of a lesser known tarantula species from the Nilgiris. The species, although poorly studied, it has a potential threat of international pet trading, which adds to the risk prone scenario along with habitat destruction. Conservation managers and experts are warranted to find a mitigation regime for their conservation.

The ecology of the *H. nilgirinus* is not well understood, but it is known to inhabit moist evergreen forests, and burrow into the soil. It is also known to feed on insects, and likely plays an important role in controlling insect populations in its habitat.

CONCLUSIONS

In conclusion the study identifies some key areas to concentrate that would enhance the conservation of *H. nilgirinus*, including: Protection of habitat, the spider's habitat is threatened by deforestation and habitat fragmentation. Protecting and restoring the forests where the spider lives is essential for its survival. Avoidance of pesticides: Pesticides can harm the spider and its prey, and should be avoided in areas where the spider is known to live. Education and awareness: Raising awareness among local communities, forest officials, and policymakers about the importance of the spider and its role in the ecosystem can help garner support for conservation efforts.

Research and monitoring: Further research on the ecology and behaviour of the spider is needed to better understand its conservation needs. Regular monitoring of populations can also help track changes and inform conservation actions. Captive breeding and reintroduction: if wild populations continue to decline, captive breeding and reintroduction programs may be necessary to maintain genetic diversity and ensure the long-term survival of the species. In summary, conservation efforts for the Nilgiri large burrowing spider should focus on protecting its habitat, avoiding pesticide use, raising awareness, conducting research and monitoring, and implementing captive breeding and reintroduction programs if necessary.

CONFLICT OF INTEREST STATEMENT

"The authors declare no conflict of interest"

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بيئة عنكبوت نيلجيري الكبير الحفار 1899 ,*Haploclastus nilgirinus* Pocock (Araneae, Theraphosidae) في نيلغيري، الهند

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الخلاصة

عنكبوت نيلجيري الكبير الحفار 1899 ,*Haploclastus nilgirinus* Pocock، هو عنكبوت نيلجيري مستوطن في منطقة نيلجيريس في الهند، وهذا أمر بالغ الأهمية للحفظ ولكنه غير مفهوم جيدًا من حيث بيئته وموائله. تتناول هذه الدراسة هذه الفجوة من خلال فحص عادات التعشيش، وديناميكيات ثقب الأشجار، وتنوع الفرائس للأنواع في كونور، ونيلجيريس، وتحديدًا داخل مزارع الشاي وبساتين الفاكهة. ركزت الملاحظات على سبع أشجار كمثرى تعمل كمواقع تعشيش، مع قياسات تفصيلية لفتحات التعشيش، بما في ذلك المحيط الخارجي والداخلي، والعمق، وقاعدة الجذع، والارتفاع الأرضي height ground-based (gbh)، والارتفاع عن الأرض. جمعت البيانات على مدى أربعة أشهر متتالية، في الصباح والمساء. كما تم تقييم تنوع الحشرات في البستان من خلال التعداد ومؤشرات التنوع، مما يكشف عن التباين بين الأشجار. الشجرة السابعة لديها أكبر عدد من العناكب، مع 13 عنكبوتًا في 10 أعشاش. كانت رتب الحشرات مثل Blattodea وOrthoptera وDiptera وHemiptera وLepidoptera هي الأكثر انتشارًا حول أعشاش الشجرة السابعة. في جميع الأشجار، تم توثيق ما مجموعه 25 عنكبوتًا في 21 عشًا، مع وجود

اختلافــات في حجــم الحفــرة وقياســات الأشــجار الأخــرى. يقــدم هــذا البحــث رؤى مهمــة حــول عــادات التعشــيش، وديناميكيــات ثقــب الأشــجار، وتنــوع فرائســة، ممــا يرشــد جهــود الحفــاظ على هــذه الأنــواع المعرضــة للخطــر. نظــرًا لأن هــذا النــوع يواجــه تهديــدات ناجمــة عــن تــدمير الموائــل وتغيــر المنــاخ والتجــارة غيــر المشــروعة، فــإن فهــم احتياجاتــه البيئيــة يعــد أمــرًا حيويًــا لتطــوير اســتراتيجيات الحفــاظ الفعالة والحفاظ على صحة النظام البيئي.