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Original article

Natural history of the trapdoor spider *Idiops joida* Gupta et al 2013 (Araneae: Idiopidae) from the Western Ghats in India

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ABSTRACT

We studied the habitat preferences and burrow characteristics of trapdoor spiders, *Idiops joida* Gupta et al 2013, within Dandeli Wildlife Sanctuary and nearby reserve forests of Uttara Kannada district of Karnataka, Western Ghats, India, from January 2010 to April 2010. We sampled 293 plots using 5 m^2 quadrats, randomly placed in six habitat types at four localities. Spiders showed patchy distribution throughout the study area. The density of *I. joida* was highest in uncanopied habitats having sparse vegetation or bare grounds. Steep slopes were strongly preferred by spiders. Burrow characteristics of *I. joida*, such as burrow diameter, depth, and lid thickness, were independent of habitat type.

Introduction

Studies on mygalomorph spiders in the Western Ghats started during the British colonial period. This area has been relatively well explored as compared to other regions of the country (Siliwal et al 2013). The main focus of the study has been species documentation (Siliwal et al 2013). Information on the ecology, biology, and behavior remains poorly documented. The natural history and ecology of long-lived mygalomorphs need to be documented so that rational conservation plans can be implemented. This species was also selected because it is highly vulnerable to habitat modification and habitat destruction due to its sedentary habit, extended maturation time, and prolonged nesting time. Therefore, the present study was undertaken to understand habitat preference and burrow characteristics of *Idiops joida* Gupta et al 2013 (Mygalomorphae: Idiopidae) across different habitats.

Materials and methods

The study was carried out in Dandeli WLS and nearby reserve forests of the Uttara Kannada district (13°55′–15°32′ N latitude; 74°05′–75°05′ E longitude) of Karnataka, northern Western Ghats, India. The area is classified as the Northern Evergreen Zone (Champion and Seth 1968; Daniels 1989), in which the moist deciduous and semi-evergreen forest types predominate.

We selected four different locations in the study site: Kulgi, Potoli, Kumbarwada, and Joida. Within each location, we sampled six habitat types: moist deciduous forest, mixed forest, semi-evergreen forest, teak plantations, human settlements, and agricultural fields.

The sampling was carried out between 0700 hours to 1300 hours from January 1, 2010 to April 30, 2010. In each habitat ($n = 6$), sample points were randomly selected using Global Positioning System (GPS) coordinates on Google maps. At each point, a 5×5 m^2 quadrat was laid out with a minimum distance of 250 m between quadrats. A total of 293 quadrats were placed in the study area (76 in Kulgi, 64 in Potoli, 85 in Joida, and 68 in Kumbharwada). Differences in the number of quadrats in each location are because some of the randomly generated quadrat points ($n = 100$) fell in areas that were not accessible and were omitted.

The number of active and inactive burrows was counted in each quadrat. Burrows with closed, intact lids and spiders inside were considered active, whereas those with missing or worn-out lids and no spiders inside were considered inactive. We also recorded microhabitat parameters (percentages of canopy cover, vegetation cover, rock cover, and bare ground) around every active burrow within a radius of 1 m.

For burrow characteristics, we measured diameter, depth, and lid thickness for 10 females and 10 juveniles in every habitat, except in moist deciduous and semi-evergreen forests, where we measured three and two burrows, respectively, because there were

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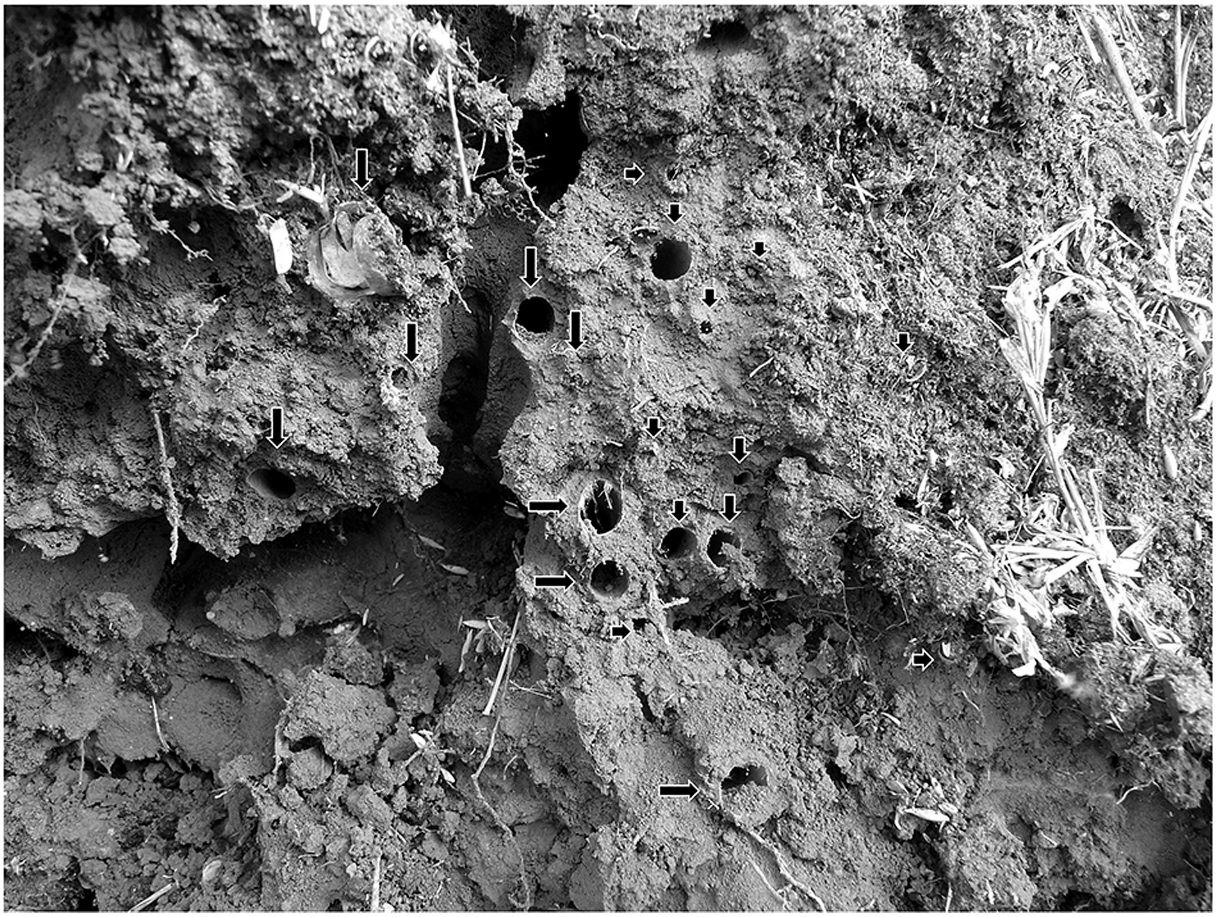

Figure 1. Partially excavated area, showing multiple burrows (shown with arrows) of *Idiops* in close vicinity.

fewer active burrows. Female and juvenile burrows were identified by body size. For burrow morphometry, we directly measured the depth of excavated burrows (in cross-section). Burrow characteristics of males were not recorded because males were found wandering, hidden in temporary hideouts, and not in their burrow during the study hour. A few burrows of gravid females were also excavated to collect the egg sacs.

From each quadrat, one to two adult specimens were collected for confirmation of the species and preserved in 70% ethanol. Variations in active burrow density (number of active burrows/area surveyed), area of occupancy (quadrats with active burrows/total quadrats $\times$ 100), microhabitat parameters (see above), and burrow characteristics (diameter, depth, and lid thickness) across different habitat types were tested using Kruskal–Wallis test, Wilcoxon signed rank test, and regression analysis.

All specimens collected are deposited in the museum collection of Wildlife Information Liaison Development Society, Coimbatore, Tamil Nadu, India.

Table 1. Record of *Idiops joida* across different habitat types and ecological parameters.

Habitat type	Total area sampled (ha)	Total quadrats	Quadrats with burrows	Burrows with spiders or occupied burrows (total number of burrows)	No. of nesting females	Active (occupied) burrow density/ha	Area of occupancy or % quadrats with active burrows (total number of quadrats)	Elevation range	Canopy cover (%)	Vegetation cover	Rock cover (%)	Bare ground (%)
Mixed forest	0.165	66	33	87 (114)	5	527.27	50.00 (66)	490–655	18	22.6	0.2	77.2
Moist deciduous forest	0.103	41	10	25 (46)	2	242.72	24.39 (41)	468–631	28.8	22.4	0.1	77.5
Semi-evergreen forest	0.088	35	4	9 (9)	2	102.27	11.43 (35)	521–682	59.8	53.5	0.1	46.4
Teak plantations	0.103	41	11	87 (87)	0	844.66	26.83 (41)	499–626	10.4	26.6	0	73.4
Human settlements	0.118	47	13	121 (121)	0	1025.42	27.66 (47)	497–634	16.9	9.7	0	90.3
Agriculture fields	0.158	63	11	101 (101)	1	639.24	17.46 (63)	522–615	12	10.9	0.3	88.8
Total	0.735	293	82	430 (554)	10	3381.58	27.99 (293)		—	—	—	—

Table 2. Slope preference of *Idiops joida*.

Type of slope (road-cut) (°)	Angle (°)	Total active burrows	Bund height (m)	Burrow height on bund (m)
Steep	46–90	357	1.2	0.8
Moderate	10–45	21	1.2	0.9
Gentle	< 10	52	0.2	0.1
Total		430		

Results and discussion

Habit and habitats

I. joida were solitary burrowers and nocturnal like many other mygalomorphs (Tso et al 2003; Ferretti et al 2010). They showed a patchy distribution in all study areas. The majority of burrows appeared to be clustered within quadrats (Figure 1), but we did not measure nearest-neighbor distances. *I. joida* burrows were found in 82 of 293 quadrats sampled during the study, with an overall area of occupancy of 27.9% (Table 1).

I. joida were found across most of the quadrates (active burrows in 50% quadrats), but at medium density (527 burrows/ha) in the mixed forest (Table 1). The highest burrow density (639–1025 burrows/ha) was found in human settlements, teak plantations, and agricultural fields, the three open habitats where burrows were clustered (active burrows < 28% quadrats). However, no significant difference was observed between the active burrow densities and the area of occupancy of *I. joida* ($H = 2.077$, df = 5, $p = 0.838$) and microhabitat parameters (percentages of canopy cover, vegetation cover, and bare ground) ($H = 0.786$, df = 5, $p = 0.978$) across different habitats (Table 1). In addition, distribution of burrows in different quadrates (percent area of occupancy) and burrow densities also did not vary significantly ($Z = -1.826$, $p = 0.68$) across open and closed habitats (Table 1). Human disturbance (clearing of vegetation, cutting of road sides for maintenance and widening of roads, and fire) and the decrease in habitat quality due to fragmentation and clearing of vegetation could be responsible for clustering of burrows in these habitats. Semi-evergreen forest with the lowest burrow density and area of occurrence was the least preferred habitat by these spiders. This could probably be because these spiders do not like moist grounds for burrowing.

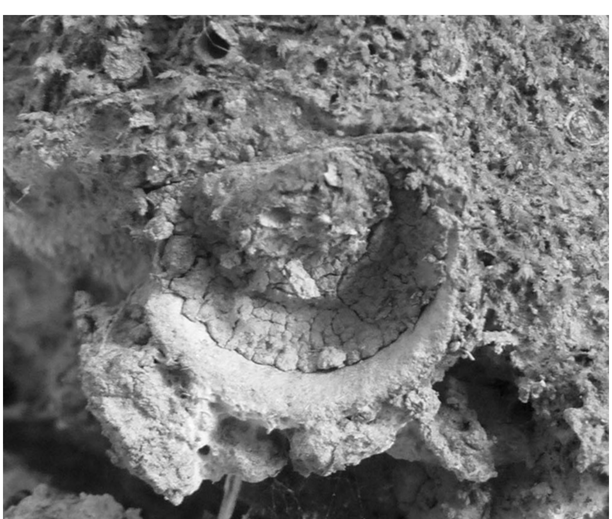

Figure 2. Closed trap-door burrow entrance.

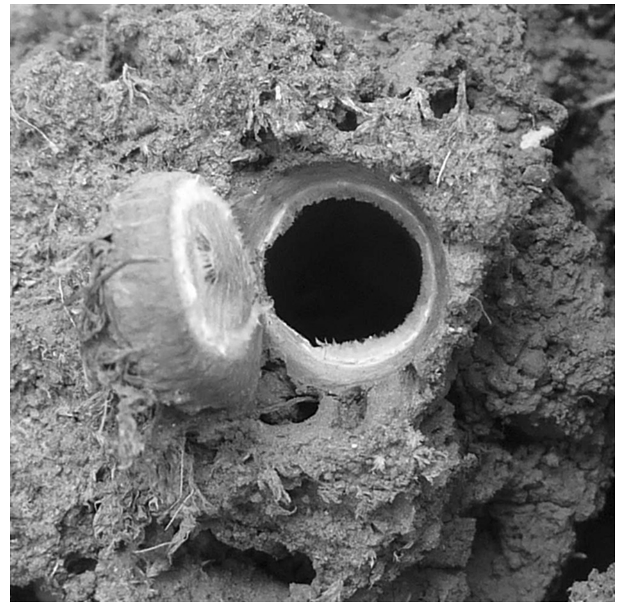

Figure 3. Open trap-door burrow showing crock-shaped thick door of the burrow.

Microhabitats

The trapdoor burrows were found on barren ground, and occasionally on termite mounds or in soil deposited at the base of trees. Most burrows (83% of active burrows) were found on steep slopes. Similarly, burrows of *Ummidia* sp. are located on steep sloping (60–90°) earthen embankments in Costa Rican rain forests (Bond and Coyle 1995). The Uttara Kannada district also gets heavy rains, which could be the probable reason for *I. joida* to prefer steep slopes to escape from flooding of burrows during rain. A Chi square test ($\chi^2 = 482.24$, df = 2, $p < 0.001$) also indicated a significant difference between the numbers of active burrows across different slopes (Table 2). Most active burrows (357 of 430) were found on steep slopes of 46–90°. Few burrows (21 of 430) were found on

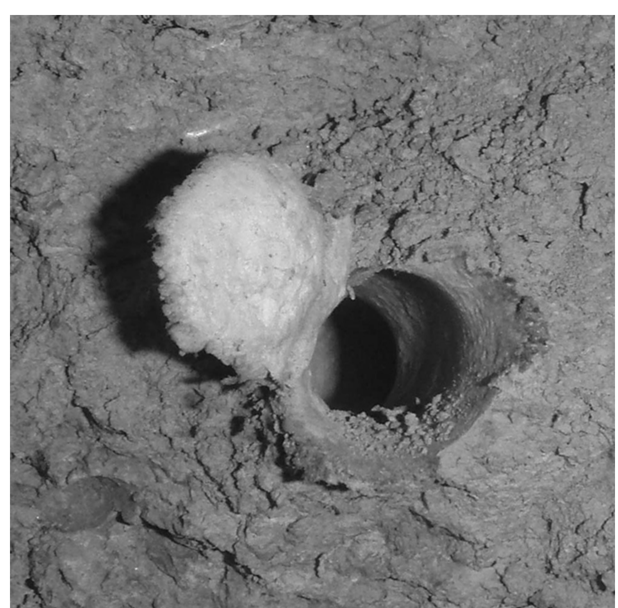

Figure 4. Thin lid or door of the trap-door burrow.

Table 3. Burrow characteristics of females and juveniles of *Idiops joida* across different habitat types.

Sample no.	Habitat	Female				Juvenile			
		No of burrows analyzed	Burrow diameter (mm)	Burrow depth (mm)	Lid thickness (mm)	No. of burrows analyzed	Burrow diameter (mm)	Burrow depth (mm)	Lid thickness (mm)
1	Mixed forest	10	8.5 ± 2.6	70.5 ± 18.0	2.8 ± 3.3	10	4.1 ± 0.9	45.5 ± 6.4	1.3 ± 0.4
2	Moist deciduous forest	3	8.8 ± 3.5	72.9 ± 42.2	1.5 ± 0.8	3	4.5 ± 1.1	39.3 ± 7.4	1.4 ± 0.5
3	Semi-evergreen forest	2	6.6 ± 2.1	40.4 ± 11.6	1.4 ± 0.5	2	5.0 ± 1.4	47.5 ± 10.6	1.8 ± 0.4
4	Teak plantations	10	9.6 ± 1.6	74.2 ± 33.1	2.6 ± 1.1	10	4.1 ± 1.3	38.7 ± 5.7	1.4 ± 0.5
5	Human settlements	10	11.2 ± 1.9	77.9 ± 32.6	2.3 ± 1.1	10	4.1 ± 0.7	42.0 ± 5.4	1.4 ± 0.5
6	Agricultural fields	10	9.9 ± 3.3	67.5 ± 23.5	1.2 ± 0.3	10	4.3 ± 0.7	45.0 ± 8.5	1.5 ± 0.4
Overall		45	9.1 ± 2.5	67.2 ± 26.8	2.0 ± 0.7	45	45	43.0 ± 7.3	1.5 ± 0.4

intermediate slopes of 10–45°. Flat ground or gentle slopes of < 10° had more active burrows than intermediate slopes (52 of 430).

Burrows were found on roadside-cut height ranged from 0.1 m to 4.5 m (mean 1.2 m) and burrows were located from 0.0 m to 3.5 m height (mean 0.8 m) on these roadside-cuts.

In human settlements, agricultural fields, teak plantations, and mixed forest, active burrow density (527–1025 burrows/ha) was higher and canopy cover was low (10–20%, Table 1). By contrast, active burrow density was very low (102–243 burrows/ha) in moist deciduous and semi-evergreen forests, where canopy cover was ≥ 29% (Table 1). Overall, 98% of active burrows were recorded where there was little ground cover (bare ground > 50%; Table 1). Therefore, our data suggest that *I. joida* may prefer to burrow in wide open areas. Above-ground vegetation and associated roots could obstruct construction and widening of burrows by spiders. Similar observations were recorded for other trapdoor spiders, *Ummidia* sp. (Ctenizidae), from Costa Rica, where the majority of burrows were located on nonforested grounds or in very young secondary growth forests (Bond and Coyle 1995). However, regression analysis indicated that burrow density variation was not significant with the percentages of canopy cover (r^2 = 63.2%, p = 0.059), vegetation cover (r^2 = 51.3%, p = 0.110), bare ground (r^2 = 51.7, p = 0.107), and rock cover (r^2 = 09.4, p = 0.55) (Table 1). Moreover, a Kruskal–Wallis test (H = 0.786, df = 5, p = 0.978) indicated no significant difference between habitat types for microhabitat parameters (percentages of canopy cover, vegetation cover, and bare ground), and Wilcoxon signed rank test showed that the percent area of occupancy and burrow densities did not vary significantly (Z = −1.826, p = 0.68) for open and closed habitats (Table 1). Therefore, preference of *I. joida* to open canopy over closed canopy areas is subject to further investigation.

Figure 5. Egg sac of *I. joida* Gupta et al 2013.

Burrow structure and morphometry

I. joida constructed simple tube-like burrows, with "D"-shaped trapdoor lid (Figure 2) from the outer side and rounded on the inner side. Thickness of the trapdoor or lid varied considerably, and accordingly, we placed burrows into two categories: those with 1.3–7 mm thick cork-like doors (Figure 3) and those with 2.1–2.5 mm thin, flat doors (Figure 4). According to Main (1957), the trapdoor spiders with cork-like burrow lids are found in flood plains of Australia, suggesting these lids are an adaptation to prevent water from entering the burrows.

The inner surface of burrow lids of *I. joida* was lined with silk, as reported in the case of other trapdoor spiders (Tso et al 2003; Leroy and Leroy 2005). However, unlike *Ummidia*, in *Idiops*, we observed a unique pattern of silk thread arrangement. The silk was knitted in a direction parallel to the hinge (not continuous with the door hinge) on the inner side of the lid, whereas in *Ummidia* the inner surface of lid is covered with a thick layer of silk and is always continuous with the entrance rim and burrow lining (Bond and Coyle 1995). The outer surface of burrow lids in *I. joida* was covered with dry moss and soil particles, camouflaged with the surroundings (Figure 2), which is common among various trapdoor spiders of Idiopidae as well as Ctenizidae, Barychelidae, and Nemesiidae (Bond and Coyle 1995; Tso et al 2003). It makes the burrow a very effective shelter cum trap by helping the spider remain unnoticed by prey as well as predators. Additionally, some *I. joida* doors possessed a small raised "cuff" or "hook", carved as a mound of soil particles mixed with plant debris of dry moss or grass. It is likely that these were much older burrows.

In most of the burrows, doors were attached to the burrow either horizontally or vertically, and rarely tilted, unlike in case of *Ummidia* sp., where the burrow lids are reported to be tilted in most cases, although occasionally they are horizontal or vertical (Bond and Coyle 1995). The entrance rim of the door was either exactly fitted with the outer substrate or it has a silken extension up 1–4 mm beyond the entrance of the burrow.

We observed three types of burrow shapes in *I. joida*: straight, gently curved, and C shape. Burrow diameters ranged from 2 mm to

18 mm, and the depth was 10–185 mm in the active burrows. The burrow diameter was found to be almost constant throughout the descending depth of the burrow without being widened at the base, irrespective of age class (juveniles or adults except for the nesting females), as reported in the case of *Ummidia* (Coyle 1981; Bond and Coyle 1995). Further, the overall burrow diameter in case of gravid or nesting females, in comparison to non-nesting females, was found to be larger with a wider diameter at the bottom. A similar burrow shape was reported in case of antrodiaetids and many other burrowing mygalomorphs, in which the posterior end of the burrows, irrespective of sex, has been reported to be larger in diameter than the rest of the burrow (Coyle 1971). According to Coyle (1971), the widening of burrow at the base is an adaptation to provide the spider space for turning around, ensnaring prey, molting, and keeping egg sacs and spiderlings. In *I. joida*, the overall burrow size (diameter, depth, and lid thickness) of females was found to be larger than that of juveniles (Table 3), suggesting that the burrow diameter is in proportion to the body size of the spider. It is also supported by Wilcoxon signed rank test, which indicates a significant difference between burrow characteristics (diameter, depth, and lid thickness) of females (all adults) and juveniles ($Z = -1.992$, $p = 0.046$). However, we did not find significant differences between burrow characteristics of females (Kruskal–Wallis test, $H = 1.070$, df = 5, $p = 0.957$) and juveniles ($H = 1.126$, df = 5, $p = 0.952$) across different habitats (Table 3). These results indicate that the burrow characteristics of the species vary widely during different growth stages of the species and are not dependent on habitat types. Main (1957) reported differences in lid thickness of burrows across different habitat types in case of Australian trapdoor spiders of the tribe Aganipinnae (now under Idiopidae). In case of Indian species *I. joida*, lid thickness is probably related to the age of burrow rather than to habitat types. However, more detailed study across different stages of spiders in different seasons is required to understand the behavior of these spiders.

I. joida nested from mid-March onward until June–July (MS per. Obs.). Egg sacs of *I. joida* were ovoid with a flattened upper surface (Figure 5). The number of eggs in 10 egg sacs ranged from 50 to 250 (mean = 102 eggs). The number of eggs may be correlated to the body size of the spider or burrow diameter, but the sample size was too low to derive any conclusion. Moreover, information on the dispersal of spiderlings from their natal burrow was not collected.

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