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Termitophagy and kleptoparasitism by *Menemerus bivittatus* (Dufour, 1831) (Araneae: Salticidae: Chrysillini) in India

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Spiders are perhaps the most diverse true predators (Begon et al., 1996; Coddington & Levi, 1991). Spider species are known to specialise in one of six arthropod prey categories, including ants, termites, spiders, woodlouse, moths, and flies (Pekár & Toft, 2015). However, most species are polyphagous, generalist predators (Pekár et al., 2011). Many generalist predators avoid the former prey categories except for flies because of their chemical or physical defences, aggressive or defensive behaviour, and social organisation. Predators with specialised hunting skills have developed adaptations that make it easier to catch and process prey (Pekár & Toft, 2015). Therefore, it may be better to specialise to avoid competition from other generalist predators, and to gain access to more, often plentiful, food sources (Nentwig, 1986). Optimal foraging theory predicts that an increase in prey food quantity will increase specialisation by predators (Pyke et al., 1977).

Termite communities represent dense populations and a variety of creatures, from arthropods to mammals, have taken advantage of this situation, often feeding exclusively on termites (Dippenaar-Schoeman et al., 1996a; Sheppe, 1970; Wesołowska & Haddad, 2002). The most important termite predators may be ants (Sheppe, 1970). Other termitophagous arthropod predators include beetles (Coleoptera: Staphylinidae: *Zyras*), centipedes, true bugs (Reduviidae), phasmids and spiders (Nel, 1970; Sheppe, 1970).

Termites, the most frequent arthropod decomposers in tropical woodlands, can be found in large numbers and in various habitats (Collins, 1983; Bignell & Eggleton, 2000). Their presence influences both biotic and abiotic components of a tropical environment (Pardeshi et al., 2010). The Indian termite fauna has been constrained by the country's high altitude and extreme temperatures. The north-eastern parts of India have a greater diversity of species than the rest of the country. An estimated 35 of India's 337 termite species are associated with damage to both agriculture and buildings. *Odontotermes* are the most common mound-builders in India. *Coptotermes*, *Heterotermes*, *Microtermes*, *Microcerotermes* and *Trinervitermes* are the most common subterranean genera in India (Paul et al., 2017). *Odontotermes obesus* was identified as a pest on all crops, regardless of their stage of development (Pardeshi et al., 2010).

Several spider species from various families (Ammoxenidae, Gnaphosidae, Philodromidae, Salticidae, Thomsidae, Theridiidae and Zodariidae) have been commonly found in association with different termites (Vandenberg & Dippenaar-Schoeman, 1991; Dippenaar-Schoeman et al., 1996a, 1996b; Dean, 1988; Wilson & Clark, 1977; Nel, 1970; Sheppe, 1970; Michálek et al., 2021; Wesołowska & Haddad, 2002; Jackson, 2000; Li, 1996; Haddad & Wesolowska, 2006; Hesse, 1942; Marshall et al., 2015; Eberhard,

1991). Some species are only *termitophilous* (permanently residing in the termite mound), while others are *termitophagous* (prey on their hosts; Table 1). According to one stable isotope study, spiders are the top predators of the invertebrate food web in *termitaria* (termite mounds), but they rarely prey directly on the termites (De Visser et al., 2008).

Table 1. Spiders known to feed on termites. Almost half of these termitophagous spiders are salticids.

Family	Species	Field Obs.	Lab Obs.	References
Ammoxenidae	*Ammoxenus amphalodes*	*	*	Vandenberg & Dippenaar-Schoeman, 1991; Dippenaar-Schoeman et al., 1996a, 1996b
	Ammoxenus coccineus	*		Dean, 1988
	Ammoxenus daedalus		*	Wilson & Clark, 1977
	Ammoxenus pentheri	*		Dippenaar-Schoeman et al., 1996a, 1996b
	not identified	*		Nel, 1970
Gnaphosidae	*Asemesthes* sp.	*	*	Vandenberg & Dippenaar-Schoeman, 1991
	Haplodrassus stationis	*	*	Vandenberg & Dippenaar-Schoeman, 1991
	Zelotes vryburgensis	*	*	Vandenberg & Dippenaar-Schoeman, 1991
Philodromidae	*Philodromus* sp.	*		Nel, 1970
Salticidae	*Chalcotropis* sp.		*	Li, 1996
	Cyrba algerina	*		Michálek et al., 2021
	Cyrba ocellata		*	Jackson, 2000
	Cyrba simoni		*	Jackson, 2000
	Euophrys sp. 1		*	Li, 1996
	Euophrys sp. 2		*	Li, 1996
	Heliophanus termitophagus	*		Michálek et al., 2021; Wesołowska & Haddad, 2002
	Menemerus bivittatus	*		Tripathy, 2022 (present study)
	Phlegra sp.	*	*	Vandenberg & Dippenaar-Schoeman, 1991
	Siler sp.		*	Li, 1996
	Stenaelurillus sp. 1	*		Haddad & Wesołowska, 2002
	Stenaeurillus sp. 2	*		Haddad & Wesołowska, 2002
	Telamonia masinloc		*	Li, 1996
	not identified	*		Sheppe, 1970
Thomisidae	*Heriaeus* sp.	*		Nel, 1970
Theridiidae	*Latrodectus indistinctus*	*	*	Hesse, 1942; Vandenberg & Dippenaar-Schoeman, 1991
	Janula sp.	*		Marshall et al., 2015
	Chrosiothes tonala	*		Eberhard, 1991
Zodariidae	*Diores salisburyensis*	*		Sheppe, 1970

Several salticids, including *Cosmophasis bitaeniata* (Allan & Elgar, 2001) and *Menemerus* spp. (Jackson et al., 2008; Huston 2017) are known to *snatch* food from ants (engage in *kleptoparasitism*). *Menemerus* were observed as they watched a column of ants on the wall of a building, turned to grasp prey from the mandibles of ants with their chelicerae, and then moved away from the ants to feed.

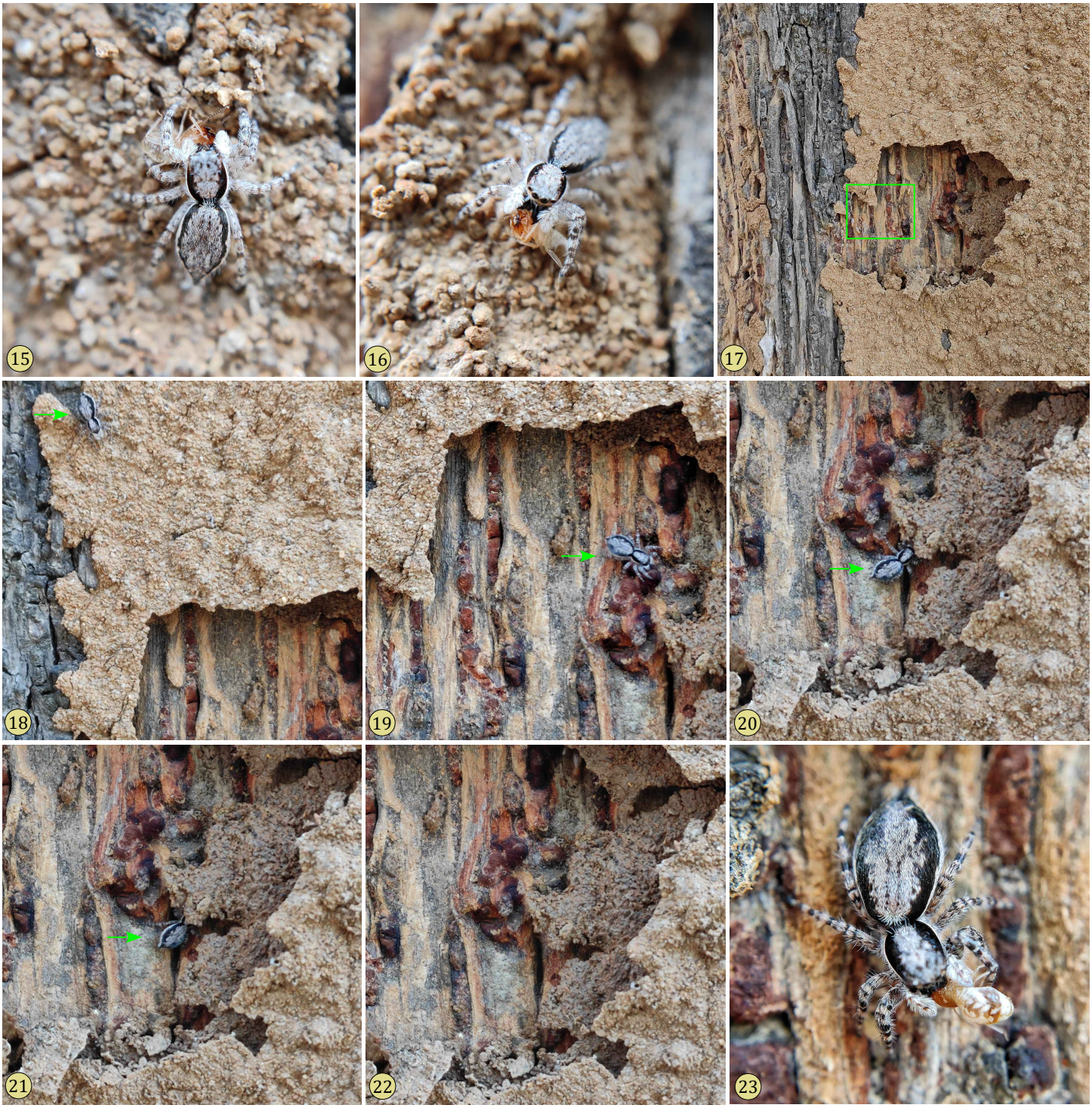
On 24 March 2022, at 14:30, while observing the termite damage on a *Neolamarckia cadamba* tree in Birsa Agricultural University (23.449158°N, 85.31716°E) at Ranchi, Jharkhand, India, I first observed the termitophagy and kleptoparasitism behaviour of two different *Menemerus bivittatus*. One female *M. bivittatus* was watching termites near a recently formed *Odontotermes* termite nest (Figures 1-6). This spider did not attack directly, and did not enter the small, open paths into the nest. Instead, it waited for the termites to appear, and then grabbed a worker (not a soldier) caste termite. I also watched a small ant (unidentified sp.) holding a termite worker on the same tree, and subsequently observed an immature *M. bivittatus* snatching this termite away from the ant. The tussle between this spider and the ant continued for half a minute, until the ant released its hold on its prey (Figures 7-11).

On 25 March 2022, at 10:25, a different, darker *M. bivittatus* was observed as it fed on a termite (Figures 12-13). Later on the same day, at 15:11 and 15:21, other *M. bivittatus* were seen feeding on both worker and soldier castes of these termites (Figures 14-16). On 28 March 2022, at 12:03, a gravid female *M. bivittatus* was observed as it entered a termite nest that I had opened, and then caught one of these termites (Figures 17-23).

Figures 1-3. Termites (*Odontotermes* sp.). **2,** Detailed view of workers. **3,** Soldier (at bottom) and worker castes.

Figures 4-6. Female *Menemerus bivittatus* hunting on a newly formed termite nest. **5,** Detail of 4. **6,** Female *M. bivittatus* with captured termite (*Odontotermes* sp.).

Figures 7-14. Female *Menemerus bivittatus* preying on termites (*Odontotermes* sp.). **7-11,** Snatching a termite from an ant. **12-13,** Dark female *Menemerus bivittatus* feeding on a captured termite. The carapace of this spider was apparently rubbed (scales removed). **14,** Another female feeding on a captured termite.



Figures 15-23. Female *Menemerus bivittatus* preying on termites (*Odontotermes* sp.). **17-23,** Sequence showing a gravid female entering the opened termite nest to capture a termite. **17,** Three termites are visible inside of the green rectangle. 18-**21,** Female (green arrows) approaching and then entering the termite nest. **22,** View of nest after the female has entered it. **23,** Feeding on a captured termite.

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