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continued on the back inside cover

Caption: Stripe-backed Weasel *Mustela strigidorsa*. Medium—digital, Software—procreate, Device—iPad + Apple pencil © Dhanush Shetty.



## New record of *Myrmarachne melanocephala* MacLeay, 1839 (Araneae: Salticidae) from Jharkhand, India and biogeographical implications of the co-occurrence of its ant model *Tetraoponera rufonigra* Jerdon, 1851

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**Abstract:** We report the occurrence of the ant-mimicking jumping spider *Myrmarachne melanocephala* MacLeay, 1839 for the first time from Hazaribagh Wildlife Sanctuary, Jharkhand, India. Digital illustrations and descriptions of the spider, the female's exuviae, and video records of a live male are also presented. The distribution pattern of *M. melanocephala* has not been studied in detail across India whereas its ant model, *Tetraoponera rufonigra* Jerdon, 1851 is known to have a wide distribution. Co-occurrence of the mimic and the model implies a wider range of biogeographical distribution of these species in India.

**Keywords:** Distribution, eastern India, exuviae, Hazaribagh Wildlife Sanctuary, jumping spider, mimicry, myrmecomorphy.

**Abbreviations:** ALE—anterior lateral eye | AME—anterior median eye | md—mid-dorsal | pd—pro-dorsal | PLE—posterior lateral eye | PME—posterior median eye | pv—proventral | rv—retroventral.

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**Author contributions:** Conceptualization of the research and manuscript writing was done by RK. Site visits, data collections and analyses were done by RK, MS and AKS. Manuscript was reviewed and finalized by AKS before communication. Correspondence to the journal and subsequent revisions were done by RK.

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## INTRODUCTION

Ant-mimicry (myrmecomorphy) is not very uncommon among arthropods. Most myrmecomorphs display Batesian mimicry where non-ant species mimic unpalatable and aggressive ants in order to avoid predatory attacks which is the result of adaptive evolution (Cushing 1997). Myrmecomorphy has achieved a distinct level of perfection among salticids (jumping spiders). The genus *Myrmarachne* MacLeay, 1839 is one of the largest salticid genera consisting of 186 accepted species globally out of which 23 are found in India but only six of them are well characterized and all of these species exhibit Batesian mimicry displaying profound morphological as well as behavioural resemblances towards ants (Caleb 2016; Prószyński 2016; Wanless 1978; World Spider Catalog 2021; Yamasaki & Ahmad 2013; Yamasaki & Edwards 2013; Caleb & Benjamin 2017; Caleb & Sankaran 2021).

The genus *Myrmarachne* forms part of a phylogenetic group of the subfamily Salticinae Blackwall, 1841 (Maddison 2015). *Myrmarachne melanocephala* MacLeay, 1839 is the type species of the genus *Myrmarachne* which was originally described from Bengal (which corresponds to present day West Bengal in India and Bangladesh combined) (Edwards & Benjamin 2009; World Spider Catalog 2021). *M. melanocephala* mimics the worker of *Tetraponera rufonigra* Jerdon, 1851, an arboreal ant with conspicuous eyes and long slender body (Pocock 1909). This species was originally described from the Carnatic-Malabar region (which corresponds to present day Indian states: Karnataka, Kerala, Tamil Nadu, and Andhra Pradesh) (Ward 2001). The genus *Tetraponera* Smith, 1852 belongs to subfamily Pseudomyrmecinae of Formicidae which is represented by 95 extant species globally, of which 10 are found in India (Bharti & Akbar 2014; Bolton 2021).

This paper is concerned with the discovery of *M. melanocephala* from Hazaribagh Wildlife Sanctuary, Hazaribagh, Jharkhand with detailed morphological descriptions and observation on its ant model *T. rufonigra*. For the first time, in addition an undamaged whole body exuviae of a freshly moulted female *M. melanocephala* has been used here as material for morphological descriptions of this spider. Both taxonomic as well as behavioural (mimicry related) aspects have been noted. The biogeographical implications of the co-occurrence of the mimic and the model together in the same habitat has also been discussed in the Indian context.

## MATERIALS AND METHODS

Sampling and collection were performed at Hazaribagh Wildlife Sanctuary, Hazaribagh, Jharkhand, India (Image 1). The spiders and ants were observed on and around Sal *Shorea robusta* trees. One male and two female spider specimens were spotted on a Sal tree trunk. The male specimen was captured alive and one freshly moulted female specimen and its undamaged whole body exuviae were manually collected and preserved in 70% ethanol for further investigations. The live male spider and ant specimens were photographed and videoed using a cellphone camera (Samsung M42). Measurements of the live male spider specimen were taken in millimeters (mm) using ocular micrometer placed within the eyepiece of a stereoscopic microscope by keeping the material on a cavity slide with a drop of water. A coverslip was temporarily placed over the cavity of the cavity slide in order to keep the material static for quick measurements. The water drop was added to create surface tension in order to keep the cover slip in firm position without killing the spider. The specimen was kept alive for behavioural studies. Note: one leg of the male spider got detached while trying to measure it alive. The ventral and dorsal sides of the palp and dentition of the live male spider were studied using hand-held magnifying glasses and stereoscopic microscope. The ethanol preserved specimen of the female spider was dissected for its epigyne, palp, and head containing chelicerae and fangs using a fine surgical scalpel. Epigyne was cleared by boiling it in 10% potassium hydroxide (KOH) solution for a minute. After boiling, the epigyne was rinsed thoroughly in water to remove excess KOH and was temporarily mounted in a drop of glycerol using coverslip on a glass slide for microscopic observations. The ethanol preserved female spider (before dissection), its undamaged whole body exuviae, and dissected epigyne, palp & head with chelicerae & fangs were photographed using Leica DFC 425C digital camera mounted over Leica M205FA stereozoom automontage microscope at National Pusa Collection, Division of Entomology, Indian Agricultural Research Institute, Pusa, New Delhi 110012. Measurements were taken in millimeters (mm) using inbuilt settings of the automontage. The format of the description follows Yamasaki (2010), Caleb (2016), and Ward (2001). The studied ethanol preserved specimen of the female spider and its exuviae were deposited in the museum collections of University Department of Zoology, Vinoba Bhave University, Hazaribagh.

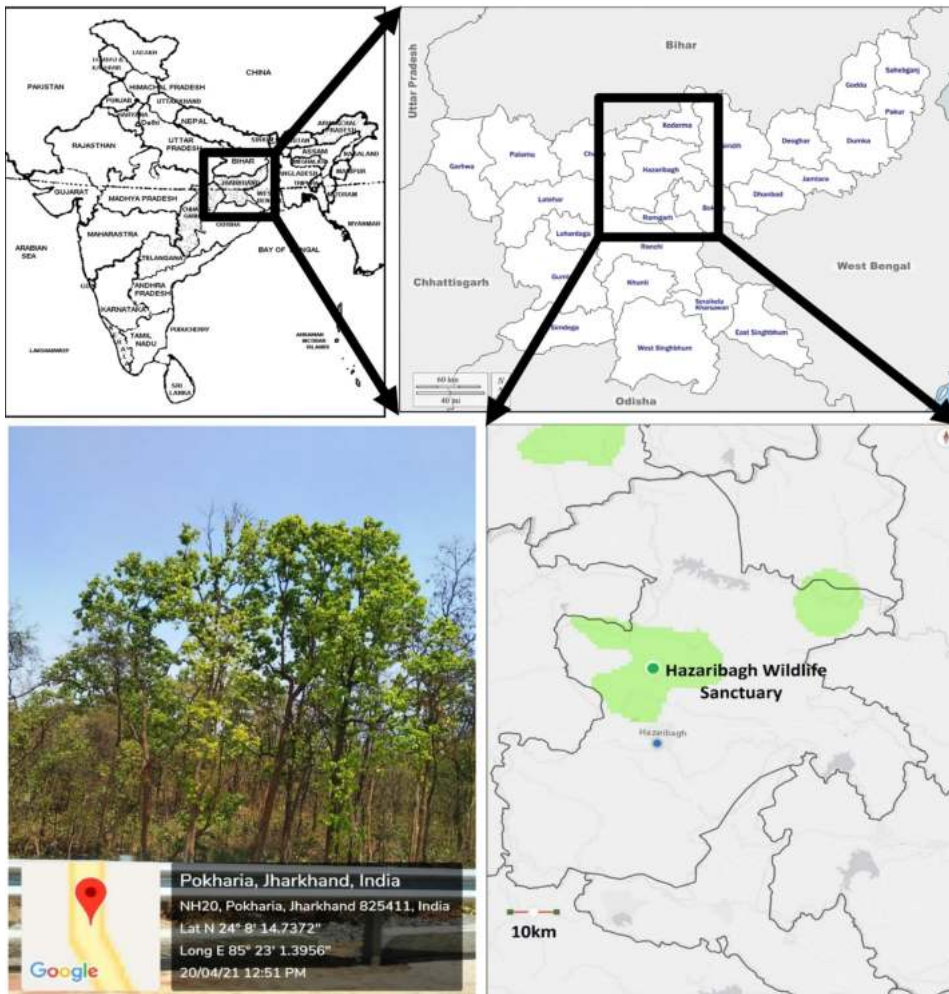


Image 1. Geographical location of Hazaribagh Wildlife Sanctuary, Hazaribagh, Jharkhand, India. The longitudes and latitudes are indicated in the lower left geo-tagged photograph, which also shows Sal trees, the dominant trees of Hazaribagh Wildlife Sanctuary.

## TAXONOMIC NOTES ON THE MYRMECOMORPH

### *Myrmarachne melanocephala* MacLeay, 1839 (Images 2A–D, 3 & 4A–E; [supplementary video 1](#))

*Myrmarachne melanocephala* MacLeay, 1839: 11, pl. 1, fig. 4; Galiano, 1969: 146; Edwards & Benjamin, 2009: 5, figs. 1A–H, 2A–D, 3A–D, 4A–E, 5A–D; Yamasaki & Edwards, 2013: 15, figs. 46–58; Yamasaki & Ahmad, 2013: 541, figs. 32A–G, 33A–H, 34A–C; Benjamin, 2015: 17, figs. 17A–D, 18A–D, 19A–D; Caleb, 2016: 409, figs 20–30.

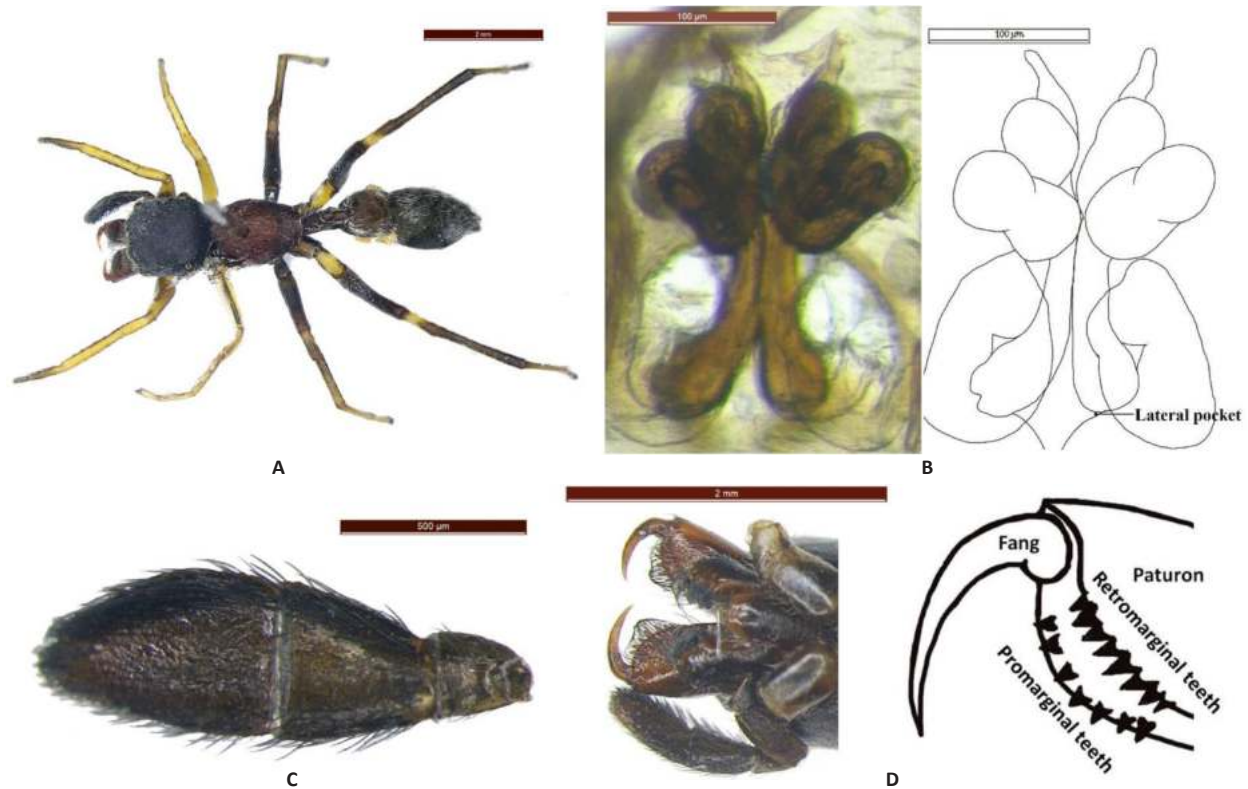
Further references may be read in World Spider Catalog (2021).

**Materials examined (n=3).** 1 preserved freshly moulted female specimen, 1 preserved complete whole-body exuviae of female, and 1 live male. Hazaribagh Wildlife Sanctuary (24° 8' 14.7372" N, 85° 23' 1.3956"

E ), Hazaribagh, Jharkhand, India, 20.iv.2021, R. Kumar & M. Sharma.

**Diagnosis** (following Yamasaki & Edwards 2013). Pedicel in both sexes as long as ALE-PLE. Males are further distinguished from other congeners by the shape and dentition of chelicerae. Females can be distinguished by abdominal markings and structure of epigyne (Yamasaki & Edwards 2013). For a complete diagnosis and description see Edwards & Benjamin (2009) and Benjamin (2015).

**Female.** Body length 7.8; carapace length 2.25, width 1.5; abdomen length 3.4, width 1.66. Width of eye row I 1.11; II 1.1; III 1.2. Eye sizes and interdistances: AME 0.3, ALE 0.2, PME 0.05, PLE 0.2; ALE-PLE 0.8; ALE-PME 0.39. Leg spination: tibia I pv 4, rv 5; metatarsus I pv 2, rv 2; tibia II pv 3, rv 3; metatarsus II pv 2, rv 2. Pedicel 0.6 long. Cephalic region rugulose and dark brown to black, covered with white hairs; thoracic region reddish



**Image 2.** *Myrmarachne melanocephala* MacLeay, 1839 (female): A—Habitus of preserved specimen, dorsal view | B—Epigyne, ventral view | C—Left palp, ventral view | D—Chelicerae and fangs, ventral view. Scale bars: A—2 mm | B—100 µm | C—500 µm | D—2 mm.

brown, sparsely covered with white hairs. Cephalic region slightly higher than thoracic region. Sternum brown. Chelicerae dark brown, geniculate with seven teeth on promargin and 8 teeth on retromargin (Image 2D). Legs I and II light yellow, coxae I brown, tarsi I light brown which gets darker near the tip, legs III, IV brown, trochanter and patella of leg IV yellowish, patella of leg III lighter in colour. Leg IV longest. Palp paddle shaped and fringed with preening setae (Image 2C). Abdomen elongate, and slightly constricted in the anterior third, covered with white hairs, almost oval (Image 2A). Epigyne with laterally oriented large oval copulatory atria; copulatory ducts twist to form butterfly shaped structure just before reaching ovoid spermatheca; lateral pockets present between artia just at the bases of copulatory ducts (Image 2B).

**Exuviae of female:** The undamaged whole body exuviae revealed morphological features of the female spider (Image 3). Exuviae contains imprints of the outer surface of spider's body. Abdominal markings (dark and lightly pigmented areas) are sharply revealed in the exuviae which is otherwise not clearly visible on the spider body. The inflated abdominal region displays the site of exit of the spider after moulting from its own



**Image 3.** *Myrmarachne melanocephala* MacLeay, 1839: female exuviae (whole mount). Scale bar: 2 mm.

exuviae. Locations of four pairs of limbs, limb markings, geniculate chelicerae, fangs, and paddle shaped pedipals are clearly visible.

**Male:** Body length 7.5; carapace length 3, width 1.2; abdomen length 2.9, width 1.5; chelicerae 2. Pedicel 0.5 long. Legs I and II light brown but not yellow as in female, coxae and trochanters of legs I, II and III white, and tarsi I brown which gets darker near the tip, legs III

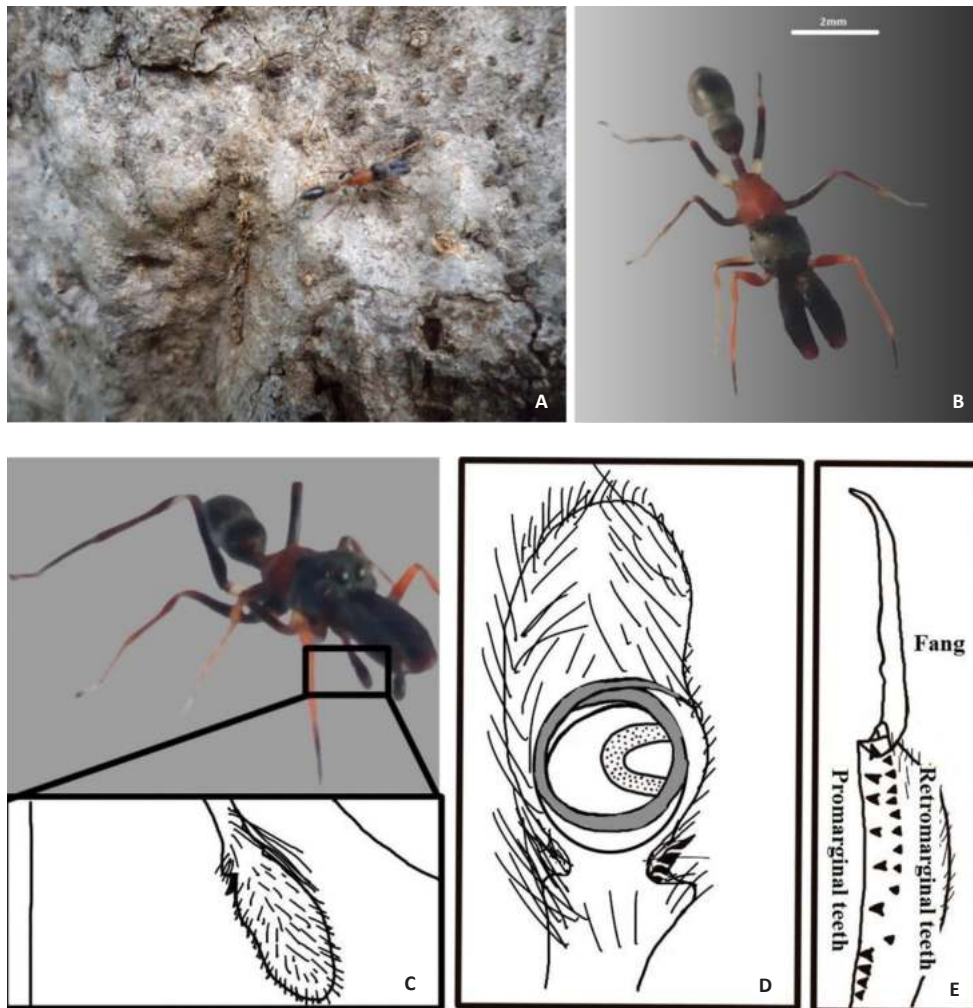


Image 4. *Myrmarachne melanocephala* MacLeay, 1839 (male): A—Spider on a tree trunk | B—Habitus of a live spider, dorsal view | C—Right palp, dorsal view | D—Left palp, ventral view | E—Chelicera and fang, ventral view.

and IV brown in colour, trochanter and patellae of leg IV white. Cephalic region rugulose and black; thoracic region reddish brown. Cephalic region slightly higher than thoracic region. Chelicerae black throughout except the region from where fangs arise which is reddish brown. Chelicerae porrect with 10 teeth each on prolateral and retrolateral margin (Images 4B, E; [supplementary video 1](#)). Sternum light brown. Abdomen elongate-oval, constricted in the anterior third. Palp with oval cymbium, round tegulum with distal-retrolateral C-shaped sperm duct, embolus with two coils, spiralled helix like retrolateral tibial apophysis with prominent flange (Images 4C, D).

**Remarks:** Exuviae has been used as a material for species description by some workers, and some have used it even as a holotype (Kranzfelder et al. 2017; Lin et al. 2017). We have used it here as additional material for morphological studies. We suggest that exuviae can

also provide such useful information while describing a species which may not be clearly recognizable in the type or non-type material.

**Biology:** The spider specimens were spotted on a tree trunk at the Sal forest. Refer ecological notes on mimic-model coexistence in a subsequent section for other important details.

**Distribution:** Pakistan to Indonesia (Edwards & Benjamin 2009; World Spider Catalog 2021), the records from India include states of Tamil Nadu, West Bengal, Assam, Uttarakhand (Caleb 2016) and Jharkhand (present study) (Images 1 & 6).

**TAXONOMIC NOTES ON THE ANT MODEL**

***Tetraponera rufonigra* Jerdon, 1851  
(Image 5A–D; supplementary video 2)**

*Tetraponera rufonigra* Jerdon, 1851: 111; Smith, 1877: 68; Bingham, 1903: 108; Wheeler, 1922: 1015; Ward, 1990: 489; Ward, 2001: 649.

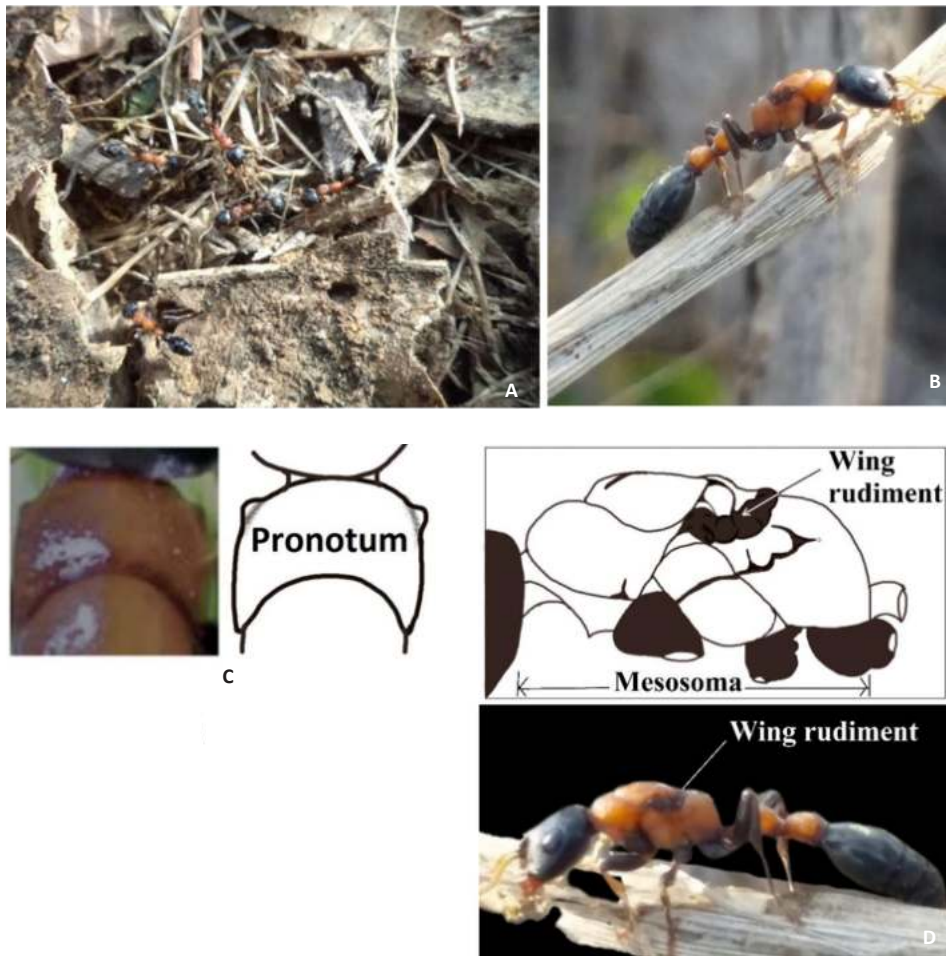
Further references may be read in Bolton (2021).

**Materials examined (n= 6):** 1 live solitary dealate gyne and 5 foraging live workers. Hazaribagh Wildlife Sanctuary (24°8'14.7372" N, 85°23'1.3956" E), Hazaribagh, Jharkhand, India, 20.iv.2021, R. Kumar & M. Sharma.

**Diagnosis:** (following Bolton 2021). Larger than other *Tetraponera* species. Bicoloured body. Head and gaster darker than mesosoma. In case of the examined specimen, head and gaster are black in contrast to the orange-brown mesosoma. The species is so distinctive

that its identity has never been a matter of confusion or doubt. For a complete diagnosis and description see Ward (2001).

**Dealate gyne:** Large body (larger than other species of *Tetraponera*) with broad head, with small but conspicuous crystalline glass like compound eyes and three ocelli. Head densely punctate but without clearly visible puncture interspaces. Clypeus with long and narrow median lobe. Bicoloured body, head and gaster dark in colour (dark brown to black) which contrast with the orange-brown mesosoma. Antennae, mandibles, tarsi and protibia light in colouration (light brown to yellowish-brown), matching with the colour of mesosoma to some extent (Image 5B). The studied specimen also shows the presence of a conspicuously wide semicircular band of highly pigmented (dark brown to black) wing rudiment which contrasts with the light orange background of the mesosoma which is characteristic feature of the dealate gyne (Image 5D).



**Image 5.** *Tetraponera rufonigra* Jerdon, 1851 (workers and dealate gyne): A—Workers foraging on the forest floor | B—A dealate gyne cutting a twig on a tree branch | C—Magnified dorsal view of pronotum of a foraging worker | D—Lateral view of mesosoma displaying a wide dorsal semicircular band of highly pigmented (dark brown to black) wing rudiment (characteristic feature of a dealate gyne).



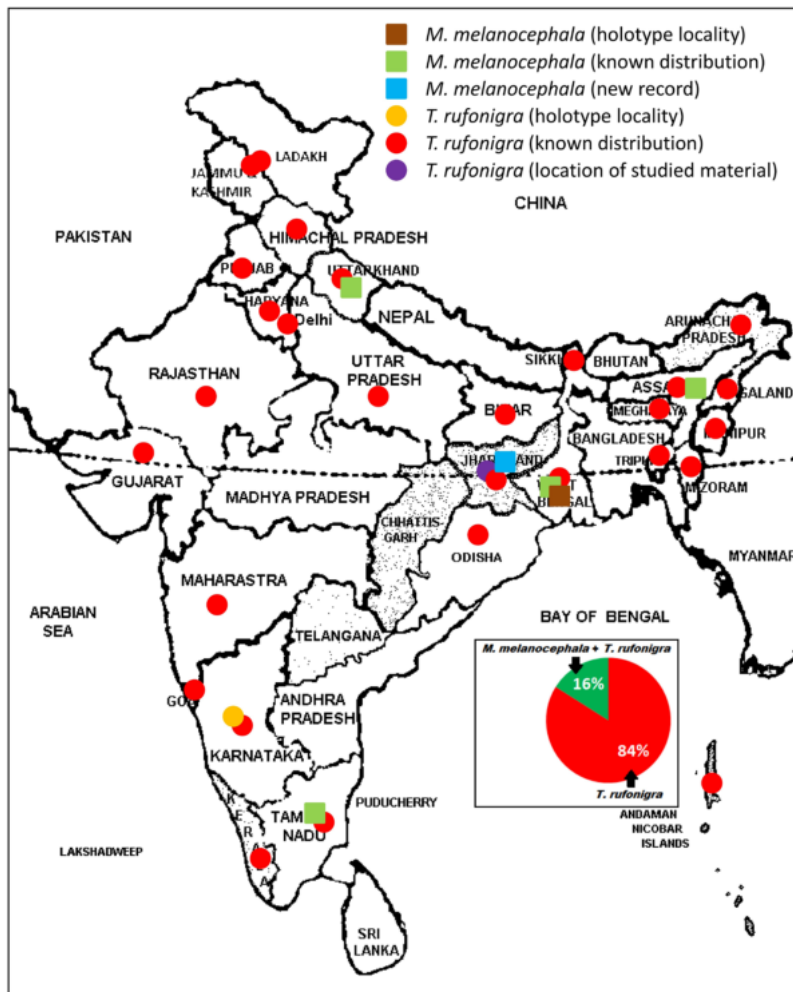


Image 6. State wise distribution of *Myrmarachne melanocephala* MacLeay, 1839 and *Tetraponera rufonigra* Jerdon, 1851 in India. Pie chart represents the percentage of distribution of *M. melanocephala* in India vis-à-vis distribution of *T. rufonigra*.

**Worker:** They display similar morphological features and colouration pattern like the dealate gyne except the wing rudiment which is absent in workers. Pronotum with well developed lateral margin and punctate humeral corners (Image 5C). Workers are smaller than the dealate gyne. Abdomen is more tapering in the workers compared to the more inflated abdomen of the dealate gyne (Image 5A).

**Remarks:** This ant is known to exhibit regional morphological variations. For example, the ants studied from some places in Sri Lanka are uniformly dark (mesosoma approaching colour of head and gaster) in comparison to the typical bicoloured ants like those found in India (head and gaster darker than mesosoma). As already reported by various workers, common morphological variations include variation in integument sculpture, colour of mesosoma, and pilosity (Ward 2001).

**Biology:** The ants were spotted on and around trees of the Sal forest. Refer ecological notes on mimic-model coexistence in a subsequent section for other important details.

**Distribution:** Pakistan to Indonesia including India (Ward 2001). Widely distributed in India; the records from India include Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Ladakh, Jharkhand, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand, and West Bengal (Bharti et al. 2016) (Image 6).

## DISCUSSION

### Ecological notes on mimic-model co-existence

As an ideal myrmecomorph, *M. melanocephala* shares many morphological features with its ant model *T. rufonigra*. The most striking feature is its ant like bicolored body and size. Both share similar body colour pattern, body size and appearance. The female spider mimics the ant more efficiently than the male spider due to the absence of long chelicerae found in the male spider. The long pedicel of the spider mimics the whole petiolar and post-petiolar structure of ants due to its comparable length. The inflated elongate ovate abdomen of the spider and ant also appears similar in appearance. The limbs of the spider also display a lighter colouration pattern like that of the ant (Images 2A, 4A, B, 5A, B). Along with morphological resemblances, *Myrmarachne melanocephala* MacLeay, 1839 also exhibits some behavioural similarities to its ant model. In this regard, the first two pairs of legs are lighter in colour (yellowish in female) than the third and fourth pairs, and bear no stripes or markings in the spider (Image 2A). The spider waves its first pair of limbs in the air to mimic the long antennae (which is also yellowish) of the ant model occasionally. The spider also displays a zig-zag movement like the ant along with occasional salutatory movement typical of the jumping spiders (Supplementary video 1 & Supplementary video 2). Therefore, *M. melanocephala* perfectly imitates the gait and gestures of its ant model *T. rufonigra*.

### Biogeographical implications of mimic-model co-discovery

Most myrmecomorphic spiders have been found to occupy spaces in close vicinity to their ant models (Pekar & Jarab 2011a). Such associations provide a space devoid of potential enemies as ants are mostly avoided by frequent predators who prey upon birds, wasps and spiders (Edmunds 1974). Association of myrmecomorphs with a particular ant species could be the result of either preference to ant dominated habitat or ant's prey preference (Pekár 2014). A large number of myrmecomorphic species go with the former strategy where they prefer to occupy ant dominated habitats and they capture prey other than ants. *M. melanocephala* fall under the same category (Edmunds 1978; Oliviera 1988; Pekár 2014; Pekár & Jarab 2011b). Apparent from their global distribution pattern, both *M. melanocephala* and *T. rufonigra* are adaptable to multiple climatic regions. The association between *M. melanocephala*

and *T. rufonigra* was first observed by Pocock (1909). Global natural distribution of the ant model *T. rufonigra* completely overlaps with the reported distribution of its mimic *M. melanocephala* which means they follow a parallel biogeographical distribution pattern (Ward 2001; Yamasaki 2010). But if we look at India (which has the largest land area among the countries falling under the habitat range of the spider and the ant), we find that the myrmecomorph is confined to only five states (including the present study) as per available reports, whereas the ant model is widely distributed across Indian Territory (24 states including Jammu & Kashmir along with Ladakh and three other union territories) (Bharti & Akbar 2014; Caleb 2016) (Image 6). Therefore, in India *T. rufonigra* shows a continuous distribution pattern whereas *M. melanocephala* shows a highly discontinuous distribution pattern. This big difference in the distribution pattern may be attributed to the gap in studies pertaining to this spider in India. This is also true for many other spider species in India. The spider fauna of India has never been studied in entirety as noted by Keswani et al. (2012). This gap in study in turn may be attributed to a very small number of arachnologists in India. It can also be observed that all the states from which *M. melanocephala* has been reported also have reports of *T. rufonigra*. In the present study also, the spider mimic has been reported from the state where the ant model is already known to exist. Local extinction of *M. melanocephala* in other states where it coexisted with *T. rufonigra* in past or range expansion of *T. rufonigra* outside the states from where *M. melanocephala* have been reported may be speculated as a reason of such a sharp difference in their distribution pattern but it cannot be inferred with certainty because of the huge study gap and also due to high adaptive capabilities of these animals to multiple climatic regions, there is no apparent plausible reason to presume such extreme events in their natural history. Therefore, we suggest that *M. melanocephala* could also be present in other states from which the ant model has already been reported. *M. melanocephala* could have a wider distribution across different states of India vis-à-vis the distribution of the ant model *T. rufonigra*.



Supplementary Video 1. *Myrmarachne melanocephala* MacLeay, 1839. Live male.



Supplementary Video 2. *Tetraponera rufonigra* Jerdon, 1851. Live dealate gyne.



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