Ultra structure of the compound eyes of the ants – *Odontomachus haematodus* and *Diacamma rugosum*

Diacamma rugosum and *Odontomachus haematodus* are ants found coexisting locally in different niches like soil litter, forest floor, gardens, etc. Though they differ in size and morphological features, the similarities in their life styles and behaviours are striking. They are solitary foragers and prey on a number of arthropods, mainly depending on their visual-sensory system[1–3]. However, foraging periods of these ants differ; *O. haematodus* forages during day and night, whereas *D. rugosum* is a day time 'hunter gatherer' species. They construct nests in soil, rotting logs, or even in trees[4–9]. Sensory strategies adopted by these ants could differ considerably as the light quality changes dramatically from day to night. Both ants are highly visual and rely on their visual repertoire for environmental interface. So, it is logical to presume that such adaptations could reflect in the organization of their compound eyes and visual-sensory areas of the brain. Therefore we explored the structural features of their compound eye to derive insights into visual sensory adaptations of these ants.

Dissected heads of the ants were kept in 4% paraformaldehyde for 24 h before haematoxylin and eosin staining. Morphometric measurements were taken using Magnus software attached to the Magnus MSZ-TR stereo zoom microscope. Detailed morphology of the compound eyes was obtained through scanning electron microscopy.

Compound eyes of *D. rugosum* has a large surface area endowed with about ~1300 ommatidia. By comparison, compound eye of *O. haematodus* has a smaller surface area with about ~600 ommatidia. The organisation of ommatidial facets in *O. haematodus* is not compact and there is more interstitial space between each ommatidium compared to that of *D. rugosum* (Figures 3 and 4). However, the ommatidial facets of *O. haematodus* do not conform to the generally observed hexagonal shape of ommatidial facets as seen in the apposition of eyes of diurnal insects. We observed that the neighbouring ommatidial facets are separated by interfacetal cuticle. Ommatidial facets with nearly rectangular and oval shapes were observed in the compound eyes of

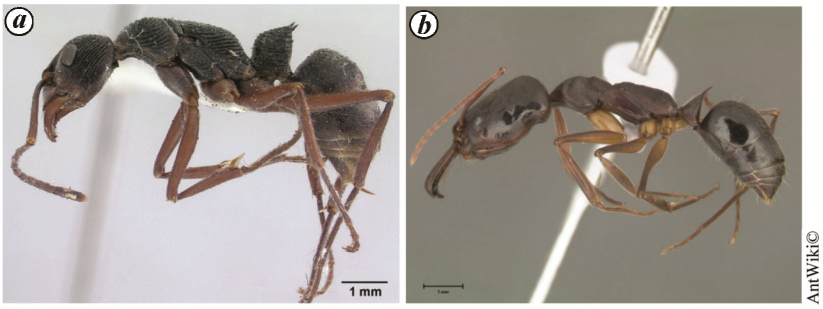

Figure 1. Photomicrographs of the lateral view of (***a***) *Diacamma rugosum* and (***b***) *Odontomachus haematodus.*

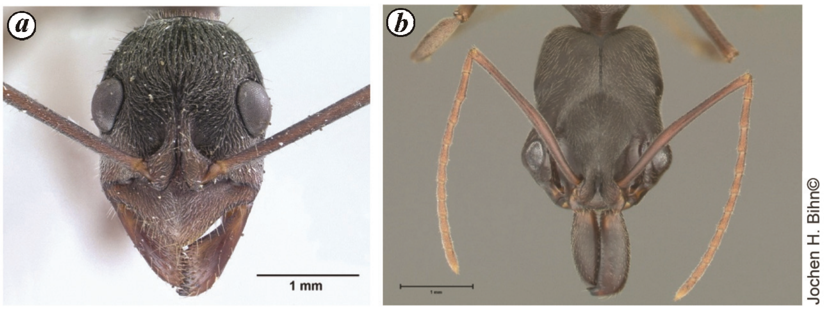

Figure 2. Dorsal view of the head of *D. rugosum* (***a***) and *O. haematodus* (***b***).

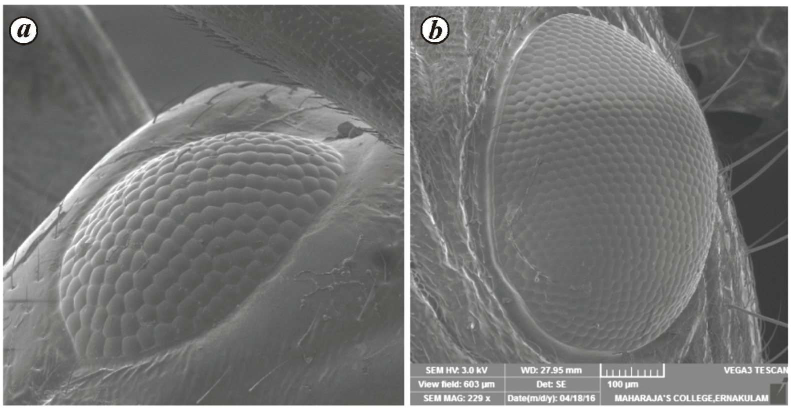

Figure 3. SEM photographs showing the general morphology of the compound eye of *O. rugosum* (***a***) and *D. rugosum* (***b***).

Table 1. Morphometrical meaurements of compound eye features of *D. rugosum* and *O. haematodus*

	D. rugosum	*O. haematodus*
Head width	2786 μm	1259 μm
Eye diameter	557 μm	408 μm
Ommatidial facet length	17 μm	28 μm
Total number of ommatidia	1300 × 2 μm	600 × 2 μm
Total surface area	203187 μm^2	66637 μm^2
Rhabdom length	240 μm	160 μm
Basal lamina	420 μm	200 μm

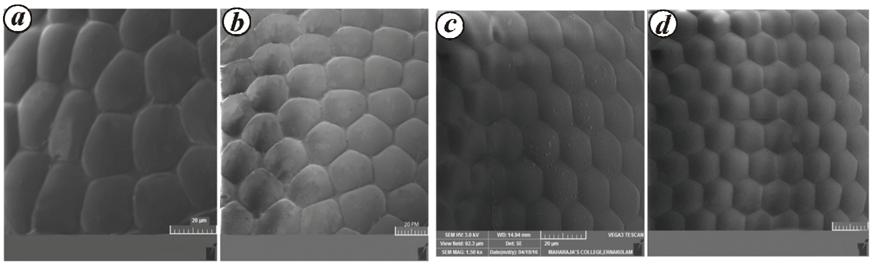

Figure 4. SEM photographs of ommatidial facets at different areas of the compound eye: ***a***, *D. rugosum*; ***b***, *O. haematodus*.

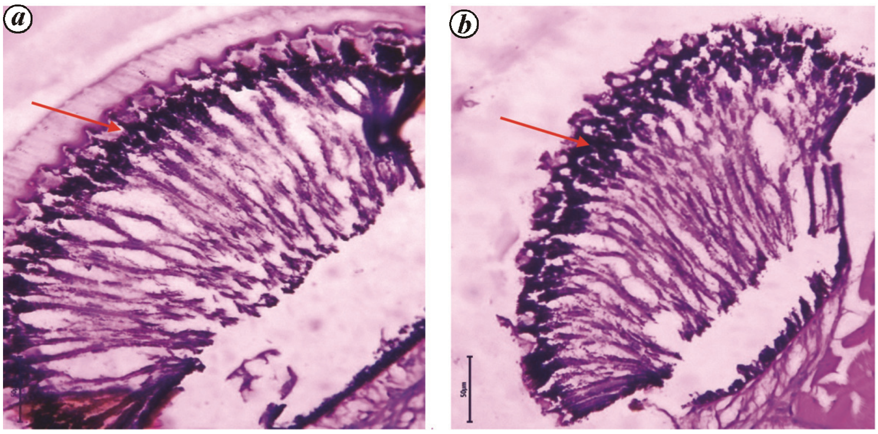

Figure 5. ***a***, Longitudinal section of the compound eye of *D. rugosum*. ***b***, Longitudinal section of the compound eye of *O. heamatodus*. The red arrow shows differences in the staining pattern indicating the differnces in the primary pigment distribution in the retina area. Notice the arranged pattern of *D. rugosum* and the comparatively disarrayed pattern of corneal lense in *O. haematodus*.

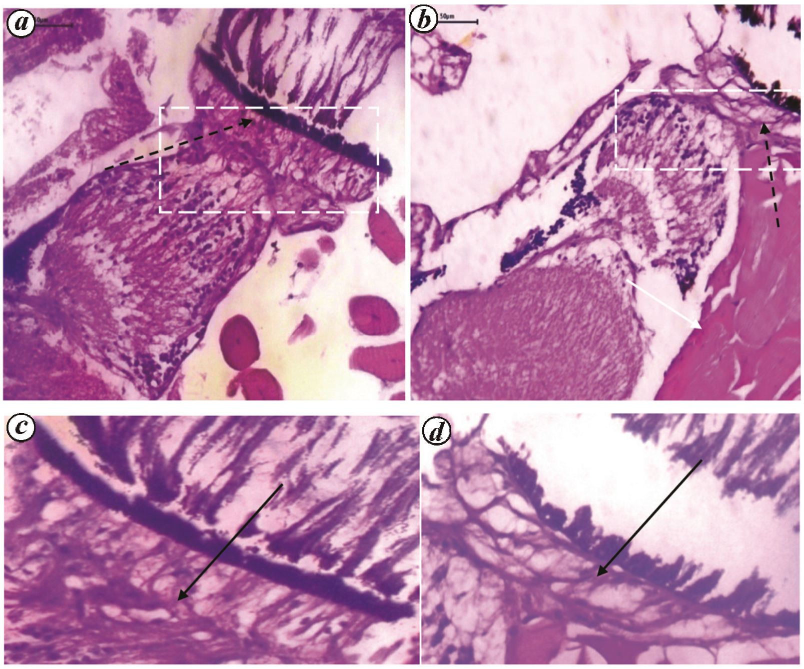

Figure 6. Haematoxylin and eosin stained lamina and medulla visual neuropils of (***a***) *D. rugosum* and (***b***) *O. haematodus*. Dashed arrow indicates the neuronal tracts from the retina to lamina. ***c***, ***d***, show the topographical differnces in the lamina neuropilar area represented by a dashed line.

O. haematodus. Further, we found many other visual components that vary between the compound eye of *D. rugosum* and *O. haematodus* (Table 1). The primary pigment distribution in the retina is different (Figure 5). The closed type of rhabdoms found in both ants differed in their length. *D. rugosum* had a rhabdom length of 240 µm whereas in *O. haematodus*, it measured 160 µm.

A study of the visual sensory neuropils – lamina, medulla and lobula of the brain and the visual sensory tracts of these ants also reveals differences. The neural tracts originating from the lamina of *D. rugosum* appear extensive, indicating a higher level of sensory inputs from the retina. The neural tracts of *D. rugosum* originate from the basal layer of retina and extend up to a breadth of 400 µm. It appears to be highly reticulating which probably is an indication that the complex neuronal network innervating the medulla, the subsequent neuropil layer of medulla, also appear to be elaborate and extensive (Figure 6). Neuronal tissues are expensive in terms of energy, therefore organisms invest more in such tissues only if the returns give them an edge for survival over other competitors[10].

Sensory capabilities of animals are reflections of the sensory structures they possess. Lifestyle-based variations in the organization of compound eyes and antenna – the primary sensory organs of insects – have been reported[11–16]. Insects engaged in different visual or olfactory tasks as well as animals that are active during the day or night, possess striking differences in the design of their sensory organs.

O. haematodus, though reportedly forage diurnally in open spaces, adopt a *modus operandi* based on the fast snapping action of their mandibles[17]. *D. rugosum* actively go in search of the food and find the prey. Differences in the designs of compound eyes indicate differences in the optics and physiology of the compound eyes[15]. It would be interesting to note how these differences help ants in their visual predatory strategies.

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Spectacular Basalt columns of Panhala-Masai range, Maharashtra: a potential geoheritage site in the Deccan Traps

The ~65 Ma old Deccan Traps cover about 0.5 million km^2 in western and central India. The Deccan Traps region has huge geotourism potential with several potential geoheritage sites[1–3]. We report here the occurrence of spectacular columns in basalt near Bandivade village (16°49′18″N and 74°01′0″E), in Kolhapur district, Maharashtra (Figure 1). The locality is situated on the Panhala-Masai Range, about 22 km west of Panhala Fort and ~43 km from Kolhapur. At Bandivade, the stout, pentagonal basalt columns in different stages of disintegration are present (Figure 2 *a*). The columns rise above an east-west oriented low ridge (~850 m ASL), connecting two laterite-capped tablelands. Thick ferricrete (laterite) duricrusts cap the tablelands[4]. The tableland on the east is known as the Masai Plateau/Tableland (>950 m ASL). Stratigraphically, the columnar-jointed basalt flow occurs below the early Paleogene ferricrete duricrusts. This flow is nearly 80–90 m thick and consists of stout (diameter >1.0 m), pentagonal columns. The *in situ* ferricretes occurring on top of the Masai Tableland are developed in a protolith of Panhala Formation basalt of the Wai-Subgroup[5]. The basalt flow, with well-developed colonnade, thus, belongs to the Panhala Formation, one of the youngest formations of the Deccan Traps. Recently, the base of the Mahabaleshwar Formation of the Wai-Subgroup has been dated to 65.6 Ma (ref. 6). The flows of the Panhala Formation are younger than the Mahabaleshwar Formation and were emplaced during early Paleocene (Paleocene 56–66 Ma). Unlike Deccan flows in central India, well-developed, strikingly contrasted colonnade-entablature tiers are rare in the nearly ~2 km thick lava flows of Western Ghat Escarpment[3]. The Bandivade site, therefore, deserves greater attention from earth scientists.

Due to their remarkable polygonal pattern, columnar-jointed volcanic rocks have fascinated geologists in general and volcanologists in particular for a long time. To understand the process of their formation, field studies, laboratory experiments, and modelling have been undertaken by several workers and different

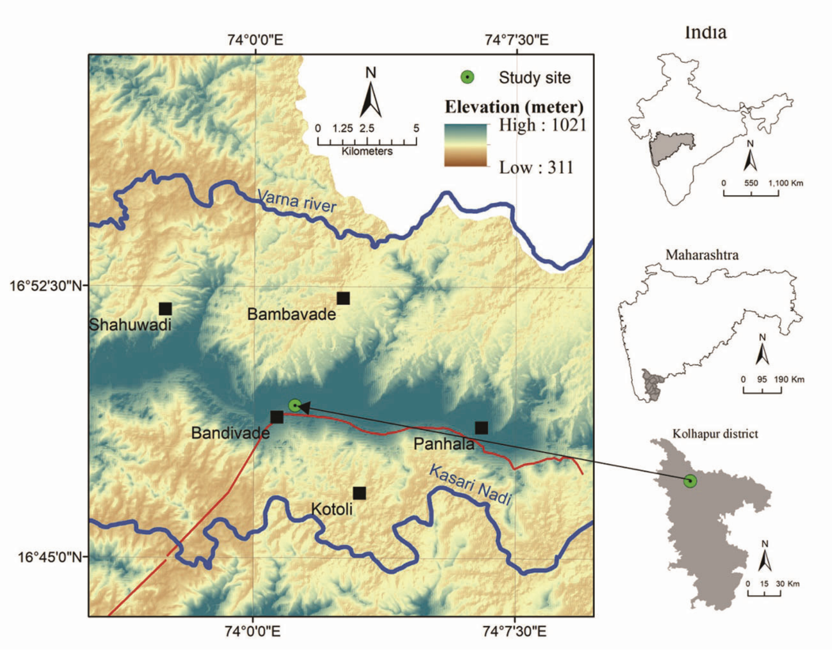

Figure 1. Map showing the location of the Bandivade site with the spectacular columns.