

# STUDIES ON THE DEVELOPMENTAL STAGES OF HOUSEHOLD PEST CARPENTER ANT, *CAMPONOTUS COMPRESSUS* (FABRICIUS) (HYMENOPTERA: FORMICIDAE)

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**ABSTRACT:** The carpenter ant, *Camponotus compressus*, (Fabricius) is the polyphagous household pest responsible for damaging the utility poles, shade trees and lawns and also attacks sugar, molasses, sweet, stored grains and all kind of human food. It is a social polymorphic insect forming a large colony consisting of reproductive and sterile castes. The fertile queen and male are concealed together in the royal chamber with numerous sterile workers and soldiers. The development of carpenter ant, *Camponotus compressus* passes through the stages like eggs, larvae, pupae and adult stages. The pre-adult stages were recognized as the three larval instars and four pupal stages as pre, early, mid and late pupae. The time period for pre-adult development under the natural conditions ranges from one to two months while, the adults are produced around the same time of the year during late summer or early winter. Being polymorphic, the adults are of three forms, reproductive castes the queen (fertile female), the king (fertile male) and the workers (sterile caste). The workers differentiated into three types such as small workers, the minims or nanitics; medium size workers, the foragers and major workers, the soldiers in the colony.

**Key words:** *Camponotus compressus*, polyphagous, pre-adult, polymorphic, nanitics, forager

## INTRODUCTION:

The carpenter ant, *Camponotus compressus* is a social insect forming a large colony consisting of reproductive and sterile castes. Sometimes (Akre and Hanson, 1990; Franks, 2005), they form a clear ground level trail to their more persistent foraging site, in search of food and nesting sites and become nuisance pest (Clark, 1986; Narendra and Sunilkumar, 2006). The pre-adult development time varies from species to species under natural conditions it ranges from one to three months, except in winters where it is completely halted. The life cycle and general morphology of the developmental stages of *Camponotus* has been described by earlier workers (O' Neal and Markin, 1975; Lone *et al.*, 2008). Mating of winged reproductives of *Camponotus* species is thought to occur aerially during swarming as in most of the hymenopterans, after which a male dies and a female founds a nest singly by constructing small, closed cells in the soil or in performed wood cavities (Mayhe Nunés and Lanziootti, 2002). The newly mated queen ant lays the eggs adhere in clusters reported creamy white colour likely similar to fire ants (Narendra and Sunilkumar, 2006). The pre-adult stages of *Camponotus compressus* are identified depending upon the incubation period, mouthparts and chetotaxy (Höllodobler and Wilson, 1990; Lone and Sharma, 2008). The unsclerotized mouthparts consists micro hairs may facilitate intake of food provided by the adult workers to the developing larvae and pupae (Petralia and Vinson, 1978). In carpenter ant, *Camponotus pennsylvanicus* and *Camponotus rufipes* the last instar larvae were stop feeding at the end of the development and start silk production to construct the cocoon (Wheeler and Wheeler, 1976; Sehna and Akai, 1990). In Ponerine ants, *Pachycondyla obscuricornis* reported four developing pupal stages as white body and brown body pupae depending upon the colour of eyes and body (Lommel *et al.*, 2003; Zara and Caetano, 2003). In the carpenter ant, *C. pennsylvanicus* and in many species of Camponotinae the reproductive capability differentiates the workers from the reproductive caste, a fertile female and male. Along the reproductive's three forms of workers were generally noticed in Camponotinae with well developed ocelli and larger eyes (Dejean *et al.*, 2000 and Ravary *et al.*, 2007).

## MATERIALS AND METHODS:

The adults undertake mating flights in the months of April-May-June. After mating they dig deep into the soil to form nests. The colonies of carpenter ant, *Camponotus compressus* are found more than one and half feet deep under the soil after digging. Soon after their mating the mated queens were collected and kept at constant 21<sup>o</sup>26<sup>o</sup>C, 5585% RH, and L16:D8 photoperiod temperature in the laboratory to study the developmental stages and polymorphic forms. All the experiments were conducted in the RTM Nagpur University campus, Nagpur. The fresh food was provided on the same day to all colonies in the form (Bhatkar and Whitcomb, 1971) of dilute honey solution and grinded sugar particles on the paper strip. Observations were made with utmost care to avoid any disturbance to the queens and the developing larvae. Percentage viability was calculated as the percentage of eggs that successfully hatched as larvae, while those eggs that disappeared were treated as nonviable (trophic) eggs.

## RESULTS :

**1. Eggs:** The eggs of carpenter ant, *Camponotus compressus* are oval in shape and transparent, glistening, creamish white in colour (Fig. 1). The newly laid eggs of *Camponotus compressus* are covered with sticky gum-like substance causing the eggs to adhere together in cluster. The measurements of size and weight of eggs are given in the Table-1.

**2. Larval stages: I Instar larva:** The freshly emerged first instar larva hatched within 6-9 days (Fig. 2). The body is white to creamy in colour. The eyes and mouthparts are absent. The body is tubular in structure with the undifferentiated head, thoracic and abdominal segments. The body shows segmentation narrow towards anterior while broad to the posterior. The measurements body and weight were variable (Table-1). The larvae live for 5-8 days and undergo moulting.

**II Instar larva:** The freshly moulted second instar larva are likely similar to the first instar larva in colour and structure (Fig. 3) with the observed changes, the rudimentary antennae and hypognathous mouthparts. The body of larva is slightly curved on the anterior segments covered by sparsely distributed fine hairs, setae. The measurements body and

weight were variable (Table-1). The larvae live for 8-10 days and undergo moulting.

**III Instar larva:** The freshly moulted third instar larva is creamy (Fig. 4). The head region of larvae is extended more antero-ventrally than that in the earlier instars. The mandibles are fine and unsclerotized with indistinct labrum and maxillae. The body is well-differentiated into head, thorax and abdominal region showing similarity to earlier developmental stage with variable size and weight (Table-1). The larvae live for 5-8 days and undergo moulting.

**IV Instar larva:** The fourth instar larvae are creamy yellow in colour (Fig. 5). The head region is slightly spherical with partially sclerotized mouth parts with setae. Eyes are indistinct. The mandibles are partially sclerotized with dentine ridges. The maxillary palps, galea, labium and labial palps are indistinct. The body of larva is straight and slender from anterior to posterior with distinct head, thoracic region and abdominal region gradually increases in diameter with distinct nine segments (Table-1). The larvae live for 7-10 days and undergo moulting.

**V Instar larva:** The fifth instar larvae are creamy white in colour (Fig. 6). The body is dorso-ventrally spherical in shape. Eyes are rudimentary. The head shows partially sclerotized mouth parts and thoracic regions becomes curved from rest of the straight and long abdominal region. The body segments are about nine segments differentiated into well developed head, thorax and a long, cylindrical abdominal region with variable size and weight (Table-1). The anus is situated posteroventrally on the terminal abdominal segment. The larvae live for 5-10 days and undergo moulting.

**3. Pupal Stage:** The last instar larva spins cocoon case around itself. The cocoon is measured about  $10.2 \pm 2.56$  mm in length,  $4.2 \pm 0.023$  mm in width and  $92.4 \pm 12.5$  mg in weight. The cocoon is creamy white in colour and elliptical in shape (Fig. 7). The pupal stages are observed as three forms as below:

**The Pre-Pupa:** The anterior body of the pre-pupa is curved from third thoracic segment (Fig. 8). The pre-pupa shows clear demarcation in between head, thoracic and abdominal region showing similarity to earlier developmental stage with variable size and weight (Table-1). The pre pupa lives for 5-7 days and undergo moulting.

**The Pink Eye Pupa (Early-pupa):** The body of the pink eye pupa is creamy white with characterized pink coloured eyes (Fig. 9). The body is divisible into separate three distinct regions, the head, thorax and abdomen with variable size and weight (Table-1). The head is triangular and oval in shape, broad towards the thoracic region and tapering anteriorly. A pair of pink coloured eyes is observed on the dorso-lateral region of the head. A pair of unsclerotized antennae is well developed which lies in front of the eyes towards the clypeus region. The mouthparts are well developed showing the unsclerotized structure of a labrum, labiomaxillary complex and mandibles with sclerotized dentine ridges. The prothorax, mesothorax, and metathorax shows three pairs of unsclerotized legs are observed on the ventro-lateral region. The abdomen differentiated into unsclerotized bulbous gaster with five abdominal segments and small triangular plate like petiole, a modified structure of the first abdominal segment. All the abdominal segments vary in size. The early pupa lives for 6-8 days and undergo moulting.

**The Brown Eye Pupa (Mid- Pupa):** The body is milky white

with a paired well developed brown coloured eyes distinctly observed on dorso-lateral region of the unsclerotized head (Fig. 10). The body is divisible into three distinct regions, head, thorax and abdomen showing similarity to the earlier developmental stage with variable size and weight (Table-1). The midpupa lives for 4-5 days and undergo moulting.

**The Brown Eye with Brown body Pupa (Late-Pupa):** The body of pupa is chitinous, dark brown in colour with a pair of brown coloured eyes (Fig. 11). A pair of geniculate type of antenna was observed on dorso-lateral region of the head. The mouthparts are well developed showing the sclerotized structure of a labrum, labiomaxillary complex and mandibles with sclerotized dentine ridge of incisors and molars. The body is divisible into three distinct regions, head, thorax and abdomen showing similarity to the earlier developmental stage with variable size and weight (Table-1). The late pupa lives for 6-10 days and undergo moulting to become an adult.

**4. ADULT STAGES:** The adult ants consist of both reproductive and sterile castes. The reproductives are of two forms, the queen (Gyne/fertile female) and the king (Aner/fertile male) which can easily be identified from the sterile caste by the presence of well-developed pairs of wings. The paired compound eyes are large, medium and small in size in the queen, worker and king respectively. The three ocelli are highly developed in queen than those in king while totally lacking in the workers. The antennae are geniculate type and long in queen, medium in worker and short in king in size. The head is large, medium, and small in size in the worker, queen and king respectively. The successive developmental changes are variable in size Table-1.

**The Queen:** The queen is larger in size among other adult forms of the colony. The body is highly sclerotized, black in colour and differentiated into small triangular head, narrow thorax, and large, broad abdomen. A paired antenna is long eleven segmented and consists of scape, pedicel and funniculus. The funniculus or flagellum is composed ten segments, the flagellomeres. The mouth parts are well-developed consist of a labrum, a pair of mandible and a labiomaxillary complex. The labio-maxillary complex consists of a pair of maxillae with a median labium. The maxillary palps are six segmented while the labial palps are four segmented structure. The galea and lacinea are distinct. The mandibles show distinct four incisors and three molars teeth (Fig.12). The abdomen is separated into a gaster and a narrow petiole. After the mating process queen becomes wingless. The wingless female is morphologically similar to that of fertile (Gyne) queen but differ in size and weight (Table-1).

**King /Fertile male:** The king is fertile male reproductive castes observed black in colour. The body is highly sclerotized with a small triangular head. The king bears well-developed pair of antennae and eyes on the dorsolateral side with three large ocelli situated at the middorsal region of head. A paired antenna is long twelve segmented and consists of scape, pedicel and eleven segmented funniculus. The mouthparts are hard, chitinous with poorly developed a labiomaxillary complex, a labrum, a pair of mandible with two sharp incisors teeth. The thorax consists of three pairs of legs and the two pair of wings (Fig.13). The abdomen is narrow and pointed and separated from thorax by a gaster and thin petiole. The petiole

is similar to that in queen but erected vertically at 45° angle (Table-1). The terminal segment shows externally exposed gonocoxites as the genital appendages.

**Workers:** The workers represent the sterile caste in the colony. Three types of workers are observed in the colony such as, small workers, the minims or nanitics (Fig.14), medium size workers, the foragers (Fig. 15) and major workers, the soldiers (Fig. 16). The body of each worker is black, strongly sclerotized and distinguished into three regions, the head, thorax (mesosoma) and abdomen (gaster). The head is oval, conical towards the anterior end while posterior end is bilobed and broad. Each antenna is a long curved, eleven segmented and consists of scape, pedicel and funniculus. The funniculus or flagellum is composed ten flagellomeres. The mouthparts are hardly sclerotized structures. The labial palps, maxillary palps and galea and lacinea are well-developed. The mandibles are provided highly sclerotized strong with incisor and molar teeth. The thorax is narrow with three pair of legs lacking wings. The abdomen is broad six segmented structure distinctly separated from the thorax by a petiole and gaster, terminal spherical telescopic structure. At the tip of the pygidium a small slit like opening anus was well evident (Table-1).

## DISCUSSION:

The life cycle of black carpenter ant, (Goudzilla's ant) *Camponotus compressus* is more or less similar to that of other social ants described by earlier workers (Akre and Hansen, 1990; Lone *et al.*, 2008). After mating at the onset of monsoon and winter season and founding a suitable nest, the queen become ready for the egg laying. The incubation period of eggs is reported from forty hours to two weeks in various species of ants (Narendra and Sunilkumar 2006). In *Camponotus compressus*, the eggs are hatched within the period of six to nine days which seems to be depending upon environmental factor. The present study reveals four moultings producing five instars of larvae in *Camponotus compressus* (Sehna and Akai, 1990 and Franks, 2005) similar to *Solenopsis invicta* (Wheeler, 1976), and the Ponerinae ants. No significant morphological differences could be noticed among I to V instar larvae of *Camponotus compressus* except sclerotization of mouth parts and an increase in size, weight and length of the body (O'Neal and Markin, 1975). The mature larvae possess salivary glands and the secretion of these glands is primarily involved in silk production for cocoon formation rather than in digestion (Febvay and Kermarrec, 1981; Sehna and Akai, 1990 and Zara and Caetono, 2001, 2003). In *Camponotus compressus* four successive developing stages of pupae viz. prepupa, pink eye pupa (early pupa), brown eye pupa (mid pupa), and brown eye with brown body pupa (late pupa) are well evident. Lommelen *et al.*, (2002) described the similar type of stages of pupal development in the Ponerinae ant, *Pachycondylla obscuricornis*. The pupal stages moulted into the adults developmental stages in the colony of ants the queen, a fertile male, the workers called as minims, or nanitics, the foragers and the major worker, soldiers (Gadau *et al.*, 2003; Narendra and Sunilkumar 2006). The adults in the Ponerinae ants are significantly variable in size, weight and length of the body with morphological differences (Zara and Caetono, 2001, 2003). The queen and king shows three ocelli well evident on

the dorsal surface of head while they are totally lack in the workers, of *Camponotus compressus* (Wheeler, 1972). A paired genniculate type of antennae are found to be eleven in female and worker while twelve segmented in male in *Camponotus compressus* shows similarity with other *Camponotus* ants (Okada *et al.*, 2006). The abdomen of the latepupa and adults in *Camponotus ants* differentiated into a distinct sclerotized bulbous gaster with five abdominal segments and small triangular plate like petiole similar to fire ants (O'Neal, J. And Markin,1975). In the *Camponotus ants* (Okada *et al.*, 2006) the chief criteria for separating castes are reproductive capability which distinguishes workers from reproductive (Hanns, 1999). Although the duties like, care for brood d attend to nest maintenance are assigned to the major workers they mainly act as protein foragers, and soldiers, as the "tankers" The carpenter ant, *Camponotus compressus* is a social insects shows a evolved developmental plasticity and division of labour which could be an evolutionary consequence of such ecological and social selection pressures (Franks, 2005 and Ravary *et al.*, 2007).

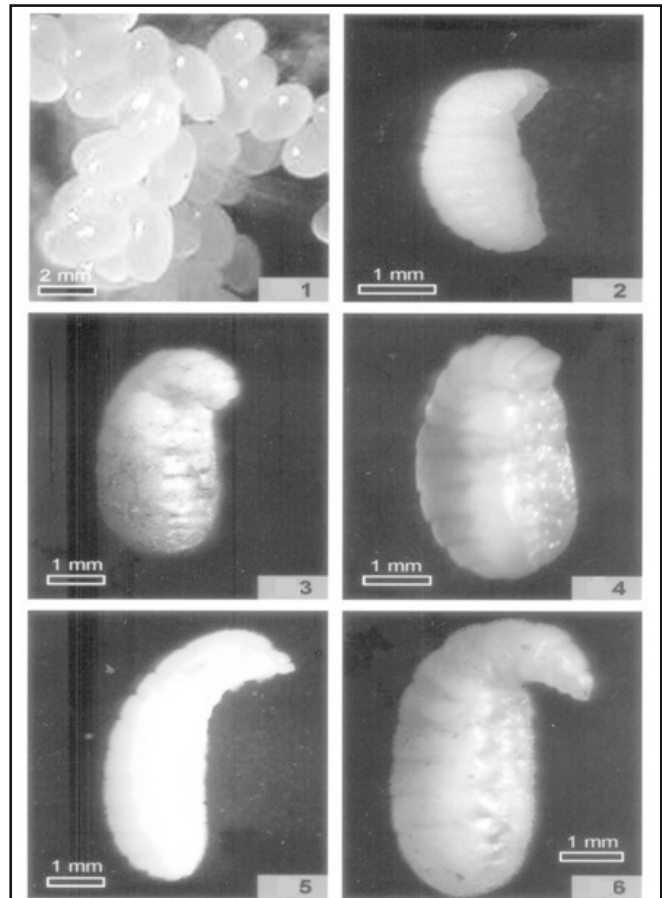


Fig. 1 to 6 Shows larval developmental stages of carpenter ant, *Camponotus compressus* F.

- Fig. 1- Eggs
- Fig. 2- I Instar Larva
- Fig. 3- II Instar Larva
- Fig. 4- III Instar Larva
- Fig. 5- IV Instar Larva
- Fig. 6- V Instar Larva

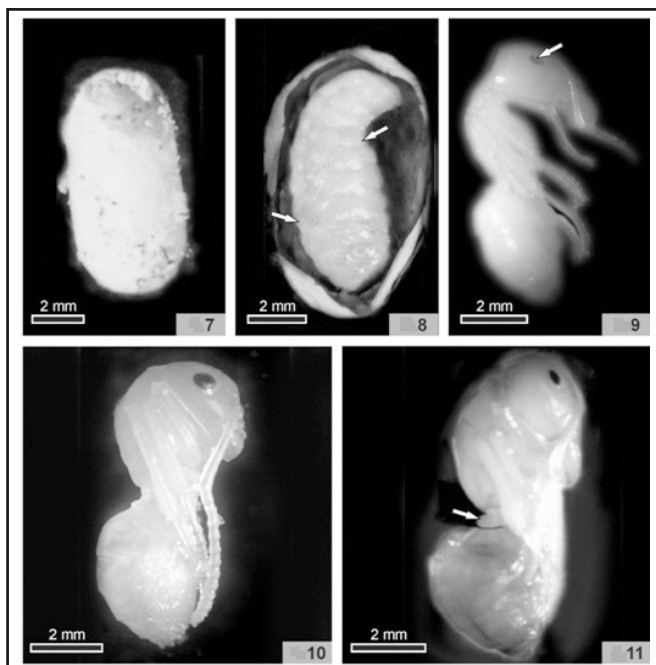


Fig. 7 to 11 Shows pupal developmental stages of carpenter ant, *Camponotus compressus* F.  
 Fig. 7- Cocoon  
 Fig. 8- Pre pupa  
 Fig. 9- Early pupa (Pink Eye Pupa)  
 Fig. 10- Mid pupa (Brown Eye Pupa)  
 Fig. 11- Late pupa (Brown Eye with brown body Pupa)

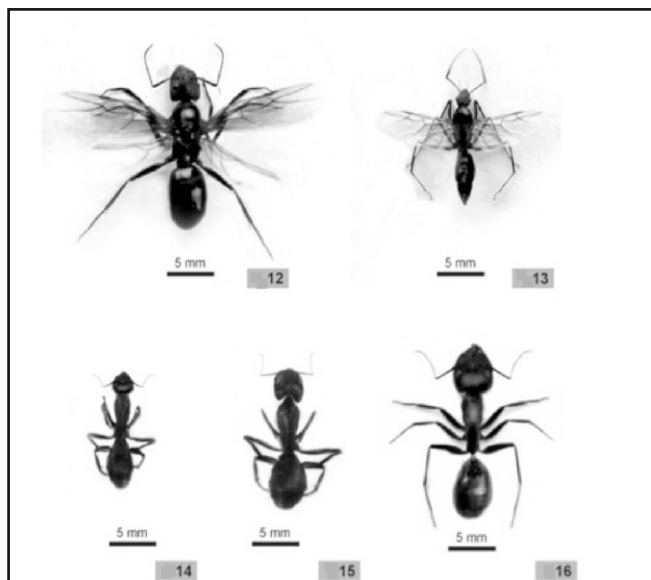


Fig. 12 to 16 Shows adult developmental stages and polymorphic forms of carpenter ant, *Camponotus compressus* F.  
 Fig. 12- Queen (Fertile female)  
 Fig. 13- King (Fertile Male)  
 Fig. 14- Minim ( Minor Worker)  
 Fig. 15- Forager (Middle Worker)  
 Fig. 16- Soldier (Major Worker)

Table 1: Measurement of developmental stages and adult polymorphic forms of carpenter ant, *Camponotus compressus*

S. no	Stages	Total Length (mm)	Weight in (mg)	Head		Thorax		Abdomen	
				Length(mm)	Width (mm)	Length ( mm)	Width (mm)	Length(mm)	Width (mm)
1.	Egg.	1.65±0.007	6.23±0.0983	---	---	---	---	---	---
2.	I-Instars larva.	3.54±0.05	16.3±2.46	---	---	---	---	---	---
3.	II-Instars Larva.	4.55±0.07	32.2±3.70	---	---	---	---	---	---
4.	III-Instars Larva.	5.65±0.55	46.3±6.53	---	---	---	---	---	---
5.	IV-Instars Larva.	6.58±0.085	58.2±3.57	---	---	---	---	---	---
6.	V-Instars Larva.	6.42±0.581	66.3±5.28	2.17±0.094	0.92±0.02	3.23±0.0934	1.62±0.028	4.19±0.051	2.61±0.07
7.	Pre-Pupa	8.30±1.12	64.9±6.5	2.65±0.076	1.22±0.056	2.52±0.073	2.12±0.061	3.34±0.072	3.51±0.05
8.	Early-Pupa	11.4±1.30	82.8±7.59	3.12±0.069	2.65±0.041	3.35±0.094	2.17±0.032	3.55±0.538	3.6±0.094
9.	Mid Pupa	11.6±2.53	93±11.35	3.55±0.068	3.12±0.029	3.55±0.054	2.15±0.062	3.5±0.048	3.12±0.19
10.	Late Pupa	13.4±1.63	103±22.3	4.12±0.091	4.11±0.014	5.14±0.0113	2.57±0.073	4.5±0.035	3.49±0.45
11.	Queen	16.5±0.743	182±17.76	3.45±0.043	3.32±0.096	5.53±0.041	3.32±0.056	6.63±0.143	5.17±0.03
12.	King	12.5±0.101	71.4±5.43	2.1±0.05	1.46±0.073	4.52±0.77	2.11±0.052	4.52±0.031	2.61±0.03
13.	Wingless Female.	15.2±1.15	166±7.95	3.45±0.018	3.10±0.06	5.52±0.0382	3.34±0.032	6.52±0.053	4.15±0.19
14.	Worker (Soldier).	14.2±0.082	112±5.71	4.48±0.054	4.45±0.056	5.15±0.073	2.51±0.086	4.55±0.021	3.49±0.05

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