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## KINEMATICS OF SOME ANTS IN A GORAKHPUR LOCALITY

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### ABSTRACT

The kinematics and the underlying biomechanics of ant locomotion emerge from effective interactions of them with its environment. Speed, an important aspect of study in kinematics, has been estimated here for four different local species viz. *Camponotus compressus*, *Monomorium indicum*, *Monomorium pharaonis* and *Paratrechina longicornis*. *Camponotus compressus* showed the highest displacement per unit time ( $8.27 \pm 0.34$  cm s<sup>-1</sup>).

**KEYWORDS:** Ants, kinematics, speed, locomotion.

### INTRODUCTION

Ants are mobile and highly successful social insects living in very complex colonies. They have well advanced division of labour, communication between individuals, and an ability to solve complex problems. (Dicke *et al*, 2004). Locomotion in ants emerges from effective interactions of them with its environment. The female worker ants do not have wings and reproductive females lose their wings after their mating flights in order to begin their colonies. Therefore, unlike their wasp ancestors, most ants do locomotion by walking. Ants, being insects, are hexapods having a front, middle and rear pair. These legs are in pairs and have different working volumes. Through experimental observations of

the ant's legs, the left and right side of ant leg pairs are identical in length and working angle. Interestingly the front, middle and rear legs are different in length with the rear usually being the longest. In the same ant species, the leg length ratios are similar. (Lozano *et al*, 2011). The kinematics of ant locomotion has been found to be fairly similar to those observed in other six-legged runners (Reinhardt *et al*, 2009)

Principles of their biological terrestrial locomotion have been investigated on various substrates and inclinations (Gravish *et al*, 2013). The biomechanics involved in locomotion has remained poorly characterized in smaller animals. The kinematics of ant locomotion seems to be fairly similar to those

observed in other fast moving insects. However, ants are much smaller than the insects investigated so far and at their level gravity may no longer be the dominant factor when compared with other forces such as drag and those involved in securing a foothold (Federle *et al.*, 2000; Full and Köhl, 1992; Reinhardt *et al.*, 2009).

Velocity or displacement in a unit time is an important aspect of study in kinematics. The current study was conducted to find out the normal walking speed in four common ant species viz. *Camponotus compressus*, *Monomorium indicum*, *Monomorium pharaonis* and *Paratrechina longicornis*, at a Gorakhpur locality (26.7588°N 83.3697°E).

## MATERIALS AND METHODS

For this experiment the ants were observed very carefully at their natural habitat

in the month of March during midday (Temperature: 25-30°C, RH: 55-65%). Ants walking on its usual path were used for experiment. Using a stopwatch, set for 10 seconds, the distance travelled during that particular time was noted. This was repeated for at least three times for each ant and such readings from a total of four ants (numbered 1 to 4) were collected for the calculation of average speed. This was repeated on all the four species.

Care was taken as not to agitate or panic the ants and all the readings were taken at a very basal level of activity. The whole experiment was videographed at full hd (MP4 format) and photographed at 13MP (JPEG) resolution for species identification and further reference. For further reference and study the ant specimens were also preserved in 70% alcohol.

## OBSERVATIONS

**Table 1. *Camponotus compressus***

Ant	Distance (in cm) covered in 10 seconds				Average speed (cm s <sup>-1</sup> )
	Observations			Average	
	I	II	III		
1	80.5	81.5	75.0	79.0	7.9
2	82.0	83.0	85.0	83.3	8.33
3	80.0	84.5	88.5	84.3	8.43
4	84.5	82.0	85.5	84.0	8.4
<b>Mean speed= 8.27 cm s<sup>-1</sup>±0.34</b>					

**Table 2. *Monomorium indicum***

Ant	Distance (in cm) covered in 10 seconds				Average speed (cm s <sup>-1</sup> )
	Observations			Average	
	I	II	III		
1	24.0	24.0	24.6	24.2	2.42
2	23.0	25.0	24.6	24.2	2.42
3	22.6	23.3	25.5	23.8	2.38
4	24.0	23.0	24.5	23.8	2.38
<b>Mean speed= 2.4 cm s<sup>-1</sup>±0.08</b>					

**Table 3. *Monomorium pharaonis***

Ant	Distance (in cm) covered in 10 seconds				Average speed (cm s <sup>-1</sup> )
	Observations			Average	
	I	II	III		
1	15.5	14.0	15.5	15.0	1.5
2	16.5	14.0	14.5	15.0	1.5
3	14.0	15.5	14.5	14.66	1.46
4	15.0	16.0	17.0	16.0	1.6
<b>Mean speed= 1.52 cm s<sup>-1</sup>±0.1</b>					

**Table 4. *Paratrechina longicornis***

Ant	Distance (in cm) covered in 10 seconds				Average speed (cm s <sup>-1</sup> )
	Observations			Average	
	I	II	III		
1	20.0	23.5	22.0	21.8	2.18
2	21.5	23.3	23.0	22.6	2.26
3	25.0	21.0	23.0	23.0	2.30
4	21.3	23.5	23.0	22.6	2.26
<b>Mean speed= 2.25 cm s<sup>-1</sup> ±0.14</b>					

**RESULT AND DISCUSSION**

The normal walking speed of the four common ant species viz. *Camponotus*

*compressus*, *Monomorium indicum*, *Monomorium pharaonis* and *Paratrechina longicornis* from the locality at Gorakhpur were

found to be  $8.27 \pm 0.34$ ,  $2.4 \pm 0.08$ ,  $1.52 \pm 0.1$  and  $2.25 \pm 0.14$  cm/sec respectively (**Table 1-4**). *Camponotus compressus* showed the highest displacement per unit time ( $8.27 \pm 0.34$  cm/sec) owing to its comparatively larger size. The ant species investigated here display high variability in both body proportions and size. This is also reflected in the differences in locomotory performance which may be traced to a variety of factors, such as mechanical constraints, scale effects and caste-specificity or species-specificity of behavior (Zollikofer, 1994). The ability to move fast enhances the ability to forage, locate food and mate locations. Colony establishment along with its capacity of offence and defense is largely dependent on the ability to move fast. Ants normally move along its path at a fairly constant speed unless it encounters other members for communication or any disruption of pheromone trail. When agitated, the ants especially of the *Camponotus* and *Paratrechina* genera show a remarkable increase in speed. Walking speed also depends upon climatic conditions.

The kinematics of ant locomotion has been found to be fairly similar to other small insects with similar pattern of ground reaction forces (Reinhardt *et al.*, 2009). Moreover, the effect of gravity on these comparatively smaller insects seems to be an insignificant factor as compared to other forces such as drag and those involved in securing a foothold (Federle *et al.*, 2000; Full and Köhl, 1992). The kinetics and kinematics of locomotion among insects which

are slow walkers such as stick insects (Graham and Cruse, 1981), leaf beetles (Pelletier and Caissie, 2001) and locusts (Burns, 1973; Duch and Pflüger, 1995) display an alternating tripodal gait (Reinhardt *et al.*, 2009). Fast moving insects such as cockroaches and many ants also display similar gait (Delcomyn, 1971). Seidl and Wehner (Seidl and Wehner, 2008) has distinguished between these two categories (i) Slow locomotion largely relying on sensory feedback with simultaneous braking and propulsive forces during part of each stride, as in stick insects (Graham, 1983). (ii) Dynamically stable bouncing gaits, as in cockroaches (Full and Tu, 1990).

Fast and agile insect species exist that can easily adapt their locomotor performance to a variety of substrates and inclines (Graham and Cruse, 1981; Full and Tu, 1991; Duch and Pflüger, 1995; Goldman *et al.*, 2006; Gladun and Gorb, 2007; Seidl and Wehner, 2008; Weihmann and Blickhan, 2009). Although many ant species in general show small size or even absence of eyes they rely on tactile and chemosensory orientation and are generally agile. Some extinct primitive ant genus, like *Sphecomyrma* and extant basal genera *Nothomyrmecia* and *Myrmecia* have relatively large eyes, suggesting that these predators rely on vision, as do some more advanced genera in different subfamilies (e.g., *Harpegnathos*, *Gigantiops*, *Myrmoteras* and *Pseudomyrmecinae* genera).

The kinetics and kinematics of locomotion in insects have been used primarily as tools or models for the study of neural function for understanding the interaction to develop models of peripheral force inputs and the neural control of locomotion (Delcomyn, 1985; Cruse, 1976; Graham, 1983). It also has implications in the field of robotics.

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#### REFERENCES

- Burns, M. D. (1973). The control of walking in Orthoptera. I. Leg movements in normal walking. *J. Exp. Biol.* 58, 45-58.
- Cruse, H. (1976). The function of legs in the free walking stick insect, *Carausius morosus*. *J. comp. Physiol.* 112, 135-262.
- Delcomyn, F. (1971). The locomotion of the cockroach *Periplaneta americana*. *J. Exp. Biol.* 54, 443-452.
- Delcomyn, F. (1985). Insect locomotion: past, present and future. In *Insect Locomotion* (ed. M. Gewecke and G. Wenzler), pp. 1-18. Berlin: Paul Parey.
- Dicke E, Byde A, Cliff D, Layzell P (2004). A. J. Ispeert, M. Murata & N. Wakamiya, ed. "An ant-inspired technique for storage area network design". *Proceedings of Biologically Inspired Approaches to Advanced Information Technology: First International Workshop, BioADIT 2004 LNCS 3141*: 364-379.
- Duch, C. and Pflüger, H. J. (1995). Motor patterns for horizontal and upside down walking and vertical climbing in the locust. *J. Exp. Biol.* 198, 1963-1976.
- Federle, W., Rohrseitz, K. and Hölldobler, B. (2000). Attachment forces of ants measured with a centrifuge: better 'wax-runners' have a poorer attachment to a smooth surface. *J. Exp. Biol.* 203, 505-512.
- Full, R. J. and Köhl, M. A. R. (1992). Drag and lift on running insects. *J. Exp. Biol.* 176, 89-101.
- Full, R. J. and Tu, M. S. (1990). Mechanics of six-legged runners. *J. Exp. Biol.* 148, 129-146.
- Full, R. J. and Tu, M. S. (1991). Mechanics of a rapid running insect: two-, four- and six-legged locomotion. *J. Exp. Biol.* 156, 215-231.
- Gladun, D. and Gorb, S. (2007). Insect walking techniques on thin stems. *Arthropod Plant Interact* 1, 77-91.
- Goldman, D. I., Chen, T. S., Dudek, D. M. and Full, R. J. (2006). Dynamics of rapid vertical climbing in cockroaches reveals a template. *J. Exp. Biol.* 209, 2990-3000.
- Graham, D. and Cruse, H. (1981). Coordinated walking of stick insects on a mercury surface. *J. Exp. Biol.* 92, 229-241.
- Graham, D. (1983). Insects are both impeded and propelled by their legs during walking. *J. exp. Biol.* 104, 129-137.
- Gravish, N., Monaenkova, D., Goodisman, M. A., & Goldman, D. I. (2013). Climbing, falling, and jamming during ant locomotion in confined environments. *Proceedings of the National Academy of Sciences*, 110(24), 9746-9751.

- Gronenberg, W. (2008). Structure and function of ant (Hymenoptera: Formicidae) brains: strength in numbers. *Myrmecological News*, 11, 25-36.
- Lozano, A., Peters, G., & Liu, D. (2011). Analysis Of An Arthropodal System For Design Of A Climbing Robot. In *Proceedings of the 28th International Symposium of Automation and Robotics in Construction, Seoul, Korea*, 832-838.
- Pelletier, Y. and Caissie, R. (2001). Behavioural and physical reactions of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (Coleoptera: Chrysomelidae) walking on a slanted surface. *Biol. Cybern.* 84, 269-277.
- Reinhardt, L., Weihmann, T., & Blickhan, R. (2009). Dynamics and kinematics of ant locomotion: do wood ants climb on level surfaces?. *The Journal of experimental biology*, 212(15), 2426-2435.
- Seidl, T. and Wehner, R. (2008). Walking on inclines: how do desert ants monitor slope and step length. *Front. Zool.* 5, 8.
- Weihmann, T. and Blickhan, R. (2009). Comparing inclined locomotion in a ground-living and a climbing ant species: sagittal plane kinematics. *J. Comp. Physiol. A Neuroethol. Sens. Neural. Behav. Physiol.* 195, 1011-1020.
- Zollikofer, C. (1994). Stepping patterns in ants- influence of speed and curvature. *The Journal of experimental biology*, 192(1), 95-106.