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Impact of ants on natural enemies and plant reproductive fitness in cotton, sesame and castor

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ABSTRACT

The population of natural enemy was significantly highest in the treatment (ant excluded) in cotton hybrid, sesame variety and castor wild. The natural enemies were significantly low in wild in control (ant present) in all the three crops in the three genotypes. In all the three genotypes, the natural enemy number was lower in control (ant present) than the treatment (ant excluded). Plant reproductive fitness was significantly highest in the hybrid of cotton, variety of sesame and wild of castor in control (ant present) and it was significantly lowest in variety of cotton, castor and wild of sesame in treatment (ant excluded).

Key words : *Ants, Natural enemies, Reproductive fitness, Cotton, Sesame, Castor*

Introduction

The extrafloral nectar from a variety of plants is known as a valuable resource for adult ichneumonid and braconid parasitoids (Bugg *et al*., 1989; Stapel *et al*., 1997; Baggen *et al*., 1999) and is significant in efforts to conserve natural enemies (Barbosa, 1998; Bugg and Pickett, 1998; Gurr *et al*., 1998; Baggen *et al*., 1999; Landis *et al*., 2000). However, except for work on cotton (*Gossypium* spp.), the influence of EFNs on natural enemy effectiveness has been largely overlooked (Beattie, 1985; Rogers, 1985). Leal *et al*. (2006) observed that *Passiflora coccinea* was associated with diversity community of ant species which were particularly attracted to the plant reproductive organs (flowers, fruits) and also the ants guarded effectively by attacking invertebrate herbivores and gave most protection. And they also concluded that, flowers to which ants had free access produced twice as many seeds per fruits (seed set) as compared to flowers from which ants were experimentally excluded. Because, the extrafloral nectaries visiting ants repel floral nectar thevies, more nectar available to the pollinators. In consequence, flower should experienced an increased number of probes and achieve higher level of pollination success translating in turn into a higher number of seeds per fruit.

Materials and Methods

Effect of ants on natural enemies

Twelve plants were selected and the number of predators and parasitoids were counted in three genotypes of cotton, sesame and castor in both control and treatment and identified to family level. Ants were prevented from climbing on treatment plants by applying to their base a sticky barrier of plants, castor oil at weekly intervals. Ants had free access to the control plants. Observations were recorded for a month at weekly intervals (4 counts) at 7-11 am lasting five minutes in each plant.

Effect of ants on plant reproductive fitness

To know the effect of ants on reproductive fitness, twelve plants were selected in cotton (hybrid, variety), sesame and castor (hybrid, variety, wild). The number of sympodial branches, bolls, weight of seed cotton; effective fruit bearing branches, capsules, weight of seed; effective spike, capsules, weight of seeds were recorded in cotton; sesame; castor respectively for both control and treatment. Ants were prevented from climbing on treatment plants by applying to their base a sticky barrier of plants, castor oil at weekly intervals. Ants had free access to the control plants.

Results and Discussion

Effect of ants on natural enemies

The data on the effect of the ants on natural enemies of cotton are furnished in Table 1. The population of natural enemy was significantly high in hybrid (2.64) in the treatment (ant excluded). The numbers of natural enemies in wild were significantly low (0.33) in control (ant present). The numbers of natural enemies in variety were 1.43 and 1.25 in treatment and control respectively. The data on the effect of the ants on natural enemies of sesame are furnished in Table 2. The population of natural enemy was significantly highest in variety (1.01) in the treatment (ant excluded). The numbers of natural enemies in wild were significantly low (0.15) in control (ant present). The numbers of natural enemies in hybrid were 0.54 and 0.45 in treatment and control respectively. In wild, the population of natural enemy in both control and treatment were found to be with non-significant differences. The data on the effect of the ants on natural enemies of castor are furnished in Table 3. The population of natural enemy was significantly high in wild (1.98) in the treatment (ant excluded). The numbers of natural enemies in wild were significantly low (0.38) in control (ant present). The number of natural enemies in hybrid; variety were 1.24; 0.45 and 1.07; 0.40 in treatment

Table 1. Effect of ants on natural enemies in cotton

Genotype#	Mean number of natural enemies/plant		SEd	CD (0.05)
	Control (ant present)*	Treatment (ant excluded)*		
Hybrid	1.40 (1.26)	2.64 (1.62)	0.02	0.08
Variety	1.25 (0.86)	1.43 (1.19)	0.02	0.06
Wild	0.33 (0.56)	0.39 (0.62)	0.008	0.02

*Mean of twelve plants
#Mean of four counts
Values in parentheses are transformed values √+0.5
Ants includes *Camponotus sericeus, Camponotus rufoglaucus, Pheidole sp., Monomorium scabriceps, Crematogaster sp., Monomorium sp., Meranoplus bicolor.*
Natural enemies includes, Chrysopidae, Coccinellidae, Stephalinidae, Anthocoridae, Araneae, Mantidae, Tiphiidae, Tachnidae, Vespidae, Pompilidae, Braconidae, Chalcididae.

Table 2. Effect of ants on natural enemies in sesame

Genotype#	Mean number of natural enemies/plant		SEd	CD (0.05)
	Control (ant present)*	Treatment (ant excluded)*		
Hybrid	0.45 (0.66)	0.54 (0.73)	0.01	0.04
Variety	0.78 (0.88)	1.01(1.00)	0.06	0.05
Wild	0.15 (0.37)	0.21 (0.39)	0.005	NS

*Mean of twelve plants
#Mean of four counts
Values in parentheses are transformed values “x+0.5
NS-Non significant
Ants includes *Camponotus rufoglaucus, Camponotus compressus, Monomorium scabriceps. Pheidole sp.*
Natural enemies includes Coccinellidae, Chrysopidae, Mantidae, Ichneumonidae, Araneae.

and control respectively.

The population of natural enemy was significantly high in the treatment (ant excluded) in cotton hybrid, sesame variety and castor wild because EFNs number were more in them and when ants were excluded, naturally it increased natural enemy population. The natural enemies were significantly low in wild in control (ant present) in all the three crops in the three genotypes (Table 1, 2 and 3) because ants disturb other natural enemies by their territorial aggressive behaviour. In sesame wild, the population of natural enemy in both control and treatment were found to be with non-significant differences.

This is confirmed by Torres-Hernandez *et al.* (2000) whom also found that predator numbers on *Turnera ulmifolia* were increased when ants were excluded, and that these predators provided better defense against herbivores than some ant species. Spiders have been shown to enhance seed set of *Chamaecrista nictitans* host plants with extrafloral nectaries (Ruhren and Handel, 1999).

Similar to present study results research around the world confirmed that ant exclusion from citrus canopies in Australia resulted in a 2-fold increase in beneficial arthropod abundance (James *et al*., 1999). Ants excluded from pineapple in Hawaii led to increased mealybug [*Dysmicoccus brevipes* (Cockerell)] parasitism by *Anagyrus ananatis* (Gahan) (Gonzalez-Hernandez *et al*., 1999). Likewise, when ants were excluded from grapefruit [*Citrus paradisi* (MacFayden)] trees, parasitism of the scale *Aonidiella aurantii* (Maskell) by the parasitoid *Aphytis melinus* (DeBach) increased (Murdoch *et al*., 1995).

More predators inhabited trees with ant exclusion than trees with ants permitted to forage in the canopy. Ant exclusion also significantly affected spiders (Mathews, 2004). This is in accordance with the present study results.

Effect of ants on plant reproductive fitness

The data on the effect of ants on reproductive fitness of cotton are presented in Table 4. The numbers of sympodial branches, bolls, seed yield were significantly highest in hybrid in control (ant present) were 23.00, 47.33, 110.54 respectively. The number of

Table 3. Effect of ants on natural enemies in castor

Genotype#	Mean number of natural enemies/plant		SEd	CD (0.05)
	Control (ant present)*	Treatment (ant excluded)*		
Hybrid	0.45 (0.67)	1.24 (1.11)	0.03	0.10
Variety	0.40 (0.63)	1.07 (1.03)	0.01	0.05
Wild	0.38 (0.61)	1.98 (1.40)	0.01	0.03

*Mean of twelve plants
#Mean of four counts
Values in parentheses are transformed values "x+0.5
Ants includes *Camponotus rufoglaucus, Camponotus sericeus, Tetraponera nigra, Meranoplus bicolour, Monomoium criniceps, Monomorium sp., Pheidole sp.*
Natural enemies includes, Chrysopidae, Coccinellidae, Araneae, Tiphiidae, Vespidae, Pompilidae, Braconidae, Chalcididae.

Table 4. Effect of ants on plant reproductive fitness of cotton

Characters of reproductive fitness	Genotype	Control (ant present)*	Treatment (ant excluded)*	SEd	CD (0.05)
Number of sympodial branches/plant	Hybrid	23.00 (4.78)	20.15 (4.48)	0.08	0.27
	Variety	17.38 (4.16)	13.55 (3.67)	0.005	0.01
Number of bolls/plant	Hybrid	47.33 (6.87)	40.20 (6.33)	0.12	0.39
	Variety	32.40 (5.68)	23.85 (4.87)	0.09	0.31
Seed cotton yield/plant (g)	Hybrid	110.54 (10.50)	95.47 (9.76)	0.18	0.60
	Variety	91.55 (9.56)	80.46 (8.96)	0.17	0.55

*Mean of twelve plants
Values in parentheses are transformed values √x+0.5

sympodial branches, bolls, seed yield were significantly lowest in variety in treatment (ant excluded) were 13.55, 23.85 80.46 respectively. The data on the effect of ants on reproductive fitness of sesame are presented in Table 5. The numbers of effective fruit bearing branches, capsules, seed yield were significantly highest in variety in control (ant present) were 4.60, 60.45, 11.02 respectively. The number of effective fruit bearing branches, capsules, seed yield were significantly lowest in wild in treatment (ant excluded) were 1.00, 27.55, 0.10 respectively. The number of effective fruit bearing branches, capsules, seed yield in hybrid were 3.18, 41.07, 8.94; 2.73, 36.01, 7.85 in control and treatment respectively. In wild, the number of capsules and seed yield in both control and treatment were found to be with non-significant differences. The data on the effect of ants on reproductive fitness of castor are presented in Table 6. The number of effective spikes, capsules and seed yield were significantly highest in wild in control (ant present) were 12.33, 340.52, 200.46 respectively. The number of effective spikes, capsules and seed yield were significantly lowest in variety in treatment (ant excluded) were 5.87, 190.02, 150.08 respectively. The number of effective spikes, capsules, seed yield in hybrid were 9.56, 249.79, 181.67; 8.43, 212.60, 161.60 in control and treatment respectively. In wild, the number of capsules and seed yield in both control and treatment were found to be with non-significant differences.

Plant reproductive fitness was significantly high in the hybrid of cotton, variety of sesame and wild of castor in control (ant present) and it was significantly lowest in variety of cotton, castor and wild of sesame in treatment (ant excluded) (Table 4, 5, 6). Yield was not recorded in wild cotton both *Summer*

Table 5. Effect of ants on plant reproductive fitness of sesame

Characters of reproductive fitness	Genotype	Control (ant present)*	Treatment (ant excluded)*	SEd	CD (0.05)
Number of effective fruit bearing branches/plant	Hybrid	3.18 (1.76)	2.73 (1.64)	0.03	0.10
	Variety	4.60 (2.09)	4.10 (2.02)	0.04	0.12
	Wild	1.50 (1.22)	1.00 (0.99)	0.02	0.06
Number of capsules/ plant	Hybrid	41.07 (6.40)	36.01 (5.99)	0.11	0.36
	Variety	60.45 (7.77)	53.88 (7.33)	0.14	0.44
	Wild	28.28 (5.31)	27.55 (5.24)	0.05	NS
Seed yield/plant (g)	Hybrid	8.94 (2.98)	7.85 (2.79)	0.02	0.08
	Variety	11.02 (3.31)	9.81 (3.12)	0.02	0.08
	Wild	0.22 (0.46)	0.10 (0.44)	0.008	NS

*Mean of twelve plants
Values in parentheses are transformed values √x+0.5
NS-Non significant

Table 6. Effect of ants on plant reproductive fitness of castor

Characters of reproductive fitness	Genotype	Control (ant present)*	Treatment (ant excluded)*	SEd	CD (0.05)
Number of effective spikes/plant	Hybrid	9.56 (3.08)	8.43 (2.89)	0.05	0.17
	Variety	6.61 (2.56)	5.87 (2.41)	0.04	0.15
	Wild	12.33 (3.50)	10.34 (3.21)	0.06	0.20
Number of capsules/plant	Hybrid	249.79 (15.80)	212.60 (14.57)	0.28	0.90
	Variety	201.00 (14.16)	190.02 (13.07)	0.24	0.77
	Wild	340.52 (18.44)	328.05 (18.11)	0.25	NS
Seed yield/ plant (g)	Hybrid	181.67 (13.47)	161.60 (12.70)	0.24	0.79
	Variety	165.67 (12.86)	150.08 (12.24)	0.11	0.35
	Wild	200.46 (14.14)	195.45 (13.97)	0.19	NS

*Mean of twelve plants
Values in parentheses are transformed values √x+0.5
NS-Non significant

and *Kharif* because it was in the start of flowering stage during the end of this study period. In both sesame and castor in wild the number of capsules and seed yield in both control and treatment were found to be with non-significant differences. This is supported by Tillberg and suarez (2010) whom stated that, on the invasive *Leucaena leucocephala*, *Technomyrmex albipes* is more predacious; it attacks the *Leucaena* psyllid and its presence results in increased growth and seed production for the tree. It is not unusual for ants to have different effects on different plant species depending on the mix and characteristics of herbivores and predators present.

Barton (1986) reported that herbivores appeared to pose a serious threat to the reproductive success of *Cassia fasciculata* individuals; defenses other than ants did not shield the plants from herbivore attack. Ants on plants could remove some herbivores, and removed *Drosophila* larvae placed on these plants faster than on background vegetation (even in the site with the lowest level of ant visitation). In the exclusion experiment, *C. fasciculata* individuals with ants were attacked by fewer *Phoebis sennae* larvae (all sites) and suffered lower pod predation (site 1) than plants from which ants were excluded. Because of this lower herbivory, at both site 1 and site 2 ant-occupied plants had higher reproductive output than did exclusion plants**.** Ants can positively affect plant seed-set through foraging behavior alone. Schemske (1980) found that *Wasmannia auropunctata* increased seed production of *Costus woodsonii* (Zingiberaceae) in Panama by preying on the larvae of a seed-eating fly.

Similar studies were conducted by Leal *et al.* (2006) who stated that seed set almost doubled among fruits originating from ant-visited flowers as compared to flowers from which ants were artificially excluded. The study results suggested a protective role of ants for flowers of *Passiflora coccinea* against both herbivores and nectar thieves, improving plant reproductive success. Oliveira *et al.* (1999) also observed round-the clock visitation by ants to *Opuntia stricta*'s EFNs can reduce herbivore damage to plant reproductive structures and increase by 50% the plant's fruit set under natural conditions.

Several studies have shown that ants protect EFN-bearing plants against herbivores, increasing their reproductive success in different parts of the world (Bentley, 1977a; Davidson and McKey, 1993; Keeler, 1989; Koptur, 1992). Ant visitation to EFNs can reduce herbivore damage and increase the plant's reproductive output (Rico- Gray and Thien, 1989; Oliveira *et al.,* 1999).

Protection from fire ants against two of the same sulfur butterflies, resulted in greater plant height, number of leaves, and reproductive fitness (Fleet and Young, 2005). *Chamaecrista debilis* nectaries are visited by ants that decrease herbivory and increase fruit set (Nascimento and Del-Claro, 2010). The nectaries of *Cassia fasiculata* have also been shown to support protective ants that reduce herbivore damage (Kelly, 1986), and increase plant fecundity (Barton, 1986).

References

Baggen, L.R., Gurr, G.M. and Meats, A. 1999. Flowers in tri-trophic systems: mechanisms allowing selective exploitation by insect natural enemies for conservation biological control. *Entomology for Exerimental Applications*. 91 : 155-161.

Barbosa, P. 1998. Agroecosystems and conservation biological control. Pp. 39-54. In Barbosa, P. (Ed) *Conservation Biological Control.* Academic Press, New York, NY.

Barton, A.M. 1986. Spatial variation in the effect of ants on an extrafloral nectary plant. *Ecology*. 67 : 495-504.

Beattie, A.J. 1985. *The Evolutionary Ecology of Ant-plant Mutualisms.* Cambridge University Press, New York.

Bentley, B.L. 1977a. The protective function of ants visiting the extrafloral nectaries of *Bixa orellana* (Bixaceae). *Journal of Ecology*. 65 : 27–38.

Bugg, R.L. and Pickett, C.H. 1998. Introduction: Enhancing biological control-habitat management to promote natural enemies of agricultural pests. Pp. 124. In: Pickett, C.H. and Bugg, R.L. (Eds) *Enhancing Biological Control.* University of California Press, Berkeley, CA.

Bugg, R.L., Ellis, T.R. and Carlson, R.W. 1989. Ichneumonidae (Hymenoptera) using extrafloral nectar of faba bean (*Vicia faba* L., Fabaceae) in Massachusetts. *Biological Agricuculture and Horticulture*. 6: 107-114.

Davidson, D.W. and McKey, D. 1993. The evolutionary ecology of symbiotic ant plant relationships. *Journal of Hymenoptera Researcch.* 2 : 13-83.

Fleet, R. R. and Young, B. L. 2005. Facultative mutualism between imported fire ants (*Solenopsis invicta*) and a legume (*Senna occidentalis*). *Southwest National.* 45 : 289–298.

Gonzalez-Hernandez, H., Johnson, M.W. and Reimer, N.J. 1999. Impact of *Pheidole megacephala* (F.) (Hymenoptera: Formicidae) on the biological control of *Dysmicoccus brevipes* (Cockerell) (Homoptera: Pseudococcidae). *Biological Control.* 15 : 145-152.

Gurr, G.M., Van Emden, H.F. and Wratten, S.D. 1998. Habitat manipulation and natural enemy efficiency: implications for the control of pests. Pp. 155-184. In Barbosa, P. (Ed) *Conservation Biological Control.* Academic Press, San Diego, CA.

James, D.G., Stevens, M.M., O'Malley, K.J., and Faulder, R.J. 1999. Ant foraging reduces the abundance of beneficial and incidental arthropods in citrus canopies. *Biological Control.* 14 : 121-126.

Keeler, K. H. 1989. Ant-plant interactions- Pp, 207-242 in Abrahamson, W,G. (ed.), *Plant-Animal Interaction.* McGraw Hill. New York, 481 pp.

Kelly, C.A. 1986. Extrafloral nectaries: Ants, herbivores and fecundity in *Cassia fasciculata*. *Oecologia*. 69 : 600-605.

Koptur, S. 1992. Extrafloral nectary-mediated interactions between insects and plants. In: Bernays, E. (Ed.), *Insect–Plant Interactions.* CRC Press, *Boca Raton.* Volume IV, pp. 81–129.

Landis, D.A., Wratten, S.D. and Gurr, G.M. 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annual Review of Entomology*. 45 : 175-201.

Leal, I.R., Fischer, E., Kost, C., Tabarelli, M. and Wirth, R. 2006. Ant protection against herbivores and nectar thieves in *Passiora coccinea* owers. *Ecoscience*. 13: 431-438.

Mathews, C.R. 2004. *Role of peach* [*Prunus persica* (L.) *Batsch] extrafloral nectaries in mediating natural enemy herbivore interactions.* PhD dissertation, *University of Maryland,* College Park, MD.

Murdoch, W.W., Luck, R.F., Swarbrick, S.L., Walde, S., Yu, D.S., and Reeve, J.D. 1995. Regulation of an insect population under biological control. *Ecology*. 76 : 206-217.

Nascimento, E.A. and Del-Claro, K. 2010. Ant visitation to extrafloral nectaries decreases herbivory and increases fruit set in *Chamaecrista debilis* (Fabaceae) in a neotropical savanna. *Flora.* 205 : 754–756.

Oliveira, P.S., Rico-Gray, V., Diaz-Castelazo, C. and Castillo-Guevara, C. 1999. Interaction between ants, extrafloral nectaries and insect herbivores in Neotropical coastal sand dunes: herbivore deterrence by visiting ants increases fruit set in *Opuntia stricta* (Cactaceae). *Functional Ecology.* 13 : 623–631.

Oliveira, P.S., Rico-Gray, V., Diaz-Castelazo, C. and Castillo-Guevara, C. 1999. Interaction between ants, extrafloral nectaries and insect herbivores in Neotropical coastal sand dunes: herbivore deterrence by visiting ants increases fruit set in *Opuntia stricta* (Cactaceae). *Functional Ecology.* 13 : 623–631.

Rico-Gray, V. and Thien, L.B. 1989. Effect of different ant species on reproductive fitness of *Schombirgkia tibicinis* (Orchidaceae). *Oecologia.* 81 : 487-489.

Rogers, C.E. 1985. Extrafloral nectar: entomological implications. *Bulletin Entomological Society of America.* 31 : 15-20.

Ruhren, S. and Handel, S.N. 1999. Jumping spiders (Salticidae) enhance the seed production of a plant with extrafloral nectaries. *Oecologia.* 119 : 227–230.

Schemske, D.W. 1980. The evolutionary significance of extrafloral nectar production by *Costus woodsonii* (Zingiberaceae): an experimental analysis of ant protection. *Journal of Ecology*. 68 : 959-968.

Stapel, J.O., Cortesero, A.M., de Moraes, C.M., Tumlinson, J.H. and Lewis, W.J. 1997. Extraoral nectar, honeydew, and sucrose effects on searching behavior and efciency of *Microplitis croceipes* (Hymenoptera: Braconidae) in cotton. *Environmental Entomology.* 26: 617–623.

Tillberg, C.V. and Suarez, A.V. 2010. Contrasting effects of an invasive ant on a native and an invasive plant. *Biological Invasions.* 12 : 3123-3133.

Torres-Hernandez, L., Rico-Gray, V., Castillo-Guevara, C. and Vergara, J.A. 2000. Effect of nectar-foraging ants on the reproductive fitness of *Turnera ulmifolia* (Turneraceae) in a coastal sand dune in Mexico. *Acta Zoologica Mexicana*. 81: 13-21.