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Abundance pattern and differential behavioural responses of the ants and the coexisting arthropods on plant *Parthenium hysterophorus* L.

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Abstract: *Parthenium hysterophorus* is an invasive weed species and potentially major weed in India, indigenous to the Americas. It has spread into 50 tropical and subtropical countries in Asia, Oceania, and Africa. Plant invasion not only changes native plant communities, it also alters associated arthropod community diversity and structure. These impacts often are contradictory and context-specific by study location. In present study, results of the field study revealed that *Parthenium* plants visited by fifteen genera which belongs to seven arthropod orders. All these play a significant role on *P. hysterophorus* plants as pollinators (ants and dipteran flies), leaf defoliators (beetles and cricket), sap suckers (hemipteran bugs) and predators (spiders). Among all arthropods, ants were found to be most abundant (about 73% of total arthropods) than other arthropods while among ants, *Camponotus compressus* were found to be most significant abundance pattern than other ants. Field and laboratory-based experiments revealed that *C. compressus* worker ants were aggressive towards the *spiders* but showed neutral behaviour towards the other arthropods while arthropods showed submissive behaviour towards the ants.

Index Term: *Parthenium hysterophorus,* arthropod abundance*, C. compressus*, confrontation experiment

1. INTRODUCTION

Plant invasions in general have been shown to reduce diversity of native plant species (Alvarez and Cushman 2002; Flory and Clay 2010). Habitats increase arthropod species richness – particularly that of herbivores (Agrawal et al., 2006; de Groot et al. 2007; Simao et al., 2010). The interactions between arthropods and plants are complex and reciprocal. *Parthenium* weed (*Parthenium hysterophorus* L.) of family Asteraceae is an herbaceous annual plant reaching a height of 2 m when growing in good soil and capable of flowering within 4 to 6 weeks of germination, although a significant amount of seeds may remain viable in soil for several years (Navie et al., 1998). It was accidentally introduced into India around 1951 (Chandras and Vartak, 1970; Rao, 1956) and has since spread over most parts of the Indian sub-continent, and also spread to southern China, Taiwan and Vietnam in Asia (Nath, 1981).

Insects and ants visits to plants for food in form of floral or extrafloral nectar secreted from the floral and extrafloral nectaries (Extrafloral nectaries are glands which are located anywhere on a plant except those sites involved in pollination). These nectaries attract insects, which defend plants against herbivores and/or seed predators (Elias and Gelband 1975; Bentley 1976, 1977a, b; Keeler 1977). These glands produce an aqueous solution containing sugars and other compounds (Baker and Baker 1975, Bentley 1977a, Keeler 1977). *P. hysterophorus* bears floral nectaries, which produces small amounts of sugar in floral nectaries. Thus it has been identified as a primary nectar source for ants and other insects (Bhusari et al., 2010). and thus these nectaries involved in pollination. During collection of nectar from nectaries, ants may affect other components of the community, such as arthropod abundance (Parker & Kronauer, 2021) and plant fitness (Rico-Gray and Castro 1996; Renault et al. 2005).

Exotic plant invasion not only changes native plant communities, it also alters associated arthropod community diversity and structure. The origin of *Parthenium* is considered to be from Mexico, America, Trinidad and Argentina (Navie et. al., 1996; Picman & Picman, 1984). After noticeable occurrence of *Parthenium* in Pune (Maharashtra) in 1955, it has spread like a wild fire throughout India. At present Parthenium has invaded about 35 million hectares of land in India (Kumar & Varshney 2010). Parthenium weed (*Parthenium hysterophorus* L.) is one of the most aggressive invasive weeds, threatening natural ecosystems and agroecosystems in over 30 countries worldwide (Kumar & Varshney 2010). Present study designed as to study of ant and co-existing arthropods on *P. hysterophorus* plants which were visited by ants. These studies addressed several hypotheses: (i) Plant arthropods abundance pattern on *P. hysterophorus*. (ii) Abundance of co-existing arthropods are strongly related to their specific role on plants. (iii) Behavioural responses of arthropods on interaction on plant.

2. MATERIAL AND METHODS

2.1 Study site and system

All the study was conducted in S.N.S. College campus, Motihari, East Champaran, Bihar, India. All these observations had taken in year, 2022 and were made by visual search during 5 minutes for each plant (n= 110 pants) with care for not disturbing the number of arthropods and plant structure on which they were located. After observations arthropods were collected from the plants. After their collection from plants arthropods were kept in alcohol for their identification.

2.2 Field and laboratory – based behavioural bioassays (involving confrontation experiments) between ant and the coexisting arthropods

The behavioural interactions (if any) were recorded, by the visual scan method, (15 minutes/ plant) between the various arthropods and ants on plants. Petri dish experiments were carried out in the laboratory in which arthropods were introduced (in 1:1 ratio, n=15, in each case) and predation events (if any) were recorded (for 60 min).

All confrontation tests were carried out similarly, in paired Petri dishes (a fresh dish being used for each test) and the behaviour of each individual was recorded under 3 categories: (1) Neutral – ignore, antennate and move (i.e. after antennation move in another direction), (2) Aggression – threat display (adopt threat display on encountering the prey), lunge (try to attack), lunge and bite (attack the prey), and, bite and kill, (3) Submission- run away, avoid, remain still and feigning death.

2.3 Statistical analysis

All the analysis was done by using MS Excel 2010 and XL stat 2023. The similarity and dissimilarity in the behavioural responses of the ant when confronted with the various arthropods were represented through Correspondence Analysis (CA with the software XL stat 2023).

3. RESULTS

3.1 Arthropods abundance and their role on plant *P. hysterophorus*

On the basis of the field observations results revealed that *Parthenium* plants harbour many arthropods such as ants, beetles, bugs, butterflies, flies, cricket and spiders. Only those arthropods were taken under calculation which was found on more than twenty *Parthenium* plants. I have identified more of them but few of them were unidentified and represents as species.

All the arthropods were belongs to two class, seven orders and fifteen genera. Out of 15 arthropods genera four species of ants (Order: Hymenoptera) i.e. *Camponotus compressus. C. paria, C. sericius* and *Tapinoma melanocephalum* occupies 73% of total abundance. Instead of ants, other arthropods occupy only 27% of abundance which includes 3 species of Dipteran flies, 2 species of beetles i.e. *Zygogramma bicolorata* and *Phaedon* sp. of Order Coleoptera, one species of Lepidopteran butterfly, one species of Orthopteran cricket, *Metioche* sp., Two species of Hemipteran bug i.e. *Cletus* sp., *Leptocorisa* sp. and two species of order Araneae i.e. *Pardosa* sp., *Oxypus javanus* (Fig. 1). Out of 15 arthropods genera each arthropods play a significant role on plants such as (i) Pollinator (*Camponotus compressus. C. paria, C. sericius* and *Tapinoma melanocephalum)* and dipteran flies (ii) Leaf defoliater (*Z. bicolorata, Phaedon* sp. and *Metioche* sp.) (iii) Sap sucker (*Cletus* sp., *Leptocorisa sp.)* and (iv) Predators (spiders: *O. javanus*, *Pardosa* sp.) (Fig. 2). Ants abundance were significantly higher than other arthropods and among ants, *Camponotus compressus* were most abundant on

Parthenium Plants. So further behavioural confrontation experiments were limited to behaviour of ant *C. compressus* towards other coexisting orthropods and vice versa.

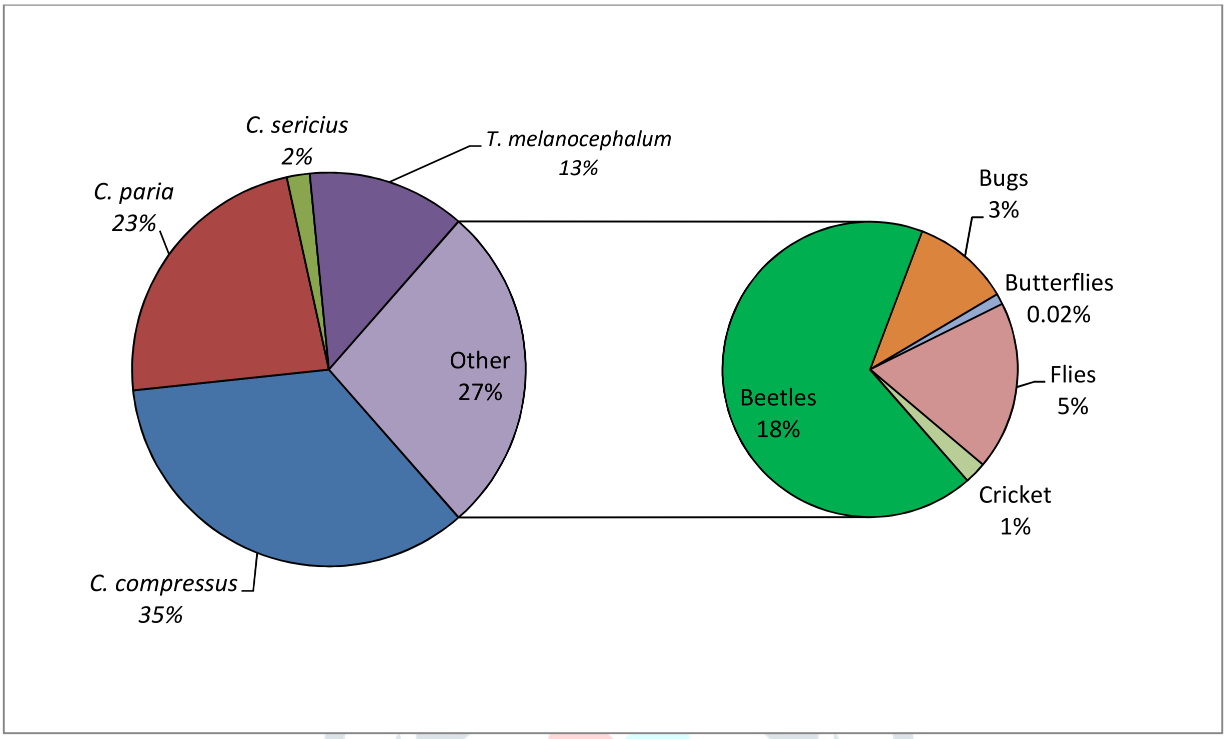

Figure 1. Abundance pattern of ants and other arthropods present on per plant of *Parthenium*

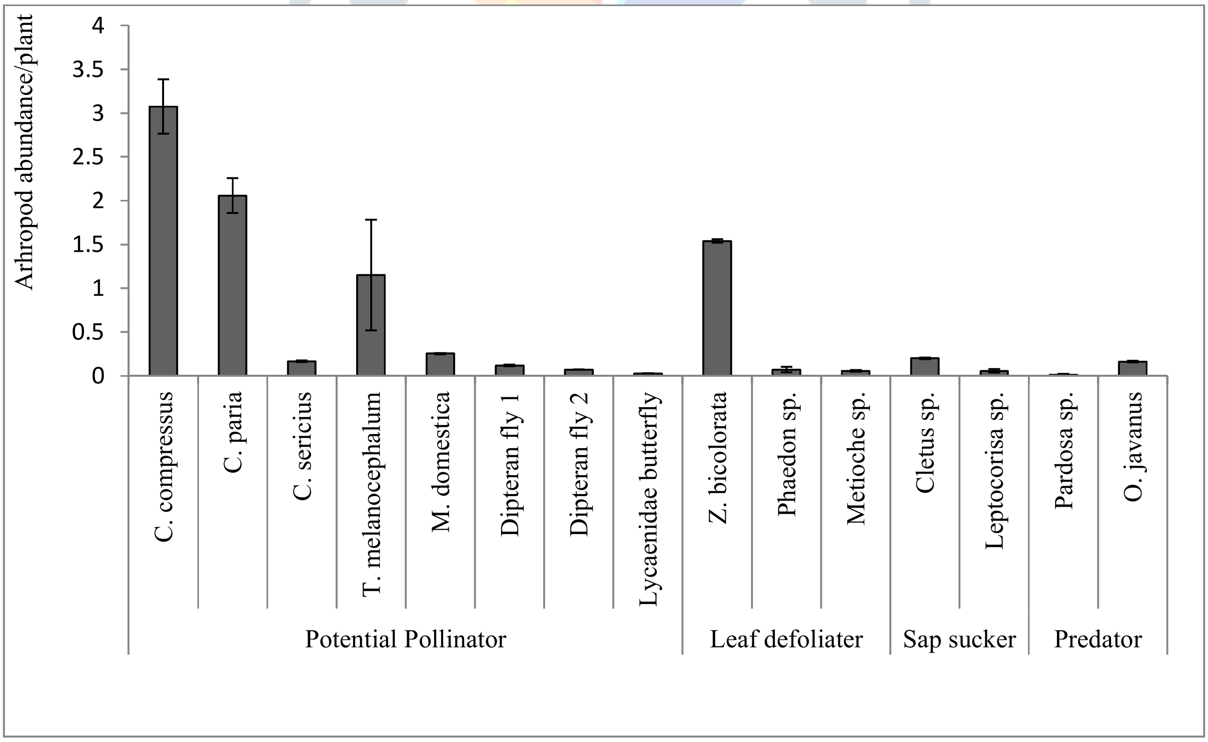

Figure 2. Role of different arthropods on *Parthenium* Plant i.e. Potential pollinator, leaf defoliater, sap sucker and predators.

3.2 Field and laboratory observations of behavioural interactions occurring between the arthropods

In field condition there were no significant behaviour showed between ants and arthropods because this is a time taking observations. In field arthropods avoide or running away (Submissive behaviour) while ants showed neutral behaviour (Ignore) on interactions with other arthropods.

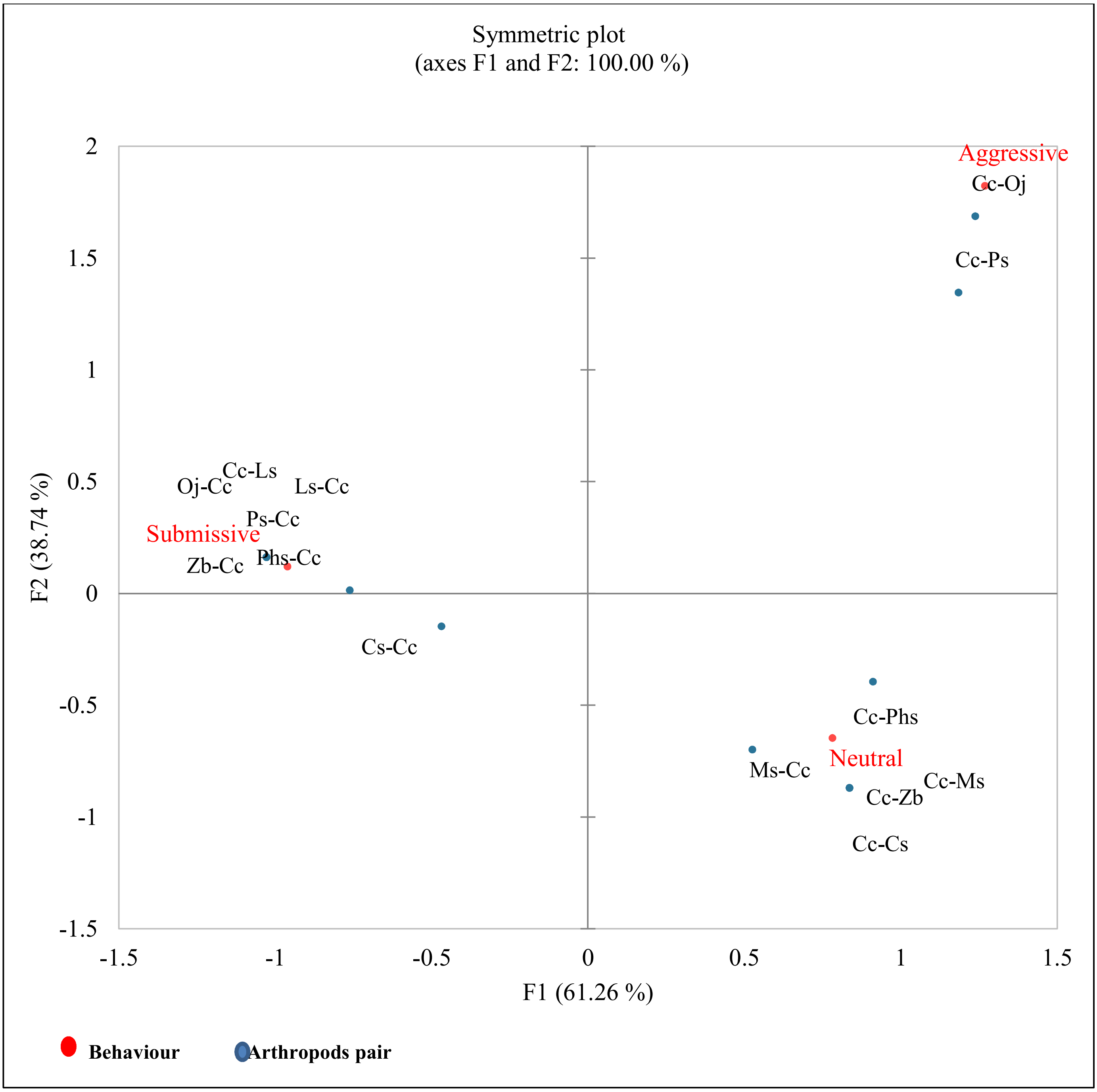

Figure. 2. CA ordination graph to show the behaviour of ant, *C. compressus* worker ants and the arthropods during laboratory confrontation experiments. The first set of two letters indicates the behaviour of an arthropod and the second set of two letters indicates the individual at which its behaviour was directed. For example: Cc-Zb shows the response of *C. compressus* worker ant toward the *Z. bicolorata*. (Abbreviations used in graph i.e. Cc= *C. compressus,* Zb= *Z. bicolorata,* Phs= *Phaedon* sp., Ms= *Metioche* sp., Cs= *Cletus* sp., Ls= *Leptocorisa* sp., Ps= *Pardosa* sp.and Oj= *O. javanus*)

In laboratory confrontation experiment, during behavioural interaction with ant, *C. compressus,* there were distinct differences in the behavioural responses of *C. compressus* worker ants towards the coexisting arthropods. Correspondence analysis (C.A.) study of the behavioural responses of ants during interactions with the coexisting arthropods revealed that the ants ignore (neutral behaviour) the arthropods but were aggressive towards the spiders. In correspondence analysis graph (Fig. 3), axes F1 and F2 pertaining to the behavioural responses of the ant and arthropods during the confrontation experiments explain 100% of the data. During interactions with the arthropods, ants show proximity to neutral behaviour. Significantly higher level of aggression was directed by the worker castes towards spiders. However, arthropods exhibited submissive behaviour towards the ants (indicated by behaviours such as 'running away', 'remaining still' and/or 'feigning death').

4. DISCUSSION

Congress grass, *Parthenium hysterophorus* L., of the family Asteraceae (tribe: Heliantheae), is an erect and much branched annual or ephermeral herb known for its notorious role as environmental, medical, and agricultural hazards. Field observation results and laboratory experiments suggest that ants preferentially select the plant, *Parthenium* for floral nectar while other arthropods select ant-visited plant to escape predation by the co-existing potential predators. It is reported that the presence of ants negatively affects the abundance and biomass of spiders (Sanders and Plater 2007; Nahas et al. 2012). Most spiders did not attack even the minor caste workers of *C. compressus* although lynx spiders reportedly prey upon arthropods not exceeding the length of spiders and also show myrmecophagy (Huseynov et. al., 2007). In fact, our results reveal that worker castes of *C. compressus* are extremely aggressive and occasionally killed the spiders, during laboratory confrontation experiments. In contrast, spiders either avoided ants by running away or displayed submissive behaviour, thus supporting earlier studies which report that most spiders' species stay safe by usually avoiding contact with ants (Ceccarelli, 2009). Hence the preference of the vulnerable stages of arthropods ensures protection againsts predators. The host plant selection may be done by the ovipositing female bugs to increase their reproductive success and the survival of the vulnerable stages, though field observations need to be made in future studies to confirm this aspect. Female lycaenid butterfly, *Athene usamaba*, is however, reported to use the presence of *Crematogaster mimosae* ants, as oviposition cue (Martins et al., 2013).

The lynx spiders, not only shows high abundance during the monsoon season (Butt and Tahir. 2010; Nahas et al., 2012) but is also reported to be a strongly predaceous (Vanitha et al. 2009) polyphagous, foliage-hunting, diurnal spider (Sherawat and Butt, 2014). C.A. ordination graph analysis of differential behavioural response data represents very clear pictures about their respective responses during interaction. On field observations and laboratory confrontation experiments indicate that the lynx spiders are important predators of the plant-visiting bugs. The spiders avoided the ants by running away (submissive behaviour). Thus under natural field conditions it is likely that the spiders do not attempt to attack the arthropods in the presence of ants on the plants. The contrasting behavioural patterns of the *C. compressus* ants, i.e. neutral towards the arthropods and aggressive towards the spider.

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