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Biodiversity of natural enemies in Agro-ecosystem of Jorhat district, Assam, India

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Abstract
A survey was conducted to assess the diversity of different natural enemies. Insect specimens were collected from different ecosystems of Jorhat district during 2017- 2018. Collections of various natural enemies were made from various ecosystems and a total of 50 surveys were conducted during the study period. The study reveals that the area under the survey has natural enemies belonging to 8 orders, 16 families, 32 genera, and 40 species and their ecological roles span from predator to parasitoids. The order Coleopteran was dominant with (11 species) occupying the maximum number of species where Hymenopteran order with (10 species), followed by Araneae with (9 species), Odonata with (7 species), Diptera with (1 species), Lepidoptera with (1 species) and Mantodea with (1 species) counts only a few during the study. The presence of different natural enemies indicated that it has a good potential source for better cultivation and therefore required to study about the efficiency of some important predators and parasitoids.

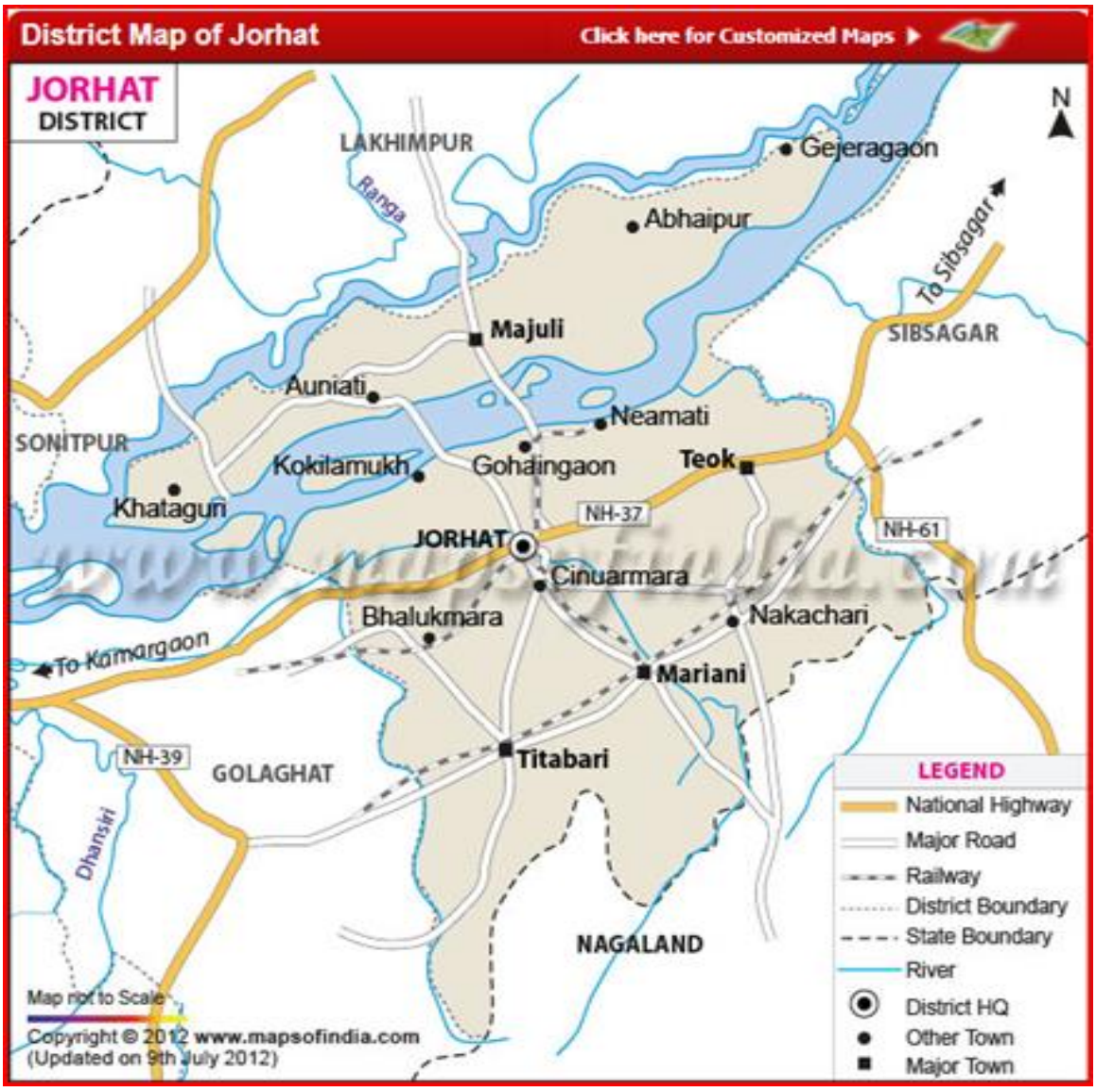
Keywords: Natural enemies, survey, diversity, Jorhat district

Introduction
Biological control of pests by natural enemies is important for ecosystem service delivered to agriculture worldwide. Quantifying and predicting its effectiveness at large scales is important for increasing sustainability of agriculture production. Globally, 10% of agriculture yields are destroyed by pests before harvest, despite of intensive measures of crop protection including the use of chemical pesticides. However, indiscriminate use of chemical pesticides has given rise to many serious problems, including toxicity to non-target organisms, development of resistance, resurgence and environmental contaminations. The option that has gained interest is integrating pesticides with biological control agents or natural enemies including parasitoids and predators. So, the control of pests by naturally occurring biological agents is of key economic and ecological importance. These natural enemies are responsible for about 50- 90% of the biological pest control occurring in crop fields. Natural enemies can lower insect densities, as well as stabilize populations by virtue of their prey selection, functional responses.

Biological control is a result not only of enemy diversity and abundance, but also of the trophic interactions occurring between enemies. Use of Natural Enemies maintains a natural balance in the ecosystem do not cause any environmental pollution and self-perpetuating in nature.

Climatic conditions, interaction between species, geography, local history and many other factors. The patterns of biodiversity in space consist of the area, latitude and altitude etc. that consist of season and life history. Jorhat falls within the upper Brahmaputra valley agro-climatic zone of Assam. This survey work of the present study was to assess the biodiversity of important natural enemies in Assam Agricultural University.

Materials and Methods
1. Location, Constitution and Area
Jorhat is located at an altitude of 87 meters above with latitude 26º45'N and 94º12'E. Jorhat is surrounded by Sivasagar in the east, Lakhimpur in the north, Golaghat in the west and Wokha district (Nagaland) in the south. The district comes under semi-arid region with summer temperature 25°–35 °C and winter temperature 22°–10 °C. In case of vegetation structure of Jorhat is concerned, the district comprises of wide types of agricultural land to forest areas. The district is spread over 2851 sq. km. with mean annual rainfall is 2029 mm.



Constitution and Area

2. Methods Adopted For the Study

Collections of various insects were made from different locations of varying habitats of Assam Agricultural University Experimental farm. The areas chosen for the collection of natural enemies comprises agricultural land with an average elevation of 116 meters (381ft). Details of the diversity pattern of the surveyed undertaken in different area are presented in Table 1 and a total of 50 surveys were carried out. The insect collections were made in the early hours of the day because insects are usually active at early hours of the day.

Methods of Collection

a) Hand picking: Insects were collected from leaves by hand picking like coccinellids.
b) Sweep net: Insect collecting net was used to collect active flier odonata insects. Insects trapped in the insect collecting net were first killed by the vapour of killing agent to facilitate collection.
c) Line transects method: Insects were collected by walking a straight line at a constant speed through the plants and the number of individuals can be counted.

3. Pinning of Insects

a) Pinning of hard bodied hymenoptera insects were pinned directly by piercing entomological pin through through right of middle line of thorax of pinning hymenoptera insects. The body and care was taken to choose the correct size and number of pin to avoid damage to the internal part. Usually 0-3 size pins were used, although longer pins of 37-39 mm. in length were used for large bodied insects.
b) Spreading- It is a process to arrange the wings for taxonomic study, with the help of spreading board which consists of two flat parallel pieces of soft wood with an inner groove lined by cork. A properly relaxed specimen, with a pin thrust vertically, was inserted inside the groove so that the wing bases remained at level with the edge of top part. Two narrow paper strips were used to hold and spread the wings, and after adjustment of the wings at a desirable position the collected specimen was pinned using an entomological pin.
c) Mounting- Small delicate specimens were pinned with a minute, fine pin on a piece of pith, and the other end of which a longer pin is inserted. The collection date and other details on a paper label were attached to this long pin. The mounted specimens were kept in insect cabinet. Naphthalene balls and Para dichlorobenzene were used in cabinet for safe preservation against any pest or fungal attack.

4. Sampling and Identification:
Collections of insects were made mainly by hand picking or holding a tube close to the web for the spiders and foliage trunk. The collected specimens were killed and preserved in 70% alcohol in glass tubes and labeled. The identification was achieved by presenting subsequent appropriate diagnostic characters in a series of alternative choices with the help of published keys (Srivastava, 2004) [7]; (Atwal and Dhaliwal, 2010) [1]. Some of the specimens were identified and confirmed by comparing with the specimens in Department of Entomology, Assam Agricultural University, Assam, India and identified specimens were arranged in systematic order.

Results and Discussion
In the present study, natural enemies belonging to 8 orders, 16 families, 32 genera, and 40 species are depicted in Table 1. On the basis of field observations and specimens collected, insects were divided into their order and families. Out of the 40 species recorded, coleopteran order recorded the highest natural enemies followed by Hymenoptera, Araneae, Odonata, Diptera, Lepidoptera and Mantodea.

Table 1: List of some natural enemies collected from different ecosystems.

Order	Family	Species Identified
1) Araneae	Araeneidae	*Araneus mitificus*
	Araeneidae	*Argiope pulchella*
	Araeneidae	*Cyrtophora citricola*
	Araeneidae	*Cyclosa bifida*
	Lycosidae	*Hogna lenta*
	Lycosidae	*Perdosa pseaudoannulata*
	Oxyopidae	*Oxyopes assamensis*
	Oxyopidae	*Oxyopes sitae*
	Tetragnathidae	*Tetragnatha sp*
2) Coleoptera	Coccinellidae	*Adalia bipunctata*
	Coccinellidae	*Brumoides suturalis*
	Coccinellidae	*Coccinella septempunctata*
	Coccinellidae	*Cheilomenus sexmaculatus*
	Coccinellidae	*Chilocorus nigritus*
	Coccinellidae	*Coccinella 11 punctata*
	Coccinellidae	*Coccinella transversalis*
	Coccinellidae	*Micraspis discolor*
	Coccinellidae	*Harmonia dimidiata*
	Coccinellidae	*Harmonia conglabata*
	Chrysomelidae	*Zygogramma bicolorata*
3) Diptera	Syrphidae	*Episyrphus belteotus*
4) Hymenoptera	Vespidae	*Vespa affinis*
	Vespidae	*Vespa cincta*
	Vespidae	*Vespa magnifica*
	Vespidae	*Vespa orientalis*
	Formicidae	*Solenopsis sp*
	Formicidae	*Oecophylla smaragdina*
	Trichogramatidae	*Trichogamma chilonis*
	Trichogramatidae	*Trichogamma japonicum*
	Ichneumonidae	*Isoptima javensis*
	Scelionidae	*Telenomus remus*
6) Lepidoptera	Lycaenidae	*Spalgius epius*
7) Mantodea	Mantidae	*Archimantis latistyla*
8) Odonata	Coenagrionidae	*Aciagrion hisopa*
	Coenagrionidae	*Agriocnemis pygmaea*
	Libellulidae	*Bradinopyga geminata*
	Libellulidae	*Brachythemis contaminate*
	Libellulidae	*Crocothemis servilia servilia*
	Libellulidae	*Neurothemis tullia*
	Libellulidae	*Pantala flavescence*

During the studies, the order Coleopteran was dominant with (11 species) occupying maximum number of species where Hymenopteran order with (10 species), Araneae with (9 species), Odonata with (7 species), Diptera with (1 species), Lepidoptera with (1 species) and Mantodea with (1 species) counts only a few during the study. The dominant coccinellid predators were *Adalia bipunctata, Brumoides suturalis, Coccinella septempunctata, Cheilomenus sexmaculatus, Chilocorus nigritus* (*Female*), *Coccinella* 11 *punctata, Coccinella transversalis, Micraspis discolor, Harmonia dimidiate* and *Harmonia conglabata*. Among the natural enemies, 3 species were from parasitoid viz., *Trichogamma chilonis, Trichogamma japonicum*, and *Telenomus remus.*
The present finding is found similar with (Majumder *et al*., 2013) [4] who reported 24 species of coccinellids under 17 genera from Tripura state. (Sharma *et al.,* 2015) [6] found 36 species of predatory coccinellids belonging to 24 genera, 11 tribes and 4 sub- families from Himachal Pradesh. The present results are in conformity with the findings of (Biswas *et al.,* 2001) [2] who reported 17 different species of predators and 2 species each of parasitoids from Bangladesh. Order Coleopteran, Hymenopteran, Araneae, Odonata, Lepidoptera, Dipteran, and Mantodea being a group of agriculturally important insects including its role in bio control agent in this region, demands its biodiversity studies. (Elpino-Campos *et al.,* 2007) [3] encountered 29 species of social wasps species distributed in 10 genera which are found similar with the present findings. Also, (Uetz *et al.,* 1999) [8] reported 18 families of spider, 56 genera and 95 species arranged on their foraging behavior in the field. 12 species of coccinellids were reported from Assam by (Ramya and Rojeet 2016) [5] which are found similar with the findings.

Conclusion
Many predators, parasitoids have been identified from an agro-ecosystem of Assam. It is therefore required to study about the efficiency of some important predators and parasitoids to reduce the environmental problems, health hazards, reduce chemical pesticides and also conserved natural enemies and maintain a balance in agro-ecosystem.

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