Annexure: III

UNIVERSITY GRANTS COMMISSION
BAHADURR SHAH ZAFAR MARG
NEW DELHI-110002

FINAL REPORT OF THE WORK DONE ON THE MINOR RESEARCH PROJECT

1. Project Report No. **: FINAL**
2. UGC Reference No. **: File No. 47 - 1701 / 10 (WRO), dated 10 / 05 / 2011**
3. Period of Report from **: 10 / 05 / 2011 to 10 / 05 / 2013**
4. Title of Research Project **: *"Use of Spiders as Predatory Natural Enemies to Control Rice Insect Pests of Vidarbha Region of Maharashtra."***
5. (a) Name of the Principal Investigator **: Dr. M. F. Jadhao**

   (b) Dept. and College where work has progressed: **Departmet of Zoology, Seth Narsingadas Mor Arts, Comm & Smt. G. D. Saraf Science College, Tumsar, Dist. Bhandara, (Maharashtra)**
6. Effective date of starting of the project **: 10 / 05 / 2011**
7. **Grant approved and expenditure during the period of the report:**

   (i) Total amount approved : **Rs 95, 0000**

   (ii) Received of first installment : **Rs 57,000**

   (ii) Total expenditure done : **Rs. 98,670**
8. **Report of the work done : (A separate Report is attached)**

   (a) Brief objective of the project:

   - ✓ To know the biodiversity of the spiders inhabiting the rice ecosystem of Vidarbha region of Maharashtra.
   - ✓ To record maximum possible number of new species of spiders from the study area.
   - ✓ To compare the abundance and richness of spiders between two cropping seasons and during different stages of the crop growth.
   - ✓ To create awareness among farmers to conserve the natural enemies especially spiders found in their fields only by minimising the indiscriminate use of pesticides.

Dr. M. F. Jadhao
(Principal Investigator)

Principal
(Dr. C. B. Masram)

SUMMARY OF THE WORK DONE (FINAL REPORT)

INTRODUCTION:

Among the cereals, rice and wheat share equal importance as leading source of food for man kindkind. Rice (*Oryza satia* L.) is a staple food for nearly one half of the world's population and provides 27 per cent of dietary energy and 20 per cent of dietary protein In India rice is the staple food crop for more than two third of the population. It is one of the largest rice producing country (Juliano, 1993). It accounts for about 31.4% of the cultivated area and about 40% of the country's total food grain production. However, despite of having the largest area under rice, its yield is among the lowest in the world (Rangi, 1993).

In Maharashtra, rice is second important crop of people, which is grown over an area of 14.99 lakh hectares with an annual rough rice production of 32.37 lakh tones. The average productivity of the state is 2.01 tone /hectare. Maharashtra ranks 13th place in rice production in the country. The average productivity of the state is low as compared to other rice growing states. Maharashtra has four rice producing regions viz. Konkan, Western Maharashtra, Marathwada and Vidarbha. Area under rice cultivation in Konkan was 4.136 lakh ha, Western Maharashtra 3.298 lakh ha, Marathwada 0.242 lakh ha, Vidarbha 7.319 lakh ha with annual rough rice production of 15.10 lakh tones, 8.82 lakh tone, 0.14 lakh tone, and 8.31 lakh tones, respectively. Vidarbha region covers the largest area under rice cultivation than other regions but it has low productivity than Konkan and Western Maharashtra region. (Maharashtra state Statistics dept report Pune, 2008-09).

Bhandara district belongs to low productivity group (yield 1,000-1,500 kg/hectare). Biennial average productivity of this group was 1,168 kg/hectare as against 1,480 kg/hectare biennial average productivity of the state. Though Bhandara district occupies the largest area under rice cultivation and production in the state, per hectare yield of 1,304 kg is very low as compared to those of Sangali (2,393 kg/hectare), Sindhudurg (2,370 kg/hectare), Kolhapur (2,361 kg/hectare), Raigad (2,294 kg/hectare) and Ratnagiri (2,267 kg/hectare) districts of western Maharashtra (ICAR, 2002).

Among the various factors, the insect pests may be one of the major one responsible for low yield of rice crop. Over 1400 insect species attack standing and stored rice in the world (Pathak, 1977 and Arora & Dhaliwal, 1996). Reported about 300 species of insects attacking at various stages of rice crop in India, 20 species have been found to be the major pests causing 21 to 51 percent yield loss (Singh & Dhaliwal, 1994). Jadhao and Khurad (2009) have documented 23 insect pests in rice ecosystem of Vidarbha region, especially Bhandara district. Of all these, 4 pests species that cause

significant yield losses are Yellow Stem Borers (YSB), *Scirpophaga incertulus,* Leaf Folder (LF), *Cnaphalocrosis medinalis*, Brown Planthoppers (BPH), *Nilaparvata lugens* and Whitebacked Plathopper (WBPH), *Sogatela furcifera* were infesting rice crop very commonly and thus representing major pest status .

For many decades, insecticides have been widely used to control rice pests which are very hazardous to environment and biodiversity (Heinrich and Mochida, 1984; Ganeshkumar and Velusamy, 1996; Holland *et al*., 2000; Amalin *et al*, 2001 and Lu Zhongxian, 2007). Indiscriminate use of insecticides has caused the resurgence of several primary and secondary pest species and development of insecticide resistant pest population (Smith, 1994; Ooi and Shepard, 1994). Other detrimental effects of pesticide misuse include human health impairment due to direct or indirect exposure to hazardous chemicals, contamination of ground and surface water through runoff & seepage and transmission of pesticide residues though the food chains (Pingali and Roger (eds), 1995). Pesticides directly reduce the population of natural enemies by killing them or indirectly by eliminating their hosts and causing starvation. According Kenmore *et al.* (1984) brown plant hoppers population increased drastically when insecticide use was intensified, insecticide resistant strain of insect pests emerged; spiders and valid predators were removed. Further, farmers are not aware to use of insecticides. Indiscriminate use of insecticides causes heavy loss of money and low production which ultimately results in increase in number of farmer's suicide cases, especially in Vidarbha region of Maharashtra. Due to these constraints researcher developed an alternative economical and eco-friendly method of insect control by utilizing the natural enemies found in the fields (Venturino *et al*., 2008; Chatterjee *et al*., 2009).

Natural enemies of rice pests include wide range of predators and parasitoids that are important biological control agents. Predators are capable of not only reducing pest densities below economic threshold level but also stabilize pest densities over time. Predators include a variety of spiders and insects such as carabid beetles, aquatic and terrestrial predatory bugs and odonates. Parasitoids include many species of hymenopteran wasps and few dipterans flies. According to Way and Heong (1994) in most instances the species richness and abundance of predator population may be greater than those of pest population when little or no insecticides are used. Abdullah *et al*., (1998) reported that planthopper population in the Muda agro-ecosystem in Malaysia was probably held in check by combination of natural arthropod predators (mainly spiders and dragonflies) and common insecticides.

Spiders

Among the various predators, spiders (Class: Arachnida and Order: Araneae) are economically potential biological control agents in agro-ecosystems which help regulate the population densities of insect pests (Pickett *et al.,* 1946; Dondale, 1956; Kajak *et al.*, 1968; Fox and Dondale, 1972; Riechert Lockley, 1984; Tanka, 1989 and Riechert and Bishop, 1990). The body of spider consists of two parts, namely the cephalothorax and abdomen. Dorsal side of cephalothorax is called carapace. Most of the spiders have eight simple eyes. The shape of the carapace and arrangement of the eyes are the characteristics for the family. Spiders are air-breathing arthropods having eight legs. Poison glands are found in all the spiders except members of two small families. Spiders use their venom to kill the prey and as means of defense (Gajbe, 2004). They possess spinnerets which produce silk composed of protein called fibroin. Spiders use the silk for various purposes. A web spider uses its silk to trap the prey.

Spiders find everywhere at every time and they are abundant in both habitat natural as well as agriculture habitat (Turnbull, 1973; Nyfeller and Benz, 1987).The most important use of spiders is in agriculture and forestry where these small arachnids act as little "Murderers" in regulating insect pest population. They are present in all stages of developing rice, attacking many pest species at one time. They are exclusively carnivorous consuming large number of preys without damaging plants. When pest populations increase in the field, spiders react in two ways; either by increasing the prey consumption or by increasing their own density. Spiders often capture and kill more prey than they actually consume even when satiated (Nyffeler *et al.,* 1994). Riechert and Lockley (1984) reported that spider may kill as many as 50 times the number of prey it consumes.

Spiders in rice field can play an important role as predator in reducing the densities of planthoppers and leafhoppers (Hamamura, 1969; Sasaba *et al.*, 1973; Gavarra and Raros, 1973; Holt *et al.*, 1987; Tanka, 1989; chiu, 1979). Lee *et al*., (1997) reported that spiders represent more than 90% of natural enemies of brown plant hopper in rice fields in Korea. Because of this fact, most of studies related to biological control of plant hopper have focused on spiders. According to Samiayyan Chandrashekaran (1998) spiders were effective against leaf folder, case worm and stem borer. Bamboradeniya (2000) observed that more than 50% of terrestrial arthropod species in Sri Lankan rice field consisted of predators with spider being the dominant predatory group.

The orb-web weavers Araneidae and Tetragnathidae feed upon Homoptera such as leafhoppers, Diptera, and Orthoptera, especially grasshoppers. The smaller, sheet-web weavers such as Linyphiidae, Dictynidae, and Theridiidae capture Diptera, Hemiptera, and Homoptera (especially aphids and leafhoppers), as well as beetles in the family Curculionidae. The funnel-web weavers (Agelenidae, Atypidae, Ctenizidae, and Eresidae) prey upon Orthoptera, Coleoptera, and Lepidoptera (Riechert and Bishop, 1990; Nyffeler *et al*., 1994). Hunting spiders (Lycosidae, Oxyopidae, Thomisidae, and Salticidae) frequently capture Orthoptera, Homoptera, Hemiptera, Lepidoptera, Thysanoptera, Diptera, and some Coleoptera and Hymenoptera (Riechert and Bishop, 1990; Young and Edwards, 1990; Nyffeler *et al*., 1994). According to Samiayyan (1996) the predatory potential studies of *Paradosa sp*., *Tetragnatha sp*. and *Oxyopes sp*. indicated that they were effective against lepidopteran pest of rice fields.

The wolf spider, *Lycosa pseudoannulata* is probably the most important predator in rice fields in Asia (Barrion and Litsinger, 1994). One wolf spider can eat up to 45 hoppers a day (IRRI, 2000). *L. pseadoannulata* is one of the most important predators of brown planthopper and can consume 15-20 adult planthopper per day (Samal and Misra, 1975). According Fagan *et al*. (1998) and Ishijima *et al*. (2006), wolf spider reduced densities of sucking herbivores (Delphocidae and Cicadellidae) in tropical rice fields.

Paradosa pseadoannulata is perhaps the single most important predator of BPH and can effectively regulate the pest population of leafhoppers and plant hoppers, whorl maggot flies, leafolder, case worm and stem borer (Gavarra & Raros, 1975; Kiritani & Kakiya, 1975; Kenmore, 1980; Kemore *et al.*, 1984; Shepard *et al.*, 1987; Ooi & shepard, 1994., Barrion and Litsinger, 1984; Rubia *et al.,* 1990; Visarlo Preap, 2001; Drechsler and Settele, 2001; Lu Zhang - Xian *et al*., 2006). *P. pseadoannulata & Atypena formosana* both spiders are considered important predator of brown planthopper (BPH) and green leafhopper (GLH) (Sigsgaard *et al,* 1999). *Pardosa* species consumed instars nymph of green leafhopper, brown plant hopper white baked planthopper. This species kills developing sucking pest that otherwise transform to full adult & produce another generation of pest (Barrion, 2001).

According to Mathirajan, (2001) *Tertagnatha javanus* is one of the common spiders found in rice field & effectively reduces the population of green leafhopper & brown plant hopper. Sigsgaard *et al.* (2001) reported that a spider species *Atypena formosana* (Linyphiidae) was found effective against rice BPH under field conditions. S

Spider Diversity

Spiders are the largest order of arachnids and rank seventh in total species diversity among all other group of organisms. The current global list of spider fauna is approximately 43,244 belonging to 3821 genera and 111 families (Platnick, 2012). In term of numbers, spiders seem to form one of the most important groups of natural enemies of rice insect pests. Barrion and Litsinger (1995) have recorded about 342 species of spider from rice field in Philippine and other South East Asian countries. Settle *et al*, (1996) have documented 765 species of spider from lowland irrigated rice fields in Indonesia. Bambaradeniya & Edirisinghe (2001) have documented 60 species of spiders from an irrigated rice field ecosystem in Sri Lanka. Tahir, (2009) has recorded 44 species belonging to 30 genera and 12 families in rice ecosystem of Punjab, Pakistan.

The spider fauna of India is represented by1685 species belonging to 438 genera (Keswani, *et al*., 2012). In India, Ghode *et al*. (1985) have recorded 21 species of spiders belonging to 8 families in wetland rice ecosystem of Orissa; Sudhikumar *et al*. (2005) recorded 94 species from Kuttanand rice agro system of Kerala and Sebastian *et al*. (2005) recorded 92 species of spider from 47 genera and 16 families from irrigated rice ecosystem in central Kerala. Khan (2006) has recorded total of 39 species belonging to 18 genera under 9 families from Uttar Pradesh.

In Maharashtra, many researchers have studied spiders in different agro-ecosystem such as cotton, soybean, wheat, jowar, pulses, mango, papaya, citrus plants and banana (Chapke, 2012; Keswani and Hadole, 2012; Keswani and Vankhede, 2014; Keswani, 2014 and Phartale *et al.,* 2015) and other habitats such as Katepurna sanctuary Akola district, Toranmal Sanctuary., Lonar crater sanctuary, Buldhana district., Melghat Tiger sanctuary, Amaravati district., Southern tropical thorn forest ecosystem, Solapur district., Salbardi forest., Satpura Range, Amravati district., Sarangpuri lake, Arvi and Wadali lake, Amravati (Meshram, 2011; Hippargi *et al.,* 2011; Shegokar, 2012; Deshmukh and Raut, 2014; Khandelwal, 2014 and Dar, 2015).

From the above review of literature, it is clear that some workers have studied the diversity and population fluctuation of spiders in India and abroad in various habitats. However, no exhaustive study has so far been carried out on spider diversity and their population fluctuation in rice ecosystem in Maharashtra; especially Bhandara district of Vidarbha region. Keeping in view the above mentioned fact, the present work has proposed to study the following objectives:-

OBJECTIVES:

- ✓ To know the biodiversity of the spiders inhabiting the rice ecosystem of Vidarbha region of Maharashtra.
- ✓ To record maximum possible number of new species of spiders from the study area.
- ✓ To compare the abundance and richness of spiders between two cropping seasons and during different stages of the crop growth.
- ✓ To create awareness among farmers to conserve the natural enemies especially spiders found in their fields only by minimizing the indiscriminate use of pesticides.

METHODOLOGY (PLAN OF WORK):

Study Area: The areas selected for proposed study for general survey belong to Bhandara, Gondia, Chandrapur and Gadchiroli districts of Vidarbha region of Maharashtra. Among the above districts, Bhandara (21.09° N and 79.42° E) is rightly called as the "Rice Bowls" of Maharashtra because it contributes nearly 15% of rice production of the state. Although Bhandara district occupies first position in area and rice production in the state but per hectare yield is very low as compared to those of other districts of western Maharashtra (ICAR, 2002). Therefore, fields of this district were selected for sampling. The sampling units were selected at random in all the localities (fields).

Study Period: The study was carried out for a period of two years from July 2011 to February 2013. The sampling was conducted in four cropping seasons viz., Kharif 1 (July 2011 - October 2011), Rabi 1 (November 2011 - February 2012), Kharif 2 (July 2012 - October 2012) and Rabi 2 (November 2012 - February 2013). Kharif season is characterized by heavy rains (South-West Monsoon) and high humidity whereas Rabi season is characterized by low rainfall and dry weather. The study was conducted at the following randomly selected 7 sites located at the same altitude: Tumsar, Mohadi, Lakhani, Sakoli, Bhandara , Paoni and Lakhandur

Sampling: Sampling was done every 7 Days After Transplantation (DAT). Spiders were collected from 4 quadrates (1m by 1m) placed at 4 corners of 10m by 10m area of selected site. Collections were done during early morning hours (between 7:30 to 9:30 hours) since it was observed that spider activity was the maximum at that time of day in the rice fields. The area around each plant was searched for possible webs and the plants were thoroughly examined for spiders from the top to bottom. Simultaneously data on weather parameters will be collected. Visual search was used for sampling in each selected study site. All 4 quadrates were searched for a total of one hour. Around 12 visits were made per site per season. A total of 28 quadrates were studied in each season

per site. Spiders were collected from the ground stratum and from the terminals of plants. Spiders of all life stages were collected during sampling.

Preservation: The spiders collected from each site every week were preserved in 80% ethyl alcohol with proper labeling of locality, date of collection and other notes of importance. The preserved specimens were counted under a Binocular Stereo-zoom microscope (Leica-MS5).

Identification: The adult preserved spiders were identified to the species level with the help of Binocular Stereo-zoom microscope and available literature (Tikader and Bal 1981, Tikader and Biswas 1981, Tikader 1987 and Barrion and Litsinger 1995) except the immature ones, which be identified only to the generic level. The preserved spiders (voucher specimens) were deposited in the in the reference collection of Zoology Department of S. N. Mor College, Tumsar, Dist. Bhandara (Maharashtra).

Data Analysis: Weekly data was prepared for both seasons (*rabi* and *kharif*) with detailed information on the occurrence of spiders. The collected data was analyzed by using statistical software, SPSS.

RESULTS AND DISCUSSION:

The spiders recorded from the rice fields of Bhandara district of Vidarbha region of Maharashtra belong to three foraging guilds Viz., hunting, web- building and ambushing (Table 1). A total of 7,579 spiders belong to 10 families, 19 genera and 28 species were collected. The widely distributed families were Tetragnathidae, Lycosidae, Araneidae, and Salticidae. The major component of the spider population found in this region was the family Tetragnathidae, Lycosidae, and Araneidae and Linyphiidae. Linyphiidae and Oxyopidae were also found in relatively large numbers.

The spider population in the Kharif and Rabi seasons exhibited differences in family composition. In Kharif season, Tetragnathidae and Lycosidae were the dominant families. However, in the Rabi season the dominant families were Salticidae and Lynyphiidae. Some families were widely distributed through out the study area while others were restricted to one or few localities. The species level composition also shows differences between two cropping seasons. Out of 28 species, 16 species of web- building, 11species of hunting and only one species belonging to hunting spiders were recorded during the present investigation.

The population growth showed a gradual increase in the 15^{th}, 30^{th}, and 45^{th} DTA (Days After Transplantation) followed by a slight decrease in the 60^{th} DAT. Then continued to grow up to the

90th DAT and reached the peak and the showed a sudden decline. The number of species collected during the sampling showed a gradual increase in number as the growth of the plants advanced. The fluctuation in the population density showed a difference between the web builders and the non-web builders. The density of web builders gradually increased and then decreased at the time of harvest. But hunters showed a trend of continuous increase in population density towards harvests.

The present study clearly reveals that the spiders are effective bio-control agent in rice ecosystem. The spider population always shows fluctuation with the crop stages and pest population. Except *T. javanas,* all the spiders were observed throughout the study. *T. javanas* was higher in early growth stage and *A. catenulata* was predominant during later stages of the crop. *Lycosa pseudoannulata* and *C. formosana* were observed throughout the study period and they were predominant in early stages of the crop. The occurrence of spiders in different days after transplantation in the field indicated that spider ensured protection of the crop from phytophagous insects. The result of the present study is similar to the findings of Sahu *et al.* (1996). The abundance of *C. formosana* was more in the early growth stages of the crop and gradually declined at 80 DAT. However, orb-weavers usually become abundant when insect damage has already occurred (Barrion and Litsinger, 1984). The nature of feeding habits of any animal depends on the nature of the food availability. The result clearly indicates that the number of spider depends on the availability of the pests. The findings support the hypothesis is that the prey population increases, the population of the spider also increases. The results also indicate that the present farming practices such as application of fertilizers and pesticide and weeding operation in the paddy fields are detrimental to the spider population and diversity. Since, assemblage of spider species is more effective in reducing a wide range of insect pests than a single species), and Good Agricultural Practices (GAP) are recommended to the farmers for maintaining and practices such as organic farming, Integrated Pest Management (IPM), System of Rice Intensification (SRI conserving the density and diversity of spiders in agro-ecosystem as well as to improve the crop productivity.

Table 1. Total number of spiders recorded from 6 different localities (tahasils) of Vidarbha Region in Maharashtra

Guild	Family	No. of Genera	No. of Species	No. of individuals
Web-building	Araneidae	3	5	934
Hunting	Clubionidae	1	1	143
Web-building	Linyphiidae	1	1	345
Hunting	Lycosidae	3	3	1423
Hunting	Oxyopidae	1	3	454
Hunting	Salticidae	4	4	856
Web-building	Tetragnathidae	2	6	2213
Web-building	Theridiidae	3	3	832
Ambushing	Thomisidae	1	1	212
Web-building	Uloboridae	1	1	167
Total	**10**	**19**	**28**	**7,579**

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