Recent Studies on Natural Enemies of the Rice Gall Midge, *Orseolia oryzae* (Wood-Mason)

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Introduction

The rice gall midge (RGM) in the family Cecidomyiidae, Diptera, is one of the important insect pests of rice in tropical Asia. Biological studies on the natural enemies of the insect have been fragmentarily carried out in China, India, Indonesia, Sri Lanka, and Thailand. However, recently advanced studies on the natural enemies of RGM have been conducted in the following aspects. Several kinds of parasitoids and predators of RGM were identified[38], and relationship between parasitic activities and developmental stages of the host insect were also clarified. Morphological investigations on developmental stages of parasitoids such as *Platygaster oryzae* and *P. foersteri* were also conducted in detail in Thailand[20,21] and then, parasitic competition between both parasitoids was demonstrated[21]. Effectiveness of parasitoids and predators for control of RGM was recognized in high land fields in West Java, Indonesia[5,36]. The brown colored adults of *Platygaster* sp. were also found from RGM in India[10]. An alternate host of the natural enemies was clarified in Indonesia[5].

In the present paper, the authors introduce briefly the results obtained from the recent studies on natural enemies on RGM occurring in tropical Asia.

Occurrence of parasitoids and predators

In Thailand, food-chain relationship between RGM and its natural enemies was clarified. A total of six parasitoids and 11 predators attacking RGM were reported[38]. Illustrations of five species of the parasitoids and some of predators were also provided[39].

The parasitic activities of *Neanastatus grallarius* and *Propicroscystus mirificus* were studied in wild rice fields. *N. grallarius* was an external larval parasitoid but not host-specific as it occasionally made an attack on mummies of RGM containing pupae of the parasitoids *P. oryzae* or on pupae of *P. mirificus*, as the secondary or tertiary parasitoids. *P. mirificus* was the secondary parasite that attacked pupae of *P. oryzae*, although it sometimes parasitized RGM[19].

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In Indonesia, a total of five parasitoids were found in Java Island. Of them, *P. oryzae* and *N. oryzae* were well distributed, followed by *P. mirificus* and a species of *Eurytoma*[33]. The most important parasitoid was *P. oryzae* during the wet season in Pusakanegara, West Java[6]. Several kinds of hymenopterous parasitoids such as *P. oryzae*, *P. mirificus*, *E. setitibia*, and *Trichorpia* sp. were recorded, and *N. oryzae*/*P. oryzae* and *N. oryzae* were considered to be important. The degree of parasitization ranged from 30 to 70%[35].

In a brief review of RGM, a total of six hymenopterous parasitoids i.e., *P. oryzae*, *P.* sp., *P. diplosiae*, *N. cinctiventris*, *N.* sp., and *N. grallarius* were described with special reference to the host stage, locality of country, biological and parasitic observations, and references. These hymenopterous parasitoids showed high parasitization in the late season of the rice crop, while low parasitism in the early stage of rice growing. Three kinds of predators were also listed such as *Casonoides interstitalis* and *Ophionia indica* (Carabidae), and *Nabis capsiformis* (Nabidae)[12].

P. oryzae and *N. grallarius* were reared from galls collected at Karnataka, India when 49 slender-grain cultivars of rice were tested for susceptibility to attack by RGM. *Tetrastichus* sp., *Gyrocampa* sp. (Braconidae), *Gelis areator* (Panz.) and unidentified ceratopogonid were also found[29].

The brown colored *Platygaster* sp. was recorded for the first time on RGM in Cumbum in India. The species is similar to the brown *Platygaster* sp. attacking midge on *Panicum* sp. at Cuttack, Orissa. The parasitoid activity was observed from the middle of October 1981 to February 1982 with its peak during December 1981[15].

A new pupal parasitoid, *Elaphropeza* sp. (Diptera, Empididae), was found in India to parasitize less than 1% of RGM pupae in October (the wet season). The maggots occasionally behaved as hyperparasitoid on pupae of *P. oryzae*[26].

Parasitization

In India, parasitization of *P. oryzae* in Jaya rice stubble and in wild rice in 1982 peaked from Jan. 29 to Feb. 11. Suppressed galls were maximum on April 9 to 15. Parasitization in wild rice, *O. perennis*, was higher and most galls were suppressed. RGM infestation and parasitization followed a wax and wane cycle[9].

RGM was heavily parasitized by two chalcid parasitoids, *N. grallarius* (Masi) and *P. oryzae* (Cameron) in Raipur, India, during 1981 Kharif. Parasitization ranged from 21 to 94% in October and November. *N. grallarius* (Euplelmidae) parasitized RGM pupae one month earlier than *P. oryzae*. A peak of parasitization was 75%, which was the first record of heavy parasitization in India[27]. The parasitization of *Platygaster* sp. on ratoon rice was studied during off season at Tamil Nadu, India and recorded to be 37.8%[13].

It is revealed that the parasitized galls by *P. oryzae* showed distinct external differences from non-parasitized galls. The appearance of parasitized galls was as follows: 1) shorter in length, broader in diameter and lighter in weight, 2) brown lesions at one or several places and 3 to 5 minute emergence holes only at the spongy region, 3) wall was translucent, pale green and broken off easily. Externally the pupal mass of the parasitoid is visible[16].

Parasitization to RGM by *N. grallarius* ranged from 21 to 94% was observed in October and November at Raipur during 1981 Kharif and parasitization was 75% in the 3rd week of November[27]. There was a 4:1 ratio of exposed to suppressed galls at Bhubaneswar, India. Parasitization in the suppressed galls was higher during early April, May, and June, late January and March, and in July. Parasitization started at the 4th week of September and reached its highest level at the last week of November at Raipur in the wet season.

In stubble, the parasite population was 8.5 to 15.8%. Then, the data show the role of

parasitoids in minimizing pest pressure[32]. In Ranchi, parasitization by *Platygaster* was as high as 40% in May 1981. The parasitoid appears late in Kharif, toward the end of October[1]. In Indonesia, *P. oryzae* parasitized 70 to 90% of RGM pupae in West Java[31].

Biology of the parasitoids

Surveys on natural enemies of rice insect pests were undertaken on the paddy crop in India for six consecutive years, 1975–80 Kharif season. A total of six kinds of parasitoids of RGM were identified as follows: *P. oryzae*, *P. mirificus*, *Platygaster* sp., *Proleptacis oryzae*, *Telenomus israeli* and *Neanan-status* sp. Prevalence of *P. oryzae* was moderate, while that of *P. mirificus* was high and of others trace[30].

Pan-trapping with a soft vinyl yellow pan could collect a large number of micro Hymenoptera and the brown colored species of *Platygaster* sp. which appear to be new to rice ecosystem in India[10].

Parasitization by *Platygaster* sp. in Madurai was 22.3% during October and reached a peak of 78% during December. In Melur, parasitization gradually increased from October and the peak was observed in the second week of February. It is indicated that high parasitization is obtained during the late rice growing season[14].

In Eastern Uttar Pradesh, infested tillers collected in fields were brought to the glasshouse to observe parasitoid emergence, and a parasitoid was identified as *P. mirificus* Girault (Pteromalidae)[24]. In Indonesia, biology of *P. oryzae* was studied. The parasitoid is widely distributed in Java and is the most important parasitoid of RGM. *P. oryzae* oviposited in newly hatched host larvae Reproduction was parthenogenetic. The number of ovarian mature eggs was 648, however the average number of eggs laid per female was 95. The complete life cycle averaged 30.5 days. The longevity of adult was 4.1 days when honey solution was given[28].

In Indonesia, six species of parasitoids of RGM were found in Java and biology of three important species was studied. *P. oryzae* is very common in Java, only females were found, and the host and the parasitoid were synchronised. *P. mirificus* was ectoparasitic and deposited an egg near a full-grown larva or a pupa of RGM. A solitary living larva grew rapidly and sucked the host. The duration of the total life cycle was about half that of the host. *N. Oryzae*, an ectoparasitic wasp, laid eggs near the pupa of RGM. The total life cycle was about two thirds of that of RGM[7]. In Karawang, Java Island, the parasitoids were abundant during the second generation and kept the pest populations at a much lower level at Pusakanegara[34].

In China, ontogeny and biology of *P. oryzae*, a gregarious endoparasitoid of RGM were studied. Development of its eggs newly deposited into the host egg was clarified based on the morphological characteristics. The egg stage lasted 13 to 14 days, while the larval stage was only 3 days. The fully developed larva was white and ovoid. The mouth was a simple transverse orifice. Before pupation each larva formed an ovoid cocoon. The female adult deposited two to three egg groups in one host (a group of 10 to 15 eggs were deposited at each oviposition). Nine to 61 parasitoids emerged from each parasitized pupa. The sex ratio was 8 female to 1 male. *P. oryzae* hibernates in the early embryonic stage in the first instar larvae of the host. The duration of a generation was 25 to 30 days[22].

In Thailand, developmental periods of two parasitoids, *P. oryzae* and *P. foersteri* were investigated and morphological characteristics of their immature stages were observed as follows. Developmental stage consisted of spindle, round, and blastula stages in the egg period including the embryo stage. Larva has the 1st to 4th instar stages, prepupa, and pupa respectively. Duration from egg to adult emergence in *P. oryzae* and *P. foersteri* was 27.3 and 29.7 days in the average. The parasitoid took about 5 days longer than the developmental period of the host midge. Newly emerged adults remained in the host for about four additional days before escaping from

the gall[20]. Interspecific relation of *P. oryzae* and *P. foersteri* was studied. The rate of coexistence of the two parasitoids was far lower in the field than in cage; only *P. foersteri* was supposed to complete the development. These facts indicate that there would be some factors to avoid direct competition between both species in fields[21].

Outbreak

The severe outbreak of RGM in the central rice-growing area of Thailand occurred in June 1977 in Chachengsao province. The dominant parasitoid was *N. grallarius* and parasitism ranged from 11 to 35%. *P. oryzae* and *O. indica* were also present[3]. In eastern Thailand, parasitism by *N. grallarius* was 18 to 24%, followed by 30% in southern areas, 68% in northeast, and 2.9% in northern areas. That of *P. oryzae* ranged 3 to 36% and, at the same place, that of *P. foersteri* 0.8 to 10.2%[17]. In Indonesia, parasitism by *N. oryzae* and *P. mirificus* was low when 12 localities in west and central Java were surveyed in March, the wet season, 1979[4].

Predacious mite

In Thailand, a high potential of *Amblyseius imbricatus* as an important predator of RGM egg was preliminarily studied[18]. In Indonesia, *A. imbricatus*, egg predator, was the most important to maintain low population of RGM in the concecutively planting areas at high land in West Java[5].

Alternate host of parasitoids

P. oryzae was found to have an alternate host, *Orseoliella javanica* Kieffer, which occurred on *Imperata cylindrica* abundantly growing around paddy fields. During the fallow season, *P. oryzae* attacked mainly the alternate host. The parasitoid started to attack RGM after transplanting of rice. *O. javanica* was considered to have an important role as an origin of the parasitoid occurrence[5,36]

Effect of insecticide application

The toxicity of various insecticide treatments to *P. oryzae* Cameron was determined in field-plot test at Cuttack, India. The parasitoid was not detected absent in the plot treated with granules of mephosfolan and fensulfothin at 1.5 kg(a.i.)/ha[2]. In the laboratory condition, a known number of parasitoid adults were released in the 15 × 2.5 cm glass tube containing a sprayed rice leaf and the mortality was recorded at 15 min interval after placed in the glass tube[2]. The endosulfan caused high mortality of the parasitoid within 30 min. The order of toxicity to parasitoid was endosulfan (200 ppm), phosphamidon (500 ppm), monocrotophos (400 ppm), chlorpyrifos (200 ppm), and phosalone (704 ppm). Phosalone caused mortality after 4.5 hr, indicating that it is the safest so far as tested[11]. The insecticides effective on RGM were also toxic to the parasitoid, however the highest percentage of parasitization was recorded with chlorpyrifos 10 G, indicating that it is safe for the parasitoid, while the emulsified concentration of the same insecticide recorded the lowest percentage of parasitization, indicating that it is highly toxic to the parasitoid[23].

Discussion

It is highly significant to note that interesting relationship between the natural enemies (parasitoids and predators) and RGM was clarified in tropical Asia with emphasis on biological and ecological studies of the natural enemies in international cooperation of the experts of rice entomology. In Indonesia, importance of the parasitoids and a predator was found in field condition because these natural enemies had a high potential to control RGM in a consecutive planting area in high land of West Java, and the parasitoids population was maintained for their generations through the alternate host midge, *O. javanica*, which occurs on *I. cylindrica*, alang-alang weeds, during the fallow season. The

predacious mite, *A. imbricatus*, was important for feeding on eggs of the host insect. Judging from the effectiveness of these natural enemies, natural conservation system must be established in paddy fields. However, taxonomic study is also important to identify species of the natural enemies, then cooperation of taxonomists is needed. The parasitic potential of the natural enemies has to be evaluated correctly, and the developmental stages of each natural enemy are needed to be clarified morphologically and biologically in order to establish forecasting system in future. Evaluation of the parasitic potential for key parasitoids and predators in each country is needed to be done.

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