Interactive influence of temperature and relative humidity on egg parasitoids of *Riptortus pedestris* (Hemiptera: Alydidae)

Bishwo P. Mainali and Un Taek Lim

Department of Bioresource Sciences, Andong National University, Andong

Contact: mainali.bishwo@gmail.com

Abstract

Biological attributes of parasitoids are influenced by physical factors such as temperature and humidity. Our previous studies found that *Gryon japonicum* (Ashmead) and *Ooencyrtus nezarae* Ishii, egg parasitoids of *Riptortus pedestris* (Fabricius), have different occurrence pattern. The current study was carried out in laboratory to understand the interactive effect of temperature and relative humidity on the occurrence pattern of the parasitoids. Twenty 4-5 day old mated females *G. japonicum* and *O. nezarae* were released individually on eggs of *R. pedestris* at combinations of three temperatures (20, 25, and 30°C) and three relative humidities (high, medium and low) for five consecutive days. Temperature had significant effect on all the biological attributes of both parasitoids. The highest number of eggs was parasitized at 30°C and low RH by both the parasitoids. Significant interaction of species and temperature was found in parasitism. Relative increment in parasitism by *G. japonicum* was higher than *O. nezarae* at 30°C whereas at 20°C the increment was not significant between the species. Both the temperature and RH may not have affected host quality assessment by the parasitoids as no significance in sex ratio of the progeny was detected. Temperature had significant effect on the development time of both species. Effect of RH on the development time of *O. nezarae* was also not found while development time of *G. japonicum* became longer in low RH. The relationship between occurrence pattern and response to environment conditions of the parasitoids was discussed.

Introduction

Ooencyrtus nezarae (Hymenoptera: Encyrtidae) and *Gryon japonicum* (Hymenoptera: Scelionidae) are major egg parasitoids of *Riptortus pedestris* (Hemiptera: Alydidae)[1,2] which is one of the important pests of soybean in Korea and Japan[1,3]. Biological attributes like reproductive capacity of parasitoids is fundamental for the evaluation of a biological control agent's potential[4], which is influenced by physical factors such as temperature, humidity and photoperiod[5,6].

Previous study indicated different occurrence pattern of the egg parasitoids *G. japonicum* and *O. nezarae*[7]. We hypothesized that weather conditions such as humidity and temperature might have some effect on the occurrence pattern of the egg parasitoids of *R. pedestris.* The influence of weather on the behavior of Hymenoptera is well documented for members of various families, including apidae[8,9], Ichneumonidae[10,11] and Chalcididae[12].

We investigated interactive effect of temperature and RH on reproductive capacity of the parasitoids as previous studies have not reported in this aspect. Knowledge on this may provide clues to design efficient system for mass rearing and field release of the egg parasitoids.

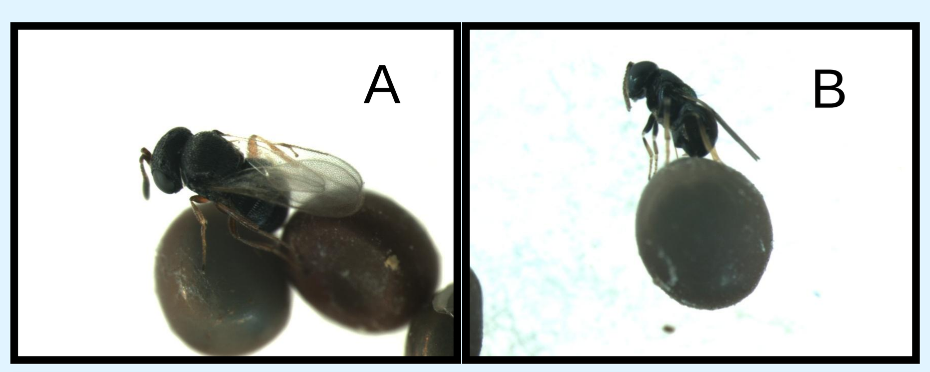

Fig. 1. *G. japonicum* (A) and *O. nezare* (B).

Materials and methods

Host egg production: *Riptortus pedestris* was reared on soybean seed as described by Alim and Lim[13] in acrylic cages (40L×40W×40H cm) with windows in three lateral sides covered with meshed screens for ventilation in the laboratory (24.1-28.8ºC). Eggs oviposited on a piece of gauge were collected daily.

Rearing egg parasitoids: *Ooencyrtus nezarae* and *G. japonicum* were maintained on the *R. pedestris* eggs in the laboratory. Adult parasitoids placed in a plastic centrifugal tube (50 ml) were provided with honey on the surface and a piece of moistened cotton on the bottom of the tube. The tubes containing parasitoids were kept under 26.6±0.1ºC, 31.4±0.6% RH, and 16L: 8D h of photoperiod in the incubator.

Experiment procedure: Eggs collected were exposed in a batch (n= 30) to each 4-5 d old mated female *O. nezarae* and *G. japonicum* in separate breeding dishes and were placed inside humidity chambers maintained at high (90-95%), medium (70-75%) and low (50-55%) RH. The RH within the chambers were maintained by using saturated salt solutions as described in Winston and Bates[14]. Salts used were $Mg(NO3)_2.6H_2O$, NaCl and K_2SO_4 for 50-55, 70-75, and 90-95% RH, respectively. Each humidity chambers was then placed inside incubators maintained at 20, 25 and 30ºC. The eggs exposed for parasitization were then collected after 24 h and a batch of 15 eggs were provided for d 2, 3, 4 and 5 to same individual species. For each day, eggs were exposed for 24 h. After 24 h the eggs were collected and kept inside an eppendorf tube (2ml) separately, and placed inside the chambers to provide same environment condition for their emergence as was provided during parasitization to observe the number of eggs parasitized, sex ratio, development time, and emergence. If any individual parasitoid is found dead during the experiment the procedure was repeated with another individual. The procedure was replicated 20 times for each parasitoid species. The temperatures and RH in this study were all recorded by using a Hobo data logger (H14-001, Onset Computer Corporation, Bourne, MA).

Statistical analysis: Data on number of eggs parasitized, development time, male proportion, and adult emergence were analyzed by the three-way ANOVA using GLM procedure in SAS and Tukey test as a post hoc analysis[15].

Results

Parasitism: The highest number of eggs, 19.3 and 35.6 in total 5 d were parasitized at 30˚C and low RH by both *O. nezarae* and *G. japonicum*, respectively. When parasitism was analyzed in terms of relative percent increment there was significant difference between the species ($F_{1, 342}$=40.44, P<0.001). In temperature higher than 25˚C and RH lower than 70%, respectively, *G. japonicum* had significantly higher relative increment in parasitism compared to *O. nezarae*. Both temperature ($F_{2, 342}$=271.34, P<0.001) and RH ($F_{2, 342}$=35.96, P<0.001) had significant effect on parasitism between species. Interaction between the species and temperature was also significant ($F_{2, 342}$=13.99, P<0.001). However, there was no significance in the interaction between species and RH ($F_{2, 342}$=1.71, P=0.182) and among species, temperature, and RH ($F_{8, 342}$=1.89, P=0.061, Fig. 2).

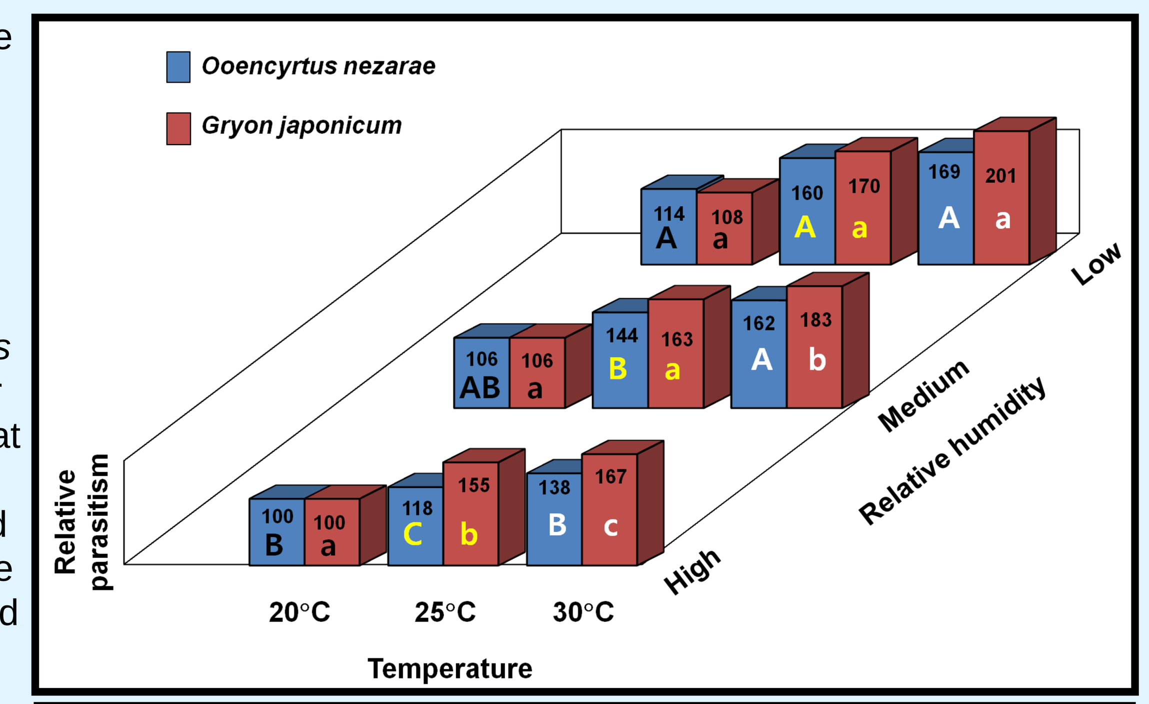

Fig. 2. Relative increment in parasitism.

Means separated using Tukey, capital letter for *O. nezarae* and small letter *for G. japonicum* at each temperature. Means with same letter are not significantly different.

Adult emergence: In case of relative increment in number of adults emerged along the temperature and RH combinations, significance was recorded between the species ($F_{1, 342}$= 15.87, P< 0.001). *Ooencyrtus nezarae* had relatively higher number of adult emergence at all level of temperature and RH except at 20°C compared to *G. japonicum*. Temperature ($F_{2, 342}$=179.26, P<0.001) and RH ($F_{2, 342}$=18.90, P<0.001) had significant effect on the number of adults emerged. However, there was no significance in the interaction between species and temperature ($F_{2, 342}$=0.82, P=0.441), species and RH ($F_{2, 342}$=2.12, P=0.122), and, among species, temperature and RH ($F_{8, 342}$=0.78, P=0.618, Fig. 3). Relative emergence within a species showed *O. nezarae* better in low to medium RH and *G. japonicum* in low RH.

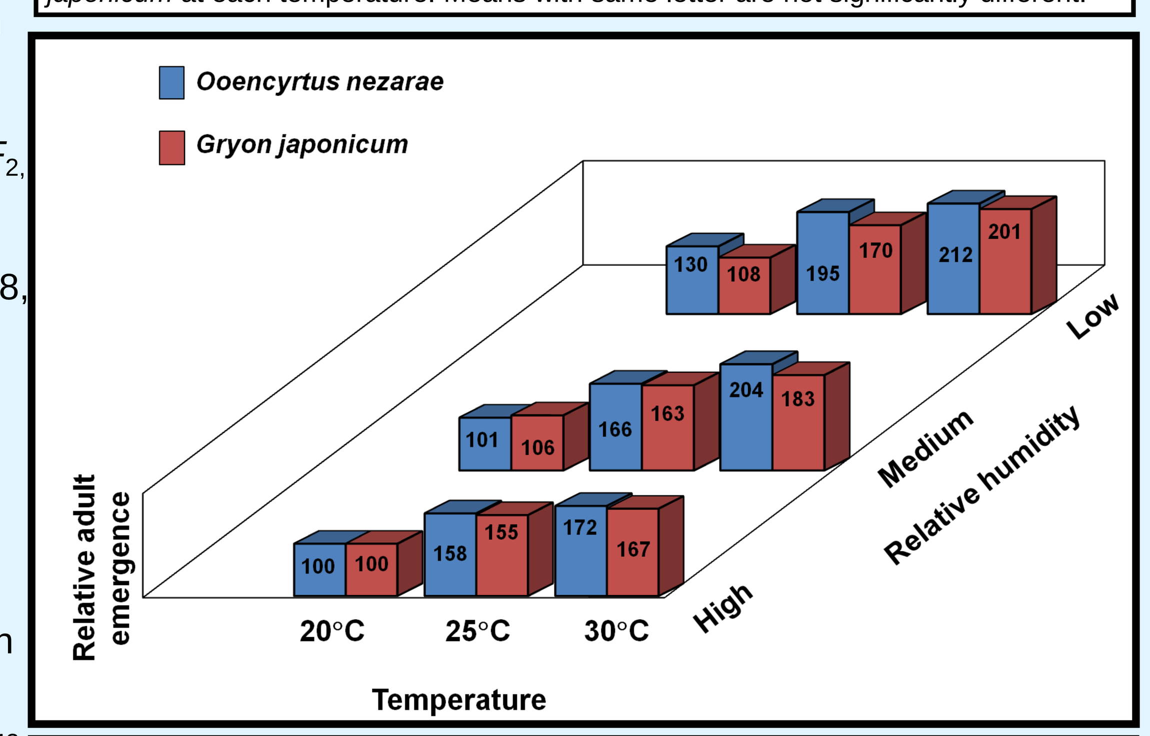

Fig. 3. Relative increment in adult emergence.

Sex ratio: There was significant difference between the species ($F_{1, 342}$=110.03, P<0.001). Temperature ($F_{2, 342}$ =7.51, P<0.001) had significant effect on sex ratio between species but not RH ($F_{2, 342}$=0.86, P=0.856). No significance was detected in interaction between species and temperature ($F_{2, 342}$=1.34, P=0.264), species and RH ($F_{2, 342}$= 1.34, P=0.264), and, among species, temperature and RH ($F_{8, 342}$=0.89, P=0.525, Fig. 4). There was no significant effect of both temperature and RH on sex ratio within species.

Development time: Development time for both male and female between the species was significant (male $F_{1, 342}$= 5801.72, P<0.001; female $F_{1, 342}$=19861.4, P<0.001). Both temperature (male $F_{2, 342}$=359408, P< 0.001; female $F_{2, 342}$=373552, P<0.001) and RH (male $F_{2, 342}$=43.73, P<0.001; female $F_{2, 342}$=37.54, P<0.001) had significant effect on male and female development time. Also, interaction between species and temperature (male $F_{2, 342}$=973.66, P<0.001; female $F_{2, 342}$=1048.29, P<0.001), species and RH (male $F_{2, 342}$=58.57, P<0.001; female $F_{2, 342}$=35.92, P< 0.001), and among species, temperature and RH (male $F_{8, 342}$=38.35, P<0.001; female $F_{1, 342}$=34.36, P<0.001) was significant (Fig. 5 A and B). However, RH did not have any effect in the development time for *O. nezarae* but *G. japonicum* had significantly longer development time at low RH and high temperature.

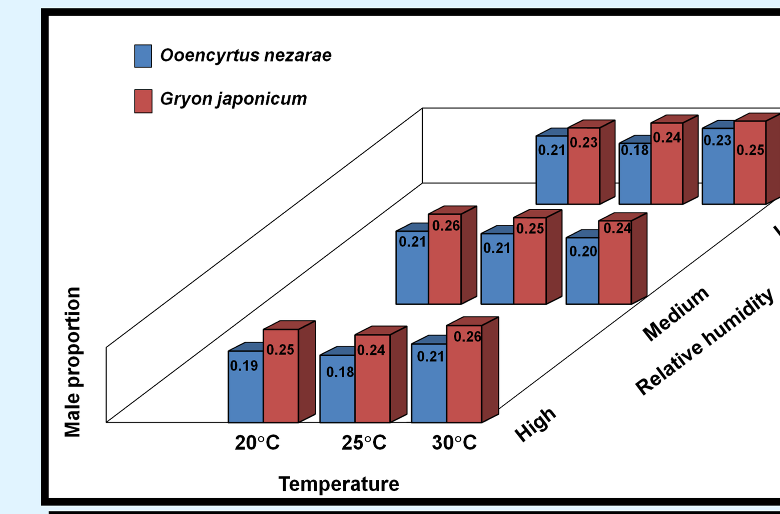

Fig. 4. Proportion of male.

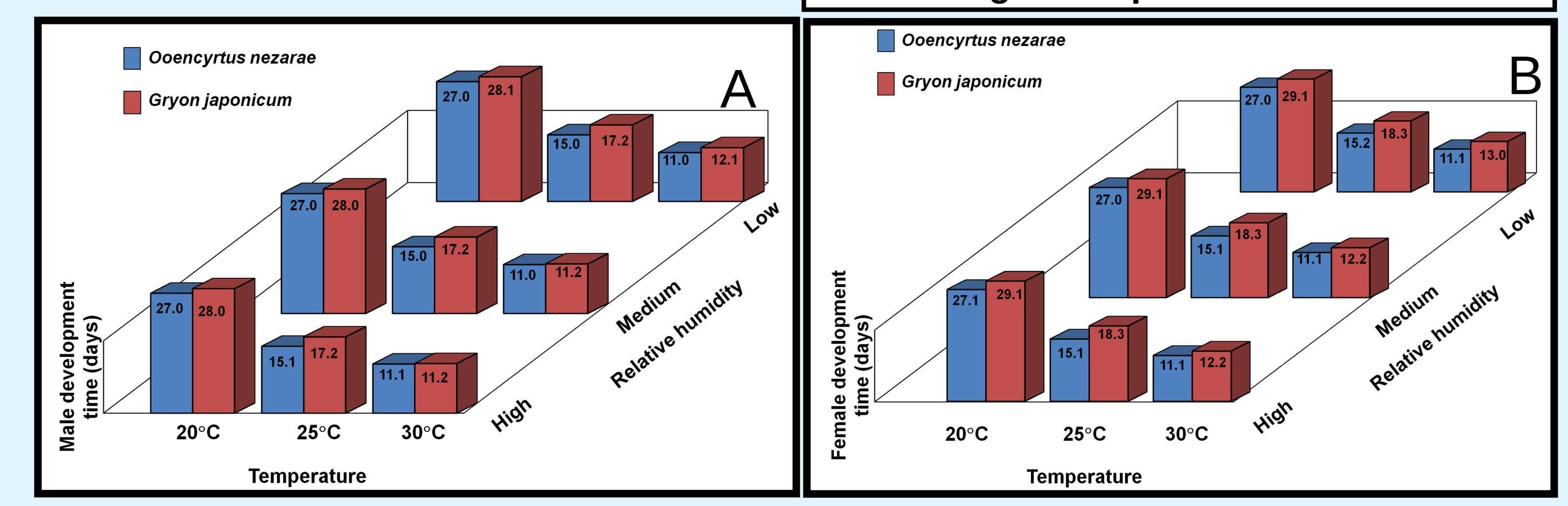

Fig. 5. Development time male (A) and female (B).

Discussion

Except for development time no interactive influence of RH and temperature was found on other reproductive attributes of both parasitoids. Though different occurrence pattern of the parasitoids in the field cannot be explained from the current results, a study by Kim et al.[16] reported reduced sensitivity to *G. japonicum* to low RH supporting evidence for its appearance in early spring[7]. Nevertheless, influence of other biotic and abiotic factors for different occurrence pattern cannot be ruled out. The major finding of this study was better performances of both the parasitoids at low RH (50-55%). Rousse et al.[17] reported increased parasitism with increased temperature and decreased parasitism with increased RH in *Fopius arisanus* an egg pupal parasitoid of fruit fly. Also, Duale[18] reported higher rate of parasitism at 50% RH by *Pediobius furvus*. Gol'berg[19] reported higher proportion of eggs laid by *Pauridia peregrina* at lower RH. Although the better parasitism in lower RH is not clear Steidle and Reinhard[20] reported pupal parasitoid *Lariophagus distinguendus* preferring low RH arena to high RH arena as habitat. Similar to our finding, Aung and Euno[6] did not find effect of temperature on sex ratio of *O. nezarae*. However, Duale[18] reported significant effect of temperature on sex ratio in *P. furvus*. Temperature had significant effect on development time of either sex of both species. But RH affected development time of male and female *G. japonicum* only. Yadav & Chaudhary[21], and Cave & Gaylor[22] reported that development time of *Cheiloneurus pyrillae* an encyrtid, and *Telenomus reynoldsi* a scelionid decreases slightly, but significantly, with increasing RH.

Conclusion

- No interactive influence of temperature and RH was found affecting reproductive capacity of the egg parasitoids but both temperature and RH had significant individual effects.
- Both egg parasitoids perform better at temperature 25-30°C and low to medium RH.

References

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