

DOI: 10.3969/j.issn.2095-1787.2018.04.007

广聚萤叶甲成虫交配时长对产卵量与孵化率的影响

郑海燕¹, 田震亚^{1,2}, 陈红松^{1,3}, 郭建英¹, 周忠实^{1*}

¹中国农业科学院植物保护研究所植物病虫害生物学国家重点实验室, 北京 100193; ²华中农业大学植物科学技术学院昆虫资源利用与害虫可持续治理湖北省重点实验室, 湖北 武汉 430070;
³广西农业科学院植物保护研究所, 广西 南宁 530007

摘要:【目的】明确不同交配时长对广聚萤叶甲雌虫产卵量和卵的孵化率的影响。【方法】在室内条件下, 对不同交配时长下广聚萤叶甲的雌虫产卵量和卵的孵化率进行观察: (1) 选取羽化第 3 d 的广聚萤叶甲雌雄虫随机配对, 观察 24 h, 记录交配情况和时长; (2) 在交配开始 1、5、15、30、60 min 时, 强行分开雌雄成虫, 然后将不同交配时长的雌虫进行单独饲养, 以正常交配一次的雌虫作为对照, 每个处理选取 23 组; (3) 将 15~30 cm 健壮豚草小苗插入注满水的塑料小瓶内, 将配对的一组雌雄成虫和豚草小苗放入养虫盒中饲养, 每天更换带卵的小苗并记录叶片上的产卵量; (4) 将上述带卵的小苗至于适宜条件下培养, 记录 5~7 d 内卵块孵化的情况。【结果】广聚萤叶甲正常交配一次的对照组的产卵水平显著高于各处理组, 单雌产卵为 889 粒, 交配时间 15 min 以下各组雌虫的产卵量明显低于交配 30 min 以上的各组雌虫。同时交配时长 5 min 以下雌虫产的卵基本不能孵化, 而交配时间达到 30 min 以上的各组卵块的孵化率明显提高。【结论】雄虫转移雌虫受精所需精子量需要耗费的时间为 30 min 左右, 且雄虫有延长交配时间的趋性。该结果为研究广聚萤叶甲的生态特性以及优化种群繁殖提供科学依据。

关键词: 广聚萤叶甲; 交配时长; 产卵量; 孵化率

Effects of mating duration on oviposition and hatchability of adult *Ophraella communa*

ZHENG Haiyan¹, TIAN Zhenya^{1,2}, CHEN Hongsong^{1,3}, GUO Jianying¹, ZHOU Zhongshi^{1*}

¹State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China; ²Hubei Insect Resources Utilization and Sustainable Pest Management Key Laboratory, College of Plant Science and Technology, Huazhong Agricultural University, Wuhan, Hubei 430070, China;
³Guangxi Key Laboratory for Biology of Crop Diseases and Insect Pests, Institute of Plant Protection, Guangxi Academy of Agricultural Sciences, Nanning, Guangxi 530007, China

Abstract: 【Aim】 The study aimed to understand the effects of oviposition and hatchability of *Ophraella communa* females. 【Method】 Under laboratory conditions, three days old (post-eclosion) males and females were randomly selected for the mating experiments. In a mating cage, a virgin male and a virgin female were allowed to mate. The copulation was artificially ended and male was then removed after 1, 5, 15, 30 and 60 min of mating treatments. The females that they completed a naturally copulation were set as the control. Each treatment and control had 23 females, which were allowed to lay eggs on 15~30 cm height twigs of common ragweed. These twigs were inserted into plastic bottles filled with water and changed every day. The number of eggs laid were recorded for each twig removed from the rearing cage. The twigs carrying eggs were placed in a rearing cage and the number of eggs that hatched within 5~7 d was recorded. 【Result】 The fecundity in the control was significantly higher than in the any other treatments, with 889 eggs per female. Mating success was significantly higher for couple mating for 30 min and more. The eggs from females that mated for less than 5 min could not hatch. Females that mated for more than 30 min had significantly higher hatching rate than any other treatment groups. 【Conclusion】 The results suggest that 30 min may be the minimum time needed to transfer sufficient sperms during mating. *O. communa* have

prolonged mating behaviours.

Key words: *Ophraella communa*; mating duration; egg production; hatching rate

广聚萤叶甲 *Ophraella communa* Lesage 是豚草 *Ambrosia artemisiifolia* L. 的重要专食性天敌, 对豚草控制效果显著 (孟玲等, 2007; Guo *et al.*, 2011; Yamazaki *et al.*, 2000; Zhou *et al.*, 2009)。广聚萤叶甲原产于北美 (Futuyma, 1990; Palmer & Goeden, 1991), 2001 年在我国江苏南京市郊首次发现 (孟玲和李保平, 2005)。

自然界中, 一般认为, 探索昆虫交配和产卵的关系是昆虫行为生态学中的重要研究内容 (Quiring, 1994; Saunders, 1982)。昆虫交配持续时间的长短对雌雄虫的适应性有着重要影响, 是性别选择中的一种重要特征 (Simmons, 2001)。足够的交配时长可保证雌虫接收到更多量的精子数量 (Arnqvist & Nilsson, 2000)。雄性在交配过程中, 精液会提供雌虫营养, 因此延长交配时间对雌虫更有利 (Thornhill, 1976; Vahed, 1998)。对于雄虫来说, 延长交配时间能向雌虫转移更多的精子 (Alcock, 1994)。所以, 一些昆虫的雄虫通过延长交配时间来保护雌虫, 并阻止其他雄虫与雌虫交配 (Parker, 1970; Simmons, 2001), 从而让自己的精子与雌虫受精。在许多昆虫中, 随着交配时间的延长, 雄虫向雌虫体内转移的精子 and 精液量会不断增多 (Parker & Stuart, 1976; Riemann *et al.*, 1967; Thornhill, 1980), 从而对雌虫产卵、寿命及卵孵化等具有调控作用 (Eberhard, 1996; Simmons, 2001)。

本研究旨在探索在不同交配时长下广聚萤叶甲产卵量与卵的孵化率, 研究结果将为广聚萤叶甲种群优化繁育提供一定的理论基础。

1 材料与方法

1.1 供试虫源和寄主植物

广聚萤叶甲成虫采自湖南省临湘市, 饲养于湖南省农业科学院植物保护研究所天敌繁殖基地内种植豚草的温室大棚内。采集豚草植株上的蛹, 羽化后记录羽化日期, 雌雄分别饲养备用。棚内温度 25~28℃, 相对湿度 70%~90%, 自然光照。豚草于 4 月初播种, 将种子用 1% 浓度的赤霉酸溶液浸泡 24 h, 然后捞出沥干, 加蛭石拌匀后, 在苗床上均匀平整地播种, 每隔 1 d 浇水一次, 待豚草幼苗长至 15~20 cm 高时用于实验。

1.2 实验仪器和材料

解剖镜: 德国奥林巴斯 (OLYMPUS) 公司 (型号: SZ51); 养虫架 (600 cm×150 cm×200 cm): 课题组自制; 养虫笼 (40 cm×40 cm×60 cm): 课题组自制; 透明塑料养虫盒 (9 cm×12 cm×6 cm): 购买于湖南省长沙市红星花卉市场; 透明小瓶 (直径 4 cm×高 6 cm): 购于长沙市各材料厂 (用于水培豚草小苗)。

1.3 饲养和观察条件

所有实验处理都在实验室内 (温度: 25~28℃, 湿度: 60%~80%) 条件下进行。

1.4 实验方法

将初羽化成虫标记日期, 雌雄分开饲养备用。选取羽化 3 d、发育良好的雌雄成虫随机配对, 观察 24 h, 记录交配情况和时长 (以雌雄成虫生殖器接合视为开始交配), 分别在交配开始 1、5、15、30、60 min 时, 强行分开雌雄成虫, 将不同交配时长的雌虫单独饲养, 以正常交配一次的雌虫作对照, 每个处理 23 组。将 15~30 cm 健壮豚草小苗插入塑料小瓶内 (瓶盖事先打好直径 0.8 cm 的小孔), 瓶内注满水以维持豚草苗的生长和新鲜性。将配对的一组雌雄成虫和豚草小苗放入养虫盒中饲养, 每天上午观察记录一次并更换新的豚草苗, 记录叶片上的产卵量, 然后将换出的豚草苗置于室内适宜条件下培养, 经 5~7 d, 在解剖镜下观察并记录卵块孵化情况和数量, 连续每天观察直至成虫死亡, 记录成虫死亡日期。

1.5 数据处理

采用 SAS 8.0 软件对数据进行正态和方差齐性检验, 必要时将数据进行反正弦平方根或对数转换。不同交配时长处理的数据经单因素多重比较进行差异显著性分析 ($P \leq 0.05$), 通过最小差异法 (LSD 法) 比较各虫体交配时长间平均数的差异程度。

2 结果与分析

2.1 交配时长对成虫产卵量影响

不同交配时长的雌虫的逐日产卵量和产卵总量均有较大差异, 随着交配时间增加, 雌虫的产卵量和产卵历期均增加, 正常交配一次的对照组的产卵水平显著高于其他各组, 单雌产卵为 889 粒; 交配时间 15 min 以下的各组雌虫产卵量明显低于交配 30 min 以上的各组雌虫 ($F_{5,132} = 23.40, P < 0.0001$) (图 1、2)。

2.2 不同交配时长对卵孵化率影响

交配时间长短对卵的孵化率影响显著,交配时间 5 min 以下雌虫所产的卵基本上不能孵化,而交配

时间达到 30 min 以上的各组卵块孵化率明显提高,正常交配一次的对照组雌虫的孵化水平最高(图 3)

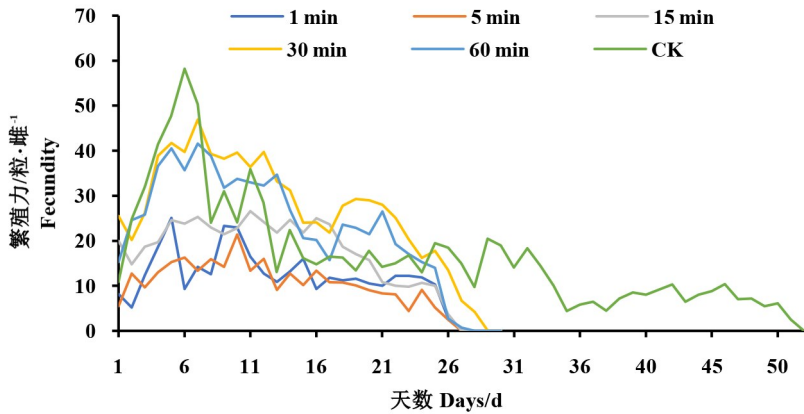


图 1 不同交配时长的雌虫逐日产卵量

Fig.1 Total number of eggs laid by a *O. communa* female female at different mating times

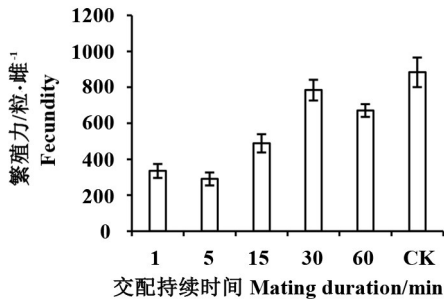


图 2 不同交配时长的雌虫产卵量

Fig.2 Total ovipositing quantities of the *O. communa* female with different mating time

3 讨论

本研究中,广聚萤叶甲成虫随着交配时间的延长,雌虫产卵量有逐步增加的趋势,交配时间 15 min 以下雌虫产卵水平显著低于交配时间 30 min 以上的雌虫,这与牵牛花果蝇 *Drosophila elegans* Bock & Wheeler (Hirai & Kimura, 1999) 及四纹豆象 *Callosobruchus maculatus* (Fabricius) (Edvardsson & Canal, 2006) 的研究结果一致。

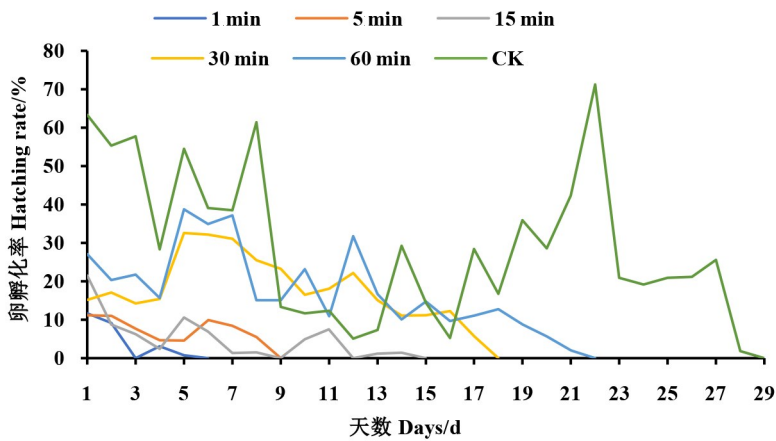


图 3 不同交配时长的雌虫卵块逐日孵化率

Fig.3 Mean number of eggs hatching per day from females exposed to different mating times

广聚萤叶甲交配 30 min 以上时,雌虫产卵量及卵孵化率与对照的差异不显著,由此推测广其在一次交配过程中,完成传递雌虫生殖所需精子量的时间大概为 30 min,这与孟玲和李保平(2006)认为成虫完成一次正常交配所需时间为 38.12 min 的结果

大致相同。本研究中,广聚叶甲雄虫需与雌虫持续交配一段较长的时间,才能提供雌虫正常生殖需要的精子量,而在交配过程中,雄虫出现了延长交配时间的现象,这种现象是为了防止精子竞争还是因为其他环境因素所致,仍待进一步探究。

参考文献

- 孟玲, 李保平, 2005. 新近传入我国大陆取食豚草的广聚萤叶甲. *中国生物防治*, 21(2): 65-69.
- 孟玲, 李保平, 2006. 豚草条纹萤叶甲的交配和产卵行为. *昆虫知识*, 43(6): 806-809.
- 孟玲, 徐军, 李海波, 2007. 外来广聚萤叶甲在我国的扩散及生活史特征. *中国生物防治*, 23(1): 5-10.
- ALCOCK J, 1994. Postinsemination associations between males and females in insects: the mate guarding hypothesis. *Annual Review of Entomology*, 39: 1-21.
- ARNQVIST G, NILSSON T, 2000. The evolution of polyandry: multiple mating and female fitness in insects. *Animal Behaviour*, 60(2): 145-164.
- EBERHARD W G, 1996. *Female control: sexual selection by cryptic female choice*. Princeton, New Jersey: Princeton University Press.
- EDVARDSSON M, CANAL D, 2006. The effects of copulation duration in the bruchid beetle *Callosobruchus maculatus*. *Behavioral Ecology and Sociobiology*, 17: 430-434.
- FUTUYMA D J, 1990. Observations on the taxonomy and natural history of *Ophraella wilcox* (Coleoptera: Chrysomelidae), with a description of a new species. *Journal of the New York Entomological Society*, 98(2): 163-186.
- GUO J Y, ZHOU Z S, ZHENG X W, CHEN H S, WAN F H, LUO Y H, 2011. Control efficiency of leaf beetle, *Ophraella communa*, on the invasive common ragweed, *Ambrosia artemisiifolia*, at different growing stages. *Biocontrol Science and Technology*, 21: 1049-1063.
- HIRAI Y, KIMURA M T, 1999. Effects of copulation duration on fertility and sexual receptivity of females in *Drosophila elegans*. *Zoological Science*, 16: 417-421.
- PALMER W A, GOEDEN R D, 1991. The host range of *Ophraella communa* LeSage (Coleoptera: Chrysomelidae). *Coleopterists Bulletin*, 45: 15-120.
- PARKER G A, STUART R A, 1976. Animal behavior as a strategy optimizer: evolution of resource assessment strategies and optimal emigration thresholds. *American Naturalist*, 110: 1055-1076.
- PARKER G A, 1970. Sperm competition and its evolutionary consequences in the insects. *Biological Reviews*, 45: 525-567.
- QUIRING D T, 1994. Diel activity pattern of a nocturnal moth, *Zeiraphera canadensis*, in nature. *Entomologia Experimentalis et Applicata*, 73: 111-120.
- RIEMANN J G, MOEN D O, THORSON B J, 1967. Female monogamy and its control in the housefly, *Musca domestica* L. *Journal of Insect Physiology*, 13: 407-418.
- SAUNDERS D S, 1982. *Insect clock*. Oxford: Pergamon Press.
- SIMMONS L W, 2001. *Sperm competition and its evolutionary consequences in the insects*. Princeton, New Jersey: Princeton University Press.
- THORNHILL R, 1976. Sexual selection and paternal investment in insects. *American Naturalist*, 110: 153-163.
- THORNHILL R, 1980. Sexual selection in the black-tipped hangingfly. *Scientific American*, 242: 162-172.
- VAHED K, 1998. The function of nuptial feeding in insects: a review of empirical studies. *Biological Reviews*, 73: 43-78.
- YAMAZAKI K, IMAI C, NATUHARA Y, 2000. Rapid population growth and food-plant exploitation pattern in an exotic leaf beetle, *Ophraella communa* LeSage (Coleoptera: Chrysomelidae), in western Japan. *Applied Entomology and Zoology*, 35: 215-223.
- ZHOU Z S, WAN F H, GUO J Y, 2009. Biological control of *Ambrosia artemisiifolia* with *Epibleme strenuana* and *Ophraella communa*// WAN F H, GUO J Y, ZHANG F. *Research on biological invasions in China*. Beijing: Science Press: 253-258.

(责任编辑:郭莹)