

环渤海湾地区棉铃虫成虫的卵巢发育特点及与迁飞行为的关系

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摘要: 1996~2000 年期间先后在河北省廊坊市、北京市西郊和辽宁省辽阳市系统研究了不同代别棉铃虫成虫的卵巢发育特点及与季节性迁飞行为的关系。研究结果表明环渤海湾南部的河北省廊坊市和北部的辽宁省辽阳市第 1 代棉铃虫成虫种群主要由外地迁入, 第 2~3 代种群多数年份主要来源于当地, 但部分年份亦有外地种群大量迁入。北京市西郊空中诱捕的棉铃虫 1~3 代成虫多为产卵前期个体, 具迁飞昆虫的生殖生理特征, 表明棉铃虫成虫迁飞活动存在于各个代别。

关键词: 棉铃虫; 迁飞; 卵巢发育

Ovarian Development of Adult Females of Cotton Bollworm and Its Relation to Migratory Behavior Around Bohai Bay of China

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Abstract: The Cotton bollworm, *Helicoverpa armigera* (Hünber), is one of the most important agricultural pests in China. Its seasonal migration, together with the ability in facultative diapause, is responsible for its pest status in different climatic regions. The region around Bohai Bay, where cotton bollworm occurs seriously in most of the years, is a major area for cotton and corn production in China. Therefore, it is extremely important to conduct experiments in the area on migration of cotton bollworm so that we can have better understanding of the general migration principle of the pest. Here reported are the research results on ovarian development of adult cotton bollworm females captured in Bohai Bay and its relation to migratory behavior of cotton bollworm.

The experiments were conducted from 1996 to 2000 in Beijing and Langfang City of Hebei Province, and Liaoyang City of Liaoning Province, which respectively located in south and north parts of Bohai Gulf. One 300W ground lighttrap was used to monitor adult dynamics of cotton bollworm in Langfang, and a 300W searchlight trap were set up in the top of a building (25 meters high) at Institute of Plant Protection, CAAS, in western suburban of Beijing for sampling insects from high altitude. In Liaoyang, a trap based on wilting poplar was designed to attract the adults of cotton bollworm. The population dynamics of cotton bollworm moths were monitored from early June to early September. The number of *H. armigera* adults caught in the traps were recorded each day, and the females were sectioned and graded according to ovarian development. The relationship between moth origin and developmental grade of their ovary was analyzed with the method described by Chen *et al.* and Li *et al.*

Three generations occur for this pest in Bohai Bay area each year. The results indicated that the first

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generation moths in both Langfang and Liaoyang, immigrated from middle or southern part of northern China, and the second or third generation moths originated mainly in local sites in most years while the moth immigration still occurred. The moths captured with a light trap from high altitude, in whole season in west suburban area of Beijing, showed that most of them were at pre-mature stage, implying that they possessed the physiological characteristics of migrating insects. Therefore, it is concluded that the migratory activities of cotton bollworm moths could take place in every generation.

Key words: *Helicoverpa armigera*; migratory behavior; ovary development

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昆虫的卵巢解剖是昆虫种群动态预测预报的重要方法之一,是明确昆虫虫源性质的重要手段^[1]。我国先后开展了不同地区稻飞虱、稻纵卷叶螟等昆虫的卵巢解剖工作,对阐明各地稻飞虱、稻纵卷叶螟的虫源性质,明确稻飞虱、稻纵卷叶螟在我国的迁飞规律提供了重要依据^[2,3]。环渤海湾地区的山东、河北和辽宁等省是我国棉花、玉米等作物的主要种植区之一,棉铃虫是该区最重要的农业害虫。已有研究表明棉铃虫为兼性迁飞昆虫,其成虫可从华北中南部迁入东北地区^[4,5]。为了深入阐明环渤海湾地区棉铃虫的种群动态特点和虫源性质,作者近年来对环渤海湾地区棉铃虫成虫卵巢进行了系统解剖。

1 材料与方法

1.1 棉铃虫雌虫卵巢发育进度

将室内人工饲料养殖的棉铃虫蛹在 26℃、75% RH 环境下羽化,每日抽样解剖观察其卵巢发育进度。

1.2 棉铃虫成虫自然种群取样地点及诱捕方法

试验地点分别在渤海湾南部的河北省廊坊市、北京市西郊和渤海湾北部的辽宁省辽阳市进行。廊坊市和北京市采用灯光(300w)诱捕法,廊坊市为地面灯诱,北京西郊为空中灯诱。地面灯诱诱捕器距地面 2m 左右,空中灯诱诱蛾器悬于中国农科院实验楼楼顶中央,其距地面约 25m 左右,灯光从楼顶向上空发射。辽阳市采用杨树枝把诱捕法诱蛾,10m 距离设 1 个杨树枝把,中间 1 行 4 把,两边两行分别为 3 把,共设 10 把。诱蛾期间视杨树枝把新鲜程度及时更换,一般 7d 左右更换 1 次。自 6 月初至 9 月上旬每天诱捕棉铃虫成虫。

1.3 棉铃虫雌蛾卵巢解剖方法

在全部诱捕期间,每日解剖所诱捕的棉铃虫雌蛾,检查卵巢发育级别及交配次数,卵巢分级标准参见^[6]。河北省廊坊市和辽宁省辽阳市棉铃虫每季节分别解剖 500~1000 头。北京市西郊空中诱捕种群每季节解剖 200 头左右。

2 结果与分析

2.1 棉铃虫雌蛾卵巢发育过程及交配次数

初羽化的雌虫卵巢体积小,为乳白色半透明,卵巢中的卵巢小管及侧、中输卵管尚未发育成熟,不易分辨。此后,卵巢管逐渐伸长加粗,可以模糊看见淡黄色未成熟的卵粒,随着卵粒由小变大,至 2 日龄时,卵巢管下部已有黄白色成熟卵,但卵巢管柄和输卵管内均无卵粒。至 4 日龄时,卵巢管已变得很长,卵粒完全成熟,进入产卵盛期,而卵巢管中由于产出卵粒,其它卵粒间出现空隙,至 6、7 日龄进入产卵末期,生殖机能开始衰弱,卵巢管变细、变短、逐渐萎缩。

对廊坊市地面诱捕的棉铃虫卵巢解剖表明,棉铃虫卵巢发育到 2 级时,开始出现交配现象,3~4 级时为交配盛期,5~6 级逐渐减少(表 1)。卵巢发育 1 级时,个体交配率为 5.13%,卵巢发育 3 级时个体未交配,交配 1 次和 2 次的比例分别为 12.07%、43.96%和 38.79%。到卵巢发育 6 级时,个体交配 1 次、2 次和 3 次的比例分别为 29.87%、41.56%和 25.97%。雌蛾一生交配次数在 1~4 次之间。1 级平均交配 0.05 次,2~3 级平均交配 1.01~1.37 次,4~5 级平均交配 1.82~1.89 次,6 级平均交配 1.96 次。

2.2 不同地区棉铃虫成虫卵巢发育及与迁飞关系

昆虫的初次迁飞都发生于成虫羽化后幼嫩阶段的后期。迁出区雌虫卵巢发育均处于 1 级和 2 级初期,而迁入区大多发育到 3 级以上^[1]。从表 2 中可以看出,辽阳市不同代别棉铃虫卵巢发育比率有明显的差别。第 1 代棉铃虫成虫卵巢 1 级比例极低,平均仅为 $2.92\% \pm 1.70\%$, 2 级比例 $17.07\% \pm 10.80\%$, 3 级以上个体占 80.01% ,表明 1 代棉铃虫成虫主要由外地迁入。2 代棉铃虫成虫卵巢发育级别 1 级为 $39.27\% \pm 6.36\%$, 2 级为 $16.91\% \pm 1.18\%$, 3 级以上为 43.65% ,表明 2 代成虫以当地虫源为主要种群。3 代棉铃虫成虫卵巢发育级别 1~2 级个体为 69.77% , 3 级以上为 30.25% ,表明主要种群亦为当地虫源。

1997~2000 年北京市西郊空中诱捕的棉铃虫卵巢解剖显示,成虫交配率较低,1 代、2 代和 3 代的平均交配率分别为 35.91% 、 17.17% 和 26.97% 。不同代别棉铃虫卵巢发育情况相似,主要以卵巢发育 1 级个体为主。第 1、第 2 和第 3 代棉铃虫卵巢发育 1~2 级的比率分别是 65.42% 、 81.66% 和 68.40% ,具迁出种群的生理特征。基于蛾子由空中捕获,应为过境迁飞个体。棉铃虫类昆虫的运动形式有短距离、长距离运动和远距离迁飞 3 种方式,其飞行高度(相对于地面)分别是低于 2m、低于 10m 和高于 30m^[7,8]。北京西郊灯诱成虫飞行高度在 25m 以上,应属长距离运动和远距离迁移类型。1997 年 6 月 17 至 10 月 6 日共捕获棉铃虫蛾子 537 头,1998 年 5 月 6 日至 10 月 1 日捕获 510 头蛾子。以 3 代成虫种群数量最大,1 代和 2 代成虫数量相当。空中种群时间动态和廊坊地面种群极为一致,表明棉铃虫的迁飞运动可发生于各个代别。

1999 年和 2000 年廊坊市地面诱捕的第 1 代棉铃虫卵巢发育低级别个体较低,2 级以下个体分别为 4.38% 和 16.32% ,表明种群主要为外地迁入。第 2 代种群年度间差别较大,1999 年 2 级以下个体为 42.52% ,应以当地种群为主,但 2000 年 2 级以下个体仅为 16.94% ,表明主要种群来自外地。2a 间第 3 代种群无大的差别,3 级以下个体分别为 56.75% 和 58.12% ,应为当地种群(表 4)。不同年份和代别成虫交配率为 $75\% \sim 93.69\%$,以迁入为主的种群代别交配率高于当地虫源代别,如 1999 年第 1 代为迁入种群,交配率达 93.69% 。第 2 代和第 3 代为当地种群,其交配率分别为 75.20% 和 75% (表 3)。

表 2 北京市西郊空中诱捕棉铃虫和辽宁省辽阳市地面诱捕棉铃虫的卵巢发育级别比例(%)

Table 2 Proportions of different stages of ovary development of adult female captured from Beijing and Liaoyang						
地点 Location	诱捕方式 Type of moths captured	代别 Generation	卵巢发育 1 级 Stage 1	卵巢发育 2 级 Stage 2	卵巢发育 3 级 Stage 3	卵巢发育 ≥4 级 ≥Stage 4
北京市 Beijing	空中诱捕 Air lighttrap	1	51.12 ± 9.53	14.30 ± 4.20	26.48 ± 17.79	8.10 ± 5.48
		2	67.42 ± 13.98	14.24 ± 3.44	14.22 ± 13.65	4.11 ± 4.96
		3	55.33 ± 13.07	16.84 ± 5.56	11.22 ± 2.44	16.67 ± 15.82
辽阳市 Liaoyang	地面诱捕 Ground trap	1	2.92 ± 1.70	17.07 ± 10.80	58.39 ± 11.17	21.62 ± 12.91
		2	39.27 ± 6.36	16.91 ± 1.18	31.58 ± 6.26	12.07 ± 6.51
		3	53.32 ± 6.19	16.45 ± 3.83	22.69 ± 1.00	7.56 ± 1.36

3 讨论

昆虫的远距离迁飞是由“起飞→运行(飞行)→降落”3 阶段组成的,气流在整个迁飞过程中起重要的作用。在我国,昆虫的迁飞与东亚地区低层大气环流季节性变化有密切的联系。6 月份我国西风带位置北移,大陆热低压的发展和西太平洋副热带高压加强北上西伸,使西南气流向北扩展,我国东部的大部分地区盛行西南气流,势力可北界可达 49°N 左右,昆虫可随此气流迁入东北。在我国华北地区 1500m 高度 6 月份气流的速度多分布于 $7 \sim 9\text{m/s}$,如以 8m/s 的风速估算,华北地区棉铃虫成虫 10 余小时即可抵达东北地

表 1 不同卵巢发育级别的交配次数(1999,河北省廊坊市)

Table 1 Mating number in different stages of the adult ovary development (1999, Langfang)

卵巢级别 Ovary stage	未交配 Virgin moth (%)	交配 1 次 Mating 1 time (%)	交配 2 次 Mating 2 times (%)	交配 3 次 Mating 3 times (%)	交配 4 次 Mating 4 times (%)
1	94.87	5.13	0	0	0
2	26.44	49.42	21.84	1.15	1.15
3	12.07	43.96	38.79	5.17	0
4	0.86	23.28	25.86	12.07	0.86
5	1.04	21.88	41.67	13.54	1.04
6	1.04	29.87	41.56	25.97	1.29

表 3 空中诱捕和地面诱捕棉铃虫成虫的交配率(%)					
Table 3 The mating proportions of the adult females captured from air and ground					
地点 Location	诱捕方式 Type of moth captured	年度 Year	1 代成虫 Adult females of 1 st generation	2 代成虫 Adult females of 2 nd generation	3 代成虫 Adult females of 3 rd generation
北京市 Beijing	空中诱捕 Air lighttrap	1997	38.71	17.39	20.31
		1998	50.00	12.90	15.12
		1999	35.71	8.31	48.43
		2000	19.23	30.00	24.00
		平均 Average	35.91±6.35	17.15±4.67	26.97±7.39
廊坊市 Langfang	地面诱捕 Ground lighttrap	1999	93.69	75.20	75.00
		2000	83.58	87.95	78.26
		平均 Average	88.64±5.06	81.58±6.38	76.63±1.63

区。基于棉铃虫不能在辽阳市越冬和渤海海面存在棉铃虫向东北地区迁飞的现象^[5,9],渤海湾北部的辽阳地区 1 代棉铃虫成虫种群应是华北棉铃虫随东亚大气环流迁移的结果。田间诱捕种群应为迁入 1 日后个体,故其卵巢发育多已成熟。位于渤海湾南部的廊坊市虽属于可以越冬区内^[10],但其第 1 代种群仍主要由外地迁入,可能和其位于西南气流向东北扩展地带上,华北地区棉铃虫向东北地区迁飞沿途大量降落有关。其不同年份和代别间卵巢发育情况变化较大,则表明此地种群虫源性质较为复杂,不同年份和代别可能存在外地迁入为主、部分外地迁入、本地虫源本地繁殖和本地虫源大部迁出几种虫源方式。

参考文献

[1] Chen R C(陈若簏), Ding J H(丁锦华), Tan H Q(谈涵秋), et al. *Insect migration* (in Chinese). Beijing: Agriculture Press, 1989. 364~373.

[2] Li R D(李汝锋), Wang J Q(王金其), Su D M(苏德明). *Insect ovarian development and prediction of their population dynamics*. Shanghai: Fudan University Press, 1987. 99~108.

[3] Chen J C(陈若簏), Cheng X N(程遐年), Yang L M(杨联民), et al. The ovarian development of the brown planthopper (*Nilaparvata lugens* Stål) and it's relation to migration. *Acta Entomologica Sinica*(in Chinese)(昆虫学报), 1979, **22**(3): 280~287.

[4] Wu K M(吴孔明) and Guo Y Y(郭予元). Flight activity in *Helicoverpa armigera*. *Acta Ecologica Sinica*(in Chinese)(生态学报), 1996, **16**(6): 612~618.

[5] Wu K M(吴孔明), Xu G(徐广) and Guo Y Y(郭予元). Observations on migratory activity of cotton bollworm moths across the Bohai gulf in China. *Acta Phytophylacica Sinica*(in Chinese)(植物保护学报), 1998, **25**(4): 337~340.

[6] Nanjing Agricultural College (南京农学院) ed. *Insect ecology and prediction of population dynamics*(in Chinese). Beijing: Agriculture Press, 1985. 315~317.

[7] Farrow R A and Daly J C. Longrange movements as an adaptive strategy in the genus *Heliothis*; a review of its occurrence and detection in four pest species. *Aust. J. Zool.*, 1987, **35**: 1~24.

[8] Fitt G. The ecology of *Heliothis* species in relation to agroecosystems. *Ann. Rev. Entomol.*, 1989, **34**: 17~52.

[9] Wu K M(吴孔明) and Guo Y Y(郭予元). On the cold hardiness of cotton bollworm, *Helicoverpa armigera*. *Acta Ecologica Sinica*(in Chinese)(生态学报), 1997, **17**(3): 298~302.

[10] Wu K M(吴孔明) and Guo Y Y(郭予元). Investigation on population fitness of cotton bollworm, *Helicoverpa armigera*. *Acta Entomologica Sinica*(in Chinese)(昆虫学报), 1997, **40**(supply): 7~12.