Utilization Efficiency and Functional Response of *Orius similis* to Different Preys


Abstract: *Orius similis* Zheng (Hemiptera; Anthocoridae) is an important predatory natural enemy in agro-ecosystem in south of China. Its adults and nymphs can prey *Aphis gossypii* Glover, *Frankliniella formosae*, *Tetranychus cinnabarinus*, and the eggs or hatched larvae of *Pectinophora gossypiella*, *Helicoverpa armigera* and *Anomis flavus* Fabricius and other pest of Lepidoptera, and it can also eat plant pollen. There has a large quantity of *O. similis* in cotton field, and it’s a kind of natural enemy beneficial to agriculture. Cotton aphids, pink bollworms, tomato fruitworms, flower thrips, cotton red spider mites, cotton pollen and south minute pirate bugs are several important ring-joints of food chains in the cotton fields ecosystem. In this paper, the utilization efficiency of *O. similis* to its preys and foods, such as cotton aphids, pink bollworms and cotton pollen, and its functional responses to different preys was studied systemically. And the energy flow relationships between *O. similis* and its preys and foods was also analysed systemically.

*O. similis* in the research was captured from cotton fields in farmland of our university, and raised in lab with wide-mouthed bottles (about 500ml) under the condition 30±2 °C, RH 60%～80%. *A. gossypii* was collected from rose mallow trees and cotton fields in our university. *F. formosae* was gathered from cotton flowers in cotton fields. Eggs of *P. gossypiella* and *H. armigera*, adult cotton red spider mites and cotton pollen were gathered from the cotton fields in our university.

Feeding *O. similis* with natural preys and foods, *A. gossypii*, *F. formosae* Moulton and cotton pollen...
in lab with single vial (about 10 ml), respectively. One O. similis was raised with 10 to 20 in numbers of preys per vial, 40 O. similis was raised per stage, and recorded the weight of O. similis and preys every stage and every day, respectively. There had the increased weight of single O. similis after preying on preys every day (A) and the reduced weight of preys that was eaten by one O. similis (B), and then A divided by B could come to the utilization efficiency of single O. similis to different preys, respectively. 10 O. similis was raised by cotton pollen in plastic container (about 165 ml), and 30 O. similis per stage, and recorded the weight of O. similis and cotton pollen every stage and every day, respectively. There had the increased weight of single O. similis after eating cotton pollen every day (A) and the reduced weight of cotton pollen that was eaten by one O. similis (B), and then A divided by B could come to the utilization efficiency of single O. similis to cotton pollen, respectively.

And the preying capacity of O. similis on different preys mixtures was measured. Enough quantities of different preys (A. gossypii, eggs of P. gossypiella and eggs of H. armigera) was mixed and fed to O. similis in the same vial, and recorded the quantity of different preys that was eaten by single O. similis.

The preying capacity of O. similis on different preys with different density was also studied. Multi-preys was made up of nymph of F. formosae, adult of T. cinnabarinus and eggs of P. gossypiella, every species of prey fed to the adult and nymph of O. similis with different densities, such as 3 insects (or eggs) with 1 O. similis, 7 insects (or eggs) with 1 O. similis, 11 insects (or eggs) with 1 O. similis, and then recorded the quantity of preys that was eaten by O. similis, and every treatment was repeated 5 times.

With the status analysed by variance analysis, it showed that there was a peak-period in the development of O. similis, the highest utilization efficiency of O. similis to different foods were in 4 stage of nymph, and the utilization efficiency of O. similis fed with A. gossypii Glover (10.74%) and F. formosae Moulton (10.5%) were higher than that with cotton pollen (0.72%). Feeding with the mixtures of natural preys (A. gossypii, eggs of P. gossypiella, eggs of H. armigera), O. similis preayed A. gossypii prior. Feeding with different preys in different density, the preying capacity of O. similis per insect per day was larger in high density than that in low density, and it did like to prey the eggs of P. gossypiella than other two in high prey density. The result was beneficial to knowing about the rule of food selecting in fields and the technology of mass rearing in artificial foods.

Key words: O. similis zheng; preys; functional responses; utilization efficiency

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1. Materials and methods

1.1 Insects and cotton flower pollen

1.1.1 O. similis Zheng (Hemiptera) (Anthocoridae), A. gossypii Glover (Hemiptera) (Aphididae), P. gossypiella (Hemiptera) (Psyllidae), H. armigera (Lepidoptera) (Noctuidae), F. formosae Moulton (Lepidoptera) (Crambidae), T. cinnabarinus (Insecta) (Coccinellidae), P.adius (Insecta) (Pyrrhocoridae), T. cinnabarinus (Insecta) (Tetranychidae).
饲养繁殖后获得大量供试南方小花蝽卵，各龄若虫及成虫。

棉蚜
花蓟马若虫
棉红铃虫卵
棉铃虫卵
棉叶螨成螨及棉花花粉。棉蚜由木槿树及试验棉田中获得。
花蓟马若虫由棉花花朵采得。
棉红铃虫卵、棉铃虫卵、棉叶螨成螨与棉花花粉均采自校试验棉田。

试验条件
室内恒温，相对湿度。在广口瓶中或一次性塑料杯子或玻璃小指管中进行饲养。

食物利用效率的测定方法
南方小花蝽对棉蚜！花蓟马的利用效率的测定方法。单管饲养。每个小指管中放入一头南方小花蝽及若干头棉蚜或花蓟马。
同龄期一次，9)1+3
同龄期内南方小花蝽每天增加的重量及捕食棉蚜或花蓟马的重量分别相加可得单头南方小花蝽在该龄期内增加的体重及单头南方小花蝽在该龄期内捕食棉蚜或花蓟马的总重。据此可得出该龄期内南方小花蝽对棉蚜或花蓟马的利用效率。

南方小花蝽对棉花花粉的利用效率的测定方法。将发育一致的南方小花蝽若虫或成虫放于一次性塑料杯内。多头饲养。每天喂以一定重量的棉花花粉。同时称量同一处理中所有南方小花蝽的总重及喂入棉花花粉的总重。隔天再称南方小花蝽的总重及剩余的棉花花粉的总重。计算单头南方小花蝽的体重及每天增加的体重和单头南方小花蝽每天取食棉花花粉的量。同龄期内南方小花蝽每天增加的体重及取食棉花花粉的重量分别相加可得单头南方小花蝽在该龄期内增加的体重及单头南方小花蝽在该龄期内取食棉花花粉的总重。由此可得出该龄期南方小花蝽对棉花花粉的利用效率。

南方小花蝽对混合猎物的捕食作用的测定方法。
将足够数量的红铃虫卵！棉铃虫卵及棉蚜置于同一指管内。配置成混合猎物。测定南方小花蝽对混合猎物中各猎物的单头捕食量。

多猎物不同密度条件下南方小花蝽对不同猎物捕食效应的测定方法。多猎物由花蓟马若虫！棉叶螨成螨！棉红铃虫卵组成。设置(个密度水平。即棉叶螨成螨！花蓟马若虫和棉红铃虫卵各(头！粒。（头！粒。（头！粒。重复3次。测定南方小花蝽在不同猎物密度条件下对各种猎物的捕食量。

结果与分析
南方小花蝽不同龄期捕食棉蚜！花蓟马及取食棉花花粉的量。在试验条件下。室内测定不同龄期的南方小花蝽对棉蚜！花蓟马的捕食量以及对棉花花粉的取食量。结果如图7所示。图7中数据经方差分析后。结果如表7。由图7及表7可知。南方小花蝽若虫的捕食量随龄期递增。若虫龄期越高。捕食量越大。成虫期的捕食量明显高于若虫期。在试验条件下。南方小花蝽取食棉花花粉的量显著高于捕食棉蚜及花蓟马的量。
Table 1 The feeding quantity of *O. similis* on different foods and its variation analysis

<table>
<thead>
<tr>
<th>Food species</th>
<th>1st stage</th>
<th>2nd stage</th>
<th>3rd stage</th>
<th>4th stage</th>
<th>5th stage</th>
<th>Preoviposition</th>
<th>Post-oviposition</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. gossypii</em></td>
<td>0.75±0.28b</td>
<td>0.83±0.17b</td>
<td>0.94±0.20b</td>
<td>1.49±0.58b</td>
<td>2.32±0.47b</td>
<td>2.51±0.26b</td>
<td>2.25±0.28b</td>
</tr>
<tr>
<td><em>F. formosae</em></td>
<td>0.80±0.24b</td>
<td>1.00±0.39b</td>
<td>1.20±0.39b</td>
<td>1.90±0.30b</td>
<td>3.00±0.35b</td>
<td>3.70±0.39b</td>
<td>2.50±0.96b</td>
</tr>
<tr>
<td>Cotton pollen</td>
<td>10.40±2.63a</td>
<td>12.29±2.24a</td>
<td>13.90±2.80a</td>
<td>19.40±1.38a</td>
<td>22.10±2.45a</td>
<td>24.10±2.82a</td>
<td>14.20±4.31a</td>
</tr>
</tbody>
</table>


Table 2 The growth rate of *O. similis* on different foods and its variation analysis

<table>
<thead>
<tr>
<th>Food species</th>
<th>1st stage</th>
<th>2nd stage</th>
<th>3rd stage</th>
<th>4th stage</th>
<th>5th stage</th>
<th>Preoviposition</th>
<th>Post-oviposition</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. gossypii</em></td>
<td>0.044±0.019a</td>
<td>0.054±0.015a</td>
<td>0.076±0.010b</td>
<td>0.16±0.047a</td>
<td>0.169±0.099a</td>
<td>0.062±0.017a</td>
<td>0</td>
</tr>
<tr>
<td><em>F. formosae</em></td>
<td>0.05±0.025a</td>
<td>0.07±0.043a</td>
<td>0.10±0.025a</td>
<td>0.20±0.090a</td>
<td>0.10±0.050b</td>
<td>0.05±0.066a</td>
<td>0</td>
</tr>
<tr>
<td>Cotton pollen</td>
<td>0.05±0.043a</td>
<td>0.06±0.025a</td>
<td>0.09±0.025ab</td>
<td>0.14±0.043b</td>
<td>0.05±0.066c</td>
<td>0.03±0.043a</td>
<td>0</td>
</tr>
</tbody>
</table>


Fig. 2 The growth rate of *O. similis* on different foods
1～5 Nymph stages, 6 Preoviposition of adult, 7 Post-oviposition of adult

Fig. 3 The utilization efficiency of *O. similis* on different foods
1～5 Nymph stages, 6 Preoviposition of adult, 7 Post-oviposition of adult
生长速度也最快。

若虫期对食物的利用效率高于

南方小花蝽对棉蚜、花蓟马的利

用效率显著高于棉花花粉

而若虫及成虫产卵前

期对棉蚜的利用效率显著高于花蓟马

这说明南方小花蝽捕食棉蚜与花蓟马较之取食棉花花粉对自身种

表 3  The utilization efficiency of O. similis on different foods and its variation analysis

<table>
<thead>
<tr>
<th>Food species</th>
<th>Utilization efficiency(%)</th>
<th>nymph stages</th>
<th>Adult</th>
<th>Preoviposition</th>
<th>Post-oviposition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st stage</td>
<td>2nd stage</td>
<td>3rd stage</td>
<td>4th stage</td>
</tr>
<tr>
<td>A. gossypii (1)</td>
<td>5.87±1.65</td>
<td>6.51±1.61</td>
<td>8.68±2.29</td>
<td>10.74±5.26</td>
<td>6.28±1.67a</td>
</tr>
<tr>
<td>F. formosae (2)</td>
<td>6.30±4.45</td>
<td>7.00±3.03</td>
<td>8.30±1.18</td>
<td>10.50±2.99</td>
<td>3.30±1.96b</td>
</tr>
<tr>
<td>Cotton pollen (3)</td>
<td>0.48±0.32b</td>
<td>0.50±0.11b</td>
<td>0.64±0.21b</td>
<td>0.72±0.27b</td>
<td>0.23±0.33c</td>
</tr>
</tbody>
</table>

①A. gossypii; ②F. formosae; ③Cotton pollen

表 4 Preying capacity of O. similis on different prey mixtures

<table>
<thead>
<tr>
<th>Preying capacity (insect/egg)</th>
<th>Adult of O. similis</th>
<th>Nymph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most</td>
<td>Least</td>
<td>Average</td>
</tr>
<tr>
<td>Aphis gossypii</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Eggs of Helicoverpa armigera</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Eggs of Pectinophora gossypiella</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

表 5 Preying capacity of O. similis on different preys with different density

<table>
<thead>
<tr>
<th>Preying capacity (insect/egg)</th>
<th>Adult of O. similis</th>
<th>Nymph of O. similis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs of Pectinophora gossypiella</td>
<td>3.00</td>
<td>6.88</td>
</tr>
<tr>
<td>Adults of Tetranychus cinnabarinus</td>
<td>2.04</td>
<td>3.97</td>
</tr>
<tr>
<td>Nymphs of Frankliniella formosae</td>
<td>2.40</td>
<td>4.55</td>
</tr>
</tbody>
</table>

2.4

3.5

小结与讨论

周集中等的研究表明，在天敌与猎物种群的共存系统中，天敌对不同猎物的捕食性有其嗜好性。本文通过测定南方小花蝽对两种猎物的捕食量以及对棉花花粉的取食量，研究南方小花蝽对不同食物的利用效率以及不同食物对其生长发育的影响。
相反，棉花花粉并非是南方小花蝽的主要食物。这与捕食者总是偏爱较为有利的食物而拒食有利性较小的食物相一致。同时研究了南方小花蝽成虫与若虫对多种猎物组成的混合食物中各猎物的捕食作用。其结果进一步证实了捕食者对不同猎物的嗜食性。

等对捕食者的取食与猎物密度之间关系的研究表明，捕食者的摄食率与猎物密度在一定范围内呈线性关系。赵鼎新等研究了黑襟毛瓢虫捕食棉蚜的生物量与各龄幼虫发育速率间的关系。结果表明各龄幼虫须在一定的捕食量以上其发育速率才呈近似线性的增长。

董应才等研究了七星瓢虫各龄幼虫增长率与麦蚜密度之间的关系。结果显示各龄瓢虫的增长率与猎物密度呈逻辑斯蒂曲线增长，即在一定范围内各龄瓢虫的增长率随猎物密度的增加而增加。

本文研究了在多猎物不同密度条件下南方小花蝽对不同猎物的捕食效应。南方小花蝽成虫和若虫对同一种猎物不同密度条件下的日均捕食量存在显著差异。高密度条件下的日均捕食量高。对同一猎物密度在低猎物密度时南方小花蝽成虫和若虫对供试的多种猎物无明显的选择性。而在中高密度时则明显地表现出对红铃虫卵的嗜食性，而后依次为花蓟马若虫、棉叶螨成螨。这是由于在低猎物密度时其食物选择余地较小，为能保证其自身的生长发育，对于其食谱范围内的食物均加以取食，因而对猎物的选择性差异不显著。

而在中高密度时，南方小花蝽对所取食的对象有较大的选择空间，因而选择最有利于其生长发育的食物，这也验证了捕食者总是嗜好有利于其生长发育的食物这一行为生态学理论，与国内外学者的研究结果相吻合。通过本论文的研究可以合理准确地评价天敌对目标害虫的控制能力，为预测农田生态系统中天敌与害虫种群之间的数量变动提供可靠的依据，充分发挥以南方小花蝽治理棉蚜、花蓟马的调控作用，同时也可以初步了解南方小花蝽在田间的食物转换规律，也为将来更好地进行室内人工大量饲养奠定基础。

南方小花蝽是棉田生态系统中一种重要的捕食性天敌，以上研究可以为更好地利用南方小花蝽进行棉田害虫的综合治理提供依据。

参考文献