



广西扶桑绵粉蚧寄生蜂发生情况调查

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摘要:【目的】调查广西扶桑绵粉蚧寄生蜂种类、种群动态及其对扶桑绵粉蚧的控制作用,为广西利用自然天敌防控扶桑绵粉蚧提供科学依据。【方法】2018年10月—2019年10月,每月中旬从广西北海、钦州、崇左和防城港4个城市分别定点采集约450头扶桑绵粉蚧带回实验室。僵蚧单头挑至2 mL离心管中等待羽化,其余粉蚧放至发芽土豆上继续饲养、每天观察,将新形成的僵蚧及时挑至2 mL离心管中等待羽化,连续观察10 d,直至再无僵蚧出现。统计僵蚧数量及所占比例,鉴定寄生蜂种类,统计其数量,计算各种寄生蜂僵蚧所占比例。【结果】野外采集到9种寄生蜂,其中跳小蜂科5种:班氏跳小蜂 [*Aenasius arizonensis* (Girault)]、刷盾跳小蜂 *Cheiloneurus* sp.、康长索跳小蜂 (*Anagyrus kamali* Moursi)、松粉蚧抑虱跳小蜂 (*Acerophagus coccois* Smith) 和黑角原长缘跳小蜂 [*Prochiloneurus nigricornis* (Girault)]; 蚜小蜂科3种:豹纹花翅蚜小蜂 [*Marietta picta* (André)]、康氏迈蚜小蜂 (*Myiocnema comperei* Ashmead) 和黄脸拟暗蚜小蜂 (*Promuscidea unfasciiventris* Girault); 广腹细蜂科1种:粉蚧广腹细蜂 (*Allotropa phenacocca* Chen, Liu & Xu)。其中松粉蚧抑虱跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为群居寄生蜂,单头僵蚧最多可羽化出14头刷盾跳小蜂 *Cheiloneurus* sp. 成蜂。寄生蜂的总体寄生率较低(2.83%~29.56%),但僵蚧总体羽化率较高(92.15%)。北海寄生蜂资源最丰富,寄生蜂的寄生率最高,共采集到9种寄生蜂;钦州和防城港均采集到6种寄生蜂,崇左采集到5种寄生蜂。班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为优势寄生蜂,二者个体数量约是其余7种寄生蜂数量的17倍,二者寄生的僵蚧合计比例多超过80.00%;在野外,5月班氏跳小蜂为绝对优势种,其他月份在不同城市二者交替占优势。【结论】广西扶桑绵粉蚧寄生蜂资源丰富,目前发现9种,其中班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为优势种,二者交替占优势,但寄生蜂总体寄生率较低。

关键词: 扶桑绵粉蚧; 寄生蜂; 种群动态; 优势种; 广西

中图分类号: S436.81

文献标志码: A

文章编号: 2095-1191(2020)04-0852-09

Investigation on the occurrence of parasitic wasps of *Phenacoccus solenopsis* Tinsley in Guangxi

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Abstract: 【Objective】In order to provide scientific reference for the control of *Phenacoccus solenopsis* Tinsley by

收稿日期: 2020-02-24

基金项目: 国家自然科学基金项目(31760542); 广西自然科学基金项目(2017GXNSFAA198286); 广西创新驱动发展专项(桂科AA17204041); 广西农业科学院科技发展基金项目(桂农科2018JZ28)

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natural enemies in Guangxi, the species, population dynamics and control effects of parasitic wasps of *P. solenopsis* were studied. 【Method】From October, 2018 to October, 2019, about 450 *P. solenopsis* individuals were collected from designated locations in Beihai, Qinzhou, Chongzuo, and Fangchenggang separately in the middle of each month and were brought to the laboratory. The single *P. solenopsis* mummy was placed in a 2 mL centrifuge tube until the emergence of the parasitic wasp. The rest of *P. solenopsis* were placed on sprouted potatoes to allow continue feeding and were observed daily, the newly formed mummies were placed in a 2 mL centrifuge tube until the wasps emergence. The process lasted for 10 d until no more mummies appeared. The number and percentage of *P. solenopsis* mummies were counted, the species of parasitic wasps were identified, the number of each parasitic wasp was recorded, and the percentage of *P. solenopsis* mummies formed by each parasitic wasp was calculated. 【Result】In total, nine species of parasitic wasps were collected from the four localities, five species of Encyrtidae: *Aenasius arizonensis* (Girault), *Cheiloneurus* sp., *Anagyrus kamali* Moursi, *Acerophagus coccois* Smith and *Prochiloneurus nigricornis* (Girault), three species of Aphididae: *Marietta picta* (André), *Myiocnema comperei* Ashmead and *Promuscidea unfasciiventris* Girault, one species of Platygasteridae: *Alotropia phenacocca* Chen, Liu & Xu. *A. coccois* and *Cheiloneurus* sp. were gregarious species (more than one wasp individual emerged from one mummy), one mummy could emerge as many as 14 *Cheiloneurus* sp. adults. The overall parasitic rate of parasitic wasps was low (the rate ranged from 2.83% to 29.56%), but the emergence rate of *P. solenopsis* mummies was high (92.15%). Beihai was the richest in parasitic wasp resource, the highest parasitic rate and nine species of parasitic wasps were discovered there. Six species of parasitic wasps were collected both in Qinzhou and Fangchenggang, while five species of parasitic wasps were collected in Chongzuo. *A. arizonensis* and *Cheiloneurus* sp. were the dominant species, the number of the two species was about 17 times as that of the other seven species, the proportion of the *P. solenopsis* mummies formed by the two parasitic wasps was more than 80.00%. In the field, *A. arizonensis* was the absolute dominant species in May, while *A. arizonensis* and *Cheiloneurus* sp. predominated alternatively in different cities in other months. 【Conclusion】The parasitic wasp resource of *P. solenopsis* in Guangxi is rich. At present, nine species have been discovered. *A. arizonensis* and *Cheiloneurus* sp. are the dominant species, the two species predominate alternatively. However, the overall parasitic rate of parasitic wasps is relatively low.

Key words: *Phenacoccus solenopsis* Tinsley; parasitic wasp; population dynamics; dominant species; Guangxi

Foundation item: National Natural Science Foundation of China (31760542); Guangxi Natural Science Foundation (2017GXNSFAA198286); Guangxi Innovation Driven Development Project (Guike AA17204041); Project of Science and Technology Development of Guangxi Academy of Agricultural Sciences (Guinongke 2018JZ28)

0 引言

【研究意义】扶桑绵粉蚧 (*Phenacoccus solenopsis* Tinsley) 最早发现于美国新墨西哥州, 后快速传播, 现已分布至全球48个国家和地区 (Nagrare et al., 2019)。2008年在广州首次发现该害虫入侵我国 (武三安和张润志, 2009), 在大陆现分布至包括广西在内的16个省、直辖市、自治区 (张润志和王福祥, 2010; 孟醒等, 2018, 2019; Wang et al., 2020), 该粉蚧为我国重要入境检疫对象。扶桑绵粉蚧为杂食性害虫, 寄主范围广, 可取食64属267种植物 (Nagrare et al., 2019), 包括大田作物、蔬菜、观赏植物、杂草、灌木和树木等 (张润志和王福祥, 2010; Nagrare et al., 2018; Rezk et al., 2019)。扶桑绵粉蚧以若虫和雌成虫吸食植物的叶片、枝条、果实、主干和根部韧皮部汁液, 分泌蜜露导致烟煤病发生而影响植物的光合作用, 同时作为媒介昆虫传播多种植物病毒, 通过多种方式危害寄主植物 (Saeed et al., 2007; 陈红松等, 2019)。由于寄主范围广、繁殖力强、共生蚂蚁的保护、环境适应能力强、传播途径多 (水、风、动物、鸟类、农机具、棉花种植及植物贸易等)、在新侵入地

缺乏天敌, 致使扶桑绵粉蚧在新入侵地快速建立种群, 并对多种寄主植物造成巨大危害 (Nagrare et al., 2018; Tong et al., 2019)。2005—2009年, 巴基斯坦和印度部分棉区棉花因扶桑绵粉蚧造成的损失高达30%~60% (Fand and Suroshe, 2015)。广西属热带、亚热带季风气候, 为扶桑绵粉蚧的高度适生区 (Wang et al., 2010), 目前扶桑绵粉蚧在广西已分布至除桂林外的13个地级市, 入侵定殖率高达92.86%, 以崇左、防城港、梧州和北海的朱槿 (*Hibiscus rosa-sinensis* L.) 受害较严重 (孟醒等, 2019); 该虫在广西大部分地区年发生8~10代, 入侵地遭受严重经济损失的风险极高 (Chen et al., 2015)。因此, 研究扶桑绵粉蚧的防控措施, 对控制该害虫的扩散蔓延、降低经济损失极为重要。目前扶桑绵粉蚧的防治方法主要为化学防治, 但扶桑绵粉蚧体外有蜡脂保护、卵胎生和世代重叠, 因而化学防治很难奏效 (Kaur and Virk, 2011); 同时, 由于长期和大量使用化学农药, 导致扶桑绵粉蚧对多种杀虫剂产生了抗药性或交互抗性, 引起虫情反弹 (Kaur and Virk, 2011; Ejaz et al., 2019; Nagrare et al., 2019; Afzal et al., 2020);

此外,杀虫剂会影响非靶标生物、生态环境和人类健康(Asogwa et al., 2010),其使用受到限制。因此,利用捕食性或寄生性天敌防治扶桑绵粉蚧的生物防治方法受到高度重视。【前人研究进展】害虫生物防治具有持久、环境友好、自行扩散及费用低等优点(Iqbal et al., 2016; 罗丽林和李莉, 2018),日益受到人们的重视。以色列、印度和巴基斯坦学者发现班氏跳小蜂 [*Aenasius arizonensis* (Girault) (= *A. bambawalei* Hayat)] 在部分农田对扶桑绵粉蚧具有较好的控制作用,其寄生率介于79%~100% (Nagrare et al., 2011; Sahito et al., 2011; Spodek et al., 2018),防控效果优于杀虫剂,故在扶桑绵粉蚧防治措施中,相对于杀虫剂,寄生蜂居优先地位,利用寄生蜂防治粉蚧已成为一种趋势(Vennila et al., 2010)。中国、伊朗、以色列和印度学者描述了扶桑绵粉蚧寄生蜂在各自国家的种类、分布或寄主范围,共26种寄生蜂:班氏跳小蜂、松粉蚧抑虱跳小蜂 (*Acerophagus coccois* Smith)、长崎原长缘跳小蜂 [*Prochiloneurus nagasakiensis* (Ishii)]、粉蚧广腹细蜂 (*Allotropa phenacocca* Chen, Liu & Xu)、黄脸拟暗蚜小蜂 (*Promuscidea unfasciiventris* Girault)、康长索跳小蜂 (*Anagyrus kamali* Moursi)、*A. aligarhensis* Agarwal and Alam、*A. californicus* (Compere)、*A. dactylopii* (Howard)、*A. mirzai* Agarwal and Alam、*Aprostocetus bangaloricus* Narendran、*Bothriothorax serratellus* (Dalman)、*Chartocerus kerrichi* (Agarwal)、*C. kurdjumovi* (Nikol'skaya)、*Encyrtus aurantii* (Geoffroy)、*Homalotylus albiclavatus* (Agarwal)、*H. flaminus* (Dalman)、*Leptomastix algerica* Trjapitzin、*L. dactylopii* Howard、*L. mayri* Öz-dikmen、*Metaphycus* sp.、*Pachyneuron leucopiscida* Mani、*P. aegyptiacus* (Mercet)、*P. pulchellus* Silvestri、*P. rex* (Girault) 和 *Pseudleptomastix squammulata* Girault (陈华燕等, 2011; Chen et al., 2011; Nagrare et al., 2011; Spodek et al., 2018; Torfi et al., 2020)。关于班氏跳小蜂的研究最多,包括班氏跳小蜂对扶桑绵粉蚧的控制效果(Spodek et al., 2018)、不同寄主植物上扶桑绵粉蚧的寄生率及班氏跳小蜂的种群适合度(Khuhro et al., 2011; Badshah et al., 2018)、扶桑绵粉蚧虫龄对班氏跳小蜂生活史和形态特征的影响(Karmakar and Shera, 2018)、温度对班氏跳小蜂寄生率和生活史的影响(He et al., 2018; Joodaki et al., 2018)、杀虫剂对班氏跳小蜂的安全性(Badshah et al., 2017)等。【本研究切入点】明确天敌种类和控制效果是发挥生防天敌作用的前提。在扶桑绵粉蚧的天敌调查方面,我国仅对海南

和广东进行了简单的调查和描述(陈华燕等, 2011),大部分地区扶桑绵粉蚧天敌资源尚待系统调查和全面研究。【拟解决的关键问题】根据前期调查结果,在广西选取扶桑绵粉蚧发生严重和采样便利的4个城市,定时定点采集扶桑绵粉蚧样本,鉴定寄生蜂种类,统计其数量和寄生率,明确广西扶桑绵粉蚧寄生蜂种类、动态及其对扶桑绵粉蚧的野外控制效果,为广西扶桑绵粉蚧的生物防治提供科学依据。

1 材料与方法

1.1 寄生蜂采集

根据前期调查结果(孟醒等, 2019),选取采样方便、扶桑绵粉蚧为害较重的4个城市(广西北海、钦州、崇左和防城港)为采样地,每个城市选取3个50 m长的朱槿绿化带为调查点,每点用等距法选取5个1 m×10 m的样方,每个样方随机采集约30头扶桑绵粉蚧3龄幼虫或雌成虫(3龄幼虫和雌成虫体型较大,适宜寄生蜂寄生)(Karmakar and Shera, 2018),每个调查点采集约150头扶桑绵粉蚧,每个城市共采集约450头扶桑绵粉蚧。将采集的扶桑绵粉蚧带回室内[温度(28±2)℃,光周期14L:10D,相对湿度(70%±5%)],僵蚧单头挑出,置于2 mL离心管中等待羽化。其余粉蚧放至发芽的土豆上继续饲养、每天观察,并将僵蚧及时挑出,单头放至2 mL离心管中,等待其羽化,观察10 d,直至再无僵蚧出现。寄生蜂羽化后及时收集并浸泡于75%乙醇中,根据采样时间和样方分开存放。2018年10月—2019年10月,每月中旬定点采样1次。

1.2 寄生蜂鉴定

在尼康SMZ18立体显微镜下观察、测量和拍照,参考相关寄生蜂分类资料进行种类鉴定(时振亚和申效诚, 1995; 徐志宏和黄建, 2004)。

1.3 寄生率和各种寄生蜂僵蚧比例计算

统计僵蚧数量,根据采集样本数量计算各地每个月的寄生率。羽化后统计各种寄生蜂的数量,计算不同地方各月份每种寄生蜂僵蚧所占比例。

2 结果与分析

2.1 寄生蜂的种类和数量调查结果

2018年10月—2019年10月,从广西北海、钦州、崇左和防城港市共采集到僵蚧1236头,平均寄生率为8.54%(2.83%~29.56%),羽化1139头,总羽化率为92.15%(72.22%~97.47%),羽化后得到寄生蜂2548头。共采集到9种寄生蜂,其中跳小蜂科5种:班氏跳小蜂、康长索跳小蜂、松粉蚧抑虱跳小蜂、黑角原长

缘跳小蜂 [*P. nigricornis* (Girault)] 和刷盾跳小蜂 *Cheiloneurus* sp.; 蚜小蜂科3种: 豹纹花翅蚜小蜂 [*Marietta picta* (André)]、康氏迈蚜小蜂 (*Myiocnema comperei* Ashmead) 和黄脸拟暗蚜小蜂; 广腹细蜂科1种: 粉蚧广腹细蜂。松粉蚧抑虱跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为群居寄生蜂(同一寄主体内可同时存活几头或多头寄生蜂幼虫), 单头僵蚧最多可羽化出14头刷盾跳小蜂 *Cheiloneurus* sp., 最少

羽化出1头刷盾跳小蜂 *Cheiloneurus* sp.。班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为优势寄生蜂, 班氏跳小蜂标本共525头, 其中雌虫330头、雄虫195头; 刷盾跳小蜂 *Cheiloneurus* sp. 标本共1876头, 其中雌虫1219头、雄虫657头, 二者的个体数量约是其余7种寄生蜂数量的17倍。班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 均偏雌性, 其余7种寄生蜂数量均较少, 其中黑角原长缘跳小蜂数量最少, 仅采集到5头(表1)。

表 1 广西扶桑绵粉蚧寄生蜂种类和数量

Table 1 Species and the number of parasitic wasps of *P. solenopsis* in Guangxi

科 Family	种 Species	数量(头)Quantity(insect)
跳小蜂科 Encyrtidae	班氏跳小蜂 <i>A. arizonensis</i>	525
	刷盾跳小蜂 <i>Cheiloneurus</i> sp.	1876
	康长索跳小蜂 <i>A. kamali</i>	20
	松粉蚧抑虱跳小蜂 <i>A. coccois</i>	30
	黑角原长缘跳小蜂 <i>P. nigricornis</i>	5
蚜小蜂科 Aphelinidae	豹纹花翅蚜小蜂 <i>M. picta</i>	35
	康氏迈蚜小蜂 <i>M. comperei</i>	17
	黄脸拟暗蚜小蜂 <i>P. un fasciati ventris</i>	34
广腹细蜂科 Platygasteridae	粉蚧广腹细蜂 <i>A. phenacocca</i>	6

2.2 寄生蜂僵蚧百分率

12月—翌年2月, 野外很难发现扶桑绵粉蚧, 3月扶桑绵粉蚧开始出现, 4月数量增加, 5月大暴发, 数量达最大值。采集到寄生蜂的时间为5—11月, 因此只分析5—11月的数据(2.3同)。

从表2可看出, 广西北海的寄生蜂资源最丰富, 共采集到9种寄生蜂, 其中跳小蜂科5种: 班氏跳小蜂、康长索跳小蜂、松粉蚧抑虱跳小蜂、黑角原长缘跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp.; 蚜小蜂科3种: 豹纹花翅蚜小蜂、康氏迈蚜小蜂和黄脸拟暗蚜小蜂; 广腹细蜂科1种: 粉蚧广腹细蜂。班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为优势种, 二者寄生的僵蚧所占比例最高; 除2019年5、9和10月外, 其他调查月份刷盾跳小蜂 *Cheiloneurus* sp. 寄生的僵蚧比例均最高; 其余7种寄生蜂比例较低, 其中康氏迈蚜小蜂仅采集到1次。

从表3可看出, 在广西防城港采集到6种寄生蜂, 其中跳小蜂4种: 班氏跳小蜂、刷盾跳小蜂 *Cheiloneurus* sp.、松粉蚧抑虱跳小蜂和康长索跳小蜂; 蚜小蜂2种: 豹纹花翅蚜小蜂和黄脸拟暗蚜小蜂。班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为优势种, 二者寄生的僵蚧所占比例最高; 除2019年5、6和8月外, 其他调查月份刷盾跳小蜂 *Cheiloneurus* sp. 寄生的僵蚧比例均最高; 其余4种寄生蜂比例较低, 其中松粉蚧抑虱跳小蜂和黄脸拟暗蚜小蜂仅采集到1次。

从表4可知, 在广西钦州采集到6种寄生蜂, 其

中跳小蜂3种: 班氏跳小蜂、刷盾跳小蜂 *Cheiloneurus* sp. 和松粉蚧抑虱跳小蜂; 蚜小蜂3种: 豹纹花翅蚜小蜂、黄脸拟暗蚜小蜂和康氏迈蚜小蜂。班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为优势种, 二者寄生的僵蚧所占比例最高, 且二者交替占优势, 其余4种寄生蜂比例较低。

从表5可知, 在广西崇左采集到5种寄生蜂, 其中跳小蜂3种: 班氏跳小蜂、刷盾跳小蜂 *Cheiloneurus* sp. 和松粉蚧抑虱跳小蜂; 蚜小蜂2种: 豹纹花翅蚜小蜂和黄脸拟暗蚜小蜂。班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 为优势种, 二者寄生的僵蚧所占比例最高; 除2019年5和9月外, 刷盾跳小蜂 *Cheiloneurus* sp. 寄生的僵蚧比例均最高; 其余3种寄生蜂比例较低, 只在部分月份采集到。

比较表2~表5可知, 班氏跳小蜂、刷盾跳小蜂 *Cheiloneurus* sp.、松粉蚧抑虱跳小蜂、豹纹花翅蚜小蜂和黄脸拟暗蚜小蜂分布较广, 在4个城市均有分布, 其中班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 在各地均占优势, 调查期间二者寄生的僵蚧合计比例多超过80.00%, 2019年5月班氏跳小蜂在各地均占绝对优势, 5和11月寄生蜂种类相对较少。

2.3 僵蚧数量和寄生蜂的寄生率

由图1可看出, 广西北海扶桑绵粉蚧僵蚧数量和寄生蜂的寄生率在各次调查中均最高, 除2018年11月外, 其余时间寄生蜂的寄生率均不低于10.00%。其余3个城市扶桑绵粉蚧僵蚧数量和寄生蜂的寄生

表 2 广西北海扶桑绵粉蚧寄生蜂僵蚧百分率(%)

Table 2 Percentage of *P. solenopsis* mummies formed by parasitic wasps in Beihai, Guangxi(%)

取样时间(年-月) Sampling time(Y-M)	班氏跳小蜂 <i>A. arizonensis</i>	刷盾跳小蜂 <i>Cheiloneurus</i> sp.	康长索跳小蜂 <i>A. kamali</i>	黑角原长缘跳小蜂 <i>P. nigricornis</i>	松粉蚧抑虱跳小蜂 <i>A. coccois</i>	粉蚧广腹细蜂 <i>A. phenacocca</i>	豹纹花翅蚜小蜂 <i>M. picta</i>	黄脸拟暗蚜小蜂 <i>P. unfasciiventris</i>	康氏迈蚜小蜂 <i>M. comperei</i>
2018-10	28.00	34.00	0	4.00	0	0	4.00	24.00	0
2018-11	33.33	52.38	0	0	0	0	0	0	0
2019-05	50.72	28.98	0	0	0	2.90	2.90	0	0
2019-06	33.83	56.39	2.26	0	0.75	0	0.75	1.50	0
2019-07	37.78	40.00	0	0	0	0	6.67	4.44	0
2019-08	38.46	46.15	0	0	5.13	0	3.85	0	0
2019-09	49.09	40.90	0	0	1.81	0	0	4.55	0
2019-10	37.97	29.11	11.39	3.80	0	5.06	2.53	5.06	2.53

表 3 广西防城港扶桑绵粉蚧寄生蜂僵蚧百分率(%)

Table 3 Percentage of *P. solenopsis* mummies formed by parasitic wasps in Fangchenggang, Guangxi(%)

取样时间(年-月) Sampling time(Y-M)	班氏跳小蜂 <i>A. arizonensis</i>	刷盾跳小蜂 <i>Cheiloneurus</i> sp.	松粉蚧抑虱跳小蜂 <i>A. coccois</i>	康长索跳小蜂 <i>A. kamali</i>	黄脸拟暗蚜小蜂 <i>P. unfasciiventris</i>	豹纹花翅蚜小蜂 <i>M. picta</i>
2018-10	31.77	52.85	0	0	0	0
2018-11	21.43	57.14	0	0	0	0
2019-05	96.77	0	0	0	0	0
2019-06	55.56	33.33	0	2.22	0	0
2019-07	31.58	42.11	0	15.79	0	0
2019-08	42.86	41.07	5.36	0	0	3.57
2019-09	37.50	47.92	0	8.33	0	0
2019-10	36.84	47.37	0	0	10.53	10.00

表 4 广西钦州扶桑绵粉蚧寄生蜂僵蚧百分率(%)

Table 4 Percentage of *P. solenopsis* mummies formed by parasitic wasps in Qinzhou, Guangxi(%)

取样时间(年-月) Sampling time(Y-M)	班氏跳小蜂 <i>A. arizonensis</i>	刷盾跳小蜂 <i>Cheiloneurus</i> sp.	松粉蚧抑虱跳小蜂 <i>A. coccois</i>	豹纹花翅蚜小蜂 <i>M. picta</i>	黄脸拟暗蚜小蜂 <i>P. unfasciiventris</i>	康氏迈蚜小蜂 <i>M. comperei</i>
2018-10	20.00	40.12	6.67	3.33	6.67	10.00
2018-11	27.78	44.44	0	0	0	0
2019-05	90.00	0	0	0	0	0
2019-06	30.77	53.85	0	0	0	0
2019-07	46.70	26.67	0	0	0	13.33
2019-08	52.94	29.14	0	5.88	0	5.88
2019-09	32.14	32.14	3.57	3.57	10.71	7.14
2019-10	35.29	41.17	0	17.60	0	0

表 5 广西崇左扶桑绵粉蚧寄生蜂僵蚧百分率(%)

Table 5 Percentage of *P. solenopsis* mummies formed by parasitic wasps in Chongzuo, Guangxi(%)

取样时间(年-月) Sampling time(Y-M)	班氏跳小蜂 <i>A. arizonensis</i>	刷盾跳小蜂 <i>Cheiloneurus</i> sp.	松粉蚧抑虱跳小蜂 <i>A. coccois</i>	豹纹花翅蚜小蜂 <i>M. picta</i>	黄脸拟暗蚜小蜂 <i>P. unfasciiventris</i>
2018-10	26.92	34.62	0	15.38	0
2018-11	23.08	53.85	0	0	0
2019-05	93.75	0	0	0	0
2019-06	35.14	40.54	0	13.51	0
2019-07	36.36	40.91	0	13.64	0
2019-08	42.42	48.48	3.03	0	0
2019-09	44.44	40.00	6.67	0	0
2019-10	34.78	47.83	0	0	8.70

率在各次调查中较接近,崇左2019年9月、防城港2019年6、8和9月的寄生率分别为10.00%、10.00%、12.44%和10.67%,其他时间这3个城市的寄生率均低于10.00%。寄生蜂的寄生率总体不高,北海2019年6月的寄生率在4个城市各次调查中最高,也仅为29.56%。

3 讨论

探明寄生蜂种类、数量和控制效果是利用寄生

蜂进行生物防治的前提。本研究通过野外1周年系统调查,较全面地掌握了广西朱槿上扶桑绵粉蚧寄生蜂的种类、动态、分布及寄生情况,为寄生蜂的应用提供了基础数据。本次野外调查共采集到9种寄生蜂,其中跳小蜂科5种:班氏跳小蜂、康长索跳小蜂、松粉蚧抑虱跳小蜂、黑角原长缘跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp.; 蚜小蜂科3种:豹纹花翅蚜小蜂、康氏迈蚜小蜂和黄脸拟暗蚜小蜂; 广腹细蜂科1

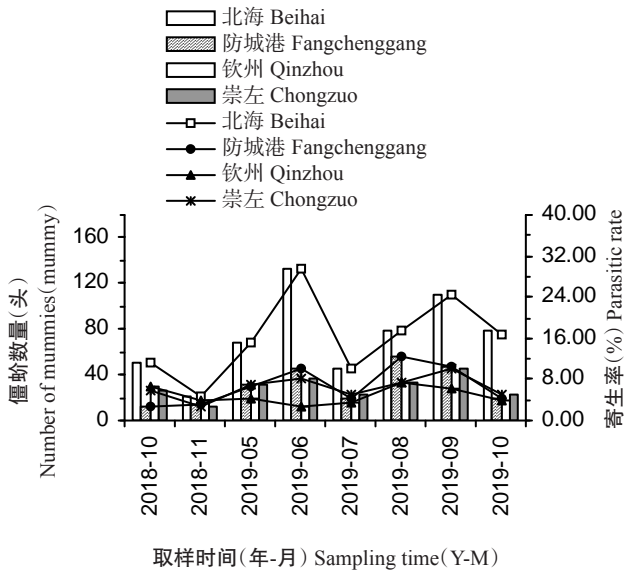


图 1 扶桑绵粉蚧僵蚧数量和寄生蜂寄生率
 Fig.1 Number of *P. solenopsis* mummies and parasitic rate of parasites
 柱形图表示僵蚧数量;折线图表示寄生率
 Column diagrams indicated the number of mummies; line charts indicated parasitic rate

种:粉蚧广腹细蜂。松粉蚧抑虱跳小蜂(火炬松短索跳小蜂)由广东省森林病虫害防治与检疫总站于1996年从美国引进用以防治湿地松粉蚧,并在野外成功建立种群(方天松等,2014),认为松粉蚧抑虱跳小蜂具有较强的适应能力。陈华燕等(2011)对广东和海南扶桑绵粉蚧的天敌进行调查,共发现4种寄生蜂:松粉蚧抑虱跳小蜂、班氏跳小蜂、长崎原长缘跳小蜂和粉蚧广腹细蜂;余海滨等(2015)对广东9种园林植物上扶桑绵粉蚧的天敌进行调查,共采集到3种寄生蜂:松粉蚧抑虱跳小蜂、班氏跳小蜂和粉蚧广腹细蜂。其中松粉蚧抑虱跳小蜂、班氏跳小蜂和粉蚧广腹细蜂在广西也采集到样本,说明这3种寄生蜂分布范围更广,也证实了松粉蚧抑虱跳小蜂具有较强的环境适应能力和扩散能力。豹纹花翅蚜小蜂在辽宁省大豆蚜虫(*Aphis glycines* Matsumura)上有报道,数量较少,发生时间为7月中旬—8月上旬(席玉强,2010)。康氏迈蚜小蜂在我国首次采集于福建的龟蜡蚧和扶桑绵粉蚧上(阮用颖等,2012),Viggiani和Ren(1993)首次报道中国新种黄脸拟暗蚜小蜂,并对其进行简单描述,本研究是这2种寄生蜂在我国的第二次报道。康长索跳小蜂和黑角原长缘跳小蜂在我国目前尚无报道,属于新纪录种,可能是随扶桑绵粉蚧入侵而定殖;刷盾跳小蜂 *Cheiloneurus* sp. 为未报道新种,有关描述另文报道。

在印度,已报道扶桑绵粉蚧寄生蜂12种,分别

为班氏跳小蜂、康长索跳小蜂、黄脸拟暗蚜小蜂、*Metaphycus* sp.、*A. bangaloricus*、*E. aurantii*、*P. pulchellus*、*A. dactylopii*、*A. mirzai*、*H. albiclavatus*、*C. kerrichi*和*P. leucopiscida*(Nagrare et al.,2011),其中班氏跳小蜂、康长索跳小蜂和黄脸拟暗蚜小蜂为广西共有种。在以色列,已报道扶桑绵粉蚧寄生蜂4种,分别为班氏跳小蜂、*A. californicus*、*P. squammulata*和*L. algerica*(Spodek et al.,2018),其中班氏跳小蜂为广西共有种。在伊朗,已报道扶桑绵粉蚧寄生蜂11种,分别为豹纹花翅蚜小蜂、班氏跳小蜂、黄脸拟暗蚜小蜂、*A. aligarhensis*、*B. serratellus*、*H. flaminus*、*L. dactylopii*、*L. mayri*、*P. aegyptiacus*、*P. rex*和*C. kurdjumovi*(Torfi et al.,2020),其中豹纹花翅蚜小蜂、班氏跳小蜂和黄脸拟暗蚜小蜂为广西共有种。从全球范围看,扶桑绵粉蚧寄生蜂资源丰富,班氏跳小蜂、豹纹花翅蚜小蜂和黄脸拟暗蚜小蜂分布范围广,国外许多种目前我国尚无报道,因此,对于寄生率高的种,可考虑引入国内,在进行安全性评价后用以防治扶桑绵粉蚧。

现有的大量文献只报道了班氏跳小蜂为扶桑绵粉蚧的优势寄生蜂(Kumar et al.,2009;Nagrare et al.,2011;Prasad et al.,2011;余海滨等,2015;Spodek et al.,2018),本研究发现在广西除班氏跳小蜂外,新种刷盾跳小蜂 *Cheiloneurus* sp. 寄生导致的僵蚧数量与班氏跳小蜂相近,且其为群居寄生蜂,个体数量远多于班氏跳小蜂,也是扶桑绵粉蚧的优势寄生蜂。在以色列,2017年夏季,野外班氏跳小蜂对扶桑绵粉蚧的寄生水平较高,多地寄生率达100%,由于班氏跳小蜂的寄生作用,使扶桑绵粉蚧的种群数量急剧降低(Spodek et al.,2018)。在巴基斯坦,多种植物上班氏跳小蜂对扶桑绵粉蚧的寄生率接近90%,不施用杀虫剂情况下,班氏跳小蜂可将扶桑绵粉蚧控制在危害水平之下(Khuhro et al.,2011)。在我国广东,野外寄主密度高时班氏跳小蜂对扶桑绵粉蚧雌成虫的寄生率可达60%以上(余海滨等,2015)。在印度,田间班氏跳小蜂对扶桑绵粉蚧的平均寄生率为57.2%(Kumar et al.,2009),其余种类寄生蜂的田间寄生率几乎均低于10%(Nagrare et al.,2011);本研究发现,除班氏跳小蜂和刷盾跳小蜂 *Cheiloneurus* sp. 的寄生率稍高外,其余7种寄生蜂的僵蚧比例大多低于10.00%,与印度的情况类似。究其原因可能是气候或寄主植物的差异所造成,本研究中,2019年6月广西北海寄生蜂的寄生率最高,也只有29.56%,远低于文献报道的班氏跳小蜂单一寄

生蜂的寄生率。同样的情况出现在印度安得拉邦瓦朗加尔市, Prasad等(2011)调查了不同时期班氏跳小蜂对不同寄主植物上扶桑绵粉蚧的寄生率, 发现班氏跳小蜂的寄生率较低, 大多在10.0%以下(其中在朱槿上的寄生率最高, 仅11.1%), 远低于印度其他地方的寄生率, 也说明寄生蜂的寄生率在不同地方存在差异。班氏跳小蜂具有温度适应范围广(2~45℃)、寄主专一性强、繁殖速度快于寄主、生活史短、雌性比率高、寄主搜索能力强、寄生率高、易人工饲养、扩散能力强及与寄主生活史同步等特点(Nagrare et al., 2011), 可能是其广泛分布, 成为优势寄生蜂并在多地成功控制扶桑绵粉蚧的主要原因。雨季后, 气温25~29℃, 相对湿度68%~73%, 最适宜班氏跳小蜂生长发育(Karmakar and Shera, 2018)。广西5~9月(7月雨水多, 情况特殊)总体上僵蚧数量和寄生蜂寄生率较高, 可能是气候条件利于扶桑绵粉蚧寄生蜂种群扩增。广西寄生蜂羽化率较高, 但寄生蜂总体寄生率较低, 推测是春季寄生蜂繁殖基数较低所致。目前关于班氏跳小蜂的文献相对较多, 但如何实现其规模化繁殖、春季在野外大量释放、提高起始虫源基数、提升防控效果, 是下一步研究的重点。新发现种刷盾跳小蜂*Cheiloneurus* sp.作为扶桑绵粉蚧的优势寄生蜂, 尚需加大研究力度, 充分发挥其生防潜能。

4 结论

广西扶桑绵粉蚧寄生蜂资源丰富, 共采集到9种寄生蜂, 其中跳小蜂科5种: 班氏跳小蜂、康长索跳小蜂、松粉蚧抑虱跳小蜂、黑角原长缘跳小蜂和刷盾跳小蜂*Cheiloneurus* sp.; 蚜小蜂科3种: 豹纹花翅蚜小蜂、康氏迈蚜小蜂和黄脸拟暗蚜小蜂; 广腹细蜂科1种: 粉蚧广腹细蜂。康长索跳小蜂和黑角原长缘跳小蜂为我国新纪录种, 刷盾跳小蜂*Cheiloneurus* sp.为新发现种。班氏跳小蜂和刷盾跳小蜂*Cheiloneurus* sp.在个体数量和僵蚧比例方面均较高, 为扶桑绵粉蚧优势寄生蜂。在广西, 5~9月为寄生蜂发生高峰期, 寄生蜂的羽化率较高, 但总体寄生率偏低, 对扶桑绵粉蚧的控制能力有限, 寄生蜂的生防潜力有待进一步挖掘。

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