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红火蚁对蚁运植物种子影响的研究概况

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摘要: 自然界中蚂蚁与蚁运植物的互惠关系是一种普遍的现象。蚁运植物种子的油质体是两者发生联系的纽带,它能为蚂蚁提供营养物质,且蚂蚁在消耗油质体的同时,搬运并散布了种子。红火蚁是近年来在华南地区严重发生的一种入侵性蚂蚁,能在短时间内迅速发展成为优势种,造成入侵地生物多样性降低和生态单一化,是世界范围内最具危险的社会性昆虫之一。由于该入侵蚂蚁极具侵略性、觅食能力强、种群庞大等特点,对蚁运植物具有深远的影响。为了深入、全面地了解红火蚁对蚁运植物种子的影响,本文综述了红火蚁对蚁运植物种子油质体的喜好及搬运行为,以及对蚁运植物种子的直接影响(搬运、取食、划痕或毁坏)及间接影响(排挤本地蚂蚁),最后展望了未来红火蚁对蚁运植物影响的研究方向。

关键词: 红火蚁; 蚁运植物; 种子; 互惠共生; 生物入侵

Review of the effects of red imported fire ant (*Solenopsis invicta* Buren) on the seed of myrmecochorous plants

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Abstract: The mutualistic relationship between ants and myrmecochorous plants is a common phenomenon. The seed elaiosomes of myrmecochorous plants are preyed and consumed by ants, which remove and disperse the seeds, in return, benefit from the seeds' germination and growth. The red imported fire ant, *Solenopsis invicta*, is a dangerous and destructive invader; the lack of natural enemies of this species results in population booms in areas where they invade. *S. invicta* has significant negative impacts on ecosystems and biodiversity, but the interrelation between *S. invicta* and myrmecochorous plant has rarely been known. The present review summarized the preference and removal behavior of *S. invicta* on the elaiosome of myrmecochorous plants. Additionally, the direct (removed, preyed, scarified, and destroyed) and indirect effects (expelled native ants) of *S. invicta* on the elaiosome of myrmecochorous plants were also discussed. Finally, some suggestions were proposed for the potential study orientation of the relationship between *S. invicta* and myrmecochorous plants.

Key words: *Solenopsis invicta* Buren; myrmecochore; seed; mutualism; biological invasion

自然界中,昆虫与植物的互惠共生关系是一种很普遍的现象,如访花昆虫从植物上获得花蜜和花粉的同时为植物提供了授粉条件(徐汝梅和成新跃,2005)。蚂蚁是一种最常见和熟悉的昆虫,几乎无处不在,并以它庞大的种群数量在陆地生态系统中起着重要作用,而它与植物的关系已引起科学家的浓厚兴趣(Christian,2001)。

蚁运植物(myrmecochore)最早由 Sernander (1906)发现并定义,是指一类需要依靠蚂蚁携带传播种子的植物,全世界具有代表性的蚁运植物类群超过 70 个科(Beattie,1985)。在北美东部森林,将近 30% 的草本植物是蚁运植物(Beattie & Culver, 1981; Handel *et al.*, 1981);南非则有将近 1300 种的蚁运植物(Milewski & Bond,1982)。蚁运植物种子

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之所以能吸引蚂蚁搬运,是由于其表面附生有油质体(Handel & Beattie,1990),能为蚂蚁提供营养物质(Marshall *et al.*,1979);蚂蚁在消耗油质体的同时,搬运并散布了种子,这种行为关系不仅能使种子逃避啮齿动物的取食(Heithaus,1981)、火烧(Berg,1975;Majer,1982;Yeaton & Bond,1991),而且能避免种子由于聚集密度大而导致的种间竞争(Handel,1978),甚至蚁巢内的微环境能为种子提供丰富的氮、磷、钾等养料,从而促进种子萌发和幼苗成长(Czerwinski *et al.*,1971)。目前,国内关于蚂蚁和蚁运植物互惠共生关系的研究较少,仅见张智英等(2001、2006)研究了舞草 *Codariocalyx motorius* (Houtt.) Ohashi 与伊大头蚁 *Pheidole yeensis* Forel 的互惠共生关系。

入侵蚂蚁对蚁运植物种子的影响一直是国外研究的热点,由于研究的难度和条件限制,当前所见报道不多,据 Ness & Bronstein(2004)不完全统计,仅有 19 篇文章报道了该方面的内容,涉及的入侵蚂蚁包括红火蚁 *Solenopsis invicta* Buren(Horvitz & Schemske,1986;Ness,2004;Zettler *et al.*,2001)、阿根廷蚁 *Linepithema humile* Mayr (Bond & Slingsby,1984;Carney *et al.*,2003; Christian,2001)、热带火蚁 *Solenopsis geminata* (Fabricius)(Horvitz & Beattie,1980)等。而在国内,该方面研究几乎是空白。红火蚁是近年来在华南地区严重发生的一种入侵性蚂蚁(曾玲等,2005),该蚂蚁具有明显的种群竞争优势,在新入侵地短时间内能迅速发展成为优势种,造成生物多样性降低和生态单一化(Allen *et al.*,2004;Lofgren *et al.*,1975;Stuble *et al.*,2009;Wojcik *et al.*,2001),是世界范围内最具危险的社会性昆虫之一。本文综述红火蚁与蚁运植物种子的相互关系,为今后开展该方面研究提供参考。

1 种子油质体对红火蚁的吸引作用

油质体是靠近或附着于种子,且能吸引蚂蚁并使其产生搬运行为的一种乳白色食物体(Handel,1976),它含有蚂蚁所需的脂肪、脂肪酸和其他一些普通营养物质,其中脂肪酸成分类似于昆虫的血淋巴(Hughes *et al.*,1994)。在北美东部的湿地森林,举腹蚁属 *Crematogaster*、前结蚁属 *Prenolepis* 和盘腹蚁属 *Aphaenogaster* 都能被这些油质体所吸引。有报道,收获蚁 *Pogonomyrmex* spp. 也能被油质体吸引,它是蚁运植物的重要传播者之一(Carney *et al.*,2003)。张智英等(2006)研究发现,云南西双版纳和思茅地区有 12 种蚂蚁帮助附生有油质体的舞草种子扩散,如伊大头蚁、菱结大头蚁 *Pheidole rhombinoda* Mayr 和圆叶铺道蚁 *Tetramorium cyclolobium* Xu et Zheng 等。

红火蚁的食物结构中具有一定比例的植物种子(Tennant,1991)。Wilson & Oliver(1968)研究表明,种子占红火蚁食物结构的比例在松树林中为 0.5%,在草坪中为 1.48%。同时,含油质体的种子对红火蚁具有极强的吸引力,Zettler *et al.*(2001)研究表明,红火蚁对延龄草属的 *Trillium undulatum* Location、*T. discolor* Hook、*T. catesbaei*,血根草 *Sanguinaria canadensis* L. 和堇菜 *Viola rotundifolia* 种子的搬运比率超过 95%,而对芝麻 *Sesamum indicum* L. 和藿香蓟 *Agerarum houstonianum* Miller 种子的搬运率为 100% 和 72.0%(黄俊等,2010)。

2 红火蚁对蚁运植物种子的影响

2.1 直接影响

红火蚁直接处理蚁运植物种子主要分为 3 个步骤,即搬运种子、取食油质体、划痕或毁坏种子(Zettler *et al.*,2001)。Dress *et al.*(1991)研究发现,红火蚁在取食种子的过程中会锉磨种皮、取食胚乳及子叶,从而损坏整个种子;黄俊等(2010)室内研究表明,红火蚁虽然对芝麻种子最为喜好,但刮啃率也最高,达到 82.4%,对芝麻、藿香蓟、象草 *Pennisetum purpureum* Suhumach 及芥蓝 *Brassica albograbra* Bailey 种子的丢弃率分别为 86.4%、50.4%、79.2% 和 88.9%;通过大田试验发现,红火蚁对堇菜属的 2 种种子破坏率高达 86% 和 100%。因此,有学者将红火蚁定义为蚁运植物种子的取食者(Beattie & Lyons,1975;Horvitz & Schemske,1986)。

种子的种皮硬度及其自身所包含的一些化合物会影响红火蚁对种子所造成的危害程度(Rodgerson,1998),种皮越硬或越厚,越可以防止种子胚部的损坏。Boyd (1996)发现,种皮厚度是其他身体部分的 3 倍时,可有效防止取食者消耗油质体后对种子的破坏。然而,种子被适当地刮划却有利于其萌发(Culver & Beattie,1980)。

2.2 间接影响

红火蚁对蚁运植物种子的间接影响主要通过干扰本地蚂蚁的丰富度和多样性而实现(LeBreton

et al., 2003; Morrison, 2002; Porter *et al.*, 1988), 因为大多数本地蚂蚁是蚁运植物种子的搬运者。Carney *et al.* (2003)研究发现,红火蚁入侵后,作为蚁运植物重要传播者的收获蚁受到排挤,并最终在生境里消失。红火蚁还会取代一些原本就对蚁运植物不利的蚂蚁类群,如热带火蚁,它是一些蚁运植物种子的取食者,而红火蚁入侵后很快就在区域里扩散并取代热带火蚁,从而对蚁运植物造成更大的危害(Beattie & Lyons, 1975)。红火蚁之所以是一个不合格的"搬运者",主要体现在 3 个方面:(1)传播散布的距离短。Holway *et al.* (2002)和 McGlynn(1999)指出,由于红火蚁个体比一些本地蚂蚁小,从而影响了它传播种子的距离(平均距离短 15 cm);(2)红火蚁不会包埋被搬运的种子,而是丢弃在不适宜种子萌发和幼苗成长的地方(Bond & Slingsby, 1984; Christian, 2001; Gomez & Oliveras, 2003; Horvitz & Schemske, 1986; Ness, 2004);(3)红火蚁搬运种子的效率低,这一观点目前还未达成一致,Christain(2001)研究表明,入侵蚁在单位时间里搬运种子的数量相对本地蚂蚁要少,而 Ness(2004)则认为红火蚁与本地蚂蚁的搬运效率没差别。

3　研究展望

红火蚁入侵我国造成区域内生物多样性降低和生态单一化已是不争的事实,通过报道我们也已深刻认识到该入侵蚂蚁对植物所造成的严重后果,但是目前国内还一直缺乏对该方面的系统研究。蚁运植物与蚂蚁具有密切联系,因此红火蚁入侵对该类植物的影响应该受到重要关注。这方面研究在国内几乎还是空白,借鉴国外研究现状,提出如下几点研究建议供参考:

(1)我国蚁运植物种类的调查、统计。我国植物类群丰富,不乏有许多蚁运植物。蚁运植物种类的调查统计是后期所有工作的基础。

(2)红火蚁对蚁运植物种子萌发、传播扩散及空间结构的影响。收集蚁运植物种子,通过室内外条件开展该项研究。

(3)红火蚁对本地蚂蚁、鸟类、哺乳动物等其他种子搬运者或取食者的影响。不应局限于考虑红火蚁通过干扰本地蚂蚁对蚁运植物造成危害,还应考虑生境内其他取食者,如鸟类和哺乳动物。

(4)结合蚁运植物的生长状况,系统调查红火蚁对蚁运植物群落结构的影响。

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