共生菌 *Hamiltonella defensa* 对蚜虫的影响 (Effects to aphid of symbiont *Hamiltonella defensa*)

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多数蚜虫体内都含有内共生菌 (endosymbiont)，分为初生内共生菌 (primary symbionts) 和次生内共生菌 (secondary symbionts)，他们相互协同进化、互利共生。Oliver 等根据次生共生菌能导致蚜虫寄主防御寄生蜂的攻击而首先提出了“共生菌介导抗性(symbiont-mediated resistance)的概念” (Oliver et al., 2005)，之后更多的研究致力于共生菌对寄主昆虫产生的影响。

Hamiltonella defensa (PABS)属于次生共生菌，在蚜虫的肠部和卵巢最早发现，小杆状，开始被指定为 PABS (pea aphid Bemisia-like symbiont) (Darby et al., 2001)，之后为纪念进化生物学家 William D. Hamilton 被命名为 “*Candidatus* Hamiltonella defensa” (Moran et al., 2005)。

H. defensa 可耐高温 (Russell and Moran, 2006) 并增加蚜虫体重和繁殖力 (Castañeda et al., 2010)。但研究最多的是 *H. defensa* 赋予蚜虫的抗蜂性。主要通过干扰寄生蜂幼虫在蚜虫体内的发育(Oliver et al., 2005; 2008)。*H. defensa* 的抗蜂水平会受到不同因素的影响：（1）不同菌株抗性水平不同 (Leclair et al., 2016)；（2）蚜虫的种群，例如 *H. defensa* 并不能增强麦长管蚜的抗蜂性 (Łukasik et al., 2015)；（3）寄生蜂种类 (Cayetano and Vorburger, 2015)；（4）寄主植物，不同寄主植物上的豌豆蚜体内的 *H. defensa* 会抵御不同的寄生蜂 (Mclean and Godfray, 2015)；（5）环境因素的影响 (Guay et al., 2009)。除了直接的抗蜂性，*H. defensa* 还可间接降低蚜虫对寄生蜂的吸引力，与含有 *H. defensa* 的蚜虫相比，寄生蜂会选择未感染蚜虫进行产卵 (Łukasik et al., 2013)。但经过足够长的时间后寄生蜂会对 *H. defensa* 逐渐产生抗性 (Dion et al., 2011)，由此可见，我们或许可以通过抗性寄生蜂的汰选来增强对于蚜虫生物防治的效果。

H. defensa 的抗蜂性依赖一种噬菌体 APSEs (Acyrthosiphon pisum Secondary Endosymbionts)的共存 (Duron, 2014; Vorburger, 2014)。研究表明被 APSE 感染的 *H. defensa* 具有抗蜂性，无 APSE 感染时，*H. defensa* 不仅不能抗蜂，而且降低蚜虫的繁殖力 (Strand, 2014)。

蚜虫、寄主植物、天敌、共生菌以及环境等因素间都有直接或间接的相互影响。近两年除了共生菌功能的研究，这些因素间的互作关系也越来越受关注。例如寄主植物、寄生蜂及共生菌间的影响 (Mclean and Godfray, 2015)，蚜虫、寄主植物及共生菌间的关系 (Peccoud et

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al., 2015; Zytynska et al., 2016)，寄主植物、寄生蜂、天敌、共生菌及环境间的相互影响 (Smith et al., 2015)。*H. defensa* 及其他防御性共生菌或许有潜力改变食物网的结构和动态 (Rothacher et al., 2016; Hrček et al., 2016)，同时共生菌相关的表型变异可能会促进种群水平上的进化 (Brady et al., 2014)。共生菌介导的防御机制的研究可能是了解许多存在拮抗现象的物种间相互作用的关键 (Oliver et al., 2014)。

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