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# 生态学报

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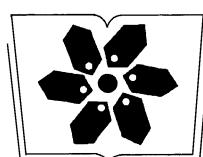
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# 生态学报 (SHENTAI XUEBAO)

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封面图说:植物生命演进石——这不是一块普通的火山岩,而是一块集中展示植物“原生演替”过程最有价值的石头。火山熔岩冷却后的玄武岩是无生命无土壤的真正“裸石”,风力使地衣的孢子传入,在一定温湿度环境下,开始出现了壳状地衣,壳状地衣尸体混合了自然风化的岩石碎屑提供的条件使叶状、枝状地衣能够侵入,接着苔藓侵入,是它们启动了土壤的形成,保持了土壤的湿度,并使营养物质反复循环。于是蕨类定居,草丛长了起来,小灌木出现,直到树木生长,最终形成森林。

彩图提供:陈建伟教授 北京林业大学 E-mail: cites.chenjw@163.com

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范凡,任红敏,吕利华,张莉萍,魏国树.光谱和光强度对西花蓟马雌虫趋光行为的影响.生态学报,2012,32(6):1790-1795.

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## 光谱和光强度对西花蓟马雌虫趋光行为的影响

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**摘要:**利用行为学方法研究了光谱、光强对西花蓟马 *Frankliniella occidentalis* (Pergande) 雌成虫的趋、避光行为的影响。结果显示:(1)在340—605 nm 波谱内14个波长其光谱趋光行为反应为多峰型,峰间主次较明显。趋光行为反应中,蓝绿区498—524 nm有一较宽峰,趋光率20.31%;其它各峰依大小次序分别位于紫光380 nm、蓝光440 nm;(2)避光行为反应中,蓝光440 nm处略高,避光率17.19%;紫外340 nm处亦有一峰,避光率15.63%;(3)随光强增强其趋光反应率增大,白光、380 nm 和524 nm 刺激时其光强趋光行为反应呈一倒“L”型式样,498 nm 为峰型,440 nm 时为一较缓的平直线型;光强最弱时仍均有一定趋光率,最强时均未出现高端平台;(4)随光强增强其避光反应率增大,440 nm 为较平缓直线;340 nm 刺激时为较缓波动线。结果表明:光谱对其趋光行为有很大影响,光强度的影响较大且影响大小与波长因素有关。

**关键词:**西花蓟马;趋光;避光;行为

## Effect of spectral sensitivity and intensity response on the phototaxis of *Frankliniella Occidentalis* (Pergande)

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**Abstract:** The western flower thrip, *Frankliniella occidentalis* (Pergande), is one of the most serious pests causing adverse effects on global crop production. Since 2003, *F. occidentalis* has been affecting the crop fields of several provinces in China. The selectivity of *F. occidentalis* on colors has been reported to have significant differences. In the present paper, the phototaxis behavior of *F. occidentalis* (Pergande) in response to spectral sensitivity and light intensity were investigated. The results were as follows: (1) The spectral sensitivity response of phototaxis at 14 monochromatic light selected within the range of 340—605 nm occurred in a curve with multiple peaks. The primary peak within the range of 498—524 nm (blue-green) is the highest response rate of phototaxis (20.31%); the secondary peak at 380 nm (violet) is the highest response rate of phototaxis (19.06%); and the rest of the peaks at 440 nm (blue) is the highest response rate of phototaxis (18.44%). (2) The spectral sensitivity response of photophobism at 14 monochromatic light selected within the range of 340—605 nm occurred in a curve with two peaks: a peak at 440 nm (blue) is the highest response rate of photophobism (17.19%), and another peak at 340 nm (ultra-violet) is the highest response rate of photophobism (15.63%). (3) The same wavelengths of light intensities appeared in different intensities in different phototactic response rates. In the white light

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and monochromatic light at 380 and 524 nm, the response rate of phototaxis is increasing together with the relative intensity of light; the relative intensity of light appeared as curves with increasing L-shaped peaks, which is the maximum response rate in log0.0. At 498 nm, two peaks appeared in log4.5 and log0.0 with the sharp having multiple peaks. At 440 nm, the response rate of phototaxis is slowly increasing together with the relative intensity of light, and the shape was

near a straight line displaying the maximum response rate in log0.0. The response rate could be detected at the lowest intensity and not at the summit of the strongest intensity. (4) The same wavelength appeared in different light intensities in different response rates. Two peaks of photophobism behavior appeared at 340 and 440 nm, respectively. The monochromatic light at 440 nm with light intensity and maximum response rate in log0.0 had a slowly increasing response rate and relatively flat linear response curve. The monochromatic light at 340 nm with light intensity and maximum response rate in log1.0 had photophobism response rate changes with a response curve that displayed more moderate fluctuations in line. Therefore, both the spectrum and intensity of light stimulus gave rise to the phototaxis of *F. occidentalis* (Pergande). However, light intensity seems to have played a more important role than the spectrum, but the effect level may also have been involved with the wavelengths. The phototactic behavior of its spectrum exerted a great influence away from light, particularly on the light intensity of the larger phototactic behavior, the effect of light intensity, and the wavelength of other the factors.

**Key Words:** *Frankliniella occidentalis* (Pergande); phototaxis; photophobism; behavior

西花蓟马 *Frankliniella occidentalis* (Pergande), 属缨翅目(Thysanoptera)蓟马科(Thripidae)花蓟马属(*Frankliniella*), 近年来已成为当今对作物危害最严重的世界性害虫之一<sup>[1]</sup>。该害虫繁殖速度快, 寄主范围广, 造成叶片、果实出现锈褐色斑点, 果实商品性丧失, 还可能传播番茄斑萎病毒病(TSWV)和凤仙花坏死斑病毒(INSV)<sup>[2]</sup>。自从2003年6月在北京市海淀区的一个大棚辣椒发现该虫以来, 迄今为止, 该虫已扩散到多个地区<sup>[3-6]</sup>, 对当地的经济造成重大的损失, 如何有效防控已成为重要课题。

不同作物上各种蓟马嗜好的颜色, 已有报道, 亦有许多关于西花蓟马对不同颜色粘卡趋性试验, 以期筛选合适颜色相关研究<sup>[7-10]</sup>。本文应用光行为学方法, 研究了波长和光强度因素对西花蓟马雌虫的趋光行为的影响, 试图揭示光源特征与其趋光性间的内在联系和趋光性的成因, 为研发高效害虫测报和防治用光源或光活性物质提供科学依据。

## 1 材料与方法

### 1.1 试虫及处理

#### 1.1.1 试虫

西花蓟马成虫为人工室内饲养。饲养条件: RXZ-300C 人工气候箱(宁波江南仪器厂), 温度(27.0±0.5)℃, 相对湿度(60±5)%, 光周期为16 h:8 h, 食物为新鲜芸豆角。

#### 1.1.2 试虫处理

选取规格近似的10日龄雌成虫, 置于行为反应箱的栖息室中(图1,1), 为使复眼适应状态一致, 每次光刺激前, 在暗室中适应2 h。

### 1.2 试验装置及方法

(1)光源、光路系统及光刺激:见陈晓霞等<sup>[11]</sup>。

(2)行为反应装置

依西花蓟马的行为特性并参考文献, 自行设计并制作了趋光行为装置。其主体分为3个部分, 即:趋光室、

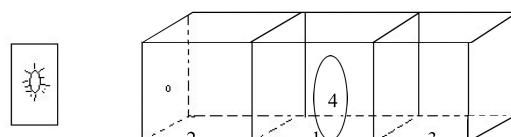


图1 趋光行为反应装置

Fig. 1 The sketch map of light-path in phototaxis behavior experiment

1:栖息活动室 2:趋光反应室 3:避光反应室 4:挡光板

避光室和栖息活动室(各活动室长、宽、高分别为8、8、7 cm)。

### 1.3 试验方法

试验在暗室中进行,自14:00开始。室内温度( $27\pm0.5$ )℃,相对湿度( $60\pm5$ )%。每次光刺激时间为20 min,各处理间隔4 min。为减小试验误差,每一波长采用多组试虫,试虫不重复利用。各波长或光强处理后,红光灯下分别统计趋光室和避光室的试虫个数,计算其趋、避光反应率。

试虫每次40头为1组,重复间换用新虫组,重复8次。

趋光行为反应百分率=趋光反应室虫数/总虫数×100%

避光行为反应百分率=避光反应室虫数/总虫数×100%

## 2 结果与分析

### 2.1 光谱行为反应曲线的测定

在340—605 nm波谱内单色光刺激下,西花蓟马雌虫的光谱趋、避光反应见图2。

从表1和图2可以看出,340—605 nm波谱内的单色光均能引发西花蓟马雌虫的趋光反应。其光谱趋、避光行为曲线均为多峰型,各峰间主次明显,各波长间趋光率和避光率差异显著。

#### 2.1.1 趋光行为曲线

趋光行为曲线中,绿光区498—524 nm波段处略高,趋光率为20%以上,紫外区380 nm波段次之,亦能达到20%,蓝光区440 nm处亦有一峰,趋光率为18%,其它波长都能引起其趋光反应,但趋光反应率较小。结果显示:波长因素对西花蓟马雌成虫趋光行为影响很大,且不同单色光间差异显著,暗示其光感受器类型可能亦包括绿光、紫外和蓝光3种。

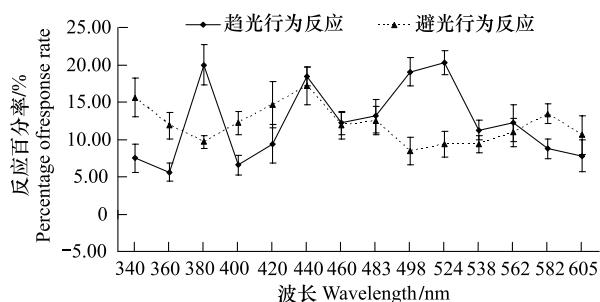


图2 西花蓟马趋、避光的光谱行为曲线

Fig. 2 Spectral response curves *Frankliniella occidentalis* (Pergande) of phototaxis and photophobia behavior

表1 14种单色光刺激下西花蓟马雌成虫的趋、避光率显著性比较

Table 1 Spectral response rate of the phototaxis and photophobism behavior of *Frankliniella occidentalis* (Pergande) at 14 monochromatic lights

单色光/nm Monochromatic light	趋光率值/% Phototactic rate (mean±S. D.)	单色光/nm Monochromatic light	避光率值/% Photophobic rate (mean±S. D.)
524	20.31±1.60a	440	17.19±2.48a
380	20.00±2.67a	340	15.63±2.59ab
498	19.06±1.86a	420	14.69±3.12bc
440	18.44±1.29a	583	13.44±1.29cd
483	13.13±2.22b	483	12.50±1.89de
460	12.19±1.60b	400	12.19±1.60de
562	12.19±2.48b	360	11.88±1.77def
538	11.25±1.34b	460	11.88±1.77def
420	9.38±2.59c	562	10.94±1.86efg
583	8.75±1.34c	605	10.63±2.59efgh
605	7.81±2.09cd	380	9.69±0.88efgh
340	7.50±1.89cde	538	9.38±1.16gh
400	6.56±1.29de	524	9.38±1.77gh
360	5.63±1.16e	498	8.44±1.866h

不同字母表示同行数据的检验结果显著( $P<0.01$ )

#### 2.1.2 避光行为曲线

避光行为曲线中,蓝光区440 nm避光率高达17%,其次紫外区340 nm处有一峰,避光率为16%,其它波

长亦能引起其避光反应,但反应率相对较小。结果显示:波长因素对西花蓟马成虫避光行为影响较大,且不同单色光间差异显著。

## 2.2 光强度行为反应曲线的测定

选取光谱趋光行为时趋光率较高的单色光(380、440、498、524 nm)和避光率较高的单色光(440、340 nm)以及白光刺激,分别用不同光强度水平对其进行光照处理。结果显示:光强度对趋光行为反应率有较大影响,对避光行为反应率亦有一定影响(图3—图8)。

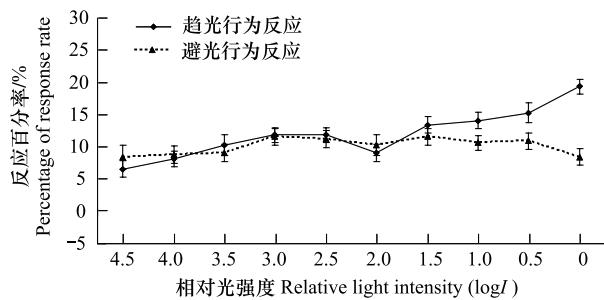


图3 白光刺激下,西花蓟马趋、避光行为反应

Fig. 3 Behavior response intensity cures of *Frankliniella occidentalis* (Pergande) on whitelight

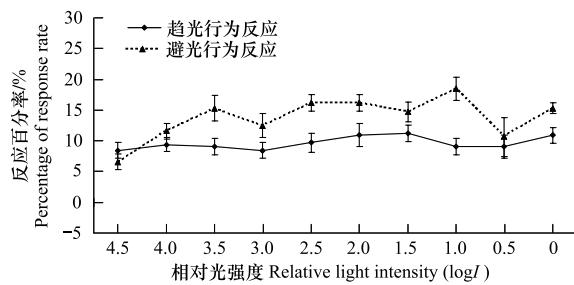


图4 340nm 光刺激下,西花蓟马趋、避光行为反应

Fig. 4 Behavior response intensity cures of *Frankliniella occidentalis* (Pergande) on the monochromatic light of 340nm

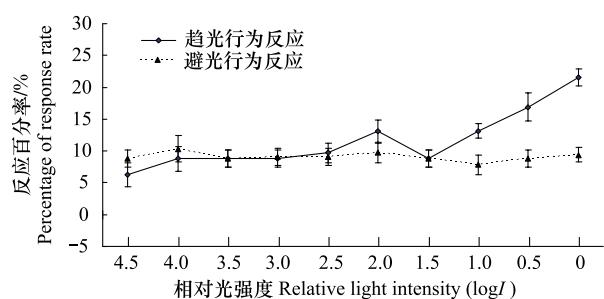


图5 380nm 光刺激下,西花蓟马趋、避光行为反应

Fig. 5 Behavior response intensity cures of *Frankliniella occidentalis* (Pergande) on the monochromatic light of 380nm

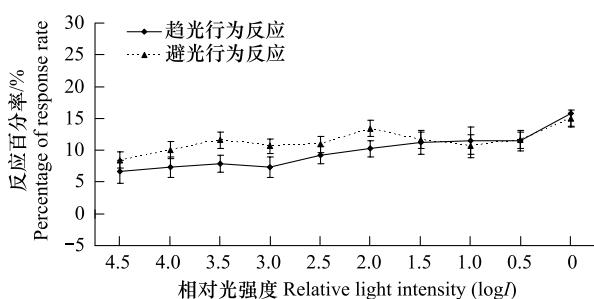


图6 440nm 光刺激下,西花蓟马趋、避光行为反应

Fig. 6 Behavior response intensity cures of *Frankliniella occidentalis* (Pergande) on the monochromatic light of 440nm

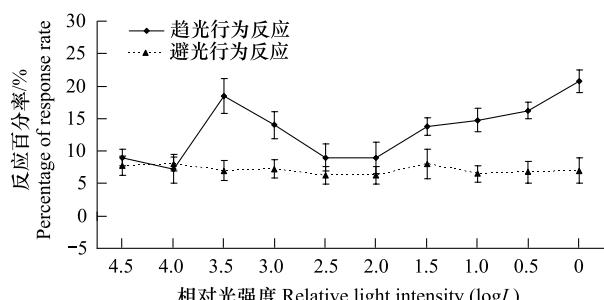


图7 498nm 光刺激下,西花蓟马趋、避光行为反应

Fig. 7 Behavior response intensity cures of *Frankliniella occidentalis* (Pergande) on the monochromatic light of 498nm

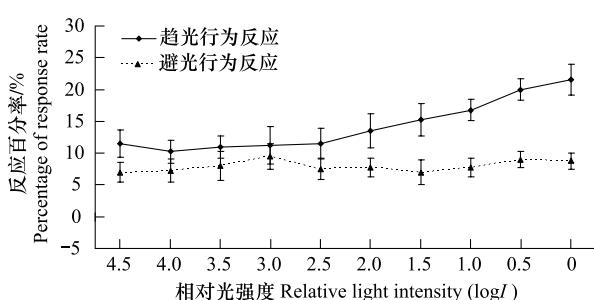


图8 524nm 光刺激下,西花蓟马趋、避光行为反应

Fig. 8 Behavior response intensity cures of *Frankliniella occidentalis* (Pergande) on the monochromatic light of 524nm

### 2.2.1 趋光行为的光强度行为反应

在白光和440 nm、524 nm单色光下,趋光行为总体随光强增强而趋光反应率增大,呈一较平直的线型(图

3,图6,图8)。

在380 nm单色光下,西花蓟马趋光反应率曲线图呈一倒“L”型。在弱光下( $\log 4.5-2.5$ )趋光反应率较低,且变化不大,呈一近似横线;在 $\log 1.5-0.0$ 下,随着光强增强趋光率增大;在 $\log 2.0$ 出有一小峰,比两端( $\log 2.5$ 和 $\log 1.5$ )略高(图5)。

在498 nm单色光下,西花蓟马趋光反应率曲线图近似呈一倒“W”型。在弱光下趋光反应率出现一峰值( $\log 3.0$ ),左端近似呈一横线( $\log 4.5-4.0$ ),右端为一向下的斜线;在 $\log 2.5-0.0$ 下,随着光强增强趋光率增大,呈一近似斜线(图7)。

值得注意的是,无论白光还是单色光,光强最弱时均仍有一定趋光率,光强最高时亦未出现常见的高端平台。光强度对其趋光行为反应影响较大,其影响大小视波长而定,另一方面也显示其复眼可感受更弱和更强的光强环境,具有相当强的光强度自调节能力。

## 2.2.2 避光行为的光强度行为反应

在白光和440 nm单色光下,西花蓟马避光反应率曲线图近似呈一直线,光强对其避光反应影响较小(图3,图6)。

在340 nm单色光下,西花蓟马避光反应率曲线呈波浪状,不同光强之间对其影响不同。整个曲线中,在 $\log 3.5$ 、 $\log 2.5-2.0$ 和 $\log 1.5$ 处出现峰值,但总体差异不大(图4)。

光强度对其避光行为反应有一定影响,但其影响程度低于趋光行为反应。

## 3 讨论

肖长坤和吴青君等在田间色板诱集试验中发现,蓝色和黄色对西花蓟马诱集效果相对较好,本论文光谱行为反应试验中得到的结果中440、498、524 nm等处为反应高峰与田间颜色诱集试验中蓝色效果较好结果基本吻合,而田间诱集试验效果较差的紫色和较好的黄色与光谱行为反应试验中得到的结果存在较大差异,即380 nm处为峰值,583 nm处趋性较低<sup>[7-8]</sup>。蓝光区3个不同的波长都有较高趋性与田间颜色诱集试验均证明了西花蓟马对蓝颜色以及蓝色光有偏好,且不同颜色梯度之间有影响。对于黄颜色和紫颜色与相对应单色光之间的差异,可能与小环境内植被颜色造成的背景色有关,或者色板反射波长与单色光波长之间有差异相关,有待于对不同生境下其趋色、光进行比较研究。

西花蓟马复眼光谱行为反应与视网膜电位也有一定差异,Matteson N等在400—620 nm波段内视网膜电位试验的结果显示其峰值在545 nm处,而在光谱行为反应中峰值为524 nm,其原因可能是复眼的光感受器接受信号后经过视觉神经加工以后做出相应的选择行为引起了视网膜电位与行为之间的差异<sup>[12]</sup>。

对于西花蓟马光谱行为反应中出现的对某些波长避光率较高的现象并无相对的田间试验中对某种颜色有明显趋避性报道,可能是寄主颜色及小生境影响,有待于深一步观察。

不同强度下其趋光反应率不同,与田间颜色诱集试验中颜色深浅的变化诱集效果不同的结果相符,说明了西花蓟马的复眼对光强度有较强的自调节及适应机制,对不同强度的光色能做出相应的选择。而且在498 nm单色光下,光强较弱时其趋光率也能达到较高水平,说明在某些弱光下,也能激发其趋光反应,更加证明其复眼对光敏感并且有较高的光强度调节能力。

总之,西花蓟马对不同单色光有明显的选择性,可根据波长对田间诱集色板进行改进或研发相应波长的诱捕光源,以其更好的对其危害进行监控和防治。

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