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RESEARCH ARTICLE

Spectral sensitivity of the compound eyes of *Anomala corpulenta* motschulsky (Coleoptera: Scarabaeoidea)

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Abstract

The scarab beetle, *Anomala corpulenta* Motschulsky (Coleoptera: Scarabaeoidea), is a widespread and destructive pest in China. Vision is one of the most important means of acquiring information about the external environment. In order to contribute to the understanding of the perception of visual stimuli in this species, the light sensitivity and spectral responses of the scarab beetle, *A. corpulenta*, were measured by using an electroretinogram (ERG) technique. In total, 14 monochromatic light intensities, between 340 and 605 nm, were applied to the compound eyes of *A. corpulenta* under varying levels of adaptation to dark and light conditions. The results showed that all light stimuli induced an ERG response, with varied amplitudes. The spectral sensitivity curve of dark-adapted eyes showed one major peak (~400 nm; near-ultraviolet), a secondary peak (from 498 to 562 nm; yellow-green) and the third peakat 460 nm. By contrast, in light-adapted eyes, only a near-UV peak was observed. From these results, we conclude that the compound eye of *A. corpulenta* is likely to have at least three spectral types of photoreceptor. Significance of differences were also recorded in the responses of male and female compound eyes, as well as diurnally and nocturnally. The amplitude of ERG in response to white-light stimuli varied with the light intensity: The stronger the luminance, the higher the ERG value. This suggests that the compound eye of *A. corpulenta* adapts quickly to changing light conditions, enabling *A. corpulenta* to maintain nocturnal activities.

Keywords: *Anomala corpulenta*, electroretinogram, insect vision, spectral sensitivity, light intensity

1. Introduction

For insects, vision is one of the most important means of acquiring information about the external environment. It plays a significant role in finding hosts, intraspecific communication, foraging, escaping from predators and in flight (Moericke 1955; Chapman *et al.* 1981; Dixon 1985; Klingauf 1987; Powell *et al.* 1995; Egelhaaf and Kern 2002). Finch and Collier (2000) showed that visual cues were central

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link of host location phytophagous insects, for example, the butterfly *Pieris rapae* was found to respond strongly to blue and blue-green light over long distances to locate a suitable spawning host (Qin 1987), female fruit females tend to move to traps with red spheres attached to the center of yellow panels (Cornelius *et al.* 1999). In addition, many phytophagous insects prefer yellow as a cue to host location (Bernays and Chapman 1994). However, Frisch (1949) showed that the honeybee *Apis mellifera* detects polarized natural light and uses it for spatial navigation. Therefore, it is important to get a more comprehensive and clear understanding of the insect color vision.

The scarab beetle, *Anomala corpulenta* Motschulsky (Coleoptera: Scarabaeoidea), is a widespread and destructive pest in China (Wu 2001). The larvae feed on the underground portion of crops, with a preference for peanuts and soybeans, whereas the adults feed on the leaves of various species of fruit and forest trees. The exocuticle of this beetle has a brilliant metallic appearance, and selectively reflects left circularly polarized light, as recorded for other jewel beetles (Sharma *et al.* 2009).

Insects are sensitive to various characteristics of light, such as its intensity, color and polarization (Wernet *et al.* 2003; Horváth and Varjú 2004). In addition, visual cues are important in intraspecific communication and host location by beetles. Many studies on vision in the jewel beetles have focused on polarization (Horváth and Varjú 2004; Brady and Cummings 2010; Blahó *et al.* 2012). However, few have studied the presence of color vision in, and impact of light intensity on, such beetles. Therefore, there is a need to further understand the physiological basis of the color vision of jewel beetles, particularly the spectral sensitivity, and effects of light intensity. Electrophysiological spectral sensitivity has been examined for many insect species, including the cabbage root fly, *Delia radicum* (L.) (Brown and Anderson 1996), the cotton bollworm, *Helicoverpa armigera* (Hübner) (Wei *et al.* 2002), the western flower thrip, *Frankliniella occidentalis* (Pergande) (Matteson *et al.* 1992), Homopteran species—the glasshouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Mellor *et al.* 1997), and the green peach aphid, *Myzus persicae* (Sulz.) (Kirchner *et al.* 2005), the click beetles, *Pyrophorus punctatissimus* in Coleoptera (Lall *et al.* 2000), etc. Most insects have two kinds of visual pigment, one detects light at approximately 550 nm (yellow-green) and the other detects blue-violet UV light, at less than 480 nm. However, there are no data available regarding the electrophysiological spectral sensitivity of the jewel beetles. In addition, mechanisms of adaptation to light intensity in *A. corpulenta* are unclear.

Therefore, to investigate the spectral sensitivities and mechanisms of adaptation to light intensity of *A. corpulenta*, the response of *A. corpulenta* to different light wavelengths and intensities, and the effects of gender and circadian rhythm on them, were measured by means of electroretinogram (ERG) technique.

2. Results

2.1. Form of the ERG

The ERG waveform of *A. corpulenta* elicited by a white light stimulus is a monophasic negative change in potential (Fig. 1). As can be seen from the waveform, the lower interference signals existed during stimulation. The ERG value was recorded as the negative ERG component. The greatest ERG amplitude was 35 mV.

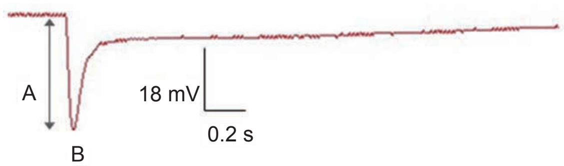

Fig. 1 A typical electroretinogram recording from *Anomala corpulenta* under white-light stimulus. A, negative sustained potential. B, off-response.

2.2. Spectral sensitivity

The spectra of ERG changes by the eyes of male and female *A. corpulenta* in response to light stimuli within the monochromatic 340–605 nm wavelength were recorded under certain dark and light adaptation times. The results showed that UV and most of the visible regions of the monochromatic light stimulus triggered an ERG response of *A. corpulenta* compound eyes with light and dark conditions adaptation. The spectral sensitivity response curves (Figs. 2–4) were obtained according to the size of the ERG amplitude.

The spectral sensitivity of the dark-adapted compound eye of both male and female *A. corpulenta* showed one major distinct peak of sensitivity at 400 nm diurnally. The second distinct peak appeared at 524 nm (yellow-green). No clear peak was found at other wavelengths (Fig. 2). When the eyes were tested nocturnally, the spectral sensitivity curve showed three further peaks (Fig. 3). The main peak position was unchanged, whereas the secondary peak position moved from 524 to 498 nm (yellow-green). The third peak occurred at 460 nm.

When the compound eyes were tested in the presence of adaptation to light, the spectral sensitivity curve of the female eyes showed only one peak, at 400 nm (Fig. 4), whereas those of the males showed three peaks: a major distinct peak at 400 nm, a second distinct peak at 498 nm (yellow-green) and the third peak at 460 nm. These peaks