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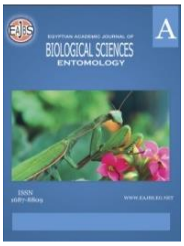

The Attraction of Stored Grain Pests Toward Various Colour Surfaces

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ABSTRACT

Colour vision is common phenomenon in living animals, but varies in insect species, depending on their vision sensitivity and photoreceptors involved. The sensitivity of the photoreceptor is determined through the absorption of visual colour pigments expressed. Photoreceptors are involved in filtering pigments, transverse wavelength, retinal image and colour signals. We have evaluated the colour attraction of two important stored grains insects, Red flour beetle (*Tribolium castaneum* H) and Pulse beetle (*Callosobruchus chinensis* L) to determine their visual sensitivity toward various colour surfaces. The data was recorded after 24hrs of releasing the insects in a chamber in which various colour surfaces were provided. The results showed that the *T. castaneum* was highly attracted toward green colour with maximum (17.3%) and (8.7%) of insects observed outside and inside the bags respectively. Whereas, minimum (4.3%) and (3.0%) *T. castaneum* found outside and inside the blue colour bags respectively. Similarly, *C. chinensis* was greatly attracted toward blue colour with the maximum (16.0%) and (7.7%) insects found attached outside and inside the bags respectively. Whereas, minimum (9.0%) and (2.0%) *C. chinensis* were recorded outside and inside the black colour bags respectively.

INTRODUCTION

Colour is an important parameter in accepting any food items. Not only in the vertebrates including mankind but also in insects the vision plays an important role in finding food , guiding directions and behaviour (Kelber and Osorio 2010; Lunau 2014a). (Frisch 1914), first time noticed that living organisms like insects are attracted by various colours. (Kooi *et al.,* 2021; Arnold;Stevenson and Belmain 2015) the deduction of colours varies among insect species, depending on their vision sensitivity which is determined by

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spectrum absorption expressed through visual pigments such as retinal structure, screening pigments, rhabdom and waveguide dimensions. (Schnaitmann;Pagni and Reiff 2020) observed that chromatic sensitivity enhances the detection of target images. Mono-chromatic animals can detect the chronological changes in luminance, whereas in insects the direct insights are limited. (Reza and Parween 2006) most of the insect prefer colours looks like colour of plants, flowers or their favourable hosts (Arnold et al., 2015; Chittka 1996). Pichaud;Briscoe and Desplan (1999) targeted colours achieved through inputs from retinal photoreceptors that differ in wavelength sensitivity.

Likewise, agricultural crops and other products the stored grains are more vulnerable to attack by insect pests, these insects are either external or internal feeders. Besides other serious pests of stored grains the pulse and wheat beetles cause significant losses to stored products (Ahmad *et al.,* 2019). About 10-40% grains losses have been recorded caused by stored grain insects worldwide. (Liang *et al.,* 2020)

Among, other serious pests of stored products the insect *Tribolium castaneum* and *Callosobruchus chinensis* are the important pests of stored grains (Njoroge *et al.,* 2019; Morrison *et al.,* 2018; Hymavathi *et al.,* 2011) which damage cereal grains and pulses such as, black gram (*Phaseoluss bengalens), chickpea (cicer arietinum) and cowpea (Vignaungui culata)* (Yan *et al.,* 2017; Kavallieratos;Athanassiou and Arthur 2015; Khamis *et al.,* 2011). These losses are not only limited to the seed germination but also reduce the commercial value of the grains (Khalequzzaman *et al.,* 2007).

For better management of stored grain pests, most of the farming communities rely on chemical insecticides to control insects in their warehouses or stored places, which not only cause hazards to the environment but also danger for humans and other living creatures (Ridley *et al.,* 2012; Saeed *et al.,* 2018; Wang *et al.,* 2019).

Keeping in view, the threats of insecticides to humans and the environment we designed a new strategy using visual cues to control stored grain insects through the natural way. For this, experiments were conducted to know the colour preference of stored grain pests, *T. castaneum* and *C. chinensis*. According to reported knowledge the limited studies were reported on the visual behavioural activities of stored grain pests. So, there is dire need of present era to apply new techniques to improve insect control strategies and minimize the application of chemical pesticides. Therefore, the present observations were made to determine the colour attraction of stored grains insect pests toward various colours surfaces of the clothe bags.

MATERIALS AND METHODS

The research trial was conducted in the Department of Entomology, Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Sciences (LUAWMS) Uthal, Pakistan during the year 2020. Two stored grain insect pests i.e., red flour beetle (*Tribolium castaneum* H.) and pulse beetle (*Callosobruches chinensis* L.) were collected from the already established culture in the entomological laboratory at LUAWMS. The infected wheat and bean stored grains were sieved in a clean stainless tray for the collection of adult insects. The sieved insects were moved to a petri dish with help of a soft camel hair brush for further use. About 100 adult insects of each species were used to observe their visual movement and attraction toward various colour surfaces.

About 100 gm of each host (wheat and bean) grains were placed in the handmade small bags, made of different coloured cloths i.e. (pink, black, white, green and blue) . These bags were kept in a transparent plastic cage (12×15×18 inches) at room temperatures (28.5 ± 2°C). The “100” insects of each species were released in the cage and observations were recorded after 24hrs. Each treatment was repeated three times.

Statistical Analysis:

The recorded data were analysed through statistical software Minitab version 18, the insect attraction movement toward different colours surfaces was noted and means evaluated by one-way ANOVA followed by tukey test (Minitab 2010). The figures were prepared using Ms. Excel 2010.

RESULTS

Colour vision is also known as visual perception of insects which helps in the recognition of retinal images. The sensitivities of the colour deduction vary among insect species depending on spectral sensitivity and photoreceptors. The spectral sensitivity of the photoreceptor is determined by expressed visual pigments.

Tribolium castaneum:

The results of the current laboratory experiment revealed that *T. castaneum* showed great response toward the green colour surface with the maximum (17.3%) and (8.7%) beetles were found outside and inside the bags respectively. Whereas, (13.7%) and (8.3%) of beetles were observed outside and inside on black colour respectively. Similarly, maximum (11.0%) and (7.3%) beetles were found outside and inside the white bags respectively. However, (10.0%) and (7.3%) beetles were noticed outside and inside of pink colour. Whereas, (4.3%) and (3.0%) beetles were observed outside and inside blue colour bags respectively. The statistical analysis showed that all colour bags had a different significant effect on the beetles vision and colour preference (DF = 9, F = 8.99, P = 0.00) (Fig. 1).

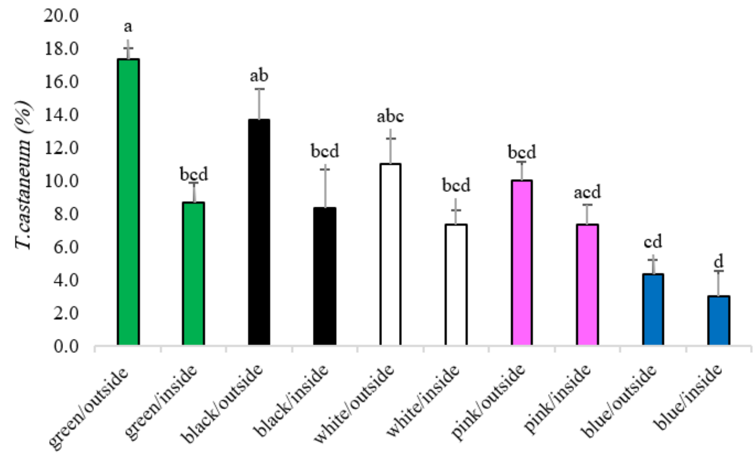

Fig.1. *T.castaneum* attracted by various colour surfaces, data recorded after 24 hours.
Note: In the figure bars that do not share a letter are significantly different at 95% confidence level.

Callosobruchus chinensis:

C. chinensis beetles were significantly attracted by blue colour and the maximum (16.0%) and (7.7%) beetles were recorded outside and inside respectively. Whereas, pink colour also showed good response to the beetles and found maximum (13.3%) and (6.0%) beetles outside and inside of bags respectively. While white colours attracted beetles and found (11.3%) (3.3%) beetles outside and inside the bags respectively. However, in green colour (9.3%) and (6.0%) beetles were found out and inside of the green bags respectively. While minimum beetles were attracted by black colour and observed (9.0%) and (2.0%) outside and inside the bags respectively. The statistical analysis showed that all colours had different significant effects on the beetles vision and colour preference (DF= 9, F = 7.52, P = 0.00) (Fig. 2).

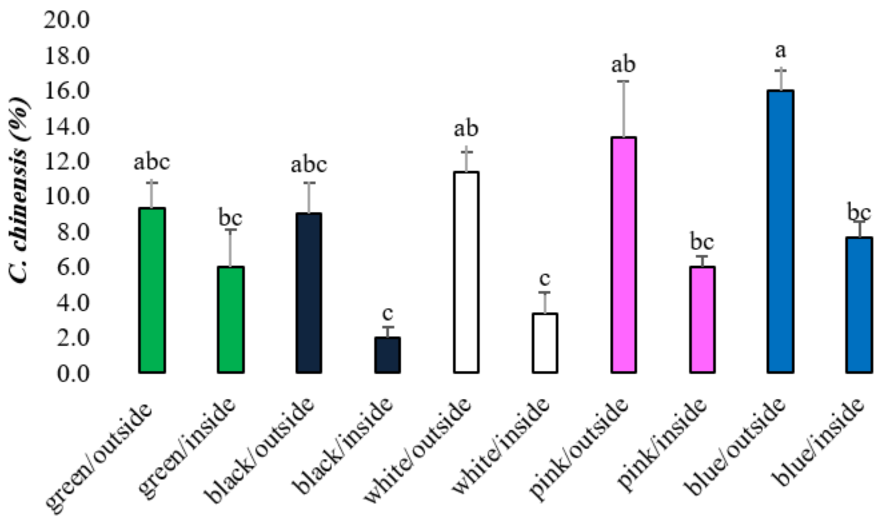

Fig. 2. *C. Chinensis* attracted by various colour surfaces, data recorded after 24 hours. Note: In the figure bars that do not share a letter are significantly different at 95% confidence level.

DISCUSSION

Most of the arthropods showed their response toward various coloured objects to find out their target host. Therefore, the present observations were made to determine the colour attraction of stored grains insect pests of significant importance toward various colours surfaces of the clothe bags. During the study it was observed that the *Tribolium spp* greatly attracted by green and black colour when compared with other colour surfaces. Similar evidence was documented by Pichaud *et al.,* (1999) in his review article he described a wide range of insect photoreceptors and exhibited wavelength response towards various colours. Similarly (Yilmaz *et al.*, 2017) conducted a laboratory experiment on memory retention of ant (*Camponotus blandus foragers*) response toward different colours, in his experiment he observed that the population of *C. blandus foragers* was able to discriminant various colour on a certain wavelength. Furthermore, he reported that blue and green colour was recognized by the test insect at a limited photoreceptor wavelength. As we found that both insect species responsed different colour surface. This may be due varied insect behaviour due to luminous signaling. Similar results were also supported in previous studies (Lunau 2014b; Arnold *et al.*, 2015) reported that each insect species has a different sizes of ommatidium which link the system of photoreceptors in a different range of wavelength sensitivity to guide the insects to find the targeted host.

Our recorded data showed both insect species showed different behavioural response toward colour surfaces (figure 1-2) i.e *T. castaneum* showed a great response toward green colour whereas *C. chinensis* significantly prefer the blue colour followed by the pink colour, that might be because of its visual sense and due to differ of host plants colour as common in insects. The similar finds were observed in past by (Chittka 1996; Kelber and Osorio 2010; Lebhardt and Desplan 2017) revealed that in order hymenoptera and some dipteran insects detection of wing movement through colour patterns to communicate with intraspecific species.

Similarly (Garbers and Wachtler 2016; Kooi *et al.*, 2021) described the spectral characteristics of photoreceptors and neural mechanisms of signals comparison involved in the determination of range and types of spectral contrast that can be detected. Colour vision and differences in the spectral strategies of healthy plants can be detected, as it was recently observed in a mixed community of native bee pollinators and their preferred plants (Wakakuwa *et al.,* 2005; Dyer *et al.,* 2012). In the present study, we observed that both insect species showed different attraction and preference toward various colour surfaces. So by avoiding storage of grain in the preferred colours places or objects the farmer community may save their products from the infestation of stored grain pests. It is suggested that to avoid the infestation of *T. castaneum sp,* the grain maybe stored in the blue, pink. While the black, green-coloured bags may be used to minimize the infestation of *C. chinensis*.

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