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Human lice show photopositive behaviour to white light

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ABSTRACT

We studied the behavioural response of body lice and head lice to white light. We also evaluated the influence of starvation and the presence of other individuals on this response. Experiments were performed in a rectangular arena, half of which was illuminated and the other half kept in the dark. Two experiments were performed: in the first, a single louse was released into the arena for 60 min and the percentage of time spent in the illuminated half was recorded; in the second experiment, a group of lice was released and the number of insects in the illuminated half was recorded. The results showed that the average number of lice and time spent in the illuminated side of the arena was statistically higher than for the controls. Starvation did not influence the reaction of lice, but the number of insects in the illuminated area did increase with the size of the group. This study shows that human lice are photopositive towards white light and that this behaviour is not affected by the nutritional state of the insects. Moreover, it is enhanced by the presence of other lice.

1. Introduction

Behavioural response to light shows the ability of animals to use this ubiquitous source of information. In insects, response to light is a stereotyped behaviour easily elicited and relatively stable (Reisenman et al., 2000). The direction of the response has evolved according to the significance light, as environmental key, has for the species. The experimental description of photoreaction may identify this significance and improve our understanding of the species' ecology. Additionally, the description of the behavioural reaction to a stimulus is the first approach to the physiological study of the sensory system involved.

There are hardly any studies on the sensory physiology of Phthiraptera. More specifically, there has been no further research on the behavioural responses to stimuli in human lice since early studies carried out during the first half of the 20th century. These studies showed that *Pediculus humanus humanus* would be photonegative, moving away from a source of light by a negative phototactic behaviour (Bacot, 1917; Wigglesworth, 1941; Buxton, 1946). Since then lice have been considered to be photophobic (Kettle, 1995). Nevertheless, reversion to a photopositive reaction was described in hungry lice (Wigglesworth, 1941). Recently, preliminary experiments conducted in our laboratory revealed a strong tendency of lice to group together within a white light circle produced by a light-fibre. Given these contradicting results, we decided to study the behavioural response of body and head lice to white light, as well as the influence of starvation and the presence of other individuals on this response.

2. Materials and methods

2.1. Insects

All the experiments used male adults of body (*P. humanus humanus*) and head lice (*Pediculus humanus capitis*). Body lice were obtained from a colony reared in our laboratory at 28 ± 0.5 °C and 50–60% RH. The insects were fed daily on rabbits. Head lice were collected from the heads of infested children from three elementary schools in Buenos Aires, Argentina, using a fine-toothed anti-louse comb according to a protocol approved by an ad-hoc committee of the Research Center of Pests and Insecticides (CIPEIN). Back at the laboratory, the males were selected and immediately used in the experiments. The time of starvation was a studied variable.

2.2. Experimental set up

Experiments were performed in a rectangular arena where one half was kept dark using a black cardboard top, leaving the other half illuminated. The arena was illuminated using a halogen white light (PHILIPS 6423 FO, 15 V/15 W) with an IR filter and a 60 cm optic fibre placed 10 cm above the arena (10,500 lux at the illuminated half). The side of the illuminated half (left or right) was changed every two trials in order to avoid biases due to external

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asymmetries. Two controls series were performed: (1) whole illuminated arena using insects starved for one day, (2) with the aim of discard possible warming effect produced by halogen lamp, we performed a control series where one half of arena was dark and other half illuminated with the ambient illumination (300 lux at the illuminated half). The illumination level was measured with a digital lux metre (TES Digital Lux Meter 1330A).

The temperatures of environment and each area of experimental arena were measured with a digital thermometer (TFA Dostman) after a stabilization period of 5 min (Table 1).

2.2.1. Experiment 1

In each trial, one louse was released for 60 min in the arena and the percentage of time spent in the illuminated half was recorded. Insects were released in the centre of the arena and recordings began 2 min later. Three starvation times were evaluated: 0, 1 and 4 days.

2.2.2. Experiment 2

In each trial, a group of lice were released in the arena and the number of insects in the illuminated half was recorded every 5 min during 45 min. Three group sizes were tested, of 6, 10 and 50 insects. A group of 10 insects was used for the controls.

2.3. Statistical analysis

Data normality and homoscedasticity were tested. Data were analysed using *t*-test (one parameter and independent samples), ANOVA, and Tukey's test.

3. Results and discussion

The control series with whole illuminated arena of both experiments did not reveal spatial asymmetries between the left and right areas ($p > 0.05$), indicating that the data from insects released in the right or left side could be pooled (Figs. 1 and 2). For body lice, the results showed that both the time spent and the average number of lice were statistically higher in the illuminated area of the experimental series than in the equivalent area of the respective controls ($p < 0.01$; Figs. 1 and 2). The results for head lice with both types of illumination showed significant differences with the controls ($p < 0.01$; Fig. 2). Whereas the temperature differences between the dark and illuminated and between those areas and the environmental (Table 1) cannot explain the lice's preferences, the results demonstrate that *P. humanus humanus* and *P. humanus capitis* both exhibit a photopositive behaviour to white light. On the other hand, there was no significant difference in the time spent in the illuminated area for body lice with different starvation times ($p > 0.05$; Fig. 3), showing that the photoreaction was not affected by the nutritional state of the insects. Finally, the number of insects in the illuminated area increased with the size of tested group ($p < 0.01$; Fig. 4), suggesting a synergism between the reaction to light and the presence of other individuals.

Table 1
Temperature of each area of experimental arena.

Area of experimental arena	Temperature (°C)
Illuminated half	26.6
Dark half	26.8
Environmental	26.9

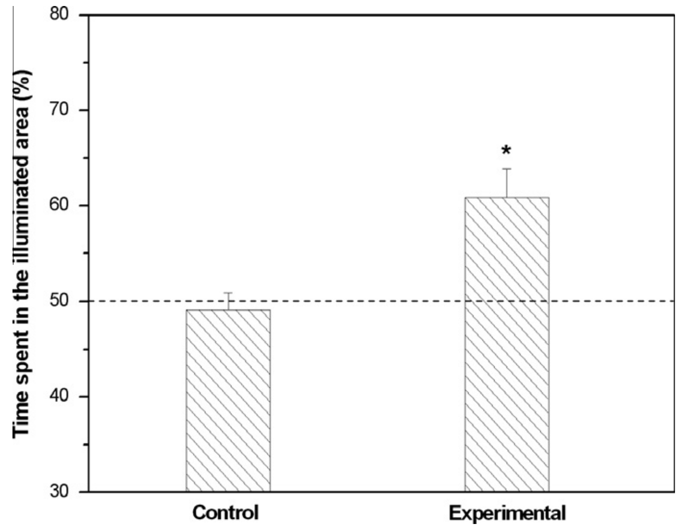

Fig. 1. Time spent in the illuminated area by one body louse (mean ± SE, $n = 10$). Asterisk indicate significant differences between experimental group and control group ($p < 0.05$). The dotted line indicates no preference for either side of the arena.

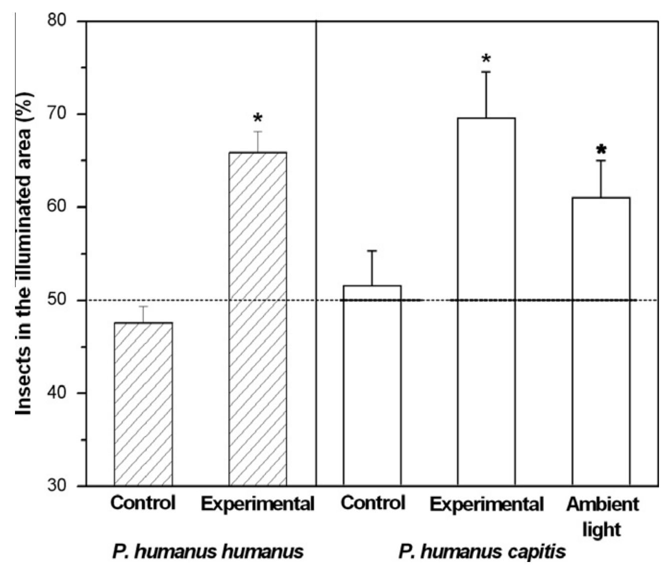

Fig. 2. Percentage of body lice or head lice in the illuminated area (mean ± SE, $n = 10$). Asterisks indicate significant differences between experimental groups and control groups ($p < 0.05$). The dotted line indicates no preference for either side of the arena.

The results obtained in this study do not agree with previous reports indicating that lice are photonegative insects and move away from a light source (Bacot, 1917; Wigglesworth, 1941; Buxton, 1946). On the contrary, in our experiments human lice always exhibited a photopositive response since they prefer light to total darkness. The reasons for these contradictory results are not clear. However, the experimental design, the experimental arena, the light source, and measured variables differ greatly between our study and the past studies. Of particular interest is the management of infrared radiation and heat generated by such radiation, associated with the light source used. The light source used in this study had an IR filter and an optical fibre that eliminated the infrared radiation which would impact on the experimental arena. The temperature values in different areas of the experimental arena confirmed empirically that the heat associated with the light was a controlled variable. The earlier studies did not describe the use

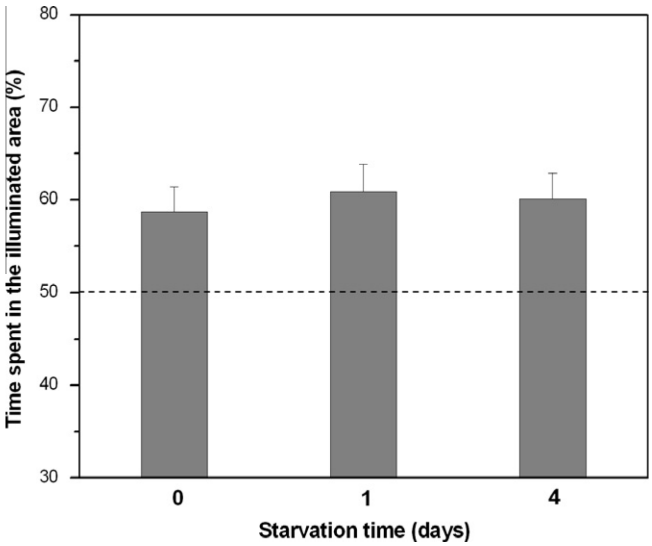

Fig. 3. Time spent in the illuminated area by one body louse with different starvation times (mean ± SE, $n = 10$). There were no significant differences between starvation times ($p > 0.05$). The dotted line indicates no preference for either side of the arena.

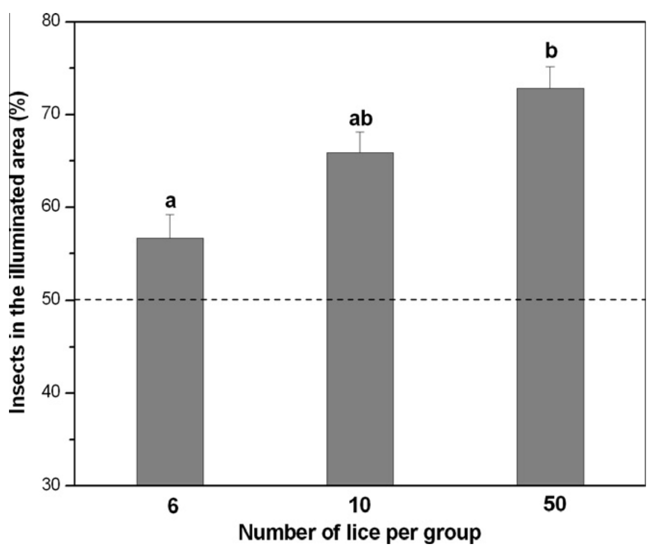

Fig. 4. Percentage of body lice in the illuminated area in groups of lice of different sizes (mean ± SE, $n = 10$). Different letters indicate significant differences ($p < 0.05$). The dotted line indicates no preference for either side of the arena.

of some type of filter that minimizes the incident infrared radiation. In those conditions, the lice could have responded to light, heat or both. In fact, it seems probable that lice had chosen the dark side in previous studies to avoid heating and dryness. Hasse (cited by Wigglesworth, 1941) described the reversion from a photonegative to a photopositive reaction in hungry lice. This should not be surprising, provided that the sign of the phototactic response may be influenced by the motivational state of the insects (Menzel and Greggers, 1985). However, the switch in the sign of lice phototaxis could not be confirmed by Wigglesworth (1941) and our results indicate that the nutritional condition of the insects does not affect the sign of the response, i.e. the photopositive direction was observed in both starved and fed lice. Further work would be necessary to answer if phototaxis is a state-dependent behaviour, as has been shown for the response to host cues in bloodsucking bugs (Bodin et al., 2009).

Human lice exhibit gregarious habits, especially when moulting (Bacot, 1916). Wigglesworth (1941) showed that the body lice prefer cloths containing lice and faeces of lice interpreting that they are attracted to the smell of other lice and their excreta. This attraction was also apparent in our study as shown in Fig. 4, where a multimodal response seemed to occur. A multimodal response is an integrated response driven by the interaction of multiple sensory cues involving different sensory modalities (Reisenman et al., 2000). Multimodal responses are common in haematophagous insects and improve their chances of finding hosts (Lehane, 1991). As an example, Reisenman et al. (2000) demonstrated a complex interaction between visual and olfactory cues in the bug *Triatoma infestans* showing that the response depended on the specific combination of spectral light and faeces. In this context, the interaction shown in this paper between light (visual cue) and the presence of other lice (olfactory cue) could be interpreted in terms of a multimodal response.

4. Conclusion

The present study shows that *P. humanus humanus* and *P. humanus capitis* exhibit a photopositive behaviour to white light. In body lice, this behaviour is not affected by the nutritional state of the insects, and is enhanced when the size of the tested group increases suggesting interaction between visual and chemical cues.

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