Stomoxys Flies Color attraction

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ABSTRACT

Blood-feeding flies, or *Stomoxy* flies, are common pests that large animals have to deal with (J. E. Cilek). These flies, as well as many other insects, have evolved to have compound eyes to have 360º vision. Compound eyes give this wide range of vision, but also come with an immense number of lenses that adjust light intensity (Miorelli, Nancy). This can cause these insects to be attracted to more dark colors that absorb more light (J. E. Cilek). In contrast to insects with compound eyes, insects with simple eyes have been found to be more attracted to lighter colors such as pink, yellow, red, and orange ("Attracting Butterflies - Garden for Wildlife"). It has been thought that zebras developed their stripes to reflect *Stomoxy* flies. In a study performed on this, it was found that out of black, white, and brown coat colors, the flies chose the black and brown more often than the white (Tombak, K.J., Gersick, A.S., Reisinger, L.V. *et al*).

INTRODUCTION

Stomoxys flies (biting or stable flies) are pests that primarily blood-feed on large-bodied animals. These pests can also try to feed on humans whenever their primary hosts are not around (J. E. Cilek). These flies are more attracted to certain colors than others, which is how they choose what animals to land on more frequently (J. E. Cilek). A study was performed to show what colors they chose to land on the most, out of blue, red, orange, black, and three shades of white, blue and black were landed on significantly more than any other color (J. E. Cilek). Blue and black were landed on the most because flies are more attracted to colors that absorb light (Waterhouse, DF). Since *Stomoxys* land on colors that absorb light, they more commonly land on brown and black colored animals, instead of white (Tombak, K.J., Gersick, A.S., Reisinger, L.V. *et al*).

Stomoxy flies have compound eyes, which are made up of many ommatidia. Ommatidia help adjust the intensity of light. Compound eyes also provide insects with 360^{o} vision as they take up the majority of the insects head and have many lenses within. Insects developed compound eyes to have 360^{o} vision, but this does affect the clarity of their vision and since there are so many ommatidia, they will generally stay away from colors that require more light adjustment (Miorelli, Nancy).

We care about the color preference of biting flies because these flies are bothersome for animals they choose to feed on. Farmers that care about their livestock take this into consideration and cover their animals with a specifically colored coat or could choose what color animals to have on the farm. This topic also comes about when discussing why zebras have stripes. Zebras developed white stripes so biting flies would not land on them as often or on their entire body, due to the ommatidia having to adjust the intensity of the white coat color (Tombak, K.J., Gersick, A.S., Reisinger, L.V. *et al*). The evolution of the compound eye in insects plays a role in their color preference for what animals they land on for feeding (Miorelli, Nancy).

MATERIAL AND METHODS

The data presented in this paper comes from "Zebras of all stripes repel biting flies at close range" by Kaia J. Tombak and a team of scientists. They performed this study to further confirm that zebras evolved their stripes to repel the biting flies. To do this, they collected sections of zebra and impala skin from carcasses found at the Mpala Research Centre. They took about a 400 cm^2 skin sample from the rumps of one plains zebra (*Equus quagga*) also referred to as PZ and one Grevy's zebra (*Equus grevyi*) also referred to as GZ. The impala (IM) sample was taken from the flank of an impala carcass due to the rump not being large enough. Muscle and fat

were cleared off the samples, the samples were treated in salt, and sun dried (Tombak, K.J., Gersick, A.S., Reisinger, L.V. *et al*).

Local biting flies were collected by using Nzi traps that were baited with fresh camel urine and milk. The traps collected flies for 6-24 hours until the number of flies was sufficient. To ensure that the flies were hungry for the experiment, they were collected from the traps and held for 12 hours before the experiment began. Before beginning the experiment, the team identified that these flies were of the *Stomoxy* species (Tombak, K.J., Gersick, A.S., Reisinger, L.V. *et al*).

To be able to count the number of flies landing on each sample of skin, this experiment took place in a controlled, rectangular Plexiglas box. At each end of the box, there was a removable piece of wood that prevented fly escape but also allowed oxygen into the box. For each trial, a piece of animal skin was hung in front of the wooden piece and held on by a clothespin. The trials were ran at 8:30-10:00am and 3:00-4:30pm as these are the times *Stomoxy* flies are the most active. A closed petri dish that contained 15-20 flies was placed in the center of the box and the lid was removed by lifting it off with fishing line threaded through a hole in the lid. The flies settled on their animal skin sample of choice and the results were recorded. It was noted on the zebra skin if the flies landed on white or black stripes. After the data was recorded, the team tapped the box to disturb the flies and have them re-land. This sub-trial was repeated 10 times in each trial (Tombak, K.J., Gersick, A.S., Reisinger, L.V. *et al*).

Each trial consisted of a different combination of the animal skin samples; Grevy's zebra skin vs. plains zebra skin, plains zebra skin vs. impala skin, and a Grevy's zebra skin vs. impala skin. Recorded landing data was combined into an average per trial and were compared using a Wilcoxon Rank Sum test (Tombak, K.J., Gersick, A.S., Reisinger, L.V. *et a*). The data in this

paper was presented using a Chi-squared analysis. Data analysis was performed in RStudio to get the degrees of freedom, P-value, and Chi-squared analysis value. The equation for a Chi-squared analysis is $X^2 = \sum \frac{(O-E)^2}{E}$; where O is the observed values and E is the expected values. The Chi-squared analysis is a statistical test used to determine if events are caused by random chance.

RESULTS

Figure 1 shows the percentage of how often the flies landed on what color in the box. The values of white and black from each zebra type were combined. It is shown that 62.8% of the time, *Stomoxy* flies landed on brown from the impala sample. Black was the second most common color at 19.8%. Wood was the third most common with a 10.9% landing percentage. White was the least landed on color with a landing percentage of 6.5%.

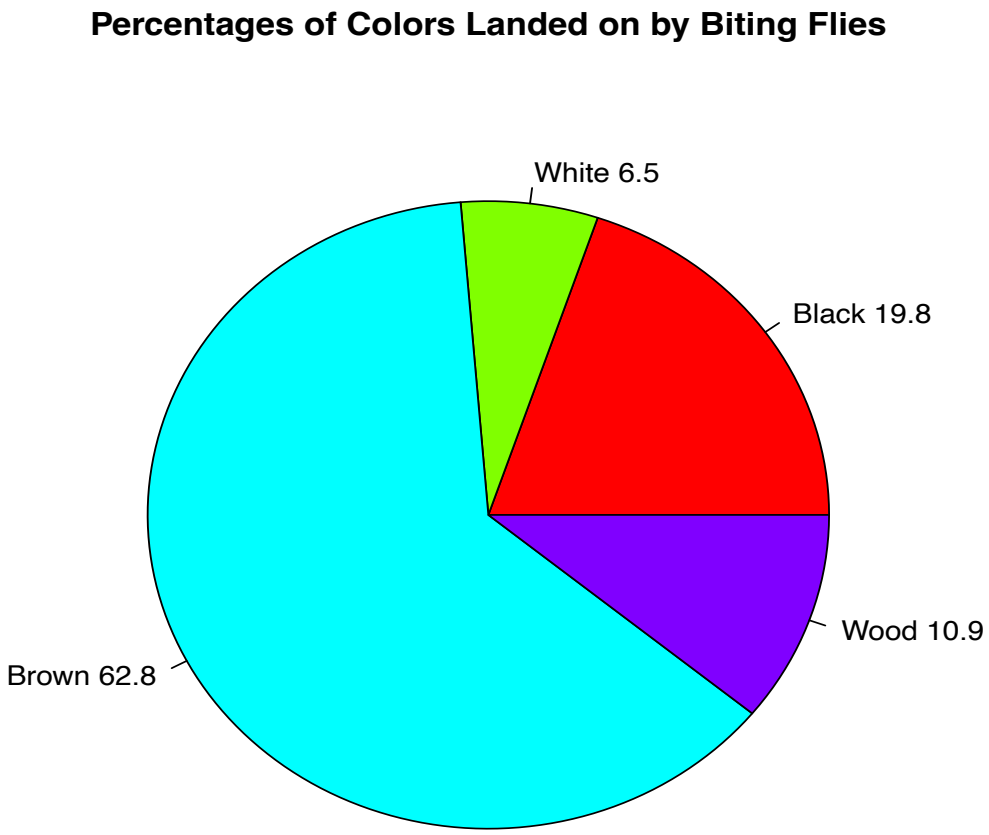

Figure 1: The percentage of how often flies landed on what color.

Table 1 represents the averages of the recorded landing data during the trials out of 1833 total average landings.

	Lands on black	Lands on white	Lands on brown
GZ	177	60	0
PZ	187	59	0
IM	0	0	1155
Wood	0	0	195

Table 1: raw results of average landing data collected from the trials.

Table 2 represents the results of a 95% confidence interval Chi-squared analysis test performed to determine if the landing values were due to random chance or by choice.

Degrees of freedom	6
P-value	2.2×10^{-16}
Theoretical value	1.635
Chi-squared analysis value	1833.4

Table 2: results and values of Chi-squared analysis generated from RStudio. Theoretical value was determined using a standard Chi-squared distribution chart according to the degrees of freedom and confidence interval.

DISCUSSION

The results of the Chi-squared analysis at a 95% confidence interval show that the flies landed on certain colors by choice and not by random chance. We can interpret this because the Chi-squared analysis value was greater than the theoretical value.

Since the results from the Chi-squared analysis show that the color landed on was by choice and not by chance, this can support that the evolution of compound eye structures does help determine what colors flies will land on. Compound eyes can be compared to simple eyes as simple eyes only have one small lens. Insects with only simple eyes, such as butterflies, are attracted to bright colors such as pink, purple, red, and yellow ("Attracting Butterflies - Garden for Wildlife"). *Stomoxy* flies are attracted to colors that absorb light due to the immense amount of ommatidia structures and lenses in their eyes.

There could be possible error in this data and results as the flies were starved before the trial run. This could have caused them to just be quick to retrieving food instead of their usual color preference. The results of this experiment could also be changed if it was run on live animals instead of flesh samples.

DATA AVAILABILTY

RStudio (version 4.2.2 (2022-10-31 ucrt)) was used to run data analysis tests. The code for this experiment can be found at https://github.com/brooklynnlafferty?tab=repositories. The data for this experiment can be found at https://datadryad.org/stash/dataset/doi:10.5061/dryad.gb5mkkwtd.

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