Recent Advances in Elucidating the Function of Zebra Stripes: Parasite Avoidance and Thermoregulation Do Not Resolve the Mystery

Reflective Essay

Introduction

The present work was written for the course UWP 104E Writing in Science during Summer Session II 2019. Although most of the reading and writing were completed then, much of the literature search and thinking had begun since January 2019. Earlier last year, as part of an effort to study the parasitoid deterrence effect of *Danaus plexippus* stripes in EVE180, I was deep into the zebra stripe literature to find any hint of how parasitoids would respond to the stripes on the monarch larvae. Unfortunately, the research took a sharp turn in May, as we shifted our focus to *Drosophila* behavior. Thus, many of what I had hope to say were never realized in writing; the impressive library I accumulated over months in Zotero too were mostly never used. Fortunately, the UWP course presented as an opportunity to explore the lingering thoughts and questions I had simmering at the back of my mind. Through the writing process, I was able to make at least some sense out of the enigma that is the function of zebra stripes and its murky present state of consensus.

The mini review is centered around the recent dispute between the research groups of Tim Caro from UC Davis and Brenda Larison from UC LA. Both groups in 2015 and 2014 published similar eco-correlative studies of striping patterns on zebra as an attempt to elucidate the evolution and adaptive function of zebra stripes. Yet, the two groups interpreted similar data differently and reached dissimilar conclusions (see Caro et al 2014, Caro and Stankowich 2015, Larison et al. 2015a, Larison et al. 2015b). At its heart, what determines whose subjective interpretation and assumptions fall within reason depends on the credibility of two proposed function of zebra stripes: the thermoregulation hypothesis and the fly deterrence hypothesis. However, with its long history of failed theories and conflicting findings, past research into the function of zebra stripes does not offer any immediately clear solution. Thus, the review seeks to evaluate the plausibility of the two dueling hypotheses to the best of our current knowledge. Especially considering the advent of Horvath et al. (2018) and Britten et al. (2016), a reexamination of the dispute between Caro and Larison seems ripe for taking.

Scope

While the review is ultimately aimed to elucidate and analyze the function of zebra stripes, it quickly dismisses most proposed theories and instead focuses only on the fly deterrence and thermoregulation hypotheses. I felt this decision was appropriate as the field increasingly shifts its attention toward the fly deterrence and thermoregulation hypotheses. In the interest of brevity and considering the excellent reviews prior workers have already offered on the other theories (e.g. Ruxton 2002), I had little more to add to the discussion.

The scope of the review is therefore any study that empirically tested the fly deterrence or thermoregulation hypothesis either directly with zebras or indirectly using "zebra like" systems. Every publication that offers any insight into their plausibility were included and discussed, or at the very least, mentioned. Due to the narrow scope, relatively recent proposal of the two hypotheses, and their challenging nature to study, few works exist that fit this criterion. A comprehensive search was therefore possible. I excluded Caro (2016), because much of the more important arguments were already made in the primary literature he published earlier. Iriondo (2015) and Cobb and Cobb (2019) were excluded because these works were not published in reputable sources and were not subjected to rigorous peer review. Cobb and Cobb (2019) in particular has such blinding methodological issues and questionable interpretations of results that I felt the work was not even worth mentioning; and I will not discuss it any further here either. Other works like that of Morris (1990) were not included as no empirical evidence was presented to support their mere speculations.

Search Strategy

I used a combination of Zoological Records, BIOSIS, and Google Scholar to search for published literature. I used taxonomic restrictions and key words like *equus, zebra*, and strip** to limit the search to zebras and stripes. Key words like *temp*, therm*, cool*, convect** were used to look for studies related to the thermoregulation hypothesis. For the fly deterrence hypothesis, I used other key words like *tabani*, fly, flies, glossini*, deter*, avoid*, and attract**. After realizing how few works turned up with this search criteria though, I removed the taxonomic restrictions and broadened the search to studies that also worked on non-zebra systems. This scope included any study that examined the cooling or fly deterring effect of "zebra-like" surfaces. Works like that of Horvath et al. (2019) and Lev-Yadun (2014, 2016) were thus considered. I have relatively high confidence that by the end of the search, I had read most of the available publications. My confidence rested on the fact that I did not encounter any unfamiliar citation in the papers I read. Cross referencing my reference library with lists of publications that cited those works about zebra stripes also did not reveal any more papers that had eluded my search.

Having read the titles and abstracts of the publications that retuned in my search, I went on to read each work closely. Using the criteria as I had defined, that the work provided empirical evidence to the hypothesis, I was able to narrow down the list of papers to just a handful. Subsequently, the task was simply constructing a narrative that summarizes the main findings and highlights the many incongruities among them. What conflicts I can resolve that others had already addressed in their discussion and published comments, I reiterated their arguments; for others, I looked to other related areas of study that I am vaguely aware of for inspiration.

I was fortunate to have access to a large diverse collection of journals through the UC Davis library database license using the library VPN. Thus, most publications were easily

accessible through a click of a button. More obscure journals and some papers from Elsevier, however, were accessed through ResearchGate directly from the authors and a website that rhymes with Ty Cobb.

Significance of Work

The search for the function of zebra stripes has excited many ecologists, physiologists, and evolutionary biologists. As such, our current state of understanding constantly renews as novel works are produced. Past reviews are therefore easily outdated. The present review organizes the more significant publications in recent years and provide an updated criticism of older studies. In particular, the review emphasize three major points: 1) the support for both the thermoregulation and fly deterrence hypothesis are surprisingly shoddy; 2) this shortcoming was due to the lack of realism in the studies that were conducted; 3) an examination of the interaction between temperature and fly-vectored disease may solve the mystery. Indeed, few works have examined vector activity, disease transmission risks, and virulence under different temperature regimes, let alone in the zebra system. I hope that this review will convince researchers to transition to more field-based experiments and investigate temperature mediated parameters of disease dynamics.

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