Effect of urbanization and varying diets on the microbiome of the western black widow (Latrodectus hesperus)

# Abstract

Keywords :

# Introduction

Human-induced environmental modifications can affect species by altering trophic interactions, resulting in the rearrangement of prey and predator communities (REFS). An increasing number of studies report a massive loss of arthropod diversity due to the combined effects of urbanization and human activities (Bosmans et al., 2018; Newbold et al., 2015). For instance, urbanization transforms the habitat caracteristics where arthropod predators hunt (REFS), which may then incur changes in the community composition of their prey (Hallmann et al., 2017; Seibold et al., 2019). Consequently, these new environmental pressures lead to novel physiological and behavioral adaptations enabling predators to survive in urbanized habitats (REFS).

It has been shown that a change in diet can influence behavior. The diversity of available prey would therefore play a major role in the evolution of the behavior and physiology of the arthropod. It is therefore not only the diversity and abundance but also the quality of the prey. These changes in prey composition modify the biodiversity but also the available nutritional components, fitness, competition and predation behaviors. We understand then the evolutionary importance that a change of prey can have on predator. Among theses consequences, it has been observed that a change of diet could have an effect on the microbiota. Thus, prey have a direct effect on behavior and physiology and a more indirect effect through their microbial environment. The composition of available prey would both have an indirect effect through the microbial environment of the predators and on their ecology. Indeed, the factor of diet seems to play a central role in the composition of the microbiota (Kennedy et al., 2020) and it is also known that prey diversity would likely be lower in urban environments, due to pesticide use, decreased biodiversity, etc. (Bosmans et al., 2018).

Until now, only a few studies have highlighted the importance of host-microbe interactions and the important role that microbial communities play in the evolution and adaptation of their hosts (REFS). Little is known about microbiota of arthropods (Engel & Moran, 2013), one of the most diverse group in the animal (Giribet & Edgecombe, 2012). Also, yet little is known about urbanization effects on microbiomes. Only a few studies have demonstrated the importance of non-pathogenic skin or gut microbes in the behavior of some arthropods, including spiders (Parks et al., 2017). The limited empirical data available have all demonstrated that there is a relative importance of environmental effects (habitat and prey) on the microbiota. These effects have often been part of a microbiological or ecological approach but only few studies combine the aspects to understand the consequences.

However, more and more studies have demonstrated the importance of the microbiota. The microbiome have been shown to contribute to nutrition, protection from parasites and pathogens, modulation of immune responses, and communication. The extent of these roles is not yet clear and awaits further study. In addition to their obvious contribution to food digestion and detoxification (Boone et al., 2013 ;Brune & Ohkuma, 2010 ), microbes can provide essential nutrients (LeBlanc et al., 2013 ), provide defense against pathogens (Kwong & Moran, 2016 ), and even influence host behavior (Sharon et al., 2010).

Predators are a good system for highlighting the consequences of urbanization but present major difficulties in terms of data collection. Predators are essential vectors of information to better understand the effects of the biodiversity of their habitat. They are opportunists that reflect the state of its ecosystem. In this study, we used the western black widow (*Latrodectus hesperus*) which is a sedentary predatory arthropod that uses its web as a predatory tool. This predator can stay in one place for almost a year and feeds exclusively on local prey (REFS). While the western black widow is a facultative generalist, it has been shown to benefit from a diversity of prey to fulfill its nutritional requirements (REFS). A balanced diet of multiple prey types may be adaptive for spiders because polyphagy provides access to a variety of nutrients not available from a single prey source. This has been shown to maximize growth rates and survival of juveniles (Uetz et al. 1992; Toft & Wise 1999). However, a mixed diet may be limited by the availability of certain prey types in the habitat where black widows establish themselves. Western black widows can be found both in desertic and urban environments. They are therefore ideal study systems to quantify the consequences of urbanization via the study of its microbiota and its web. They could be a bioindicator informing on the state of the surrounding ecosystems (REFS). The composition of the microbial environment of the spider would be an adaptive response to changes in habitat and available prey diversity.

Here, we combined field and laboratory experiments to evaluate the impacts of urbanization on microbiome communities and body condition of western black widows. In the field, we compared spiders collected from 4 different sites to measure the impacts of urbanization on microbiome diversity. Our objective is to characterize and compare the gut and web bacterial communities of western black widows according to their environment: desert (natural) versus urban. We hypothesize that the diversity and structure of the bacterial communities of the gut and webs will differ between spiders collected in desertic and urban habitats. We predict that gut and web bacterial diversity will be higher for spiders collected in the desert. In a subsequent laboratory experiment, we studied the influence of a restricted diet on microbiome diversity. Our objective is to evaluate the effect of a restricted diet (i.e. crickets vs isopods) on the alpha and beta diversity of the western black widow’s gut microbiome. First, knowing there is a functional relationship between diet and gut microbiome, spiders that consumed a similar diet should have a homogeneous community. Second, the rate of variation in beta diversity should be explained by diet. Thus, the diet of crickets will demonstrate greater abundance and diversity since they are omnivores and have a high protein and fruit/vegetable diet (Ng, Stat, Bunce, & Simmons, 2018). Thus, the isopod diet group should have a lower variety of microbiome specific to their carrot-based diet.

The last objective would be to identify if there is a basal microbiome in the L. Herperus species. One of the hypothesis would be that The permanent core microbiome should account for 30% of the species-specific microbial flora and thus be observed across groups leading to a stable and predictable microbial community (REFS). This should thus be resistant to the influence of diet on the community (Chu, Spencer, Curzi, Zavala, & Seufferheld, 2013 ; Engel & Moran, 2013 ; Reese & Dunn, 2018 ; Ruokolainen , Ikonen, Makkonen, & Hanski, 2016 ; Russell et al., 2009 ; Sanders et al., 2014 ). This study will provide a better understanding of the impacts of urbanization on the microbial ecology of L. hesperus in Arizona. It will also help determine how prey encountered by black widows shape the structure of their microbiome. And on the other hand, to improve the understanding of their co-evolutionary relationship.

# Materials and methods

# Results

# Discussion