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**SÃO PAULO STATE UNIVERSITY (UNESP)  
INSTITUTE OF BIOSCIENCES**

**GESLAINE RAFAELA LEMOS GONÇALVES**

**ECOLOGY AND TROPHIC STRUCTURE  
OF THE SPIDER CRAB *Libinia ferreirae*  
(DECAPODA: MAJOIDEA) ON THE  
SOUTH COAST OF SÃO PAULO**

**PhD Thesis**

**BOTUCATU**

**2020**

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INSTITUTE OF BIOSCIENCES**

**PhD Thesis**

**Ecology and trophic structure of the spider crab  
*Libinia ferreirae* (Decapoda: Majoidea) on the South  
Coast of São Paulo**

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*“Knowledge we learn from masters and books.  
Wisdom is learned through life and the humble”  
Cora Coralina*

*“Be the change you wish to see in the world!”  
Mahatma Gandhi*

I dedicate this work to my family for being the inspiring source of force and determination in my life.

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# **PROLOGUE**

This thesis is the conclusion of my journey since my undergraduate to my PhD, with an interest in studying marine biology, stimulated by the opportunity to have new experiences in this area. Under the supervision of Professor Dr. Antonio Leão Castilho, I fell in love with the possibility of studying Majoidea crabs in my master's and thesis project.

Following the development of my undergraduate research topic “Biodiversity of Penaeoidea shrimp (Crustacea: Decapoda) in the region of São Francisco do Sul, Santa Catarina, Brazil”, as part of BSc Biological Sciences, I became curious in studying the Majoidea crab of the genus *Libinia*. This curiosity came about during sampling expeditions on a shrimp trawler, where I was exposed to the different life habits of this species - crabs associated with jellyfish, and crabs of the same species caught outside the jellyfish, who had a different colour than those associated with the jellyfish, also carrying numerous other organisms on the carapace. This observation served as a basis for questions and fascination about symbiosis of marine animals, which led me to store the data obtained on these expeditions, thinking about future research in the area.

After my undergraduate BSc I moved to another city to work in collaboration with UNESP (São Paulo State University) and USP (São Paulo University) where I had a FAPESP scholarship (2013 / 08517-2) for technical training over one and a half years, working in the project “Decapod crustaceans: multidisciplinary in the characterization of marine biodiversity in the State of São Paulo (taxonomy, spermiotaxonomy, molecular biology and population dynamics - São Paulo”, under the supervision of Professor Dr. Fernando Luis Medina Mantelatto. With the team of Prof. Antonio Leão Castilho I was responsible in collecting, organizing, sorting, classifying and analysing the animals collected by trawl fishing for commercially valued shrimp, in the Cananéia and Ubatuba

region (both in the state of São Paulo), and in Macaé (in the state of Rio de Janeiro). I also collected and analysed samples of environmental factors such as sediment, salinity, temperature, among others. During this period, I had opportunities to learn numerous techniques for collecting and analysing abiotic and biotic samples. Also, because I was responsible for managing the communication and distribution of the sample data from the project to the other team members, I created links with countless researchers who in the future became friends and helped me throughout my career. Moved by the interest in studying and discovering more about the symbiotic relationships that the Majoidea crab of the genus *Libinia* has during its life, under the authorization of Prof. Antonio Castilho and other researchers involved in the project, I collected as many samples and as much data as possible about this spider crab and the other animals involved in symbiotic relationships. This area is seldom studied, because the species has no commercial interest and because they are not abundant in the samples, when compared to other crabs. The breadth of samples and data generated during the field activities I participated in served as a basis for the preparation and production of my Master dissertation, PhD thesis and other works developed in partnership with colleagues in the laboratory.

Thus, after my technical training experience, I started a master's degree in MSc Biological Sciences (Zoology) under the guidance of Prof. Antonio Castilho and co-supervision of Professor Dr. Maria Negreiros-Fransozo. Here my research with Genus *Libinia* began – “Populational Ecology to *Libinia ferreirae* (Brachyura; Majoidea) on the southeastern coast of Brazil” (funding by FAPESP 2014/13770-1) – using all the samples and results obtained since the initiation of my scientific career. Due to my curiosity and passion to try to understand the life habits and symbiotic relationships of this crab with different organisms, we worked on and published the following works: **(1)** Gonçalves, G. R. L., Wolf, M. R., Costa, R. C. & Castilho, A. L. (2016). Decapod crustacean

associations with scyphozoan jellyfish (Rhizostomeae: Pelagiidae) in the Southeastern Brazilian coast. *Symbiosis* 69: 193-198. DOI 10.1007/s13199-016-0395-x; **(2)** Gonçalves, G. R. L., Grabowski, R. C., Bochini, G. L., Costa, R. C. & Castilho, A. L. (2017). Ecology of the spider crab *Libinia ferreirae* (Brachyura: Majoidea): ontogenetic shifts in habitat use. *Hydrobiologia* 795:313–25. DOI 10.1007/s10750-017-3153-z; **(3)** Gonçalves, G. R. L., Bolla Jr., E. A., Negreiros-Fransozo, M. L. & Castilho A. L. (2017). Morphometric and gonadal maturity of the spider crab *Libinia ferreirae* Brito Capello, 1871 (Decapoda: Majoidea: Epialtidae) at Southeastern Brazilian coast. *J Mar Biol Assoc UK* 97(2):289–95. doi:10.1017/S0025315416000370; **(4)** Moraes, I. R. R., Wolf, M. R., Gonçalves, G. R. L. & Castilho, A. L. (2017). Fecundity and reproductive output of the caridean shrimp *Periclimenes paivai* associated with scyphozoan jellyfish. *Invertebrate Reproduction & Development* 61:1-7. doi:10.1080/07924259.2017.1282890; **(5)** Gonçalves, G. R. L., Negreiros-Fransozo, M. L., Fransozo, A. & Castilho, A. L. (2019). Feeding ecology and niche segregation of the spider crab *Libinia ferreirae* (Decapoda, Brachyura, Majoidea), a symbiont of *Lychnorhiza lucerna* (Cnidaria, Scyphozoa, Rhizostomeae). *Hydrobiologia*, 847: 1013-1025. doi.org/10.1007/s10750-019-04158-0; **(6)** Gonçalves, G. R. L., Miazakic, L. F., Bolla Jr., E. A., Grabowski, R. C., Costa, R. C. & Castilho, A. L. (2020). Growth and longevity of the spider crab *Libinia ferreirae* (Majoidea, Epialtidae). *Nauplius*, 28. doi.org/10.1590/2358-2936e2020003; **(7)** Gonçalves, G. R. L., Palomares, L. F. S., Sousa, A. N., Stanski, G., Sancinetti, G., Costa, R. C. & Castilho, A. L. (2020). Geographical ecology to the symbiont crabs *Libinia ferreirae* and *Libinia spinosa*: patterns in the distribution from south-southeastern Brazil. *Marine Ecology*. DOI: 10.1111/maec.12606.

After my MSc degree, I decided to continue studying in the PhD the relationships that marine organisms have, using new analysis tools. For my PhD under the guidance of

Professor Antonio Castilho and co-supervision of Professor Maria Lucia Negreiros-Fransozo, we decided to improve the studies on the ecology and life cycle of *Libinia* by adopting new methodologies under the project “Ecology and trophic structure of the spider crab *Libinia ferreirae* (Decapoda: Majoidea) on the South coast of São Paulo”, funding by FAPESP (2018/01659-0). Our main objective was to explore in detail the ecological interactions and the status of the marine trophic web exploited directly or indirectly by non-selective trawling. Thus, was inserted in this project together with ecological temporal and behavioural data, analysis of stable isotope for carbon and nitrogen.

A great deal of results from stable isotopes analysis of numerous species was obtained during this PhD project. However, because this area was new for both my supervisor Prof. Antonio Leão Castilho and myself, we decided to seek international partnerships with the objective of acquiring more knowledge in the area, mainly to understand and apply the tools of statistical analysis for stable isotopes in trophic relations. Therefore, a BEPE FAPESP project proposal entitled “Application of the isotopic mixing models in the ecology to trophic structure of the spider crab *Libinia ferreirae* (Decapoda: Majoidea)”, in collaboration with Professor Dr. Stuart Bearhop of Exeter University, UK, was submitted and approved by FAPESP (2019 / 00105-3). During this process, I presented my preliminary data at the 10th National Conference on Marine Sciences, at the Faculty of Exact and Natural Sciences at the University of Buenos Aires in Argentina, where I had the opportunity to meet Professor Dr. Marleen De Troch of the University of Ghent (Belgium), who suggested adding fatty acid analysis as a complementary tool to my studies. After some time strengthening this idea, a transnational access request was submitted to the Assemble Plus Scholarship under EU



Horizon 2020, with a proposal to elaborate the project “Fatty acids analysis of shrimp (of co-occurring shrimp) in the South-West to Brazil”.

I started my 6 months of BEPE scholarship at the University of Exeter, and during this time my proposal at Assemble Plus was approved. In view of this, FAPESP was asked to extend the scholarship for another 3 months so that I had time to execute my project in Ghent University, which was approved. During this period of 9 months, I developed the statistical analysis necessary for my work with stable isotopes together with Professor Stuart Bearhop and his team, which were of substantial importance for the structuring and elaboration of the work. After this, at the University of Ghent, Belgium, I learned from Professor Marleen De Troch and her laboratory the fatty acid analysis of three species of shrimp. Professor De Troch added excellent knowledge to my career and my work, assisting me in the preparation of important research papers for the area.

Both international collaborations presented me with vast knowledge that brought invaluable personal and professional maturity to my research and career. These experiences have shown me that in trying to overcome your limits, more complete and broader research can be generated, in which apparently distinct topics become closely related to the relationships experienced by marine organisms. Therefore, the research presented in this PhD thesis was divided into 5 chapters in article format, in order to answer the following questions:

- How is the symbiotic relationship of the spider crab *L. ferreirae* with the host jellyfish maintained and how does this symbiosis can influence the life of the crab?
- What is the association behaviour of the crab with its host jellyfish?
- Is it possible to define the type of symbiotic relationship that the crab *L. ferreirae* has with the jellyfish and with different organisms that live on the carapace, through stable isotope analysis?

- How does the *L. ferreirae* crab benefit from this symbiotic relationship with the jellyfish?
- How is the trophic web of organisms collected by trawling aimed at the capture of commercial shrimp in Cananéia, São Paulo, Brazil (including *L. ferreirae*) structured? Is there an ecological overlap during the winter and summer of the guilds of the organisms belonging to this trophic web?
- What is the fatty acid profile of three species of shrimp exploited by trawling in the Cananéia region, São Paulo, Brazil?
- As per the fatty acid profile of shrimp *Xiphopenaeus* spp., does it change according to sex, age and the region according to the state of conservation of the environment?

All these questions are proposed with the aim of exploring the intra and interspecific relationships of the organisms caught by trawl fishing, highlighting the importance of energy transfer in the food web between different levels of the trophic structure in which these organisms are involved.