Thermal and Behavioral Adaptations of the Invasive Asian House Geckos (*Hemidactylus frenatus*)

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Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of Professor. Dr. Jonathan Webb

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Faculty of Science

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Certificate of Original Authorship

I, Yingyod Lapwong, declare that this thesis, is submitted in fulfillment of the requirements for the award of Doctor of Philosophy, in the School of Life Science, Facility of Science, at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

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Acknowledgments

My Ph.D. has not begun from the day I enrolled and finished on the day I graduate; it is a life-long journey. As far as I remember, I started to have an interest in science even before my kindergarten. Growing up in the countryside, I had been very close to nature, and that makes me care so much about saving it. I thank my parents for raising me in a perfect environment. My grandparents are also big influencers. My grandmum, Yai Yom, is my idol scientist. She worked in a kitchen like a chemist despite her limited school education. My childhood with fraternal grandparents on an island even opened me up for a broader view of nature. Throughout 36 years of my life, my family has always been a great support. I thank my family for shaping me up for who I am today with all the love and care.

I was so lucky to have great teachers ("Kru" in Thai) throughout my education. They said, to be a great teacher, you need to be more than a teacher but a third parent. I thank all of them for not just giving me knowledge but guidance and inspiration. I want to thank Kru Suchart for introducing me to the beauty of mathematics and Kru Malee for showing me the excitement of science. Fortunately, in high school, I was recruited into the Development and Promotion of Science and Technology Talents Project (DPST). This program has forged my attitude and perspective to be like scientist's. Kru Pa Ben and Kru Pa Pong were among all the teachers there who encouraged my yet-to-be scientist fellows and me, to be honest, respectful, and loveable scientists. With the DPST, I continued my tertiary education in the Department of Biology, Prince of Songkla University. With the push by my advisor at that time, Associate Professor Anchana Prathep, I could see myself as a real scientist for the first time. I thank her for training me on how to work as a scientist. After that, I had a chance to continue my master's degree at Macquarie University. It was a big step for me to get out of the

country to live in a different culture. However, that was the right decision because it gave me a fantastic experience. I thank Andrew Simpson and Paul Meszaros for getting me in love with Australia.

My passion for herpetology started after I went back to Thailand and worked in the Princess Maha Chakri Sirindhorn Natural History Museum. I especially thank Watinee Juthong for opening up my eyes to how beautiful these animals are. Working in several conservation projects, I realized how poor people know about the fragility our natural world is. Therefore, after six years, I decided to pursue a doctoral degree to increase my capacity to conduct research that will be helpful for further conservation practices. I thank my colleagues and former director, Juthamas Satasook, for supporting me to pursue the degree.

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Throughout my candidature, I was financially supported by the UTS IRS and UTS President's scholarships and postgraduate funding from the University of Technology Sydney. All procedures have been performed following an ethical standard under the approval of the University of Technology Sydney Animal Care and Ethics Committee (UTS ACEC ETH17-1588). This project had been dealing with the introduced *Hemidactylus frenatus*, which I had acquired a permit from the Department of Primary Industry (DPI) under NSW Biosecurity Act 2015 (Reference number V18/3468). In Thailand, I performed experiments under the supervision of Ariya

Dejtaradol, who has been granted permission to conduct research involving animals (U1-02470-2559) by the Institute for Animals for Scientific Purpose Development (IAD).

My sincere apologies if I have missed anyone.

Preface

The main body of this thesis comprises seven chapters, including five data chapters that I have submitted to journals. Therefore, I have formatted each chapter following the guidelines of each particular journal. This circumstance creates some minor differences in format among chapters and some unavoidable repetition in the introduction and methods.

At the beginning of each chapter, I have stated the contributions of all authors involved as per submitted manuscripts. In all of the chapters, I am the first author and the corresponding author since I primarily conceived, designed, and implemented the research, and written the manuscripts.

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Abstract

The Asian house gecko (*Hemidactylus frenatus*) is one of the most widespread invasive species in the world; however, little is known about the factors that facilitated the success of this invasive gecko. Despite the tropical origin, the gecko has established populations in temperate regions of southeastern Australia. Therefore, I investigated thermal tolerance, thermal hardening, and thermal preference of the introduced geckos in New South Wales (NSW), in comparison with their native populations in Thailand. I found that house geckos from NSW could tolerate colder temperatures, responded to thermal stresses faster, and selected lower body temperatures than geckos from Thailand. The introduced geckos also showed an ability to acclimate seasonally and thermoregulate after feeding (post-feeding thermophily). These thermal adaptions would enable the geckos to survive and perform well in the cold climate of temperate regions, and conserve energy during the winter when food is limited.

Previous studies suggested that successful invasive species have a suite of correlated behaviors that facilitate the invasion. However, since the benefits of each behavior could vary among situations, the ability to adjust behaviors should be necessary for invasive species. Therefore, I investigated the behaviors of the Asian house geckos from different populations to determine the effects of community composition on the expressions. For exploratory behavior, I found that the geckos from core communities tended to hide more and explore less. This behavioral type ensures their safety, as well as increases their chance of getting introduced. In contrast, the geckos from edge populations tended to hide less and explore more, so they should extend their range quickly. For agonistic behavior, I found that the geckos from a competitor-rich community were more aggressive than conspecifics from a competitor-

released community. I suggest that the geckos adjust their behavior to balance the trade-off between access to resources and energy consumption.

My study has demonstrated the ability of the Asian house gecko to adjust both thermal biology and behavior in responding to different ecological contexts. Therefore, the gecko is likely to expand its range further, and cause problems beyond those predicted by static models. More screening of entry points, and community-based citizen science projects whereby people identify house geckos and their locations, may help to control and prevent future spread. Future studies of the molecular pathways underpinning shifts in thermal biology, along with studies of aggressive behaviors in other communities, would be useful for evaluating the generality of my results.