Empirical Analyses of Urban Beekeeping Regulations and Governance: Towards Evidence-Based Policy Makings

（都市養蜂の規制とガバナンスに関する実証的分析:

エビデンスに基づく政策立案に向けて）

MATSUZAWA, Tomonori

（松沢 友紀）

Doctor of Environmental Studies

Graduate School of Environmental Studies, Nagoya University

（名古屋大学大学院環境学研究科 博士（環境学））

2022

Table of Contents

Acknowledgements

This dissertation is the result of my research as a doctoral student in the Department of Social and Human Environment, Graduate School of Environmental Studies, Nagoya University.

Firstly, I would like to express my deepest gratitude to Professor Ryo Kohsaka for giving me for the opportunity to carry out this research as my supervisor, and for his guidance and support in carrying it out. I would also like to express my sincerest gratitude to Professor Yasuishi Maruyama, Professor Makoto Takahashi, and Professor Masashi Tachikawa for their advice as associate reviewers and their guidance. To Associate Professor Satomi Kohyama of the University of Toyama, as external associate reviewer and an expert in the law, provided essential suggestions and useful advice to improve the qualifications of the descriptions.

Special appreciation needs to be given to Dr. Jay Mar Quevedo. He has been a constant source of support, patience, and encouragement to me throughout the completion of this dissertation. Thanks are extended to Dr. Yuta Uchiyama, who provided sincere support to me, as I was not familiar with everything from how to carry out research and analysis to how to prepare various documents, and to Dr. Yoshitaka Miyake, who made many essential points on various occasions. I would also like to thank my laboratory colleagues Mr. Kunihiko Kobayashi and Mr. Yuya Suzuki for their helpful comments on my work.

Prof. Masayuki Omori of Meiji University advised with the research on legislation and provided information on his practice of urban beekeeping. Dr. Norie Tamura, the Senior Researcher of Research Institute for Humanity and Nature provided useful information relevant to the preparation of Chapter 2.The author is deeply indebted to the two researchers.

As a working graduate student, it would not have been possible for me to carry out my research without the understanding and cooperation of my employer, Idea Corporation. Hideo Tabata, CEO of the IDEA Consultants, Inc. provided me with the necessary funds, space, and time for my research. My colleagues in the company also provided continuous support. In particular, my supervisor Shuji Kanda, Director of the Biodiversity Research Centre, was the biggest supporter of my highly flexible research activities. Dr. Tomoyasu Shirako, who is an expert in DNA analysis, helped me a lot with the analysis of chapter 5. Mr. Keita Kosoba spent many hours helping me through keeping the honey bee for experiments and the preparation of chapter 2. Mr. Shigeru Tabata for his devoted cooperation in English editing.

I would also like to thank my family for their understanding of my research and their help in my personal life. I also wish to thank all my friends and mentor for the spiritual strength they have given me.

List of Tables

List of Figures

List of Acronyms and Abbreviations

AustLII – Australasian Legal Information Institute

AFB – American Foul Brood

CCD – Colony Collapse Disorder

EFB – European Foul Brood

e-DNA - Environmental DNA

EU – European Union

ICLEI – International Council for Local Environmental Initiatives

IPBES – Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

MAFF – Ministry of Agriculture, Forestry and Fisheries

MHLW – Ministry of Health, Labour and Welfare

MOE – Ministry of the Environment

NCIS – National Coroners Information System

NCP – Nature’s Contribution to People

NGO – Non-Government Organizations

NIES – National Institute for Environmental Studies

TEEB – The Economics of Ecosystem and Biodiversity

Abstract

Honey bees are major pollinators, influencing ecological relationships, genetic diversity in the plant kingdom, and ecosystem conservation and stability. In agroforestry systems, these organisms are essential for crop pollination and can be an important source of local's livelihoods such as the production of honey and beeswax. Their importance has been raised as an easily comprehended example of the ecosystem service brought by nature in the context of conservation of biodiversity. In a report published by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Potts et al. 2016), the economic value of the pollinating service of honeybees is estimated to be up to 577 billion dollars, highlighting its importance particularly in the context of "Nature's Contribution to People" (NCP).

However, despite their socio-ecological importance, there has been a decline in honey bee colonies over the last decade. The decline of the pollination function has been a major concern globally in social, economic, and environmental aspects, which in turn resulted in renewed interest in honey bees. There is now growing evidence that beekeeping in urban spaces might be more beneficial for their survival due to the reduced exposure to agricultural pesticides and limited assortment of plants for foraging. In addition, urban beekeeping has gained salience because of its significance in biodiversity conservation, food production, and community building.

In recent years, the number of municipalities that are actively adopting urban beekeeping as part of their environmental policies is increasing. As beekeeping practices in urban areas increase, concerns from local residents have also grown, which stemmed mainly from safety concerns and property disputes by neighbors. Thus, rules and regulations of urban beekeeping are set aiming to maximize profits while minimizing the risks. However, to date, there are limited number of municipalities or other governmental

bodies that have set rules for urban beekeeping, and in cases with existing regulations, it is not clear whether it is evidence-based.

This work highlights these knowledge gaps by conducting a mix-method approach to identify how urban beekeeping functions and what are the existing legal regulations, which are still limited globally despite being an essential part of streamlining urban beekeeping practice. Specifically, this study conducted a comprehensive systematic review (global and countries to municipality level) of existing urban beekeeping regulations, empirical analysis of bees' flight behaviors, and environmental DNA analysis. These analyses aim to provide insights and suggestions for the future of urban beekeeping regulations. An overview and the list of associated publications of this dissertation are shown in Figure 1 and Table 1, respectively. The contents of each chapter are summarized as follows:

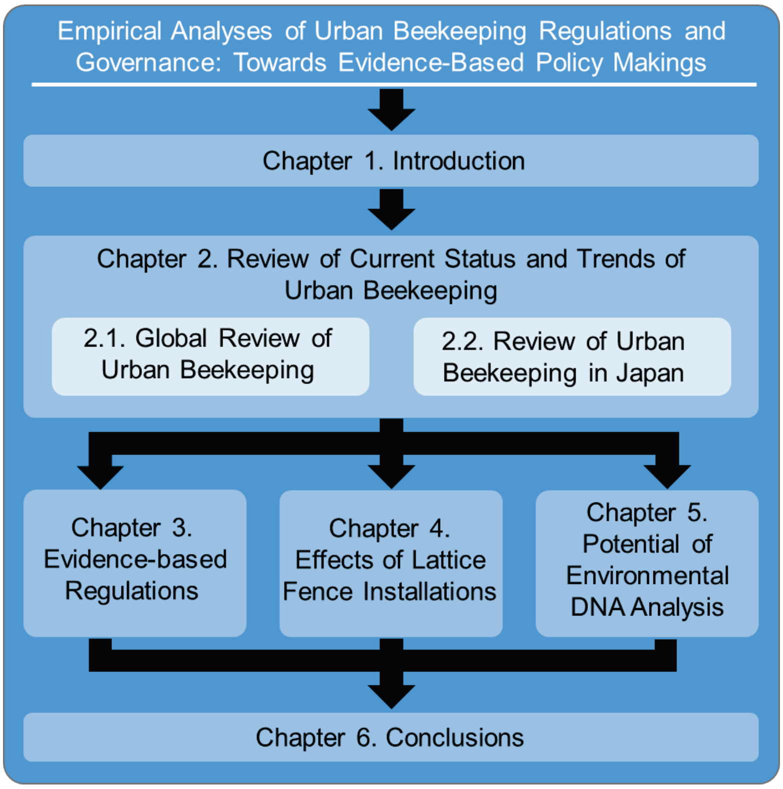

Figure 1. Overview of the research dissertation.

Table 1. List of peer-reviewed publications associated with each chapter.

Chapter	Corresponding Publication
2.1	Matsuzawa, T.; Kohsaka, R. 2021. Status and Trends of Urban Beekeeping Regulations: A Global Review. Earth, 2(4), 933 - 942. DOI: 10.3390/earth2040054
4	Matsuzawa, T.; Kohsaka, R. 2022. Preliminary Experimental Trial of Effects of Lattice Fence Installation on Honey Bee Flight Height as Implications for Urban Beekeeping Regulations. Land, 11(1), 19. DOI: 10.3390/land11010019
5	Matsuzawa, T.; Kohsaka, R.; Uchiyama, Y. 2020. Application of Environmental DNA: Honey Bee behavior and Ecosystems for Sustainable Beekeeping. In Modern Beekeeping-Bases for Sustainable Production; In Tech Open: Rijeka, Croatia. DOI: 10.5772/intechopen.92717

Chapter 1 – Introduction. This chapter presents the research background and framework of this study. Humankind has long used the honey, beeswax, and royal jelly produced by honeybees. At the same time, honeybees and other flower-visiting insects have provided enormous benefits to mankind through their pollination function. In recent years, urban beekeeping has been expanding worldwide, but it has only been in the past 20 years or so that beekeeping has flourished in urban areas around the world (e.g., London, New York). In Japan, beekeeping began in Ginza in 2006 and has now expanded to over 100 locations. The significant ecosystem services provided by beekeeping, coupled with the spread of urban agriculture and the occurrence of Colony Collapse Disorder (CCD), have led to expansion of urban beekeeping practice in the world. This, in turn, raised certain negative aspects of urban beekeeping such as interspecific competition with native flowering insects. There has been little research on the benefits and risks of urban beekeeping, particularly studies on the regulations and governance of urban beekeeping. Thus, there is a need to increase efforts to maximize the benefits while minimizing the risks of urban beekeeping through the application of suitable rules and regulations. This study focused on the governance of urban beekeeping, specifically the rules that are based on evidence, in an effort to address the above-mentioned issues, and analyzed and discussed them by combining social science and natural science (mix-method) approaches.

Chapter 2 – Review of Current Status and Trends of Urban Beekeeping. To date, urban beekeeping is practiced globally on all continents except for Antarctica. However, there are limited integrated and organized sources of information regarding beekeeping regulations and governance despite practical and academic demands. There is mounting evidence of the negative impacts of urban beekeeping on ecosystem services. Governance is critical for minimizing these negative aspects while maximizing the positive aspects of urban beekeeping. Thus, there is a need to understand the regulations, which face critical governance challenges, and summarize points to achieve sustainable urban beekeeping. This chapter presents two comprehensive systematic reviews conducted at global and country-specific (Japan) scales on the current status and trends of urban keeping are presented. Chapter 2.1 discusses a global overview of official (and partially informal or voluntary) regulations related to urban beekeeping (Matsuzawa and Kohsaka, 2021). Results showed that there were about 10 types of regulatory items on urban beekeeping, and most of them were geared towards the safety of urban residents. There were cases where non-government organizations (NGOs) established their own guidelines to complement the rules established by the government. Meanwhile, Chapter 2.2 reflects the current status and regulations of urban beekeeping in Japan. There were few laws and regulations on beekeeping identified in the country, and, in general, there were no laws and regulations targeting honeybees that ensure the safety of urban dwellers and the conservation of biodiversity.

Chapter 3 – Evidence-Based Regulations. In this chapter, a social science approach was used to review if the existing rules of urban beekeeping and beekeeping in the United States, Australia, and Japan were evidence-based. Results showed that the

development of rules for urban beekeeping was relatively advanced in Australia, developed in limited number of cities (particularly with larger populations) in the United States, and almost non-existent in Japan. Current regulations in urban beekeeping in the United States and Australia included items such as the number of hives that could be installed, hive density, installation of barriers, distance to property boundaries (setbacks), and water supply. These were often regulated with concrete numerical parameters, however, the scientific bases of these parameters were not confirmed. In general, the findings indicated that the regulatory requirements for urban beekeeping or apiculture, although often accompanied by numerical regulations, lack scientific evidences.

Chapter 4 – Effects of Lattice Fence Installations. There is an increasing trend of municipalities adopting urban beekeeping as part of their environmental policies, yet, the practice received growing concerns from local residents due to safety and property disputes. This, in turn, led to the establishment of suitable rules and regulations that maximize profits while minimizing the risks such as nuisances. However, to date, the effectiveness of these regulatory items in urban beekeeping is not well studied. Thus, this chapter (Matsuzawa and Kohsaka, 2022) provides insights into this gap by presenting an experiment of the effects of fences and setbacks on honey bee flight height, as these are frequently set within the regulations of urban beekeeping. Since current measurements of flight heights of insects are still in progress, this chapter also provided methodological implications of using 3D laser scanners, which are non-destructive, do not attach observers to the insects, and can accurately acquire a large amount of data in a short time, to localize the bees.

Chapter 5 – Potential of Environmental DNA Analysis. Urban beekeeping is gaining attention in terms of various aspects including ecosystem diversity and genetic diversity of honeybees. Yet, the promotion of urban beekeeping lacks scientific evidence

of the behavior of urban honeybee, which is a concerning issue. To provide scientific evidence, environmental DNA (e-DNA) analysis can be utilized to detect the detail of nectar sources. Identification of honey-source plants with the e-DNA analysis technique has been applied since around 2010. It has some advantages over the conventional pollen analysis, though, it is not yet fully verified that it can demonstrate a level of contribution of each honey-source plant accurately. In this regard, this chapter (Matsuzawa et al., 2020) presents the potential application of e-DNA analysis to urban beekeeping regulations, particularly in verifying the general trends of honey origins. The discussions presented in this chapter can be applied to other cases and contribute to accumulating the scientific evidence for making relevant policies of urban beekeeping.

Chapter 6 – Conclusions. This chapter serves as the final concluding remarks based on the empirical analyses of urban beekeeping regulations and governance. Overall trends showed that urban beekeeping has six functions namely: pollination, biological conservation, pest control, safety, apicultural products, and community formation. Globally, though there is an increasing number of countries with developed regulatory items of urban beekeeping, there are limited numbers with regulations based on scientific evidence. In Japan, there are no legal rules for urban beekeeping identified, and the governance of general beekeeping is weak, causing difficulties to collect the information necessary for proper governance. There is a need to establish evidence-based rules that correspond to the six functions of urban beekeeping. In Japan, it would be effective to formulate ordinances and guidelines at the prefectural level and, if necessary, guidelines by NGOs. Future studies could also look into socio-ecological contexts of urban beekeeping such as examining the potential aspects of collaborations among different stakeholders in the context of pollinator conservation, biodiversity monitoring, and management practices.

Chapter 1. Introduction

1.1. Research Background

Honeybees are integral for both honey producers and for agricultural crops as they function as pollinators (Klein et al., 2007). For instance, in Canada, beekeepers are reimbursed for their service to provide pollination services for hybrid canola seed productions (Hoover and Ovinge, 2018). Their importance has been raised as an easily comprehended example for the public of the ecosystem service brought by nature in the context of conservation of biodiversity. In the engagement of the report of "The Economics of Ecosystem and Biodiversity (TEEB)," attempts have been made to quantify (and if possible, monetize) various services of the ecosystem, and as such, the importance of the pollinating function is described as "five times value of the production of honey" (Sukhdev et al., 2010). In the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the phrase "Nature's Contribution to People (NCP) has been advocated instead of the services of the ecosystem." In a report published by the IPBES (Potts et al., 2016), the economic value of the pollinating service of honeybees is estimated to be up to 577 billion dollars, highlighting its importance.

Despite their socio-ecological importance, there has been a decline in bee colonies over the last decade, which renewed the interest on honey bees, particularly in relation to Colony Collapse Disorder (CCD) (Watson and Stallins, 2016). In the United States, roughly one-third of the honeybees kept for pollination were lost from 2007 to 2008, causing a major concern (vanEngelsdorp et al., 2009). Similar phenomena were reported in Europe, Germany, Belgium, France, Holland, Poland, Spain, Brazil, India, Taiwan, and Japan (Barnett, 2011; Dixon, 2012; Lorenz and Stark, 2015; Moore and Kosut, 2013; Ropars et al., 2019). Neonicotinoid agrochemicals are identified as one of the possible causes of the disorder (Woodcock et al., 2016), thus, they are restricted in EU countries (Stokstad, 2018). Though a number of theories have been put forward to address the causes of CCD, including agrichemicals, infections, malnutrition, electromagnetic waves, and genetically modified crops, the mechanism of CCD has not been fully understood to date.

The decline of the pollination function has been a major concern socially, economically, and scientifically. In the report, which pointed out the decrease of pollinators and their related pollinating services, some examples of research into the decline of pollinators and related vegetation were showcased as a global concern (Klein et al., 2007). This, in turn, resulted in the global expansion of urban keeping (Moore and Kosut, 2013), and scientists have argued that keeping bees in urban spaces might be more beneficial for their survival due to the reduced exposure to agricultural pesticides and limited assortment of plants for foraging (Askham, 2013; Henry et al., 2012). Urban beekeeping has gained salience because of its significance in biodiversity conservation, food production, and community building in urban areas (Baldock, 2020; Egerer and Kowarik, 2020; Skelton, 2006).

There is historical evidence that urban beekeeping has been practiced in the Mediterranean for 3,000 years (Mavrofridis, 2018), but it is only recently that it has become a worldwide practice (Lorenz and Stark, 2015; Sponsler and Bratman, 2021). Since 2005, urban beekeeping began to expand in various European countries before spreading into North America, Asia, Latin America, and Africa (Dixon, 2012). In Palais Garnier of the Paris Opera, beekeeping has been practiced on for the last 30 years, and it is currently seen in various landmark locations in the city such as Orsay Museum and Grand Palais (Lichterman, 2018; Mavrofridis, 2018). In the United Kingdom, it has increased by 200% between 1999 and 2006 (Barnett, 2011), while in New York, the number of beehives kept has gone up to 10 times since 2010 (New York City Beekeepers Association, 2018). In Paris, over 700 bee colonies are in existence (Mullins, 2018).

In Japan, the oldest record of beekeeping and honey production can be traced back to the 7th century in the “Chronicles of Japan (*Nihon Shoki*),” where there is a description that some Koreans attempted beekeeping on Mt. Miwa using four sheets of honeycomb but failed (Sasaki, 1999). There is a record during 739 of honey being listed as one of the offerings from Korea, along with other products such as those made from panthers and ginseng, which implies that honey was treated as a precious imported item (Japan Beekeeping Association, 2019). Entering the 900s, a record was found that honey and comb honey were presented to the Imperial Court from various countries. Considering the volume of honey presented from each prefecture was around 2–4 liters, it is thought that it was an extremely valuable commodity (Japan Beekeeping Association, 2019). “The Tale of Genji (*Genji Monogatari*),” the oldest novel in the world written in 1008, describes how honey was used as one of the ingredients to make incense. With the advancement of research into honey production during the Edo-era (after 1600), educational books explaining the beekeeping technology accompanied by illustrations, which showed the process of beekeeping and honey production began to be published (Figure 1.1, 1.2).

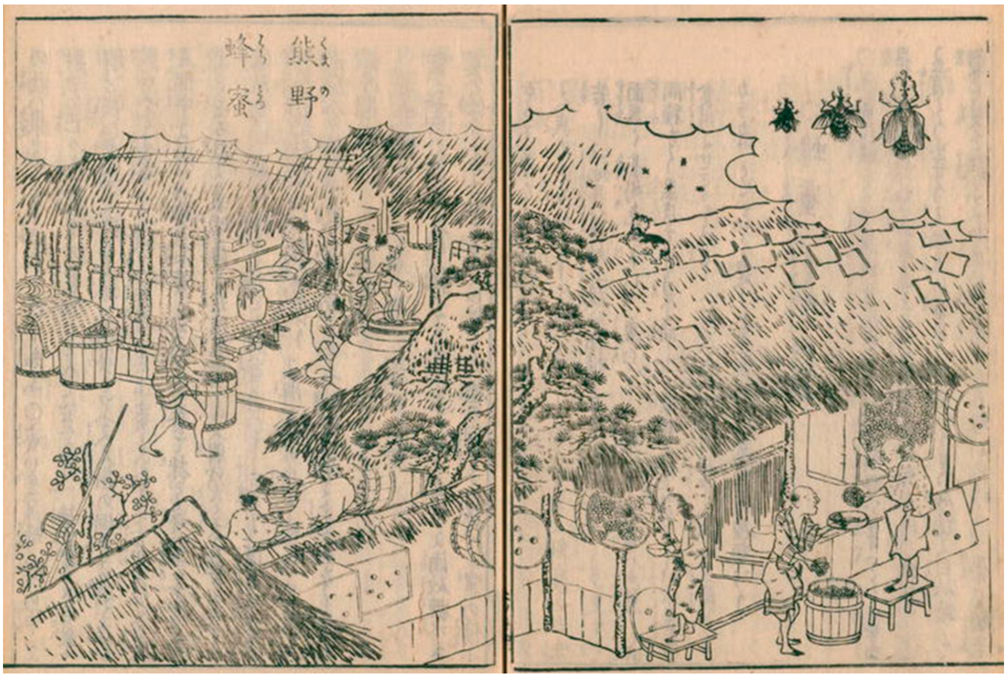

Figure 1.1. Beekeeping in Japan during the Edo period. Image photographed from the "Noted products from Land and Sea of Japan in Pictures (*Nihon Sankai Meisan Zue*), 1799."

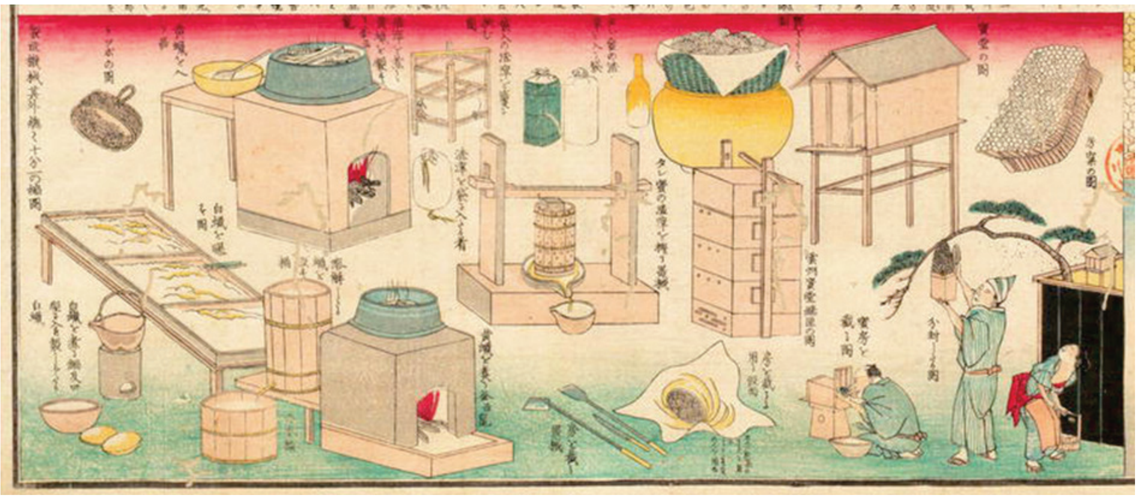

Figure 1.2. Beekeeping process and honey production in Japan during the Edo period. The texts in the image, which described the names of individual tools and production processes, were written in an ancient language. Image photographed from "The Honey Catalogue (*Hachimitsu Ichiran*), 1873."

In addition to honey production, urban beekeeping is thought to be contributing to the conservation of biodiversity by compensating for the function of the indigenous pollinators such as *Apis cerana* that had decreased due to the development of the natural environment over the years. In fact, in the surrounding areas of the Imperial Palace in Tokyo, known for the cherry blossoms, more cherry fruits have been observed after the blossoms. This suggests that the increase of urban beekeeping near the Imperial Palace can be a potential factor.

It is generally understood that urban beekeeping has a greater role in improving quality of life as it provides a form of hobby and a communication tool, in addition to the function of honey production and pollinating. In fact, commercial beekeeping is rare in urban areas, and for the most part, the number of bee colonies is usually only up to a few per area. In Japan, NGOs, private companies, and local governments are involved in urban beekeeping to revitalize civic activities by encouraging collaboration among the residents and enhancing their understanding of the environment and ecosystem services (Yamada et al., 2011).

For example, in Ginza, which is on the eastside of the Tokyo railway station, an NGO called "Ginza Honeybee Project" began urban beekeeping in 2006 using the rooftop of a building in Ginza (Ginza-Mitsubachi Project, 2008). The project was initiated as a means for environmental and dietary education, but through the years, its achievements such as the greening of the urban areas, a large amount of honey collected (producing around one ton per year), and successful sale of other agricultural and processed products began to be publicized nationwide as best practice examples of community revitalization. To date, similar activities have grown and expanded into over 30 cities throughout Japan (Moriyama, 2011; Yamada et al., 2011).

Newspaper articles on urban beekeeping in Japan, in general, have grown, from two articles in 2011 to l6 articles towards the present time. Figure 1.3 presents the number of newspaper articles with words "urban beekeeping (*toshi yoho*)" compiled from database of daily newspaper companies.

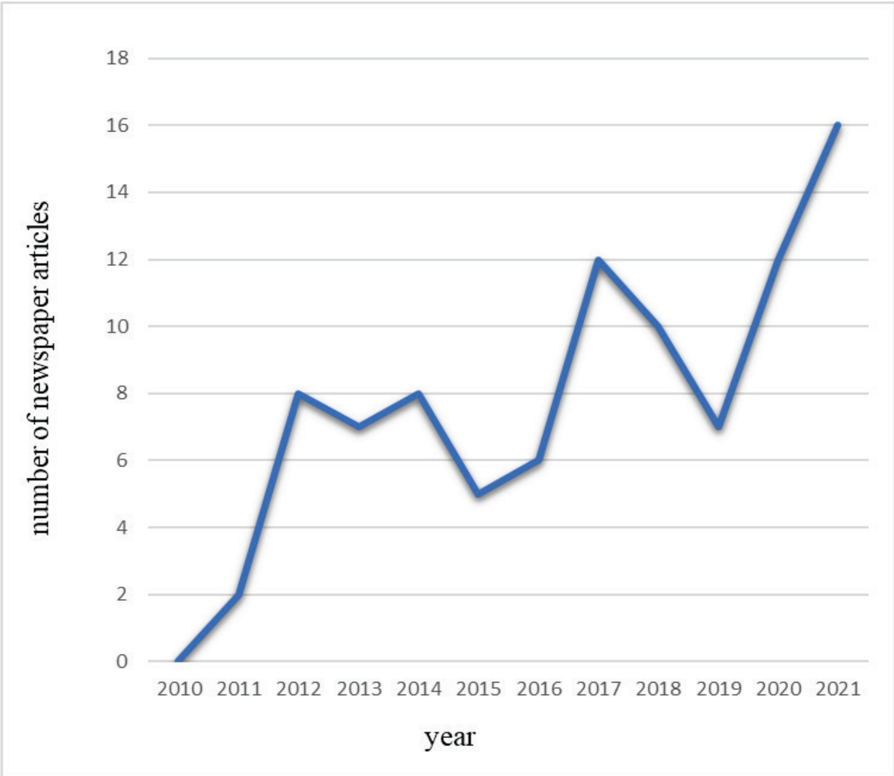

Figure 1.3. Number of newspaper articles with words "urban beekeeping (*toshi yoho*)" in Japan. Data were retrieved from: "Kikuzo II Visual" (Asahi Shimbun, Asahi Shimbun Digital, Aera, Shukan Asahi), "Yomidas Rekishikan" (Yomiuri Shimbun), "Maisaku" (Mainichi Shimbun), "Nikkei Telecom" (Nihon Keizai Shimbun), and "ELNET" (web-based newspaper article distribution and search site).

Most of the newspaper articles were about beekeeping on the rooftops of buildings in large cities such as Tokyo, Sapporo, Osaka, Nagoya, and Fukuoka. These newspaper articles featured the production and selling of honey as well as positive effect to community building such as environmental education and connection with local communities.

However, despite the increasing trend of urban beekeeping in Japan and elsewhere, the practice received negative perceptions from local residents, which stemmed from safety concerns and property disputes (e.g., nuisance, trespass claims) by neighbors, negligence accusations against beekeepers, and challenges to the legal status of the honey bee by local communities (Gallay, 2018). For example, improper access to beehives could lead to stinging incidents. Though, in reality, there are limited number of cases of damage caused by stings in urban areas with a concentrated population; it is rare for a person to be stung by honeybees away from beehives in ordinary circumstances (Feás, 2020; Forrester et al., 2018a, 2018b; NCIS, 2011; Riches et al., 2002). Nonetheless, the sight and buzzing of large numbers of honeybees kept on a balcony of an apartment would probably be enough to scare the neighbors, and they may find it dangerous for their children to play freely outside. Thus, there is a need to establish appropriate rules that maximize profits while minimizing the risks such as nuisances (Salkin, 2012), which this overall research aims to address.

1.2. Research Framework

In recent years, increasing numbers of municipalities are actively adopting urban beekeeping as part of their environmental policies. For instance, in 2019, the German state of Bayer enacted Bavaria’s nature protection law, which encourages the keeping of bees in urban areas (Wilk et al., 2019). In Los Angeles and New York, they changed their respective ordinances to allow urban beekeeping (City News Service, 2015). Moreover, pollinator-friendly cities, which promote the protection of pollinating insects including honey bees and the environment, are on the rise (Wilk et al., 2019). London in the United

Kingdom is one of the most active cities in terms of beekeeping (Rothman, 2015). In the United States, where honeybees have been regarded as a dangerous species, there has been a relaxation of restrictions due to gaining momentum of urban beekeeping (City News Service, 2015).

As beekeeping practices in urban areas increase, concerns from local residents have also grown (Gallay, 2018). This, in turn, results in a need to establish suitable rules and regulations that maximize profits while minimizing the risks such as nuisances (Salkin, 2012). However, to date, there are limited numbers of municipalities or other governments that have set rules for urban beekeeping (Larson et al., 2020). In the United States and Australia, where there are relatively more rules for urban beekeeping, there are approximately 7 to 11 regulatory items (Matsuzawa and Kohsaka, 2021; Salkin, 2012). Amongst these, some cases have specific standards and criteria set like in “Number of hives/density,” “Setbacks,” “Installation of barriers,” and “Water supply” (Matsuzawa and Kohsaka, 2021). Though, it is unclear whether the present regulations are based on scientific evidence or not, and what measures can be implemented based on science.

This work addresses these knowledge gaps by following a mix-method (combining social science and natural science approaches) research framework (Figure 1.4). Specifically, this study aims to (1) identify how urban beekeeping function and what are the existing legal regulations and (2) provide insights and suggestions for future of urban beekeeping regulations. The first research objective is answered by conducting global and country-specific (Japan) systematic reviews of urban beekeeping regulations to obtain a global or national overview of official regulations (including partially informal voluntary). Such review can evaluate how rules and functions correspond to each other and identify the appropriateness of urban beekeeping regulations in Japan. The second research objective is addressed by conducting empirical analyses of existing regulations of urban beekeeping including: a review of evidence-based regulations in the United States, Australia, and Japan, the effects of lattice fence installation, and potential application e-DNA analysis. By doing these analyses, the results can provide insights to: whether the present rules are evidence-based, requirements of formulating and implementing the rules, and future management and implementation of evidence-based policies of urban beekeeping.

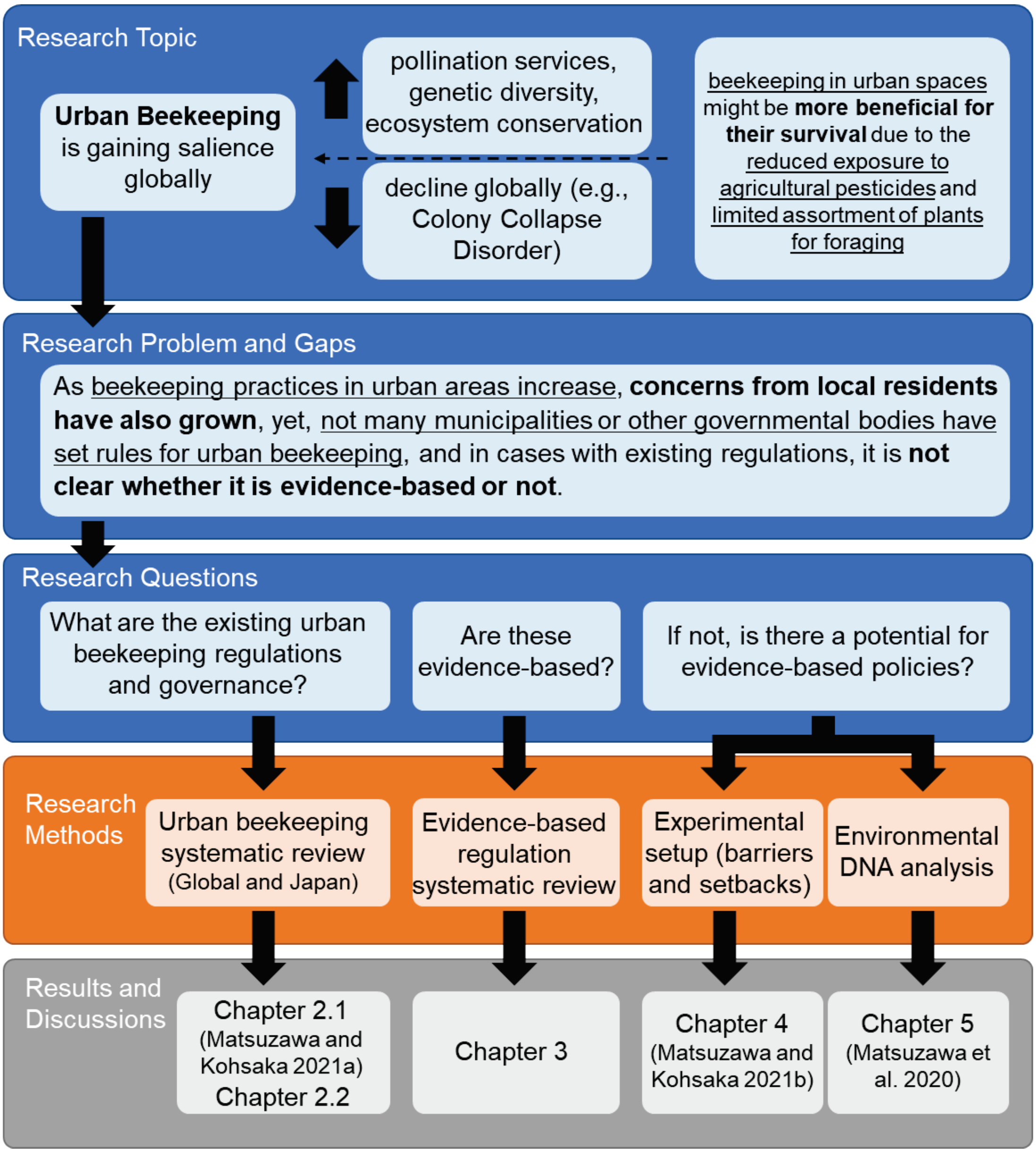

Figure 1.4. Overall research framework used in this study.

Chapter 2. Review of Current Status and Trends of Urban Beekeeping

Urban beekeeping rapidly expanded globally in major urban areas such as in Japan and South Korea in recent years (Barnett, 2011; Kohsaka et al., 2017; Lorenz and Stark, 2015). From 2011 to 2015, the number of beekeepers in London nearly doubled (Rothman, 2015), and it multiplied twice in Paris from 2013 to 2015 (Ropars et al., 2019). From 2016 to 2018, the number of hobby beekeepers in Sydney increased by 20% (Daniel, 2018). Despite the limited published data on urban beekeeping, a general increasing trend has been observed globally. The International Council for Local Environmental Initiatives (ICLEI) emphasizes that cities and towns can be major refuges for several insect pollinators, providing foraging and nesting sites, larval food plants, and nectar that may be less available on intensively managed farmland (Wilk et al., 2019).

To date, urban beekeeping is practiced globally on all continents except for Antarctica. However, there are limited integrated and organized sources of information regarding beekeeping regulations and governance despite practical and academic demands. There is mounting evidence of the negative impacts of urban beekeeping on ecosystem services (Herbertsson et al., 2016; Lindström et al., 2016; Ropars et al., 2019). Governance is critical for minimizing the negative aspects and maximizing the positive aspects of urban beekeeping (Larson et al., 2020; Sponsler and Bratman, 2021). Thus, there is a need to study urban beekeeping regulations, which face critical governance challenges and summarize points to achieve sustainable urban beekeeping.

In this chapter, systematic reviews of global and country-specific (Japan) on the current status and trends of urban keeping are presented. Chapter 2.1 presents a global overview of official (and partially informal or voluntary) regulations related to urban beekeeping (Matsuzawa and Kohsaka, 2021). Such a comprehensive review serves practical, administrative, and academic purposes. Meanwhile, Chapter 2.2 reflects the current status and regulations of urban beekeeping in Japan.

2.1. Global Review of Urban Beekeeping

2.1.1. Data Gathering and Analysis

A systematic review was conducted in this study from 10 November 2020 to 20 November 2020. First, a list of countries where urban beekeeping has been confirmed or is currently being practiced was prepared to select the countries that were analyzed (Table 1). The survey was done through Google Scholar database using the following search command “urban beekeeping” AND “[country name]”. Based on this configuration, the search generated 101 cases in 43 countries, as reflected in Table 2.1. To obtain a balanced overview, seven countries from regions (Europe, Asia, Africa, Oceania, and the Americas) with significant literature results were selected.

Next, literatures were collected by searching for the keywords “urban beekeeping” and “regulation” using the “AND” command, and both terms were required to be included in the title, abstract, keywords, or main text. Based on the results, places and organizations where urban beekeeping is practiced were identified. Though the availability of Japanese research written in English is limited, it was added as the eighth country. To reduce biases, phone interviews and email communications with officials in Osaka Prefecture, Japan, were conducted to complement the retrieved documents. Thus, in this study, the countries examined were the United Kingdom, South Africa, the United States, Canada, Australia, New Zealand, Singapore, and Japan.

Table 2.1. List of countries with the number of sites practicing urban beekeeping. Seven countries included in this review are indicated with "*" (modified from Matsuzawa and Kohsaka, 2021).

Region	Countries	Sites	Region	Countries	Sites	Region	Countries	Sites
Americas	Canada *	8	Europe	UK *	15		Luxembourg	1
	US *	8		Germany	8		Norway	1
	Brazil	2		Netherlands	4		Serbia	1
	Dominican Republic	1		Italy	3		Slovakia	1
	Mexico	1		Austria	2		Spain	1
	Uruguay	1		Belgium	2		Sweden	1
Asia	South Korea	3		France	2	Oceania	Australia *	7
	Singapore *	2		Poland	2		New Zealand *	3
	Cambodia	1		Slovenia	2	Africa	South Africa *	1
	Hong Kong/ China	1		Croatia	1	Total	43 countries	101
	India	2		Czech Republic	1			
	Indonesia	1		Denmark	1			
	Israel	1		Estonia	1			
	Malaysia	1		Finland	1			
	Philippines	1		Georgia	1			
	Taiwan/China	1		Ireland	1			
	Thailand	1		Latvia	1			

Table 2.2. Different frameworks used in this study for regulatory items (modified from Matsuzawa and Kohsaka, 2021).

Our Framework	Larson et al. Framework (2020)	Sponsler and Bratman Framework (2021)
Pollination services	-	Pollination services
Biological conservation	Biological conservation	Resource competition
Pest control	Pest control	Disease transmission to other insects
Safety	Safety	Stinging
Apicultural products	—	Apicultural products and livelihoods
Community formation	—	Expert community formation
—	Stormwater/flood mitigation	—
—	Water quality protection	—
—	Aesthetic maintenance	—
—	Encroachment avoidance	—
—	Land conservation	—
—	Water conservation	—
—	Disease avoidance	—
—	Property values	—
—	Heat mitigation	—
—	Less allergen avoidance	—

For the eight countries, the national, state, municipality, and local regulations, as well as rules pertaining to urban beekeeping, were collected. Relevant information and references were primarily collected from government websites, and additional information was collected from relevant organizations, such as beekeeping associations. For certain countries, there were existing databases (e.g., those from the municipality and state levels in the United States and at the state level in Australia), and information from other countries was collected through individual state websites and relevant organizations with certain limitations in accuracy and comprehensiveness. In the United States, Canada, and Australia, the number of municipalities with rules on urban beekeeping was extensive; thus, the scope was limited to 37 municipalities for the United States, 14 municipalities for Canada, and 38 municipalities for Australia. Approximately 10 cities with the highest frequency in the search results were selected and processed with a more detailed survey using the methods described below.

Given the exploratory nature of this study, the review focused on both regulations with legal norms (so-called "hard laws") and without legal norms (so-called "soft laws"). Thus, by considering the two legal systems of each country, this study covers a wide range of subjects such as statutes, civil laws, common laws, ordinances, local customary ones, voluntary agreements, and guidelines. The regulatory items that were related to urban beekeeping were classified based on their contents and according to the frameworks of Larson et al. (2020), Sponsler and Bratman (2021), and Salkin (2012). Based on the study of Larson et al. (2020), 13 types were identified as regulatory ordinances in residential areas of the United States: stormwater/flood mitigation, biological conservation, water quality protection, pest control, aesthetic maintenance, safety, encroachment avoidance, land conservation, water conservation, disease avoidance, property values, heat mitigation, and less allergen avoidance ordinances. In this study, the biological conservation, pest control, and safety factors were adopted because they are considered most relevant to urban beekeeping (Table 2.2).

Sponsler and Bratman (2021) classified the socio-ecological aspects of urban beekeeping into six categories: pollination services, resource competition, disease transmission to other insects, stinging, apicultural products and livelihoods, and expert community formation. Based on this framework, the following six criteria were applied to each regulatory objective:

1. Pollination services – Items in this category influence the extent of the pollination function of plants in urban areas. The service can be performed by either wild or managed bees.

2. Biological conservation – Items in this category influence the magnitude of competition for nectar resources with other honey bees (e.g., *Apis mellifera*).

3. Pest Control – Items in this category influence the extent of infectious diseases and parasites between honey bees or other pollinators.

4. Safety – Items in this category concern the negative/nuisance behaviors of honey bees to humans or pets, including stings, droppings, and noise. This category also includes the probability of physical contact between honey bees and humans and potential hazards, such as honey bee stinging incidents.

5. Apicultural products – Items in this category concern the control of the production of honey, beeswax, and other products. This category also includes the quantitative relationship between nectar resources and hives.

6. Community formation – Items in this category influence the social aspects of and community formation through urban beekeeping.

Salkin (2012) categorized the regulatory items for urban beekeeping into eight types: classification of bees, lot size and colony density, setbacks, flyway barriers, access to water, permits and registration requirements, apiary identification signs, and fire safety regulations). The "Apiary identification signs" of Salkin (2012) was considered as identical as registration, thus, it was incorporated into the registration section (Table 2.3). Moreover, four items (area restrictions/zoning, neighborhood awareness, queen bee management, and training requirements) that were frequently identified during the systemic review were added.

Table 2.3. Relationship between the framework used in this study and Salkin (2012) (modified from Matsuzawa and Kohsaka, 2021).

Our Framework	Salkin Framework (2012)
Registration	Permits and registration requirements; Apiary identification signs
Number of hives/densities	Lot size and colony density
Area restrictions/zoning	-
Installation of barriers	Flyway barriers
Setbacks	Setbacks
Permitted species or subspecies	Classification of bees
Water supply	Access to water
Neighborhood awareness	-
Queen bee management	-
Training requirements	-
Fire safety regulations	Fire safety regulations

2.1.2. Results

The results are presented by country (Table 2.4). There are no cases found where national governments set the rules or regulations for urban beekeeping. For Canada, Australia, and New Zealand, the rules for urban beekeeping were formulated at the provincial or regional, and municipal levels. Meanwhile, in the United States and South Africa, rules and regulations were formulated by the municipalities. In the United States, Canada, Australia, New Zealand, and South Africa, rules regarding urban beekeeping have been established by official bodies (e.g., states and municipalities). In contrast, official regulations were not identified in the United Kingdom, Singapore, and Japan.

Table 2.4. Distribution of urban beekeeping rules and honey bee species. "—" indicates N/A and "○" denotes the presence of rules and regulations (modified from Matsuzawa and Kohsaka, 2021).

Country	**Rules Established by**				**Distribution**	
	National Government	State/Prefecture/ Regional Governments	Cities/Basic Municipalities	NGOs	Naturally Distributed Species	Competitive Related Species
United Kingdom	—	—	—	○	*A. m. mellifera*	—
South Africa	—	—	○	○	*A. m. capensis* *A. m. scutellata*	—
United States	—	—	○	○	—	—
Canada	—	○	○	○	—	—
Australia	—	○	○	○	—	—
New Zealand	—	○	○	○	—	—
Singapore	—	—	—	—	—	*A. cerana* *A. florea* *A. dorsata* *A. andreniformis* *A. koschevnikovi*
Japan	—	—	—	—	—	*A. cerana*

Although bees are regarded as nuisances in Singapore, beekeeping is permitted in urban areas if it is declared as a hobby and not for commercial purposes. In Japan, all, except for Osaka prefecture, have no regulations or rules specific to urban beekeeping at the prefectural and municipal levels, and honey bees can be kept freely (there are rules and regulations for beekeeping as a husbandry activity). The Osaka Prefecture has a setback regulation that practically prohibits beekeeping in urban areas; however, this regulation is not intended to be applied to urban areas (as explained in interviews by a city official). The majority of the identified rules and regulations have been published in the form of acts, ordinances, and guidelines. These included both mandatory and voluntary rules, which were not distinguished from each other since the objective of the review was mainly to obtain an overview of the global regulation trends. In certain cases, non-governmental organizations (NGOs) had developed or published urban beekeeping guidelines. For instance, in the United Kingdom, NGOs have initiated the management of urban beekeeping activities.

Apis mellifera species are naturally distributed in the United Kingdom and South Africa, but they are considered alien species in the other six countries. Meanwhile, in Singapore and Japan, the indigenous species is *Apis cerana* (also known as Oriental honey bees), and they are naturally distributed. Though they are potential competitors to *Apis mellifera*, *Apis cerana* are used in traditional beekeeping throughout their natural range in Asia, for instance in Japan (Uchiyama et al., 2017), Thailand (Wongsiri et al., 2000), and Indonesia (Gratzer et al., 2019).

The most frequent regulation items were found to be related to registrations, particularly those associated with the number/density of hives, area restrictions/zoning, the installation of barriers, setbacks, permitted species or subspecies, water supply, neighborhood awareness, queen bee management, training requirements, and fire safety regulations. An overview of the relationships among the regulatory objectives and regulatory items is illustrated in Figure 2.1. Based on the results, the most common regulatory item category was found to be "Safety."

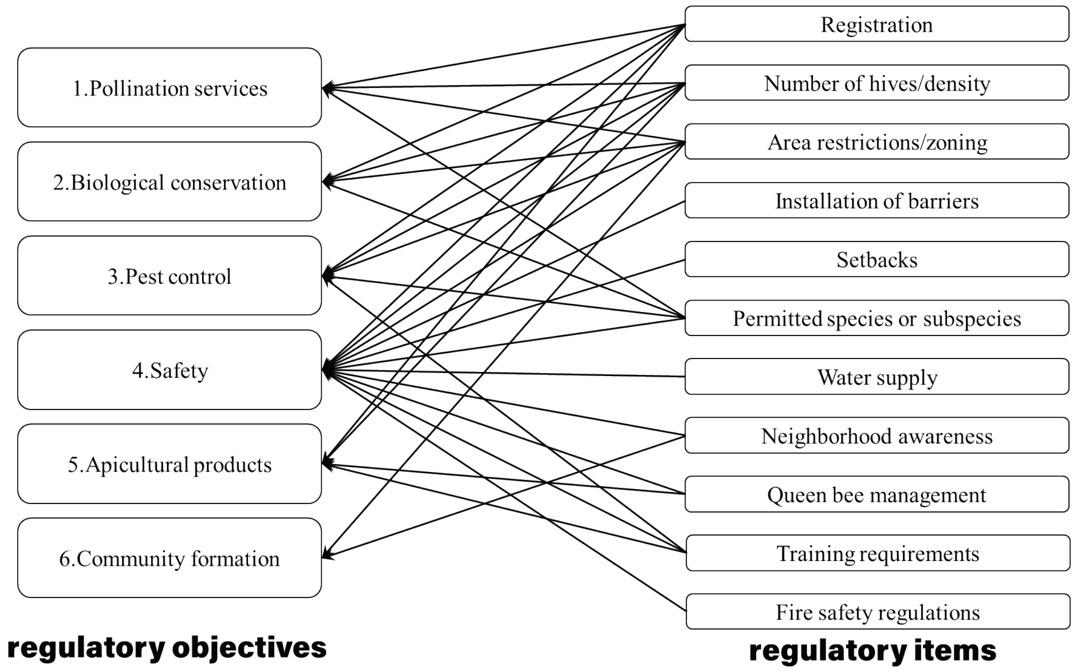

Figure 2.1. Relationships among regulatory objectives and items in urban beekeeping (modified from Matsuzawa and Kohsaka, 2021).

The hive density limit is typically defined as the maximum number of hives that are allowed in one apiary (e.g., up to four hives per location in Wellington, New Zealand [Wellington City Council Guidelines for Community Gardens, n.d.]) or per certain size of area (e.g., two hives maximum for less than 10,000 ft^2 and up to four hives for over 10,000 ft^2 in Vancouver, Canada [Vancouver, 2013]). It was not necessarily explicit. In contrast, the minimum area required for the installation of hive boxes was sometimes stipulated, for example, in Dakota City, NE, USA (Dakota City, Nebraska Code of Ordinances Chapter 6-Animals, 2018).

The setback specifies the minimum distance from the property boundary or adjacent dwelling to the hive boxes. The variation in this rule was found to be the highest, even within the same country, with the smallest setback distance being 1 ft (City of Dayton, WA, USA [Dayton, Washington Code of Ordinances]) and the largest being 1000 ft (City of Campbell, CA, USA [Campbell, California Code of Ordinances, Municode]). This study also found that it is common to specify separate distances to different site boundaries, including those to public spaces, such as roads and schools, and adjacent dwellings. In addition, there were cases found to combine setback and barrier regulations (e.g., relaxing the setback distance when a barrier is present [Anniston, Alabama Code of Ordinances]).

There were regulations and rules found to require the installation of barriers; most rules require 6 ft barriers, and there is a range of 3–10 ft (Anniston, Alabama Code of Ordinances, Anchorage, Alaska Code of Ordinances, Allen Park, Michigan Code of Ordinances). The review showed that it is common to stipulate the water supply of apiaries, and in some cases, their distance from the hive (Concord, New Hampshire Code of Ordinances). It is also highlighted that there were cases of prohibiting/allowing specific areas according to the zoning classifications of the city plan (Citrus Heights, California Code of Ordinances).

2.1.3. Discussions

This study surveyed eight countries where urban beekeeping is practiced to determine which urban beekeeping rules currently exist. To date, most rules were developed by governments and NGOs. In certain areas, no rules were identified. Regulatory items for urban beekeeping were found to be biased toward safety, with few regulations on the other aspects, such as biological conservation and apicultural production. The regulatory items extracted in this study typically agreed with those in previous reviews (Paynter, 2015; Sponsler and Bratman, 2021). The rules and regulations for urban beekeeping were found to be focused more on issues related to the safety of urban dwellers than on ecological or production-related aspects. While positive impacts of beekeeping, such as food production, pollination functions, community building, and environmental education, have been widely recognized in recent years, various negative aspects of urban beekeeping have also been recognized (Davenport, 2012; Herbertsson et al., 2016; Lindström et al., 2016; Rahimian, Rombod; Shirazi, F Mazda; Schmidt, Justin O; Klotz et al., 2020; Ropars et al., 2019). The data collected revealed that current urban beekeeping rules may be biased towards resident safety and do not adequately address the negative aspects of urban beekeeping. For the balanced expansion of urban beekeeping, safety, biodiversity, apicultural production, and quarantine aspects should be considered holistically. In the following sections, certain pitfalls are illustrated that are not fully covered in the current regulatory systems for urban beekeeping. These include:

1. Hive Density – London is among the cities with the most active urban beekeeping sites, with large number of participants. However, honey yields are declining in certain areas. This is likely due to the high density of hives (Davenport, 2012; Henry and Rodet, 2018; Laboratory of Apiculture and Social Insects, 2013). Besides, it is not only honeybees that mediate pollination, butterflies, bees, ants and birds also use nectar and pollen. Thus, the presence of honey bees in urban areas can potentially harm these other flower users (Herbertsson et al., 2016; Lindström et al., 2016; Ropars et al., 2019). Some studies have demonstrated the negative impacts of beekeeping on native pollinators (Fontana et al., 2018; Herbertsson et al., 2016; Sheppard and Meixner, 2003). Controlling the density of hive boxes in urban areas is considered to be one of the most effective methods to resolve this issue (Sponsler and Bratman, 2021); however, little research has been done in this area thus far.

2. Infectious Diseases, Pests, and Biodiversity – There are concerns related to both wild and managed honey bees. Managed honey bees can potentially transfer infections and parasites to wild bees and other species. Despite the fact that nearly all countries and regions have beekeeping quarantine requirements, there appear to be no rules to prevent the spread of parasites and diseases.

Apis mellifera is a bee species widely distributed from Africa to Europe, and it is divided into approximately 30 subspecies depending on the region (Sheppard and Meixner, 2003). An initiative has been launched to conserve the regionally endemic honey bee subspecies in Europe (Fontana et al., 2018). In the future, conserving biodiversity at the genetic level will become even more critical. In recent years, the frequency of recorded spillover cases of honey bee pathogens to other arthropods, including wild bees, has dramatically increased (Nanetti et al., 2021). Particular attention should be paid to Asia, where native species of the same genus *Apis* exist. In the future, it may be necessary to establish rules for urban beekeeping to protect native honey bee species in Singapore and Japan. These considerations are not well-stipulated in current regulations.

3. Scientific Evidence – There is a wide range of regulatory items for urban beekeeping. Certain elements are instrumental in neighborhood awareness and training and effective in avoiding problems, while other elements, such as fence and setback requirements, have questionable rationales. While fencing is one of the most frequent regulations, aiming to guide the flight path of bees upward by setting up a fence around the hive may be ineffective. The fence height ranges from 0.9 to 3.0 m, with 1.8 m (similar to the height of human beings) as the most common fence height requirement, though, there is no scientific evidence for setting such a fence height for beekeeping.

Another example is setbacks. The setback distance to the property boundary can prevent honey bees from competing with neighboring humans or pets in their flight path. The required distance can range from 0.3 to 304.8 m, and similar to the fencing rules, there is no or little scientific evidence provided for these distances.

This study observed a variety of rules limiting the number of installed hives. These included cases where the number of hives is fixed, the maximum number varies depending on the size of the site area, or there is no specific regulation. Thus, there is a wide range of numerical provisions for this regulation type with no provided scientific basis. Scientists in ecology and other fields can provide constructive suggestions for policies in this area. In a future study, a more detailed survey can be conducted on the relationship between regulatory items and scientific evidence in the United States and Australia.

4. Modification of Rules and Clarification of Definitions – Urban beekeeping is a recent phenomenon, and cities such as New York and Los Angeles have amended their ordinances to allow for beekeeping in urban areas around 2010 (Kudler, 2015; D. Smith, 2015; Sponsler and Bratman, 2021). In contrast, certain cities have explicitly banned bees because they are considered nuisances (e.g., San Clemente, CA, USA). Whether beekeeping is possible or prohibited in many areas is ambiguous because it is not well-defined whether bees are considered nuisance organisms (Berquist et al., 2012). Experts have identified that regulations before the development of urban beekeeping, such as those of the City of Toronto (Canada) and Osaka Prefecture (Japan), may be outdated, with setback distances of 30 and 20 m, respectively, that in practice prevent beekeeping in urban areas (Berquist et al., 2012). Because most urban beekeepers are satisfied with keeping only a few hives, it is critical to re-examine the current rules to meet the needs of urban dwellers. Clarifying the conditions under which urban beekeeping is possible can help reduce the nuisances related to urban beekeeping.

2.2. Review of Urban Beekeeping in Japan

2.2.1. Data Gathering and Analysis

A systematic review of urban beekeeping regulations in Japan was conducted from 2 to 5 April 2020 using two databases: "e-Gov Horei-kensaku" and "Jorei Web Archive Database." The document survey was done using the search keyword "beekeeping" or "honeybee" to look for the presence of Law or Ordinance in national and local governments. For the search of court judgements, the precedent database "D1-LAW" was used. Each local government's website was accessed and assessed methodically to check the details of the laws and regulations and other related information.

2.2.2. Results

(1) National-level Regulations - Beekeeping

The beekeeping industry in Japan is classified as "other livestock farming" under sericulture at the national level (Ministry of Internal Affairs and Communications, 2013). This classification is different from "livestock farming," which includes businesses that raise livestock animals such as horses, cotton sheep, goats, rabbits, poultry other than chickens, and fur-bearing animals. Currently, there are two laws related to beekeeping in the country namely the "Apiculture Promotion Act" and the "Act on Domestic Animal Infectious Disease Control."

The “Apiculture Promotion Act” was formulated in 1955 and is under the jurisdiction of the Ministry of Agriculture, Forestry, and Fisheries (MAFF). The purpose of this law is to increase the production of honeybee products and to improve the efficiency of pollination of crops. In order to achieve its objectives, the law allows for the conservation and promotion of nectar plants and the provision of subsidies while at the same time taking measures to minimize trouble through proper deployment. Some of the regulations under this law include: the submission of notifications, notification of changes, permission from the governor of the destination prefecture when moving across prefectural borders, the ability of the national government to make recommendations to prefectures regarding the regulation of bee colony placement, and penalties for violations.

Despite the presence of this law, the number of beekeepers was decreasing since the 1980s (Figure 2.2a). Similar trends were observed in the number of hives (Figure 2.2b). The production of honey, the main product of beekeeping, peaked at about 8,500 tons in 1965 and has been on a declining trend, falling below 3,000 tons around 2000s towards the present time (Figure 2.2c). However, in 2013, the number of beekeepers increased due to the change in the counting standard caused by the amendment of the law. In the past, cultivated lands in suburban areas were rich in nectar plants such as Oilseed rape (*Brassica napus*) and Chinese milk vetch, (*Astragalus sinicus*) but this decreased significantly during the period of rapid economic growth after the 1970s (Japan Beekeeping Association, 1995). Compared to 1970, cultivated areas with plants that were the main source of honey decreased; 11% for *Astragalus sinicus* and 5% for *Brassica napus* (Japan Beekeeping Association, 2021). Although the downward trend in nectar plants was observed in the earlier periods, present pattern is increasing (Figure 2.2d).

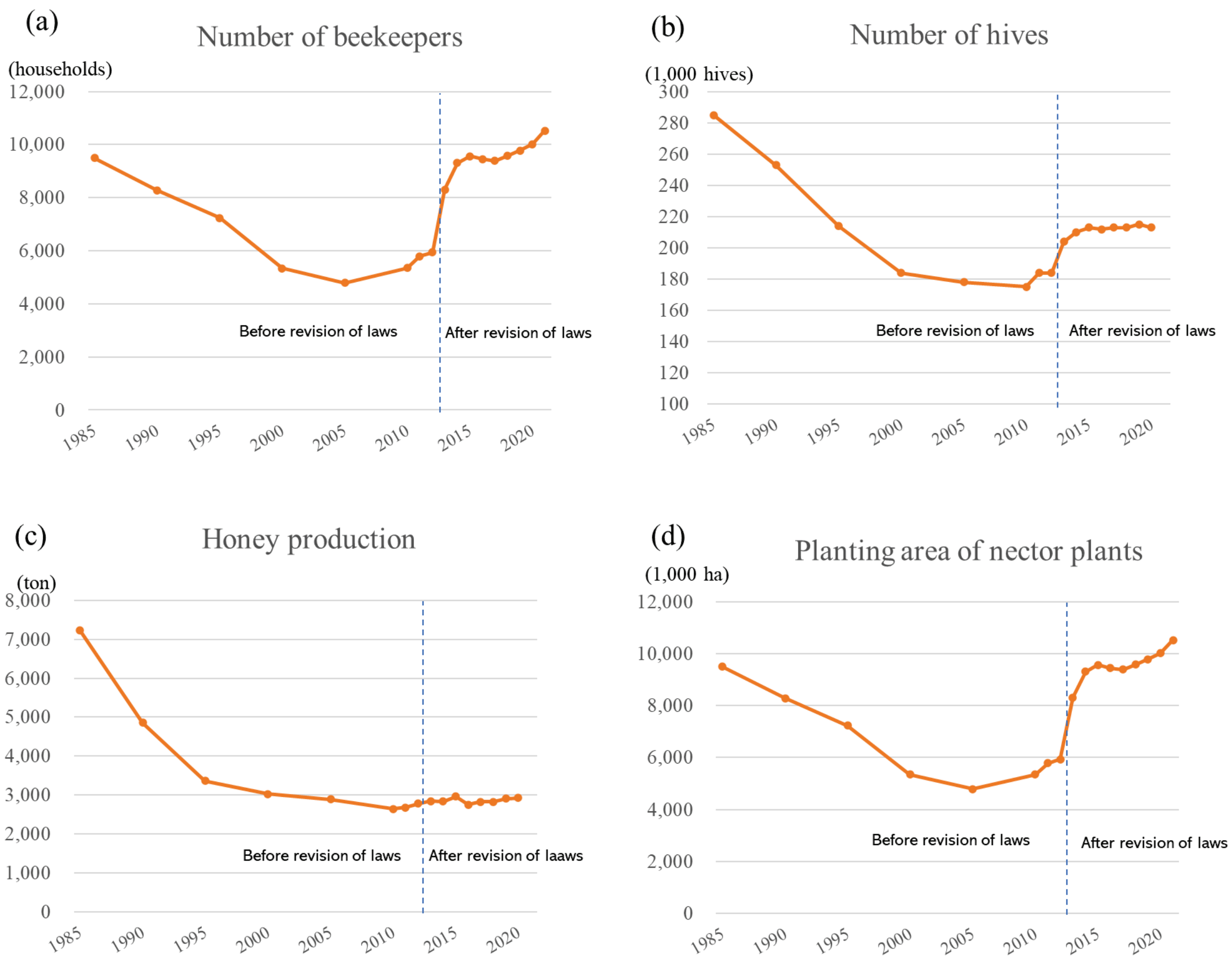

Figure 2.2. Trends in the number of (a) beekeepers, (b) colonies, (c) honey production, and (d) planting areas of nectar plants in Japan.

With the decrease in nectar plants and the increase in the number of hobby beekeepers, problems among beekeepers and with local residents have increased (Akamatsu and Nakamura, 2002; Shinkai et al., 2020). In order to cope with the changes in the environment surrounding beekeeping, the "Apiculture Promotion Act" was partially amended by a lawmaker's bill and came into effect in 2013. This revision includes several major changes. The first is that the scope of those who are obliged to submit notifications was expanded from "those who engage in beekeeping as a business" (e.g., professional beekeepers) to "those who keep bees" (e.g., beekeepers including hobby beekeepers). It is thought that the purpose of the new law is to grasp the actual situation of hobby beekeepers, which had not been grasped before, and to help them avoid trouble. Secondly, prefectures are obliged to formulate and disseminate guidelines for the proper placement and hygienic management of bee colonies. Third, the government and prefectures are obliged to take effective measures for the protection and propagation of nectar plants. Fourth, prefectures are obliged to monitor the number of colonies, locations, and breeding conditions of all beekeepers, and check the status of nectar plants and take measures for proper bee colony management simultaneously. Fifth, prefectural governors now have the right to enter, inspect and question apiaries. Sixth, penalties have been subdivided and the amount of fines has been increased; fines for violations of notification submission and transferring apiary permits were both increased from ~10,000 yen to ~200,000 yen. In addition, a new fine of "up to 100,000 yen" will be imposed for refusal or misrepresentation of the prefectural government's entry or inspection.

In order to strengthen the promotion of beekeeping, the MAFF implemented projects such as providing information on the location of bee colonies, ascertaining the actual status of the planting of nectar plants, and supporting the planting and management of nectar plants, as well as collecting surveys on good practices for the proper placement and adjustment of bee colonies.

The second law identified at the national level is the "Act on Domestic Animal Infectious Diseases Control," which is the basic law for livestock quarantine in Japan (Sugiura, 2013). The translated texts state that this law shall "promote the livestock industry by preventing the outbreak or spread of domestic animal infectious diseases (including parasitic diseases)." This law has a long history and its origins date back to 1871. Initially, the system targeted the cattle plague, but later, the number of diseases and animals to be targeted was gradually expanded, and in 1951, the law, was formulated. At the time of its enactment, honey bees were not included in the list of target animals, but with the enactment of the "Apiculture Promotion Act" in 1955, Foul brood was added as a livestock infectious disease. In 1999, four diseases were designated as notifiable infectious diseases: Varroosis, Chalk brood disease, Acaricosis, and Nosemosis of bees (Table 2.5).

Table 2.5. List of diseases regulated by the "Act on Domestic Animal Infectious Diseases Control."

Disease name	Classification	Obligation, handling
Foul brood	infectious disease	Notification, Incinerate at incidence
Varroosis	notifiable infectious disease	Notification
Chalk brood disease	notifiable infectious disease	Notification
Acaricosis	notifiable infectious disease	Notification
Nosemosis of bees	notifiable infectious disease	Notification

Table 2.6. Annual records of the number of reportable infectious disease outbreaks.

Year	Foul brood	Varroosis	Chalk brood disease	Acaricosis	Nosemosis
2009	266	607	896	0	4
2010	96	600	651	9	0
2011	175	594	725	1	0
2012	27	973	876	18	0
2013	230	1146	869	9	3
2014	168	2427	828	24	0
2015	130	826	1186	42	0
2016	89	1036	933	38	8
2017	74	964	803	62	2
2018	135	877	498	70	4
2019	104	754	343	119	4
2020	127	611	601	91	0

Foul brood includes both American Foul Brood (AFB) and European Foul Brood (EFB). The AFB is caused by the ingestion of *Paenibacillus larvae* spores with food, and the dead larvae emit a foul smell. Since the spores survive in the hive for a long time, eradication is difficult once the hive is contaminated. “Apiten” containing antibiotics Milosamycin, is approved as a prophylactic agent. EFB is caused by *Melissococcus lutonius* and is transmitted orally. In four to five days, larvae die and emit a foul odor. There is no approved drug for this purpose so far.

The number of incidents of Foul brood varies annually, but generally ranges from 100 to 200 (Table 2.6). It has been reported that Foul brood is less likely to occur under hygienic conditions, including disinfection, but may be more likely to occur in hobby beekeepers with insufficient knowledge and skills (Terasaki et al., 2015).

According to the “Act on Domestic Animal Infectious Diseases Control,” prefectures are authorized to take measures such as prohibiting the movement of animals or incinerating them to prevent the rot. The range of prohibited movement is determined individually by each prefecture and is not standardized. This will be described in Chapter 3.

Varroa is a viral infection associated with parasitism by the honey bee Varroa mite and parasitism by the mite, which has adverse effects on honey bees (Figure 2.3, Table 2.7). The Varroa mite was once known as *Varroa jacobsoni*, but mitochondrial DNA studies have since shown that the species has been split into two species, and that the globally distributed and most damaging species is *Varroa destructor*, which is indigenous to Japan (Figure 2.3a) (Anderson and Trueman, 2000). This mite is one of the most threatening diseases in the entire honey bee industry (le Conte et al., 2010). The varroa mite is a parasite of honey bee larvae that grows and multiplies by sucking body fluids. The parasitized larvae may be dwarfed in size or die prematurely due to stunting. Additionally, several viruses transmitted by the varroa mite have been identified and pose a major threat as well. For example, the deformed wing virus causes the wings of adult honeybees to shrivel up and prevent normal activity (Figure 2.3b, 2.3c).

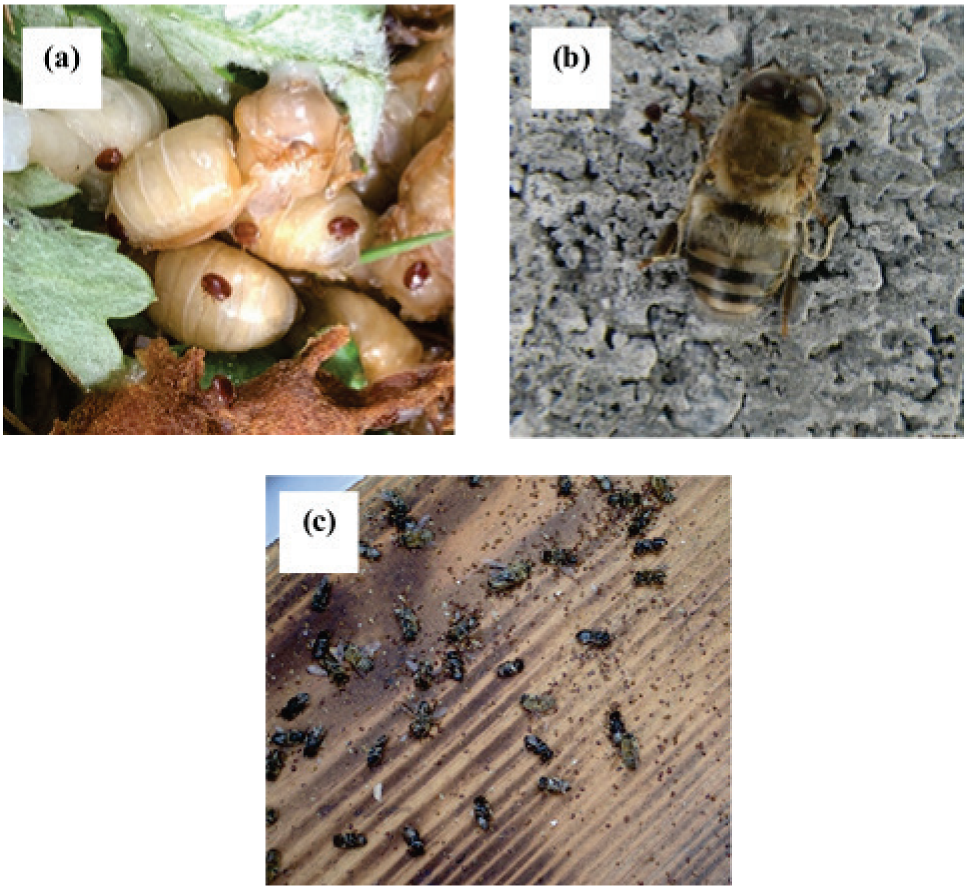

Figure 2.3. Images showing (a) the parasitic mites in honey bee pupae, (b) a honey bee with dwarfed wings, and (c) dead honey bees caused by parasitic mites (Photos taken by the author).

Table 2.7. List of major diseases of honey bees and their causative organisms and taxonomy.

Name of disease	Species responsible	Taxonomic groups
Varroosis	*Varroa destructor, V. jacobsoni*	mite
Acaricosis	*Acarapis woodi*	mite
Chalk brood disease	*Ascosphaera apis*	fungi
Nosemosis of bees	*Nosema apis*	protozoa
Foul brood	*Paenibacillus larvae, Melissococcus plutonius*	bacteria
Sac brood	Sac broo virus	virus
Paralysis virus	Acute bee paralysis virus (ABPV)	virus
	Israel acute paralysis virus (IAPV)	virus
	Kashmir bee virus (KBV)	virus
	Slow paralysis virus (SPV)	virus
	Chronic paralysis virus (CPV)	virus
	Black queen cell virus	virus

Analysis of mitochondrial DNA has shown that there are at least six genotypes of the honey bee larvae mite in Japan, there are Japanese (J) and Korean (K) types, with the K type being more likely to cause severe symptoms (Ogihara et al., 2020). It is estimated that the reason for the enormous damage by the diseases observed in various parts of the world was due to the transmission from the Asian regions to other parts of the world (Noel et al., 2020; Rosenkranz et al., 2010; Thoms et al., 2019). It is unclear how the mites that parasitized Oriental honey bees (*Apis cerana*) were transferred to Western honey bees (*Apis mellifera*) but it is known that the mites have spread multiple times around the world since the 1950s (Ogihara et al., 2020). In Japan, it is a common parasite of both *Apis mellifera* and *A. cerana* but varroa is less severe in *A. cerana* and more common in *A. mellifera*. Several factors are considered such as the short growth period of *A. cerana* and their pronounced grooming behavior to remove varroa mites (Pritchard, 2016). As of 2021, Australia is the single major honey-producing country that is free of the varroa mite.

Chalk brood disease is caused by *Ascophaera apis*, a type of fungus. When the spores infect the larvae, they reproduce by spreading mycelium and die in a white, hardened, mummy-like state (cf. Table 2.7). The disease tends to occur during humid and rainy seasons. Currently, there are no chemicals available for this disease in Japan, but it is said that infection is more common in poor nutritional conditions and when the temperature in the nest tends to decrease.

Acarine Disease is caused by a parasitic mite *Acarapis woodi* that grows in the trachea of worker bees (cf. Table 2.7). As with the varroa mite, it has been pointed out that the mite may transmit a virus when it sucks body fluids. It is a relatively new infectious disease that was first identified in Japan in 2010. In contrast to the varroa mite, acarine mite disease is more severe in *A. cerana*, but this is thought to be due to the fact that *A. mellifera* can remove more *Ascophaera apis* than *A. cerana* (Sakamoto et al., 2020).

Nosemiasis is caused by a protozoan parasite, *Plasmodium nosema*, which invades the digestive tract of adult worms, causing diarrhea-like symptoms and a shortened lifespan of the adult worms (cf. Table 2.7). Two species, *Nosema apis* and *Nosema ceranae*, are known to cause severe damage in Europe and North America. In Japan, there is relatively little damage. There are no chemicals available for use in Japan.

In addition to the diseases of honey bees designated by the "Act on Domestic Animal Infectious Diseases Control," Sac brood disease and other paralytic viral diseases (Figure 2.4, cf. Table 2.7) are also identified.

Article 17 of this law stipulates compulsory measures, including killing, to prevent the spread of legally infectious diseases when they occur, but honeybees are not included in this list, and information is limited to the incineration of contaminated items such as nest boxes. However, due to the importance of countermeasures against this highly infectious disease, the government issued the "Guidelines for Livestock Quarantine Measures" in 1999 (Notification of the Director-General of the Livestock Bureau, Ministry of Agriculture, Forestry and Fisheries, No. 11 Livestock A 467, April 12, 1999). In this document, it is clearly stated that it is necessary to incinerate infected honeybees.

Figure 2.4. Bee infected with a paralytic virus, which is indicated by the blackening of the tip of the abdomen and thorax (Photo taken by the author).

(2) National-level Regulations - Urban beekeeping

The two laws identified and discussed above are observed when keeping honeybees, regardless of the location of implementation. However, these policies are not found to be directly regulating the practice of urban beekeeping. To date, a number of existing laws and regulations at the national level related to beekeeping can be regulated for urban beekeeping practice in Japan (Table 2.8). This section explores these laws in the context of six functions of urban beekeeping (Matsuzawa and Kohsaka, 2021).

Table 2.8. List of present laws and regulations related to urban beekeeping.

Name of regulations	Purpose	Authorities	Bee
Apiculture Promotion Act	Promotion of the beekeeping industry and improvement of pollination of crops	MAFF	○
Act on Domestic Animal Infectious Diseases Control	Prevention and control of the spread of infectious diseases related to livestock	MAFF	○
Offensive Odor Control Law	Prevention of malodorous parasites generated by business activities	MOE	
Fertilizer Regulation Act	Regulation of fertilizer production	MAFF	
Water Pollution Prevention Act	Prevention of water pollution in public waters and groundwater	MOE	
Soil Contamination Countermeasures Act	Identification of soil pollution and prevention of health hazards	MOE	
Agricultural Land Act	Regulation of the sale, purchase, and conversion of agricultural land	MAFF	
Urban Agriculture Promotion Basic Act	Promotion of urban agriculture	MAFF	
Law for Promoting the Development of Citizen Farms	Promote the proper and efficient development of citizen farms	MAFF	
Production Green Space Act	Conservation of remaining agricultural land in urban areas	MAFF	
Law Concerning Special Measures for Conservation of Lake Water Quality	Preservation of water quality in lakes and marshes	MOE	
Standards for the Care and Keeping of Industrial Animals	Prevention of human injury and environmental pollution by industrial animals	MOE	
Act on the Proper Treatment of Dead Animals and Livestock	Prevention of pollution due to disposal of dead animals and livestock and animal husbandry	MHLW	
Waste Management and Public Cleansing Law	Reduction of waste discharge and promotion of proper disposal	MOE	
Act on the Promotion of Proper Management and Utilization of Livestock Wastes	Promote proper management and use of livestock and cup organisms	MAFF	
Act on Welfare and Management of Animals	Prevention of abuse and abandonment, proper care of animals, prohibition of keeping dangerous animals (specified animals), and preservation of living environment to prevent bad odors, etc.	MOE	
Standards for the Care and Keeping of Domestic Animals	Responsibilities for the proper use of animals	MOE	

Name of regulations	Purpose	Authorities	Bee
Law for Ensuring the Safety of Pet Food	Regulations on pet feed	MOE, MAFF	
Act on the Prevention of Adverse Ecological Impacts Caused by Designated Invasive Alien Species/ Invasive Alien Species Act	Prevention of damage to ecosystems, human health, agriculture, forestry, and fisheries caused by specified alien species	MOE	

The first function is “Safety,” which is identified as the most important factor in regards with urban beekeeping practice in overseas (Moore and Kosut, 2013), yet, there are no national laws or regulations that directly refer to the “Safety” of urban beekeeping. In Japan, the “Act on the Welfare and Management of Animals” designates animals that may endanger human life and safety and regulates the keeping of these animals for petting purposes. However, the species covered by the law are limited to mammals, birds, and reptiles. Honeybees, other members of the wasp family, scorpions, poisonous frogs, and fish are excluded. Similarly, the Standards for the Care and Keeping of Domestic Animals exclude creatures other than mammals, birds and reptiles. The Law for Ensuring the Safety of Pet Food regulates the safe production of so-called pet food. In beekeeping, the feeding of liquid sugar and artificial pollen is also a common practice. However, this law applies exclusively to food for pets, and pets are limited to dogs, cats, and certain birds.

Next, in the area of “Apicultural products,” there is an ordinance based on the “Apiculture Promotion Act,” but there is no mention of beekeeping in urban areas. There were no specific regulations found in the “Agricultural Land,” “Urban Agriculture Promotion Basic Act,” “Law for Promoting the Development of Citizen's Farms,” or “Production Green Space Act” despite it is identified as part of urban agriculture (personal communications with MAFF, December 16, 2021).

Thirdly, the purpose of “Pollination services” is stated in the “Apiculture Promotion Act” as “to contribute to the efficiency of pollen fertilization of agricultural crops. (Article 1).” However, as mentioned earlier, there are no regulations on urban beekeeping under this law. The purpose of the Act on the Prevention of Adverse Ecological Impacts Caused by Designated Invasive Alien Species (hereinafter referred to as “Invasive Alien Species Act”) is to prevent adverse ecological impacts caused by designated invasive alien species (Article 1). This law designates the large earth bumblebee (*Bombus terrestris*), which was introduced from overseas as a pollinating insect and has become wild in some areas, as a specified alien species and makes it subject to regulation. However, the *Apis mellifera* is excluded from the list. This will be explained in the section on “Biological conservation.”

The fourth function, “Pest control,” is clearly defined in the “Act on Domestic Animal Infectious Diseases Control,” which states that “the promotion of livestock breeding shall be promoted by preventing the outbreak and spread of infectious diseases (including parasitic diseases) in livestock.” However, there is no description specific to urban beekeeping.

For the fifth function, “Biological conservation” is strongly related to the “Invasive Alien Species Act.” This act designates species that have a negative impact on ecosystems, human safety, agriculture, forestry, and fisheries as specified invasive alien species, and regulates their breeding, cultivation, storage, transportation, importation, extermination, and other measures to mitigate the damage. *Apis. mellifera* which are mainly kept for beekeeping, are not found in East Asia in their natural distribution, so they are considered as alien species in principle. In addition, although scientific evidences are still limited, they may compete with native *A.*

cerana or with other flower-visiting organisms (Gross et al., 2019). Risks related to biodiversity loss such as presence of invasive species are also considered (Fontana et al., 2018; Klein et al., 2007). Although *Apis mellifera* are technically alien species, they are not designated as invasive species since they are major species that supports the beekeeping industry in Japan. In contrast, the large earth bumblebee (*Bombus terrestris*), which is used for pollination has been designated as a specific invasive species. This species has been found to compete with a related native species (*B. hypocriita sapporroensis*/ *B. pseudobaicalensis*), and the native species has been exterminated in Hokkaido (Inoue et al., 2008; Yokoyama and Inoue, 2010), which resulted a shift to pollination using other native species (Yoneda et al., 2008).

The MOE published a list of invasive species, including those with a high risk that are comparable to specified invasive species. The list of "Invasive Species Database of Japan" is available and can be accessed online on the website of the National Institute for Environmental Studies (NIES). The common Japanese honey bee is not included in the list. The African honeybee (*Apis mellifera scutellata*), a subspecies of the honey bee, is designated as an invasive species and the law prevents its establishment because of its aggressive nature.

Concerns regarding the conservation of biodiversity are not limited to honey bees. False Acacia (*Robinia pseudoacacia*), one of the most important nectar sources, is a representative organism of concern as invasive species. According to the "Invasive Species Database of Japan," it was introduced into Japan from North America in 1873, and grew rapidly to reach the forest canopy, forming a single, dense forest, which destroyed the native vegetation (NIES, 2021). It also breeds in river channels and often falls over, which is a concern for safety management (Muranaka et al., 2005; Sanuki et al., 2010). For these reasons, the Ecological Society of Japan designated *Robinia pseudoacacia* as one of the 100 most invasive alien species in Japan (Fujiwara and Murakami, 2000), though, Masaka (2013) states that the concern that *Robinia pseudoacacia* destroys ecosystems is an overestimation (Masaka et al., 2013).

Currently, False acacia (*Robinia pseudoacacia*) is not designated as a target species under the "Invasive Alien Species Act." The "List of Invasive Alien Species for the Prevention of Damage to the Ecosystem" formulated by the MOE, which was introduced earlier, has three categories: (1) "invasive alien species for comprehensive measures" that are subject to control and prevention of runoff, (2) "invasive alien species for industrial management" that are important for industry or public interest and require appropriate management due to lack of alternatives, and (3) "invasive alien species for prevention of establishment" that are not yet established and require preventive measures. *Robinia pseudoacacia* is designated as an invasive species under industrial management because it is an essential organism for the beekeeping industry as well as the honey bee.

Court precedents related to beekeeping and honey bee keeping were searched using Precedent database (D1-LAW). There were no cases found that were related to honey bee placement, sting damage, or fecal damage. According to the interview with an officer from Akita Prefecture, there was once a petition from a beekeeper regarding the placement and adjustment of bees, but the petition was withdrawn after discussions among the officials in charge.

In summary, presence of urban beekeeping regulations at the national level is not yet established. Existing regulations are drawn from various laws related to beekeeping only. The next section presents the results of the systematic review at a local scale (prefecture-level and municipal-level).

(3) Local-level Regulations - Beekeeping

Table 2.9 shows the responsibilities of prefectures in regard to beekeeping practice based on the “Apiculture Promotion Act” and “Act on Domestic Animal Infectious Diseases Control.”

As presented in the earlier sections, the two laws mandate certain responsibilities on prefectures with regard to the promotion and transfer of beekeeping and the prevention and spread of Foul brood. These results were supplemented with interviews with the prefectural governments and the Livestock Promotion Division of the Livestock Department of the MAFF.

According to MAFF (personal communication, December 6, 2021), the “Apiculture Promotion Act” was formulated in 1955 in response to requests from the government to set minimum unified rules in response to the problems related to transferring bees across metropolitan and prefectural borders. There were prefectures that have enacted ordinances, enforcement regulations, or guidelines to correspond to the two laws presented earlier (cf. Table 2.10). There are 43 prefectures (91.5%) that formulated their ordinances based on the “Apiculture Promotion Act.” The ordinances included notification obligations for beekeeping businesses and procedures for applying for permission to transfer bees. There are prefectures that set guidelines for the distance between apiaries, though, none of them were mandatory (e.g., 6 km in Hokkaido, cf. Table 2.10).

Meanwhile, there are 33 prefectures (70.2%) that developed their ordinances based on the “Act on Domestic Animal Infectious Diseases Control.” Since both laws clearly stipulated the authority of prefectures, each prefecture stated their operation and enforcement in ordinances. In the event of an outbreak of Foul brood, prefectures can set a range from where the outbreak occurs and restrict movement, but only 16 prefectures (34.0%) have set a regulatory range. Furthermore, 63.8% of the prefectures had developed their own guidelines, encompassing the two laws and regulations.

Table 2.9. Corresponding responsibilities of prefectures to urban beekeeping based on the "Apiculture Promotion Act" and "Act on Domestic Animal Infectious Diseases Control."

Article	Responsibilities of prefectures
Apiculture Promotion Act Article 3. Notification of beekeeping	(1) As laid down in a regulation by the MAFF as a constituent of its ordinance (hereinafter styled an "enforcement regulation"), any person who keeps bees must make a notification every year to the governor of the prefecture that has jurisdiction over the place in which he is domiciled (hereinafter designated "the competent governor") of— (a) the name and domicile of choice of such a person (if it is an artificial one, its appellation and address); (b) the number of bee colonies; (c) the location and period of apiculture; and (d) any other such matter as may be in the said regulation or another.
Apiculture Promotion Act Article 8. Measures to be taken by prefecture for proper placement of bee colonies, etc.	(1) Any prefecture shall— (a) grasp the situation of beekeeping and the state of nectar sources; (b) make adjustments to the placement of bee colonies (c) control migratory apiculture suitably; and (d) take other necessary measures,
Act on Domestic Animal Infectious Diseases Control Article 3-2. Specific Domestic Animal Infectious Disease Quarantine Guidelines	(2) Prefectural governors and mayors of municipalities shall take measures to prevent the outbreak or spread of domestic animal infectious diseases under the provisions of this Act, based on the Specific Domestic Animal Infectious Disease Quarantine Guidelines.

As mentioned so far, at the prefectural level, ordinances, enforcement regulations, and guidelines are established and operated in a complex manner. Moreover, prefectural governments have not taken sufficient enforcement measures, although, they are not expected to comply with these.

Of the four prefectures that have not formulated ordinances corresponding to the “Apiculture Promotion Act,” only Chiba Prefecture has formulated the “Chiba Prefecture Honey Bee Keeping Guidelines (2020),” which corresponded to both laws. Hyogo Prefecture also formulated a simple guideline; however, there was no mention of preventing the spread of the disease. In Okinawa Prefecture, there are no ordinances corresponding to either of the two laws, but according to the phone interview conducted with a prefectural official, there are beekeeping guidelines at the prefectural and some municipal levels, but they are currently being updated. In Ehime Prefecture, the ordinance corresponding to the Apiculture Promotion Act was abolished in 2013 mainly due to the decreasing number of users, which in turn resulted to a simpler arrangement between the parties concerned as long as it monitored by the involved authorities (Livestock Division, Agriculture, Forestry and Fisheries Department, Ehime Prefecture, personal communication, December 16, 2021).

The regulatory items in each prefecture were extracted to correspond to the regulatory items of urban beekeeping described in Chapter 2.1 (“Regulatory Items in Urban Beekeeping” in Table 2.1). The distance between apiaries was mentioned in 23 prefectures (48.9%), but a specific distance was only mentioned in 7 prefectures (14.9%).

Although *Apis mellifera* are generally used in large-scale beekeeping, native species of *A. cerana* were also identified in Japan. Despite the two species compete with each other and have different breeding methods, there were 19 prefectures that manage both species. There are four prefectures (8.5%) that mentioned the location of their apiaries, such as avoid keeping them in densely populated areas. Meanwhile, 22 prefectures (46.8%) mentioned setting back apiaries at a distance from residential areas and schools. Amongst prefectures, Osaka was the only prefecture that specified a 20 m distance of setbacks. In terms of installing watering supply, only Saitama Prefecture mentioned it.

The number and density of nests that can be installed, the minimum required area, and the installation of barriers were not confirmed in the analysis. Moreover, information related to biodiversity conservation such as interspecies competition with native species and common infectious diseases was also absent.

At the municipal level, ordinance on beekeeping was limited, and was identified in Ogimi Village in Okinawa Prefecture. This ordinance was formulated in the aim of promoting beekeeping in the village. The respondent shared that as part of a national park or a World Natural Heritage site, the village are also focusing on proper management.

Table 2.10. Status of the regulations of beekeeping formulated by local government in Japan.

#	Prefecture	Ordinances, regulations, guidelines			General issues			Regulatory Items in Urban Beekeeping												
		Promotion	Infection	Guideline	Registration	Inspection	Prohibited range	Apiary distance	No./ density	Min. Area	bee species	Zoning	Barrier	Setback	Water	Neighbor	Trouble	Training	Hive shape	Others
1	Hokkaido	○	○		○	○		6km						○						
2	Aomori	—	○	○		○	3km	○			○									
3	Iwate	○	○		○	○														
4	Miyagi	○	○		○	○		○						○						
5	Akita	○	○		○	○		2km			○			○						
6	Yamagata	○	○	○	○	○		2km			○									
7	Fukushima	○	○		○	○														
8	Ibaraki	○	○		○	○	2km													
9	Tochigi	○	○		○	○					○									
10	Gunma	○	○	○	○	○	3km				○									
11	Saitama	○	—	○	○			○						○	○					
12	Chiba	—	○	○	○	○					○	○		○						
13	Tokyo	○	—	○	○	○								○						
14	Kanagawa	○	○		○	○					○									
15	Niigata	○	○	○	○	○	2km	○						○						
16	Toyama	○	—		○						○									
17	Ishikawa	○	○	○	○	○					○									
18	Fukui	○	○		○	○														
19	Yamanashi	○	○	○	○	○	2km				○									
20	Nagano	○	—	○	○			○			○			○						
21	Gifu	○	○	○	○	○	2km													
22	Shizuoka	○	○	○	○	○	2km					○		○						
23	Aichi	○	○	○	○	○		○			○			○						
24	Mie	○	○		○	○	2km	○			○									
25	Shiga	○	○	○	○	○	2km													
26	Kyoto	○	○		○	○	2km				○									
27	Osaka	○	—		○									20m						
28	Hyogo	○	—	○	○			○						○						
29	Nara	○	○	○	○	○					○									
30	Wakayama	○	—		○	○		○			○			○						
31	Tottori	○	○	○	○	○	2km	2km/4km			○			○						
32	Shimane	○	○	○	○	○		○			○			○						

#	Prefecture	Ordinances, regulations, guidelines			General issues			Regulatory Items in Urban Beekeeping												
		Promotion	Infection	Guideline	Registration	Inspection	Prohibited range	Apiary distance	No./ density	Min. Area	bee species	Zoning	Barrier	Setback	Water	Neighbor	Trouble	Training	Hive shape	Others
33	Okayama	○	○	○	○	○		○			○			○						
34	Hiroshima	○	—	○	○	○		○			○			○						
35	Yamaguchi	○	○	○	○	○	2km	○			○	○		○						
36	Tokushima	○	—	○	○			○			○			○						
37	Kagawa	○	—	○	○			2km			○	○		○						
38	Ehime	—	○	○	○	○	2km				○									
39	Kochi	○	○		○	○	2km				○									
40	Fukuoka	○	—	○	○			2km			○									
41	Saga	○	○	○	○	○														
42	Nagasaki	○	—	○	○			○						○						
43	Kumamoto	○	○		○	○	4km				○									
44	Oita	○	○	○	○	○		○						○						
45	Miyazaki	○	○		○	○														
46	Kagoshima	○	—	○	○						○									
47	Okinawa	—	—	○				2km												
	number	43	33	30	45	36	16	23	0	0	28	4	0	22	1	0	0	0	0	0
	%	91.5%	70.2%	63.8%	95.7%	76.6%	34.0%	48.9%	0.0%	0.0%	59.6%	8.5%	0.0%	46.8%	2.1%	0.0%	0.0%	0.0%	0.0%	0.0%

2.2.3. Discussions

This study reviewed the legal governance of beekeeping and urban beekeeping in Japan, particularly the status of the development of laws and regulations at the national to local levels. Key highlights of the systematic review are presented below along with the issues and challenges of urban beekeeping from different perspectives.

(1) Current Trends in Urban Beekeeping Regulations

Systematic review indicates that two laws and regulations related to beekeeping in Japan. The first is the "Apiculture Promotion Act" and the corresponding prefectural-level ordinances based on this law, which promotes beekeeping in the context of honey production and improvement of pollination functions to agricultural crops (cf. Table 2.8). It contains limited regulatory-related mandates; one example mandate is the placing adjustment of hives. The second type is the "Act on Domestic Animal Infectious Diseases Control" and the associated prefectural-level ordinances, which prevent and control the spread of infectious and parasitic diseases that infect domestically managed bees (cf. Table 2.8). For example, the American and European Foul brood diseases are designated as legally contagious diseases and therefore subjected to strong legal restraints such as prohibiting the movements of bees and burning of hives.

These two laws currently comprise the basic regulations of beekeeping in Japan, however, these are directed towards "suburban" beekeeping for the purpose of honey production. The presence of a legal system surrounding urban beekeeping still remains, in general, insufficient and lacks mandates at the local level such as the control and regulation of beekeeping to ensure community building, Biological conservation, and safety of residents in urban spaces. For instance, some prefectures have established their own guidelines for urban beekeeping such as "Do not place hives in areas that are frequented by people" in Chiba, "Keep hives at a safe distance from houses, roads, parks, and other places where people gather" in Hyogo, and "Do not place hives near neighboring houses or roads (in residential areas, etc.)" in Niigata (Table 2.10). However, none of these guidelines provide the required distance or quantity, but merely anecdotal accounts.

In contrast, in Osaka prefecture, a guideline says, "Birdhouses must be placed at a distance (20 m) specified by regulations from residences, schools, factories, roads, parks, and other places where other people regularly enter, pass through, or congregate" (Rules for Enforcement of Ordinance on Regulation of Keeping Bees in Osaka Prefecture, 1968). This prefecture is one of the most densely populated areas in Japan, and it is thought that there are limited number of places in urban areas where a 20-meter setback can be secured, so this ordinance effectively prohibits beekeeping in urban areas.

These inconsistencies and the lack thereof suggest that urban beeping regulations in Japan are not yet established and/or streamlined at the prefectural or national level. Shinkai et al. (2020) focused on the entries in the beekeeping registration forms of Japanese prefectures and discussed the governance problems in Japan. Amongst these issues, they pointed out that even the most basic information, such as the type of bees to be kept, is not uniformly formatted in each prefecture, making it difficult to compile nationally uniform data. Their observations are also common challenges in urban beekeeping. In London, where urban beekeeping is popular, an NGO-led approach has created a web-based system (referred to as "Urban Bees.co.uk") that allows beekeepers to locate new hives and contact existing beekeepers. This example illustrates how a properly organized system can help boost the practice and promote community building among different stakeholders.

(2) Development and Deployment Planning of Urban Beekeeping

In recent years, there has been a growing social interest in zoonosis, or common infectious diseases, such as COVID-19 (Lu et al., 2020). There are other diseases such as avian influenza and swine flu, which are feared to spread among different species (Subbarao et al., 1998; Wong and Yuen, 2006). Currently, no significant common infections have been identified between honeybees and humans, but several common infections are known to occur among *Apis* species, causing certain ecological and economic damages (Rosenkranz et al., 2010; Woodcock et al., 2016). The most common is the varroa mite, which was originally hosted by *Apis cerana*, but has since “migrated” to *Apis mellifera* and is spreading worldwide (Rosenkranz et al., 2010).

Urban beekeeping may pose a greater risk of spreading infectious diseases than the traditional commercial beekeeping practice. In suburban commercial beekeeping, distances between apiaries are often set to be wide to avoid the competition of nectar plant resources. For example, in Yamagata prefecture, an ordinance sets the standard distance between beekeepers, which is 6 km apart. Meanwhile, in urban beekeeping, the number of honeybees kept in a single apiary is small, and the distance to neighboring apiaries is relaxed in certain cases. For instance, in central Tokyo, urban beekeeping is practiced in several places such as Ginza, Hanzomon, Jimbocho, and Ochanomizu areas, and some of them include large commercial apiaries, yet the distance between apiaries is less than 3 km. Terasaki et al. (2015) documented that there are certain hobbyist beekeepers that lack knowledge and management skills and are often known to be a source of contamination for infectious diseases. Thus, the risk of infectious diseases would be higher among nearby apiaries in urban areas than among those in suburban areas.

In order to avoid these problems, the location of hives in urban areas, the number of breeding groups, the duration of hive installation, and information on the breeders are required at a minimum. The "Apiculture Promotion Act" of Japan stipulates that prefectures are obliged to "coordinate the placement of bee colonies." In the case of suburban beekeeping, this is thought to be a way to avoid competition for nectar resources by ensuring the distance between apiaries. Henry and Rodet (2018) pointed out that a practical criterion for the proper placement of apiaries is the distance between apiaries. However, in the context of urban beekeeping, it is difficult for beekeepers to freely decide where to place their hives since available spaces are limited. To address such issues, Salkin (2012) suggested that limiting the number of hives should be incorporated in urban beekeeping regulations. Since most practitioners of urban beekeeping are hobby beekeepers, rather than limiting the distance between apiaries, the rules should be designed to allow certain number of beekeepers to keep a small number of swarms, rather than a large number of swarms per location, considering the carrying capacity of the entire region.

(3) Gaps and Implications

Urban beekeeping brings various benefits such as pollination, crop production, and community building, but it also has risks such as sting damage, fecal damage, and competition with native species. Therefore, in order to maximize the benefits and minimize the risks of urban beekeeping, a balanced set of rules is necessary. By comparing the "Apiculture Promotion Act" and "Act on Domestic Animal Infectious Diseases Control," it can be confirmed that out of the six functions of urban beekeeping, there are three items addressed in Japan, including (1) "Agricultural products," (2) "Pest control," and (3) "Pollination services." Other items related with “Biological conservation,” “Safety,” and “Community formation” are limited.

The “Biological conservation” is strongly related to the “Invasive Alien Species Act,” but considering the industrial importance of beekeeping, it is unlikely to be a subject of regulation. In addition, there are prefectures that do not distinguish between *Apis cerana* and *A. mellifera* in the information of beekeepers, which potentially impact biodiversity conservation. As for ensuring the “Safety” of residents and others, there are several existing laws that restrict the keeping of dangerous or odoriferous animals, but these are limited and covers mammals, birds, and reptiles. The arthropods, including honeybees, are generally excluded and thus it would be difficult to add bees to these existing laws.

For “Community formation” through beekeeping, other countries such as ICLEI Europe’s Pollinator Friendly City, have measures that link beekeeping with environmental education for the general public. Since urban beekeeping is frequently conducted in densely populated areas, it is potentially prone to the occurrence of nuisances and conflicts. Although a large percentage of urban beekeepers are hobbyists, it has been pointed out that there are participants that lack the literacy necessary for the soundness of urban beekeeping, such as compliance with laws and regulations, prevention of nuisance behavior, and countermeasure techniques (Terasaki et al., 2015). In order to reduce such concerns, it is integral to clarify the rules to be observed and to spread awareness. It would also be effective to include participation in education and training as part of the requirements for urban beekeeping.

In general, it is difficult to improve the governance of urban beekeeping solely by amending national laws. Other measures such as local government ordinances allow for a relatively high degree of freedom and may be more likely to address problems caused by urban beekeeping. For example, beekeeping ordinances could easily include aspects such as biological conservation, community building, and specific restrictions to reduce nuisance behavior in urban beekeeping. In fact, the guidelines formulated by Hiroshima, Shimane, and Shizuoka prefectures include consideration of stings and feces nuisance (without specific methods) (Shimane Prefecture Beekeeping Guidelines, 2020; Shizuoka Prefecture Beekeeping Guidelines, 2013; Hiroshima Prefecture Beekeeping Guidelines, 2021).

When considering urban beekeeping from the standpoint of administering laws and regulations, other elements need to be considered. Under the two laws presented above, there are specialists related to beekeeping that are obliged in coordinating hive placement and inspection for infectious diseases in each prefecture. At municipal level, however, there will be few bee specialists.

Each prefecture should explore the possibility of formulating prefectural urban beekeeping ordinances rather than guidelines in order to ensure its effectiveness on an ongoing basis. This is because on-site inspections and penalties can be obligatory. Besides, if there is a municipality that seems to be possible to cooperate, it is possible that the prefecture will devolve some authority to the municipality. Since it is presumed that such municipalities are medium-sized or larger, it is thought that administrative resources will be abundant, and it is also suitable for delegation of authority. Both the prefecture and municipality should be a legal system that deploys experts, cooperates with each other, and strives to further ensure its effectiveness.

Chapter 3. Evidence-Based Regulations

In chapter 2.1, it was found that there are urban beekeeping ordinances in the US and Australia. Most of the ordinances related to urban beekeeping were related to safety, and there were about 10 items, such as the density of hives that can be kept, the installation of barriers, and the installation of setbacks and water supply. These regulations have specific standards set, such as “at least 10 meters from the property boundary” or “a solid barrier of at least 6 feet in height”. In this chapter, a detailed analysis of the regulatory items related to urban beekeeping and the basis on which these regulatory contents are formulated are presented.

3.1. Comprehensive Systematic Review

Initially, a systematic search was conducted to investigate the existence of ordinances on urban beekeeping. For the United States, a private law search database (known as “LexisAdvance” authorized by Lexis Nexis Co., Ltd.), was used to search at the state and city level from August 17, 2021 to September 15, 2021. In the United States, there are several classifications of local government, such as county, township, municipality, school district, and special district, in addition to state government. In this review, the municipal government, which is the most universal unit, was selected as the target.

For Australia, the free access website (known as “AustLII” abbreviated from Australasian Legal Information Institute provided by the Free Access to Law Movement [FALM]) was used to search for state-level ordinances from 18 to 25 September 2021. For local governments in Australia, the survey was conducted at the council level. Since searchable database for bylaws set by councils was not available, the Google search engine was used as an alternative with the following search command “local laws beekeeping" + "[council name]" + "[state name]." The command applied in this chapter is different from Chapter 2.1, which used the Google Scholar database.

Since there are no ordinances related to urban beekeeping in Japan, the analysis was conducted instead using the ordinances related to beekeeping, which were extracted in Chapter 2.2.

After confirming the content of the confirmed local government regulations, classification was conducted according to the regulatory items listed in Chapter 2.1. These data were analyzed by items, countries, and local governments.

Next, 27, 26, and 11 local governments were selected from the United States, Australia, and Japan, respectively, and detailed interviews were conducted. Communications were initiated by sending emails to inquiry desk of each municipality to request for interviews. For those municipalities that did not respond, emails were sent at least twice to request their cooperation. Telephone interviews, when possible, were also conducted to those municipalities that responded particularly during the COVID-19 crisis period since 2020. During the interviews, it was thoroughly checked whether the details set in the regulatory items (number and density of hive boxes, height and length of barriers, setback distance, distance from hive to watering hole, etc.) were formulated based on evidence, and whether scientific or empirical evidence existed or not.

3.2. Results

In Australia, eight states had developed their own urban beekeeping rules (100.0%), while 14.0% of all councils had developed rules. In the United States, one state (Oregon) had developed its own rules for urban beekeeping (1.8%), and 581 municipalities had developed rules at the city level (3.0%) (Table 3.1). Japan has not yet developed any rules on urban beekeeping at either the prefectural or municipal level. However, in Osaka Prefecture, there is a rule that prohibits urban beekeeping (a setback of 20 m from the property boundary is required).

The regulatory items and the percentage of regulations formulated are shown in Table 3.2. Differences can be seen in the regulatory items between the United States and Australia, though, these differences are not significant.

A structured survey was conducted to municipalities with regulations on urban beekeeping in Australia and the United States in addition to Japan (Table 3.3). Since there is no ordinance on urban beekeeping in Japan, interviews were conducted to local governments about beekeeping in general (Table 3.4). They were asked about the evidence of setting the regulatory items set in their ordinances and guidelines.

A total of 27 valid responses were received from the local governments of the three studied countries (Table 3.5). One council in Australia (16.7%), six municipalities in the United States (66.7%), and seven in Japan (70.0%) responded that there was evidence for the content of the regulations (cf. Table 3.6, 3.7).

The breakdown of evidence-based regulations on urban beekeeping was 55% of "Existing rules set by other bodies (e.g., state, neighboring municipalities, and NGOs)" and 45% of "Expert judgment" (cf. Figure 3.1). There were no municipalities identified that developed the guidelines based on scientific evidence.

Table 3.1. Percentage of local governments with regulations in urban beekeeping.

Nation	Criteria	No. of government	No. of governments set regulations for Urban beekeeping	% of governments
Australia	State	8	8	100.0%
	Council	537	75	14.0%
US	State	55	1	1.8%
	Municipality	19,522	581	3.0%
Japan	Prefecture	47	0/ (1)	0.0%
	Municipality	1,718	0	0.0%

Table 3.2. Regulatory items of urban beekeeping at the municipal/council level in the United States and Australia.

Regulation items	US (400)		Australia (68)	
	No.	%	No.	%
Registration	118	29.5%	31	45.6%
No./density	219	54.8%	51	75.0%
Minimum area	44	11.0%	13	19.1%
Species	73	18.3%	3	4.4%
Area/Zoning	168	42.0%	16	23.5%
Barrier	202	50.5%	30	44.1%
Setback	255	63.8%	46	67.6%
Water supply	228	57.0%	35	51.5%
Neighborhood awareness	20	5.0%	3	4.4%
Responding to troubles	2	0.5%	0	0.0%
Training/education	13	3.3%	3	4.4%

Table 3.3. List of the local governments interviewed in Australia and the United States (cf. Appendix for interview data).

Australia			United States		
	State	Council		State	Municipality
1	New South Wales	-	1	Oregon	-
2	South Australia	-	2	Alabama	Gadsden
3	Tasmania	-	3	Arizona	Pima County
4	Victoria	-	4	Arkansas	Bella Vista City
5	New South Wales	City of Canterbury Bankstown	5	Arkansas	Little Rock
6	New South Wales	Coolamon Shire	6	California	Moraga
7	New South Wales	Kempsey Shire	7	Colorado	Castle Pines
8	New South Wales	Muswellbrook Shire	8	Connecticut	New Britain
9	New South Wales	City of Parramatta	9	Georgia	College Park
10	Queensland	Gold Coast City	10	Illinois	Belvidere
11	Queensland	Livingstone Shire	11	Iowa	Decorah
12	South Australia	Town of Gawler	12	Louisiana	Patterson
13	Tasmania	Hobart City	13	Massachusetts	New Bedford
14	Victoria	Greater Shepparton City	14	Michigan	Grand Haven
15	Western Australia	Augusta-Margaret River Shire	15	Minnesota	Elk River
16	Western Australia	Bayswater City	16	Mississippi	Vicksburg
17	Western Australia	Belmont City	17	Missouri	Maryland Heights
18	Western Australia	Canning City	18	Montana	Great Falls
19	Western Australia	Cottesloe Town	19	Nebraska	Dakota City
20	Western Australia	Gosnells City	20	North Carolina	Oak Island
21	Western Australia	Mundaring Shire	21	Oklahoma	Lawton
22	Western Australia	Northam Shire	22	Rhode Island	East Providence
23	Western Australia	Perth City	23	Texas	Killeen
24	Western Australia	Rockingham City	24	Virginia	Isle of Wight County
25	Western Australia	Victoria Park Town	25	Washington	Seattle
26	Western Australia	Vincent Town	26	West Virginia	Ranson
			27	Wisconsin	Fitchburg

Table 3.4. List of the local governments interviewed in Japan (cf. Appendix for interview data).

Japan	
Prefecture	**Municipality**
Osaka	-
Tokyo	-
Saitama	-
Hokkaido	-
Fukuoka	-
Aichi	-
Akita	-
Yamagata	-
Okinawa	-
Okinawa	Ogimi

Table 3.5. Number of the valid responses obtained in the in-depth interviews (cf. Appendix for interview data).

Nation	Local government	Interviewed	Valid responses	Name of local government
Australia	State	4	1	Victoria
	Council	22	5	Muswellbrook Shire, Bayswater City, Belmont City, Rockingham City, Victoria Park Town
US	State	1	1	Oregon
	Municipality	26	9	Little Rock (Arkansas), Moraga (California), College Park (Georgia), Grand Haven (Michigan), Elk River (Minnesota), Great Falls (Montana), Dakota City (Nebraska), Killeen (Texas), Fitchburg (Wisconsin)
Japan	Prefecture	10	10	Osaka, Okinawa, Tokyo, Saitama, Akita, Hokkaido, Fukuoka, Aichi, Ehime, Yamagata
	Municipality	1	1	Ogimi

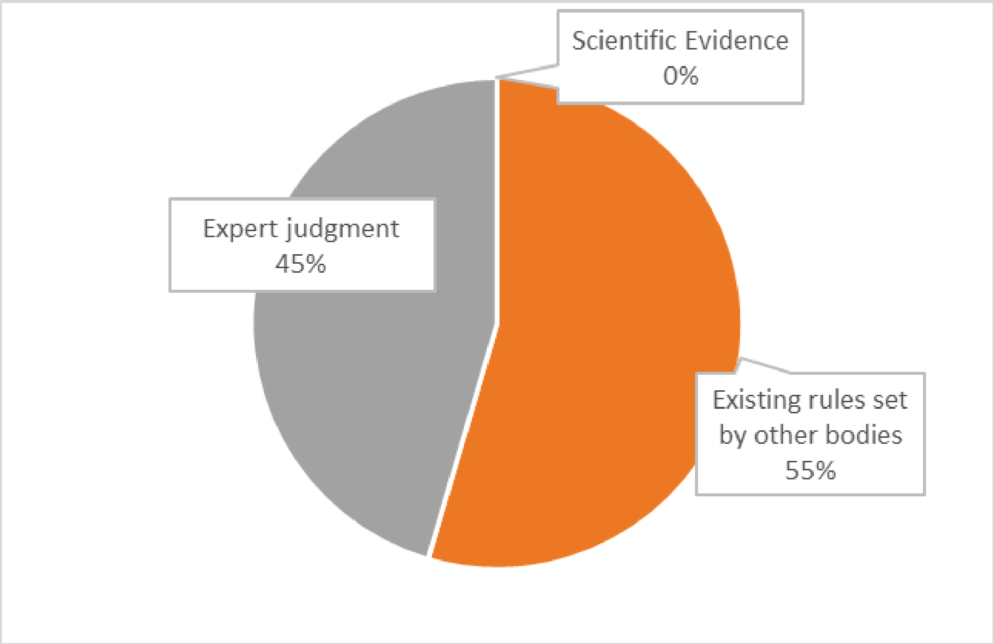

Figure 3.1. Ratio of the different types of evidence-forming bodies (experts' judgment, scientists, and other groups such as non-government organizations).

Table 3.6. Results of the evidence-based regulation survey of urban beekeeping in Australia and the United States.

Nation	State	Council/ Municipality	Regulations	Existence of evidence: No	Existence of evidence: Yes			Description
				None/ unknown	Scientific Evidence	Existing rules set by other bodies	Expert judgment	
Australia	Victoria	—	hive density, barrier, setbacks, others	○				
	New South Wales	Muswellbrook Shire	hive density, barrier, setbacks, others			○		Referred to state regulations
	Western Australia	Bayswater City	hive density, barrier, setbacks, others	○				—
	Western Australia	Belmont City	hive density, barrier, setbacks, others	○				—
	Western Australia	Rockingham City	barrier, setbacks, others	○				—
	Western Australia	Victoria Park Town	hive density, barrier, setbacks, others	○				—
United States	Arkansas	Little Rock	hive density, barrier, setbacks, others	○				Rules formulated over 30 years ago, no documentation.
	California	Moraga	hive density, barrier, setbacks, others			○	○	Referred to ordinances in neighboring cities, input from local beekeeping associations and professionalization
	Georgia	College Park	hive density, barrier, setbacks, others			○		Referred to state regulations
	Michigan	Grand Haven	hive density, barrier, setbacks, others			○	○	Flyway barrier height and width were based on recommendations from local beekeepers
	Minnesota	Elk River	hive density, barrier, setbacks, others			○	○	—
	Montana	Great Falls	hive density, barrier, setbacks, others				○	Based on the results of multiple consultations, including with experts
	Nebraska	Dakota City	hive density, barrier, setbacks, others	○				The person in charge doesn't know how it was formulated and can't find any documents.
	Texas	Killeen	hive density, barrier, setbacks, others	○				—
	Wisconsin	Fitchburg	hive density, barrier, setbacks, others			○	○	Referenced beekeepers' comments and the neighboring municipalities such as Middleton, Sun Prairie, Madison, and Wisconsin.

Table 3.7. Results of the evidence-based regulation survey of beekeeping in Japan.

Prefecture	Municipality	Regulations	Existence of evidence: No	Existence of evidence: Yes			Description
			None/ unknown	Scientific Evidence	Existing rules set by other bodies	Expert judgment	
Osaka	—	setback, adjusting for over density			○	○	Results of discussions in the committee including beekeeper association
Tokyo	—	adjusting for over density				○	—
Saitama	—	adjusting for over density			○	○	The evidence is not existent. The decision has been made after consultation with experts.
Hokkaido	—	The distance between apiaries is at least 6 km				○	There is no evidence for 6km. There are complaints about the lack of evidence.
Fukuoka	—	The distance between apiaries is at least 2km	○				There is no evidence for 2km.
Aichi	—	adjusting for over density					There are no standards of any description. Just discuss among beekeepers.
Akita	—	The distance between apiaries is at least 2km			○	○	Referred to the guidance of the Japan Beekeeping Association. There was once a complaint about a density problem.
Yamagata	—	The distance between apiaries is at least 2km	○				There is no evidence for 2km.
Okinawa	—	The distance between apiaries is at least 2km	○				There is no evidence for 2km.
Okinawa	Ogimi	The distance between apiaries is at least 2km			○		Refered to prefectural guidance

3.3. Discussion

3.3.1. Establishing Urban Beekeeping Rules

In Salkin (2014), the rules of urban beekeeping are more often developed at the state or the municipal level than at the national level for the United States. Similar results were obtained in this study, although the situation varied in each country analyzed.

In Australia, all states developed their urban beekeeping rules (including state laws, bylaws and guidelines) and 14% of Councils developed their own rules. These findings indicate that at least all local governments in the country are covered by some urban beekeeping rules. State rules, in principle, allow urban beekeeping, so unless the Council imposes a ban, urban beekeeping is in principle possible.

In the United States, it is unusual for states to formulate rules for urban beekeeping; in most cases, rules were formulated at the municipality level. However, the percentage of municipalities that have actually developed rules for urban beekeeping is small at 3.0%. This is in line with Larson et al. (2020) that rules for beekeeping, in general, have not been formulated in municipalities.

In Japan, there are no local governments that have formulated rules in urban beekeeping. Despite the lack of regulations, urban beekeeping is being practiced in more than 100 cities in Japan (Mitsumori, 2020), and the number of troubles is increasing (Akamatsu and Nakamura, 2002; Production Bureau Livestock Department, Ministry of Agriculture, 2017). It has also been identified that hobbyist beekeepers, who are mostly found in urban areas, are less literate and more likely to cause troubles in terms of legal compliance and maintenance of bee-health (Terasaki et al., 2015). Given these circumstances, it is necessary to formulate rules for urban beekeeping in Japan as well.

According to existing literatures, it is suggested that urban beekeeping regulations should be established and implemented in metropolitan cities to maximize the benefits (e.g., pollination function) while minimizing the risks (e.g., stinging incidents). Some of the ordinances identified in the analysis have been amended in recent years to allow urban beekeeping to be implemented. As Sponsler and Bratman (2021) pointed out, there is a greater demand in urban areas for future studies.

3.3.2. Importance of Evidence-based in Urban Beekeeping

Amongst the local governments identified in the three countries, 44.0% (11/25) responded that they have "no evidence/not identified." Even among the governments that responded with evidence, most of them referred to regulations established by "other governments," such as neighboring governments, or complied with "expert judgements" from local beekeepers or researchers, and none of them (0%) set standards based on scientific evidence such as papers or experiments. These results indicate that most of the regulations in urban beekeeping lack scientific evidence.

In theory, it is hard to define optimal density of hives and distances between apiaries, as they vary with the total amount of nectar plants in the surrounding area and with seasonal changes (Al-Ghamdi et al., 2016). In contrast, standards set to ensure safety for the residents in the vicinity, such as setbacks and barriers, are relatively easy to obtain empirical results (Garbuzov and Ratnieks, 2014), but no scientific evidence was provided for these standards either.

(1) Carrying capacity

In London and Paris, the number of urban beekeepers is relatively high, with a density of more than 10 hives per square kilometer (Laboratory of Apiculture and Social Insects, 2013; Ropars et al., 2019). There are indications that the nectar resource is already depleted in London (Davenport, 2012). Competition among beekeepers for nectar resources has been around for longer periods, and it may become more apparent in urban areas. Hive density standards set by the government have been used in some cases to determine the number of hives that can be installed (e.g., up to two swarms per location) and in other cases to determine the number of hives that can be installed based on the site area (e.g., More than 2 hives on an allotment area greater than $400m^2$ and less than $1000m^2$). However, based on the interviews, most of these figures seem to have lack scientific evidence.

Several NGOs, such as the Colorado State Beekeepers Association and the New York City Beekeepers Association, have developed their own guidelines for urban beekeeping, pointing out that the number of hives that can be installed should be based on the environmental carrying capacity that is based on the amount of nectar plants present and the number of beekeepers in the neighborhood (Colorado State Beekeepers Association, 2017; New York City Beekeepers Association, 2018). Although there is a long history of research on determining environmental carrying capacity from the amount of nectar plants, few research results currently exist that can be used in the context of urban beekeeping (Al-Ghamdi et al., 2016). Most of the existing studies have attempted to determine carrying capacity by measuring the amount of nectar plant resources. Given the fact that urban environments are not homogeneous, and that there are number of small-size nectar sources such as community gardens and balconies that are planted opportunistically and are not stable, a nectar plant approach may be impractical (Al-Ghamdi et al., 2016), which measures the carrying capacity based on honey production itself, may be more useful in urban areas.

(2) Biodiversity conservation

With the enormous benefits that pollinating insects bring to humanity, the emergence of CCDs, and the expansion of urban agriculture, urban beekeeping appears to have been accepted and expanded almost uncritically in certain places around the world over the past two decades. Recently, however, certain risks have also come into focus (Egerer and Kowarik, 2020). A prime example is competition with native pollinators: Henry and Rodet (2018) showed that keeping bees at high densities in urban areas has a negative impact on the bees themselves as well as on wild bee species. Thus, artificially introduced bees may negatively impact pollinators originally found in urban areas through competition for resources.

In Japan, where *Apis cerana japonica*, a close relative of *A. mellifera* lives, competition between the two species is known (Gross et al., 2019), but is currently not taken into consideration with regard to urban beekeeping rules from the perspective of conservation of the native species. Biodiversity risks also exist within *Apis mellifera* itself. There are more than 30 subspecies of *A. mellifera*, and efforts have begun to stem the genetic contamination associated with artificial migration (Fontana et al., 2018).

Furthermore, urban beekeeping practice has value in environmental education (Egerer and Kowarik, 2020; Skelton, 2006). Activities can be geared towards minimizing biodiversity conservation concerns such as competition with native species. Generally, the severity of the phenomenon of competition between wild pollinators and introduced honey bees in urban areas remains uncertain (Ropars et al., 2019) and requires further data gathering.

(3) Pest control

Recently, the pathogen spillover infectious through beekeeping has raised a concern (Alger et al., 2019; Nanetti et al., 2021). It is generally estimated that people in urban areas are hobby beekeepers, including those who lack necessary knowledge and experience, and that keeping bees under unfavorable conditions has become a potential hotbed for the spread of infectious diseases (Terasaki et al., 2015). In addition, in suburban professional beekeeping, the distance between apiaries is frequently more than a few kilometers, while in urban beekeeping, the distance between apiaries may be shorter. These situations indicate that infections are more likely to spread in urban areas. It will be necessary to collect information on beekeepers' keeping conditions and to expand educational programs for beekeepers.

(4) Safety

Bans on urban beekeeping are usually motivated by concerns for public safety (Moore and Kosut, 2013). The African honey bee *Apis mellifera scutellata*, a subspecies of the Western honey bee *Apis mellifera*, and its hybrid, the Africanized honey bee, have caused 11 deaths by 2019 due to aggressive and feral swarms (Rahimian et al., 2020). To formulate effective beekeeping ordinances, local governments need to address concerns about nuisance behavior (Salkin, 2012). The most common regulation is a limit on the number of hives, and other minimum lot sizes and densities have been shown to help control nuisance (Salkin, 2012), but there is little scientific evidence (Garbuzov and Ratnieks, 2014; Matsuzawa and Kohsaka, 2022).

Inadequate regulations may make urban beekeeping impossible (Berquist et al., 2012; Matsuzawa and Kohsaka, 2021). In establishing conservation policies, evidence of the benefits and risks of urban beekeeping must be provided, as well as improving the social benefits of beekeeping (Egerer and Kowarik, 2020). The acceptability of the evidence to ensure safety is further discussed in Chapter 4.

In summary, the rules of urban beekeeping were mainly established at state and municipality level. In Australia, the rules are established generally at the state level and cover the whole country. Though, there were cases that established individually at the city (council) level. In the United States, regulations were established mainly at the city (municipality) level, and were more common in cities with larger populations. In Japan, there were no rules documented at any level. Rules on urban beekeeping and apiculture frequently included numerical regulations (e.g., barrier heights and setback distances), but these are mostly based on experts' judgements and other bodies (e.g., other governments or NGOs). It is implied that the official rules based on scientific evidence are not well established yet. The following chapters present empirical analyses of the potential of evidence-based to urban beekeeping regulations.

Chapter 4. Effects of Lattice Fence Installations

There is an increasing trend of municipalities adopting urban beekeeping as part of their environmental policies (Wilk et al., 2019). However, concerns from local residents to urban beekeeping are growing mainly due to safety and property disputes (Gallay, 2018). This in turn results in a need to establish suitable rules and regulations that maximize profits while minimizing the risks such as nuisances (Salkin, 2012). Regulations of urban beekeeping are usually motivated by concerns for public safety (Moore and Kosut, 2013). For instance, to reduce the probability of physical encounters between bees and the people, “Setbacks,” “Flyaway Barriers,” and the number of hives that owners can keep on their property are common requirements to decrease the potential nuisance effect of beekeeping operations (Salkin, 2012).

To date, studies examining the effectiveness of regulatory items in urban beekeeping are still limited. One of the few cases is the study conducted by Garbuzov and Ratnieks (2014), wherein the effectiveness of barriers for flyway control was examined. The purpose of installing setbacks, which are defined as the distance of hives from the property boundary and/or street to raise the flight path upwards, and flyaway barriers, which refer to a solid wall or fence, or a dense hedge that helps increase the flight height of bees, is to control flyways and to lead the bees above human head height. Their study compared the flight height of honey bees with and without barriers and proved that barriers are effective at raising the mean honey bee flight height, however, results did not provide data from more than 3.6 m above the ground because they measured the height by video recording honey bees passing across a 3.6 m high whiteboard. The “3.6 m” height appears to be quite insufficient when considering the flying height of honeybees in apiaries. In addition, major parallax error is included by using a single video image. These factors suggest that the observed heights could have contained considerable errors.

To evaluate the effect of barrier location and height, multiple fence types and accurate measurement methods should be used in an experimental space with sufficient height. Though there are various methods developed for spatial localization in the wild of flying small animals such as insects (Reynolds and Riley, 2002; Smith et al., 2021), there is still, in general, a gap in the available observation methods for sufficiently measuring the flying altitude of honey bees at the apiary scale. For instance, visual and camera measurements have weaknesses in terms of accuracy, labor, and observable range while radio-frequency identification tags are small and lightweight and can be mounted on insects as large as honey bees, but their relatively short measurable range (usually a few centimeters) limits their use (Nunes-Silva et al., 2019). The retroreflector-based tracking system can track the behavior of honeybees within 35 m at a low cost (Smith et al., 2021), but it is difficult to acquire numerous individuals in a short period.

This chapter, which is already published (Matsuzawa and Kohsaka, 2022) supported this knowledge gap by presenting a preliminary experiment of the effects of fences and setbacks on honey bee flight height, as these are often set within the regulations of urban beekeeping. Since current measurements of flight heights of insects are still in progress, this chapter also provided methodological implications of using a 3D laser scanner, which is non-destructive, does not attach observers to the insects, and can accurately acquire a large amount of data in a short time, to localize the bees. The experimental setup and other methods are elaborated in the succeeding sections. The data acquired in this work were then statistically analyzed to examine the effects of the fence location and height as well as the distance from the hives on flight height. The findings presented in this chapter provide valuable data for improving urban beekeeping management and implementing evidence-based regulations.

4.1. Experimental Setup, Procedures, and Analyses

The experimental apiary site, which is a 32 x 42 m open cropland is located at the Uchino, Oshino-mura village, Minamituru-gun, Yamanashi prefecture, Japan (35°27’19.44” N, 138°52’29.73” E) (Figure 4.1). It is situated in a perfectly flat agricultural field, with an area of 4 km in the east-west direction and 2 km in the north-south direction. There are some fields of cabbage and corn around this agricultural field. The elevation is 963 m and the site is surrounded by mountains with altitudes ranging from 1200 to 1500 m. The preliminary half-day experiment and observations were conducted from 7:00 to 13:00 on 20 August 2021 to minimize variables such as weather, blooming conditions of nectar plants, and honey bee populations. The weather was sunny with occasional clouds and scattered rains at the end of the experiment.

Three powerful hives of honey bees, *Apis mellifera*, were imported from another apiary, which was located 5 km away from the experimental site, at midnight two days prior to the start of the experiment. These hives were installed on concrete blocks facing west-northwest and kept at a 1 m distance from each other. The entrances of the hives were located 15 cm above the ground and opened during the daytime before the day of the study. The area for analyzing the location of honey bees was defined as 30 m in front of the hive, 10 m in the lateral direction, and 20 m towards the sky, using the entrance of the central hive as the origin point of the Euclidean space (Figure 4.2).

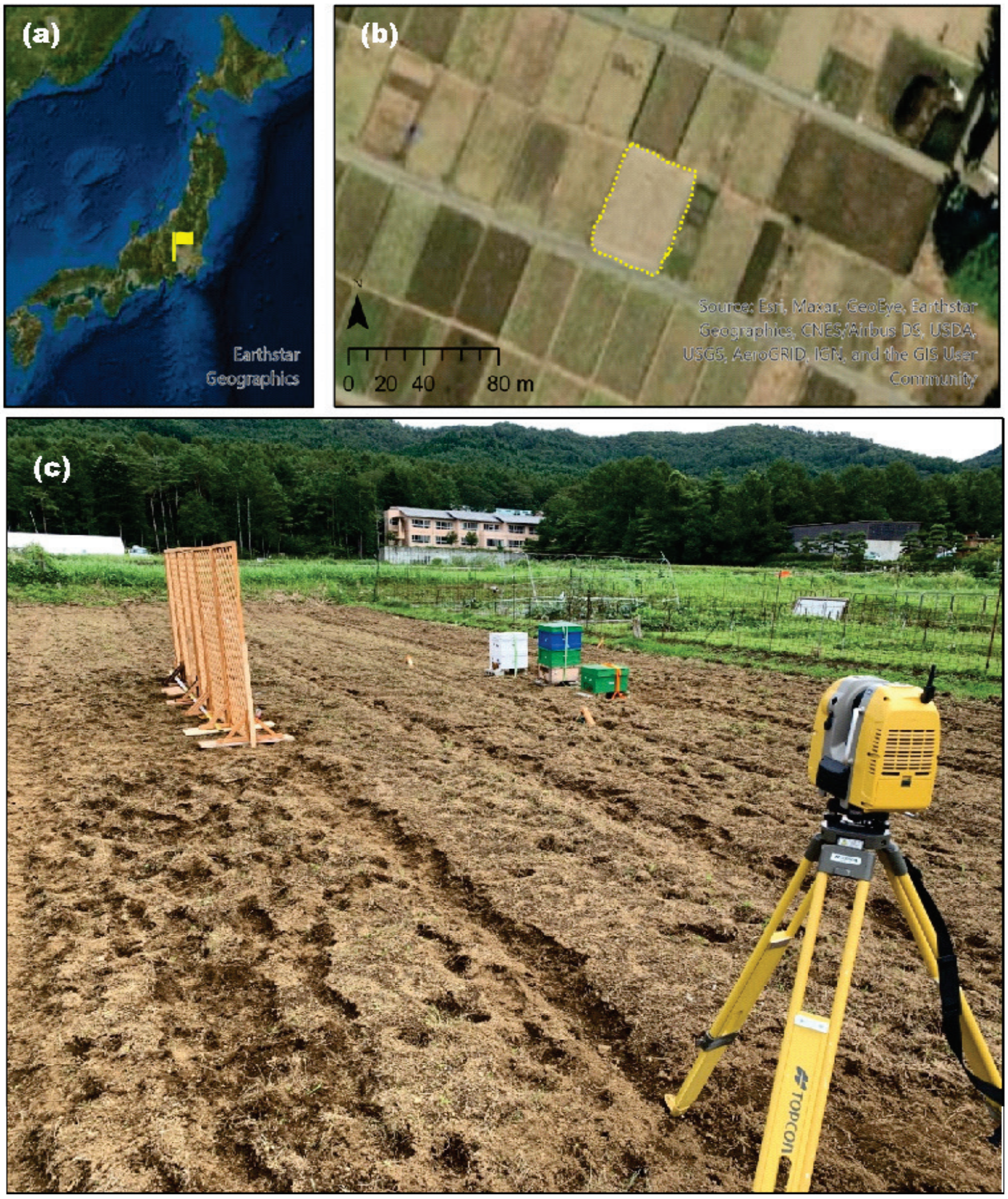

Figure 4.1. (a) Site of the experimental apiary in Japan; (b) Aerial image of the experimental apiary; (c) Hives and lattice fences installed in the experimental apiary, with a 3D laser scanner set next to the lattice fence (Photographed in the Yamanashi Prefecture, August 2021 by the author) (retrieved from Matsuzawa and Kohsaka, 2022).

In a previous study (Garbuzov and Ratnieks, 2014), no significant difference was recorded between lattice fences and hedges as types of barriers; thus, in this experiment, the lattice fence was used, which was relatively easy to install. Two heights (low and high) of wooden skeleton lattice fences ("lattice fence 90×180 cm", Cainz Co. Ltd., Honjo-shi, Saitama, Japan) were constructed as barriers. The low barriers had a height of 90 cm and a width of 540 cm while the high barriers had a height of 180 cm and a width of 540 cm. These heights were chosen based on the previously conducted comprehensive review by Matsuzawa and Kohsaka (2021), where most cases in the United States have heights ranging from 90 (180 cases) to 180 cm (156 cases).

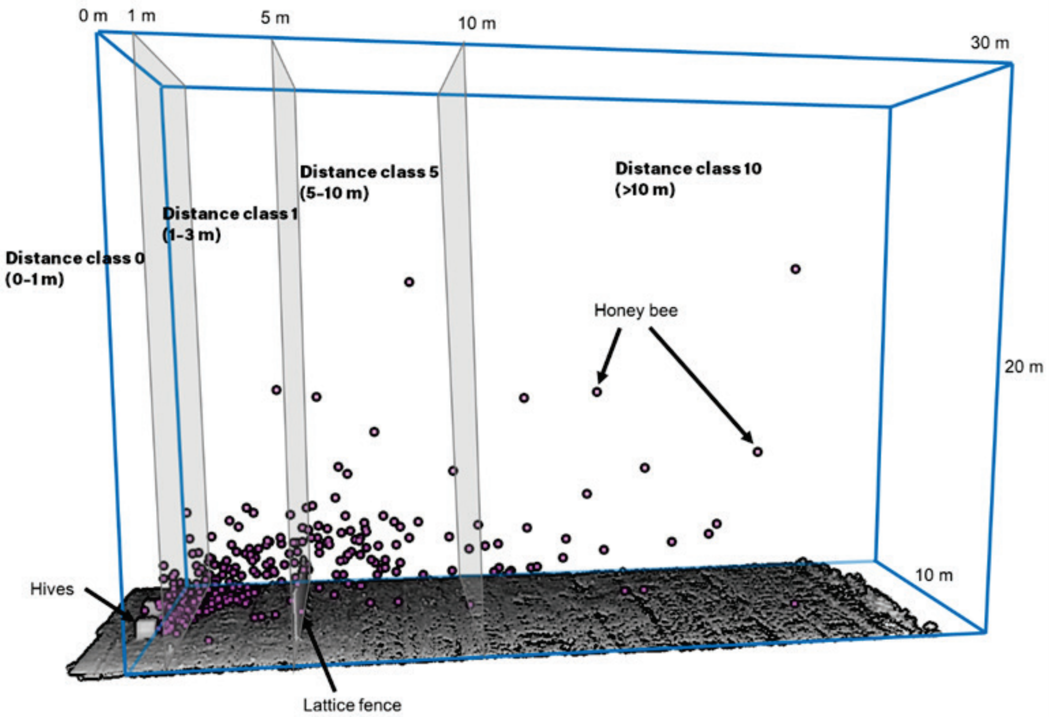

Figure 4.2. Layout of the experimental apiary. The lattice fence was placed 1 m or 5 m from the hive, and the 3D laser scanner was placed directly next to the lattice fence (retrieved from Matsuzawa and Kohsaka, 2022).

These fences were installed within a few minutes and placed at 1 m or 5 m from the hive entrance (Figure 4.2). Honeybees memorize the height of the barrier, which can influence the flying height (Garbuzov and Ratnieks, 2014). Thus, to minimize the effect of memory, five different fence types were installed, as reflected in Table 4.1. Each of the lattice fences had gaps through which bees could pass. However, bees passing through the fences were rarely observed throughout the experiment. Although the lattice fence used in this experiment has gaps, the effect of raising the flight heights of bees can be enhanced by using a solid wall or dense vegetation.

Table 4.1. The types of fences installed and their corresponding sequence and time. (modified from Matsuzawa and Kohsaka, 2022).

Fence Type	Distance from Hives	Height of Barrier	Experimental Sequence and Time
A	None	None	1st (7:34–)
B	Far (5 m)	Low (0.9 m)	2nd (8:46–)
C	Far (5 m)	High (1.8 m)	3rd (9:52–)
D	Near (1 m)	Low (0.9 m)	4th (11:15–)
E	Near (1 m)	High (1.8 m)	5th (12:20–)

To determine any data error caused by animals other than honeybees, we conducted a flying animal capture test the day before the experiment. In this test, we installed an insect net with a diameter of 50 cm on a pole 250 cm in length and swept while walking 500 times at various heights to capture flying animals. A total of eighteen individuals of six insect species were captured (Table 4.2). All insects except *Apis mellifera* and *Vespa simillima* were smaller than 2 mm, so they would not be detected by the laser beam profiler. During the experiment, butterflies (Nymphalidae gen. sp.), beetles (Scarabaeidae gen. sp.), and barn swallows (*Hirundo rustica*) passed through the experimental area less than five times. Hence, most of the plots detected by the laser scanner in this study were considered as honey bees.

Table 4.2. List of the insects captured in the sweeping test, which was conducted 500 times in the experimental apiary (modified from Matsuzawa and Kohsaka, 2022).

Scientific Name	Body Size (mm)	Number of Individuals (%)
Apis mellifera	12–14	13 (72%)
Vespa simillima	22	1 (5.6%)
Psilopa polita	2	1 (5.6%)
Phoridae gen. sp.	1	1 (5.6%)
Drosophilidae gen. sp.	1	1 (5.6%)
Aphididae gen. sp.	1	1 (5.6%)

The locations of honey bees were detected using a GLS-2200 laser scanner (Topcon Corporation, Tokyo, Japan) in high-speed mode, with 120,000 laser points/s (Class 3R) covering the entire experimental area. The laser, which was irradiated at a density of 12.5 mm and a distance of 10 m from the instrument, was placed just beside the barriers outside the analysis space (10 × 30 × 20 m). This machine was developed to create high-quality 3D images by irradiating more than 100,000 lasers per second in all directions. Due to the high density of lasers, flying objects in space can be detected, but such data are usually considered as "noise". These "noises" in this methodology were used as the location data points of the honey bees. Since the size of a honey bee is approximately 12–14 mm, one individual that would correspond to one point was considered.

Though a single scan can capture the entire apiary, 24 scans were completed for each of the five fence types to increase the number of samples. Though, there were 22 scans completed for fence type 5 due to rain. Each scan took approximately 1 min and 30 s, and the data from the 24 or 22 scans were merged into one for each fence type in the application. The number of plots of honey bees captured by the 3D scanner is shown in Table 4.3. The obtained point cloud data were manually segmented into bees and background using the point cloud processing application QuickStitch (EIVA, Skanderborg, Denmark). The point cloud data were then converted to relative locations from the origin, and the distances from the hive were classified into four categories (distance0: 0–1 m, distance1: 1–5 m, distance5: 5–10 m, and distance10: >10 m) for statistical analysis.

Table 4.3. Number of honey bee plots observed by the 3D scanner (modified from Matsuzawa and Kohsaka, 2022).

Fence Type	Height and Distance	Number of Honey Bee Plots	Number of Honey Bee Plots in the Analysis Space (W 10 m×L 30 m×H 20 m)
A	No barrier	2007	845
B	Far–Low	3004	752
C	Far–High	1190	634
D	Near–Low	1099	633
E	Near–High	1329	671
Total	-	8629	3535

The data collected from the flight height measurements were used to analyze the effects of the distance between the hive and the barrier and those of the height of the barrier on the flight height of the honey bees. All statistical analyses were performed using EZR (Easy R) software (Kanda, 2013), which is a modified version of R commander designed to provide statistical functions frequently used in biostatistics. Friedman’s test was used to determine the differences between the fence types (A–E) and distance classes (0, 1, 5, and 10). When statistically significant differences (significance level was set at 5%) were detected among the groups, a Bonferroni correction was used for multiple comparisons.

4.2. Results

Analysis was conducted to evaluate the null hypothesis of this study, which states that the population followed a normal distribution. Based on the Shapiro–Wilk normality test, all combinations excluding one case (fence type A × distance 10) were not normally distributed ($p < 0.05$), thus rejecting the null hypothesis. The same test was conducted for the flight height dataset and similar results were obtained, rejecting the null hypothesis. Based on the normality test results, non-parametric methods were used to further analyze the data.

The Friedman test performed for fence type and distance class showed significant differences between all types and classes ($p < 0.001$). Bonferroni's multiple comparisons were then conducted as a post-hoc test. For fence type, fence type C had a lower flying height than that of all the other fence types ($p < 0.001$, Figure 4.3a). For the distance class, all combinations were significantly different ($p < 0.001$, Figure 4.3b), and the flying height increased with the distance from the hives.

Kruskal–Wallis test was also conducted based on the set conditions, and the results showed a significant difference for distance class 0 ($p < 0.001$) (Figure 4.4a), distance class 1 ($p < 0.001$) (Figure 4.4b), and distance class 5 ($p < 0.001$) (Figure 4.4c). However, for distance class 10, the results did not show any significant difference ($p = 0.69$) (Figure 4.4d). Subsequently, Bonferroni's post-hoc pairwise comparison tests were performed on combinations for which significant differences were detected ($p < 0.05$). For distance class 0 (0–1 m from the hives), the results showed a significant difference in fence types D (D > A, $p = 0.025$), E (E > A, $p < 0.001$), and C (C < A, <0.001) (Figure 4.4a). For distance class 1 (1–5 m from the hives), the results showed a significant difference in fence types E (E > A, $p < 0.001$) and C (C < A, $p < 0.001$) (Figure 4.4b). For distance class 5 (5–10 m from the hives), the results showed a significant difference in fence types E (E > A, $p < 0.022$) and C (C > A, $p < 0.001$ and C > B, $p < 0.001$) (Figure 4.4c).

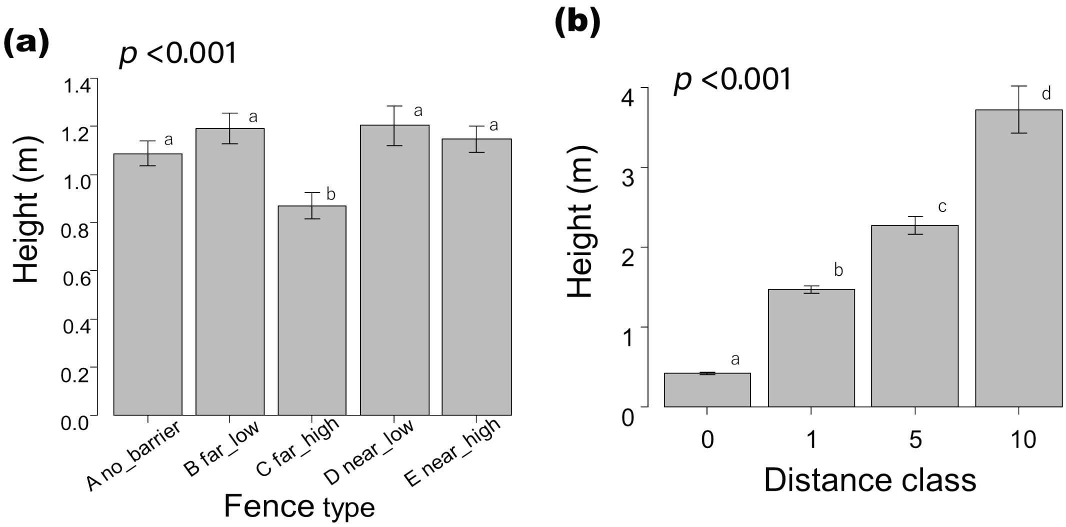

Figure 4.3. Difference in flying height by (a) fence type and (b) distance class. Letters above the error bars represent the results of Bonferroni's post-hoc pairwise comparison test. Error bar heights are means ± standard error (retrieved from Matsuzawa and Kohsaka, 2022).

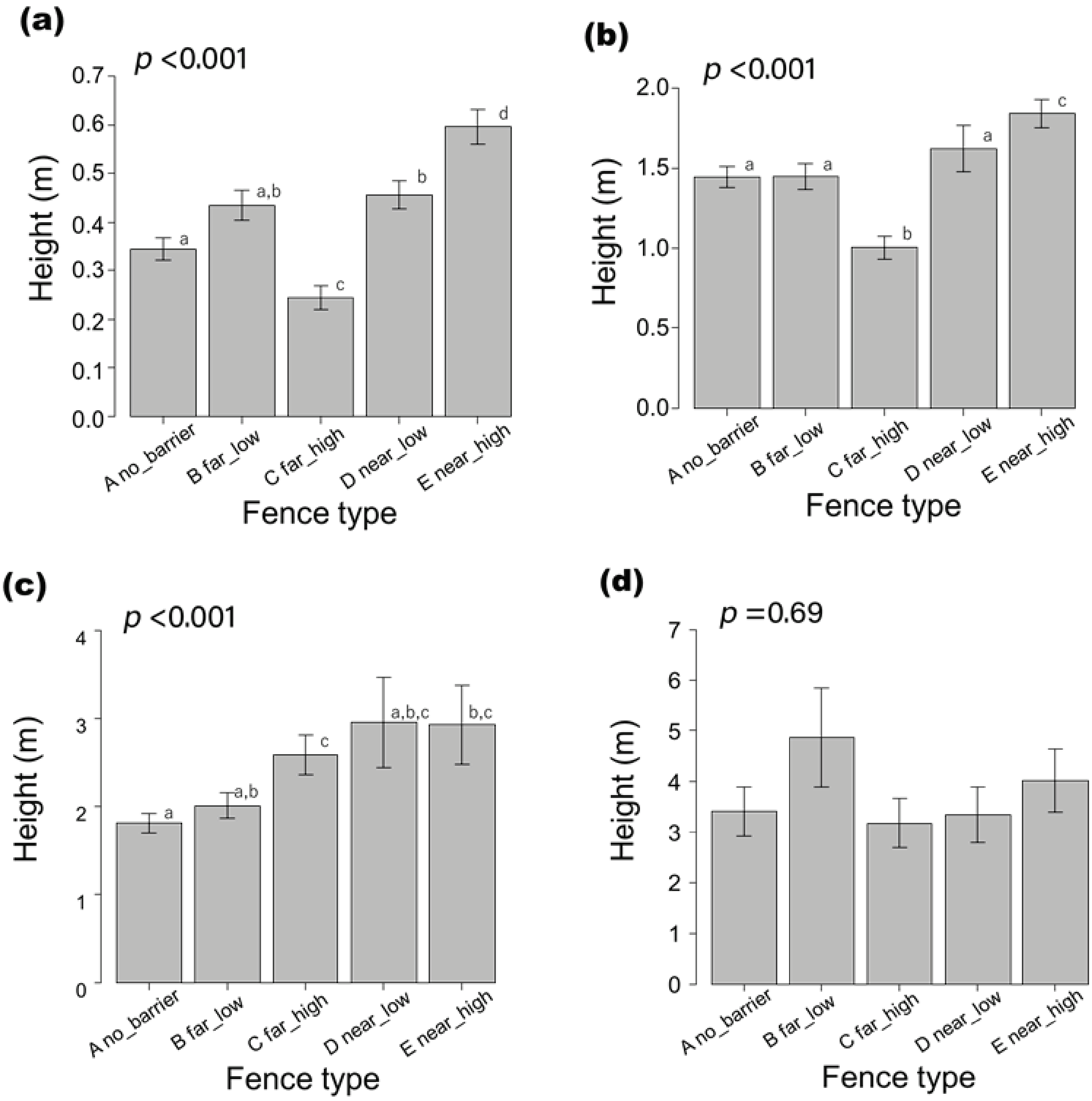

Figure 4.4. Effect of fence type on flight altitude. Average flying height for (a) distance class 0 (0–1 m), (b) distance class 1 (1–5 m), (c) distance class 5 (5–10 m), and (d) distance class 10 (>10 m). (a–c) showed significant differences among fence types, while (d) showed no significant differences. Letters above the error bars represent the results of Bonferroni's post-hoc pairwise comparison test. Bar heights are the means ± standard error (retrieved from Matsuzawa and Kohsaka, 2022).

4.3. Discussions

4.3.1. Effectiveness of the Barriers - Location and Height

The purpose of this study is to reveal the effect of barrier installation on the flight height of honey bees. The three evaluated parameters, which included the fence position, height, and distance from the hives, were found to affect the flight height of honey bees. The barriers were effective at increasing the flight height both at 1 and 5 m from the hives. However, the honey bees are likely to increase their flight height with distance from the hives regardless of the presence of the fences (Garbuzov and Ratnieks, 2014). Therefore, barriers are more likely to be effective if placed closer to the hives.

In this study, 1.8 m (6 ft) and 0.9 m (3 ft) high barriers were used, and both showed positive effects on the flight height, although the effect of the 1.8 m barrier was greater. Fence type E (1.8 m barrier placed 1 m away from the front of the hives) showed an average flight height of 1.84 m (±0.09, standard error) at distance class 1 (1–5 m from the hives), and fence type C (1.8 m barrier placed 5 m away from the front of the hives) showed an average flight height of 2.59 m (±0.22, standard error) at distance class 5 (5–10 m from the hives). Based on these results, it can be expected that this system will be effective at preventing nuisance regardless of its location. These further suggest that fences in-stalled as close as 1 m from the hives are sufficiently effective. These findings can have regulatory implications for designing apiaries in urban spaces, where the location of fences is often restricted.

For all five fence types, the flying height tended to increase with distance. Even in the case of no barrier (fence type A), the average height in distance classes 5 (5–10 m) and 10 (>10 m) was 1.81 and 3.41 m, respectively. This indicates that even without a fence, if there is enough distance to the property boundary, nuisance to people is unlikely to occur, illustrating the effectiveness of the setback.

If the setback is too large, it could be a disincentive for urban beekeeping. The City of Ontario, Canada, has a 30 m setback, while the Osaka Prefecture, Japan, has a 20 m setback requirement, which essentially prohibits urban beekeeping (Askham, 2013; Matsuzawa and Kohsaka, 2022). It may be worthwhile for these cities to re-examine whether they can make their setback provisions shorter.

4.3.2. Limitations and Implications

Though this study is a preliminary in nature, significant results were obtained. Quite simply, both the barrier and the setback had the effect of increasing the flying height. Nevertheless, future studies can increase the number of experiments, days, and sites, as Garbuzov and Ratnieks (2014) observed. Long-term effects of fencing relative to different seasons can also be investigated.

Another limitation of this work is the accuracy of detecting flying objects other than honey bees flying more than 3 m above the ground. To improve this methodological flaw, it is recommended to use a more multifunctional laser device such as wing-beat modulation LiDAR. These devices have been successfully used (Chen et al., 2014; Tauc et al., 2019). With a more multifunctional laser device, it may be possible to identify species and analyze their migration speed and direction. Having said this, the use of a 3D laser scanner was effective in obtaining 8529 points of highly accurate flight location data in about five hours, without attaching any sensing devices to the bees. This suggests the applicability of the equipment in measuring flight heights. Moreover, the data collected can be analyzed and processed in just a few hours, which is much faster than analyzing video images or using radio transmitters.

This study focused on the average flying height of honey bees. There might be a number of honey bees flying more than the average height, which could bother people. Thus, increasing the number of flight variations (e.g., lower altitudes) in future studies is recommended. Garbuzov and Ratnieks (2014) argued that honey bees memorize the height of the barriers, so the raising effect is unlikely to appear immediately after the installation of the barriers. Contrastingly, the results of this study revealed that the barrier raised the flight height even immediately after installation. In the future, more long-term observations, considering the memory effects, before and after the installation of the fence can be conducted.

The regulations on urban beekeeping may not be based on scientific evidence, although there are various provisions such as the number of hives, density, setbacks, and barrier height. It is not recommended that over-regulation reduces the various benefits that urban beekeeping could provide. Governments need to develop rules to enable urban beekeeping while ensuring safety (Salkin, 2012), yet, future studies are required (e.g., the application of environmental DNA analysis to honey bees' behavior [Matsuzawa et al., 2020]) to provide a scientific basis for the regulations, as was done in this study.

Urban beekeeping brings a variety of benefits, but also risks, so it is crucial that appropriate regulations exist (Egerer and Kowarik, 2020; Matsuzawa and Kohsaka, 2022). Existing regulations on urban beekeeping often include regulatory items, such as the number and density of hives, water supply, as well as barriers and setbacks. The effects of barriers, however, have rarely been tested (Garbuzov and Ratnieks, 2014). The approach of this study can be used as a guideline in examining and providing evidence for the effects of these regulatory items.

Chapter 5. Potential of Environmental DNA Analysis

As the IPBES assessment report suggested, management pollination services are an urgent global task (IPBES, 2016). In these circumstances, urban beekeeping is gaining salience in terms of various aspects including ecosystem diversity, genetic diversity of honeybee, and educational practices. Although the size of urban areas is relatively small as compared with farmland and other habitats of honeybees, these areas have roles in maintaining genetic diversity of organisms and enhancing the environmental awareness of citizens as suggested by existing studies (Kohsaka et al., 2017; Nagamitsu et al., 2016) and urban beekeeping is expected as a main way of beekeeping. In the promotion of urban beekeeping, the lack of scientific evidence of behavior of urban honeybee is a serious issue. To provide scientific evidence, the results presented in Chapter 3 suggest environmental DNA (e-DNA) analysis can be instrumental in detecting or estimating the detail of nectar sources.

Identification of honey-source plants with e-DNA analysis technique has been tried since around 2010 (Figure 5.1, Idea Consultants, Inc., unpublished as of 2020). It has demonstrated certain advantages over the conventional pollen analysis, but it is not empirically verified that the level of contribution of each honey-source plant accurately (Bruni et al., 2015; Hawkins et al., 2015). For instance, in the paddy fields in Fukushima Prefecture, beekeeping has been conducted with hairy vetches, *Vicia villosa* after their decontamination, with the aim to produce a local honey specialty for sale. Thorough analysis on radioactivity is in place for food safety and has been verified with the eDNA analysis technique that the product is honey from *Vicia villosa*. Although DNA is an effective indicator of honey-source plants, most honey products do not show the results of their DNA analysis. In Gifu Prefecture where beekeeping is active, it is indicated on the label on some of the honey products that they are from cherries and ilexes by their DNA analysis, but this is one of the few examples.

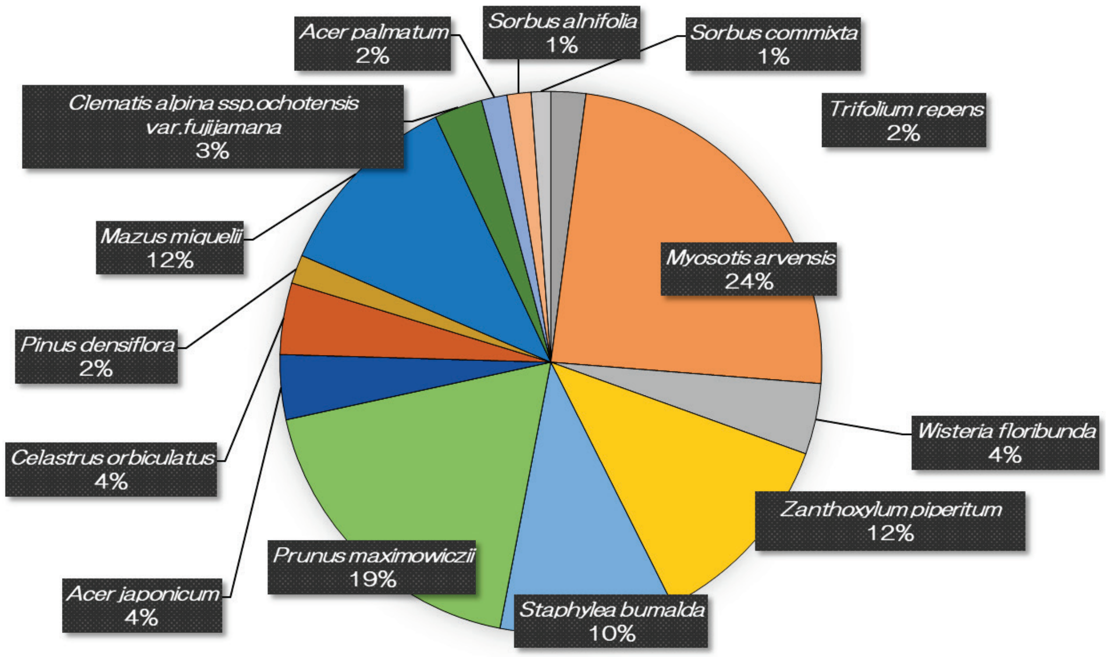

Figure 5.1. Ratio of plants identified as a honey source (Data retrieved from Idea Consultants, Inc., unpublished as of 24 May 2016).

This chapter is based on the published peer-reviewed book chapter (Matsuzawa et al., 2020), which presents the potential application of e-DNA analysis to urban beekeeping regulations. The results of the analysis enable better understanding of the flora of the areas around the hives. This method is limited to the identification of plant DNAs that were visited by bees. Furthermore, this method may not show a correlation between the amount of DNA and the volume of existing plants. Despite these disadvantages, honey e-DNA analysis is an effective tool to verify the general trends of honey origins. The discussions presented in this chapter can be applied to other cases and contribute to accumulating the scientific evidence for making relevant policies of urban beekeeping.

5.1. Environmental DNA Analysis

Verifying the quality of high value-added honey is important for the development of healthy beekeeping industry. Thus, e-DNA analysis can be a constructive tool to identify origins in case the list on the label contains a plant species that do not grow in the local area or does not contain the DNA that should be detectable as a species on the product label, thus misrepresenting the honey and its origin. However, this method is limited to the identification of plant DNAs that were visited by bees, and it will not show a correlation between the amount of DNA and the volume of existing plants. Despite these disadvantages, honey e-DNA analysis is an effective tool to verify the general trends of honey origins.

In this chapter, e-DNA analysis was conducted to identify the nectar source of honey produced domestically and compare them with those products sold in the supermarket. The DNA was extracted based on the methods of Hawkins et al. (2015) and amplified the DNA using the ITS-p3/ITS-u4 primer pair (Cheng et al., 2016). Then, the DNA metabarcoding of the plant contained in honey was implemented using the next-generation sequencer MiSeq.

5.2. Results

The e-DNA analyses were conducted on 14 honey products purchased at high-end supermarkets in Tokyo (Table 5.1). Acacia single-flower honey is much sought after in Japan, and it is traded at a high price. The DNA of False acacia (*Robinia pseudoacacia*) was detected in all of the seven well-known acacia brands, but it was found to be a dominant source in four of them. The rest of the products contained DNA of *R.*

pseudoacacia as its second dominant source. In some of those sold as honey from a single source such as astragalus, ilex, amur cork, buckwheat, or manuka, these nominal source plants were not the dominant sources, or in extreme cases, their DNA was not detected at all. The results further revealed that none of the products sold as single-flower honey/monofloral were actually from a single source, which is not surprising since honeybees visit various flowers. For instance, astragalus honey made in Tokyo is from three sources while 18 source plants were detected in another astragalus honey made in Fukuoka. Some of the honey brands tested had plants containing toxic alkaloids as their source plants.

More than half of the products contained plant DNA on the label, but in certain products, they were not detected (Table 5.1). For example, DNA of Manuka (*Leptospermum scoparium*) was not detected in the Manuka honey analyzed in this study. Manuka honey may have been shipped after aging for several years after the harvest, so it is possible that DNA degraded during their aging period because the DNA is generally unstable and fragile. Since it breaks down over time, there is a possibility that the labeled honey source cannot be detected by DNA analysis, even in case it is correct. However, this sample remains suspicious because it has confirmed several plant DNAs normally growing in New Zealand. Following the accusation that their Manuka honey was fake, the New Zealand authority has mandated DNA analysis for their Manuka honey since 2018 (Ministry for Primary Industries, 2019).

The results of the analyses also showed unique interesting insights about bee movement capacity. For instance, in the honey produced near Mt. Fuji (on the side of Yamanashi Prefecture), the DNA of several types of plants that were not identified in and around the production area were detected. One of them, *Gaultheria pyroloides*, distributes in the alpine area of Mt. Fuji, which was more than 8 km away in terms of horizontal distance and 1500 m in vertical distance from the beehives. This simple result provides two possibilities: that this plant grows at low altitudes or the bees fly over a distance of more than 8 km. Another insight was detecting the DNA of a lot of woody plants in the honey produced, which was typically thought to be sourced from grassland plants. This finding was supported by previous studies, where woody plants are more prominent as nectar plants than previously thought (Masaka et al., 2013).

The analyses also found that the DNA of the Varroa mite (*Varroa destructor*) was detected in the honey throughout the seasons. Most of the time during the study period, these parasites were not found through visual inspection, suggesting the applicability of e-DNA analysis in detecting them. In general, the amount of DNA in a sample is correlated with the abundance of organisms. Therefore, by monitoring the amount of the DNA of the Varroa mite in honey, the level of parasite damage can be predicted in advance and help provide early countermeasures.

Analysis of whole eukaryotes using the e-DNA analysis revealed the presence of aphid DNA. The presence of the DNA of aphids and scale insects in honey suggests that the honey is honeydew. Honeydew honey is produced not from nectar, but from refined honeydews by parasite insects on plants. It is widely produced as a specialty product in Germany and New Zealand. In Japan, honeydew honey was not detected until 2019. The bees kept in the forest make dark honey in August when there are few flowers. It was assumed that the honey would contain honeydew but with this result, it is identified that honeydew honey is a constituent in the honey produced domestically (Table 5.2).

Table 5.1. Result of the environmental DNA analysis of honey sold at supermarkets. The top three species with the most number of DNA reads are shaded with blue (first), yellow (second), and orange (third).

Type	Monofloral											Mixed		
Labeling name and Country	"Manuka" *Leptospermum scoparium*	"Kihada" *Phellodendron amurense*	"Soba" *Fagopyrum esculentum*	"Acacia" *Robinia pseudoacacia*							"Tochinoki" *Aesculus turbinata*	–	Forest	Alpine plant
Specific name	New Zealand	Tokyo, Japan	Tokyo, Japan	India	Romania	Switzerland	Okayama, Japan	Saitama, Japan	Kyoto, Japan	Tokyo, Japan	Okayama, Japan	Mexico	Switzerland	Switzerland
Asteraceae spp.1	34767	66624	54573	1	596	877	3971	273	497	371	7853	38068	2642	15
Robinia pseudoacacia	3			13640	63643	40622	18815	18583	20915	14749				49
Quercus sp.	2413		1	8	890	1223	3558	2784	2121	2809	35956	208	1600	3
Toxicodendron sp.			187	54		9	3753	28996	9758	2059	1439		2	21
Rosaceae spp.1	840	589		2014	2422	865	4634	3321	1725	2803	28530		324	1
Actinidia sp.	1560	18107	387			6	4070	577	28172	106	467		1	72
Persoonia spp.	27832													
Wisteria floribunda				15		12	3438	5863	3205	23550	8569		21	9
Fabaceae spp.3	790		3	2	1	2	301	1759	1499	2	246		2342	4
Prunus sp.1			1	278	3279	1846	4491	15956	5396	8330	7245		648	3
Lauraceae spp.	1236												14884	
Aesculus turbinata						2	490		122	645	14680		27	
Dalbergia sp.				13117										
Cryptocarya sp.												1	12754	
Prosopis sp.				10885								1	57	
Pterospermum heterophyllum												10169		4
Prunus sp.4			1		3	5	11	20	16	13	18		1	
Rosa sp.	2		1	1396	9395	6972	2786	2013	6905	4859	392		5092	14
Rosaceae spp.2	1082					1		110	460	583	1275		6039	3
Myrtaceae spp.1		2		1107									7856	
Asteraceae spp.2		1						1				7202		
Weinmannia spp.	6997													
Acer sp.				2	2	1	373	890	285	400	6540		22	

Type	**Monofloral**											**Mixed**		
Labeling name and Country	"Manuka" *Leptospermum scoparium*	"Kihada" *Phellodendron amurense*	"Soba" *Fagopyrum esculentum*	"Acacia" *Robinia pseudoacacia*							"Tochinoki" *Aesculus turbinata*	–	Forest	Alpine plant
Picrasma quassioides				13		8	1971	6440	339		675		1	
Anacardiaceae spp.1				6403										
Fabaceae spp.1	457				6199	4678	688		7				35	
Prunus sp.2				3			461	1174	2483	6184	4733		10	5
Prunus sp.3				3			461	1174	2483	6184	4733		10	5
Populus sp.	3147			5511		89								
Lysiloma sabicu												5237		
Monimiaceae spp.	5039													
Melicytus spp.	4766													
Asteraceae spp.3			1	1468		13	4763	2920	145	183		1818	1310	
Lopezia langmaniae												4747	318	
Argemone mexicana												4092		
Filipendula vulgaris					3850									1
Cornus controversa				11		2	254	3680	549	824	1561			
Kerria japonica								92	63	6	3583		11	
Podocarpus sp.	3430													
Leucaena leucocephala				3387								159		
Asparagus sp.			1676			100	1346		1926					2
Phellodendron amurense			48			4	1549	379	1692	46	614		1	4
Asteraceae spp.4	20	1158	80									1		
Number of detected species	31	11	16	31	21	36	36	38	42	31	30	23	45	25
Presence of labeling species	N.D.	N.D.	N.D.	1st	1st	1st	1st	2nd	2nd	2nd	3rd	–	–	–

Table 5.2. List of other organisms identified in the environmental DNA analysis of honey produced domestically.

Kingdom	Phylum	Class	Order	Family	Genus	Scientific name	Total Reads
Animalia	Chordata	Mammalia	Primates	Hominidae	*Homo*	*Homo sapiens*	48
	Mollusca	Bivalvia	Venerida	Veneridae	*Ruditapes*	*Ruditapes philippinarum*	3202
	Arthropoda	Insecta	Hemiptera	Aphididae		Aphididae spp.	42
		Arachnida	Acari	Varroidae	*Varroa*	*Varroa destructor*	41227
			Mesostigmata	Phytoseiidae	*Neoseiulus*	*Neoseiulus womersleyi*	46
			Opiliones	Phalangiidae		Phalangiidae spp.	53
			Prostigmata	Eriophyidae		Eriophyidae spp.	439
						Eriophyidae spp.	45
Fungi	Ascomycota	Dothideomycetes	Dothideales	Dothioraceae	*Aureobasidium*	*Aureobasidium pullulans*	4242
			Capnodiales	Cladosporiaceae	*Cladosporium*	*Cladosporium cladosporioides*	1398
		Eurotiomycetes	Chaetothyriales			Chaetothyriales sp.	85
		Saccharomycetes	Saccharomycetales	Phaffomycetaceae	*Wickerhamomyces*	*Wickerhamomyces anomalus*	7854
				Saccharomycetaceae	*Debaryomyces*	*Debaryomyces nepalensis*	419
					Saccharomycetales	*Saccharomycetales* sp.	3527
					Zygosaccharomyces	*Zygosaccharomyces rouxii*	15261
				incertae sedis	*Kodamaea*	*Kodamaea ohmeri*	289
					Starmerella	*Starmerella bombicola*	4372
	Basidiomycota	Basidiomycota	Microbotryomycetes		*Curvibasidium*	*Curvibasidium pallidicorallinum*	1137
	incertae sedis		Mucorales			Mucorales spp.	3110
Apicomplexa		Conoidasida	Neogregarinorida	Lipotrophidae	*Apicystis*	*Apicystis bombi*	752

5.3. Discussion

As described in the results, several findings from the novel approach of e-DNA analysis are to be derived from pollination services to product level. In summary, e-DNA analysis has the potential to contribute to six domains – pollination services, apicultural products, pest control, safety, biological conservation, and community formation, which are all important points to be considered in urban beekeeping regulations. The discussions are illustrated below from urban beekeeping from a variety of perspectives.

5.3.1. Pollination Services, Apicultural Products, and Pest Control

The e-DNA analysis revealed that honey bees in urban areas use a variety of plants, including both native species and artificially introduced plants. Though the pollination function of crops may not seem to be a significant contribution in urban areas at first glance, it can contribute to pollination of fruit trees that ordinary citizens plant in their gardens.

There were a few findings from the bee behaviors and apicultural products level as well. The price of honey varies depending on the origin and nectar source (Ministry of Finance of Japan, 2021; Ota, 2021). In general, the price of monofloral nectar from a single nectar source is high in Japan, and the price of multifloral nectar is low. If the nectar plants are located and targeted well for the pollinators, pollinations may lead to higher values of the honeys. In current practices, the honey produced from urban beekeeping remains at lower prices due to scattered nectar sources.

The nectar plants in the label did not necessarily match the indicated on the label differed from the actual nectar sources of the from the e-DNA analysis results. Interpretations of these results have significant commercial implications and require further considerations. There are two possible explanations: first, bees may not access the nectar plants assumed by the beekeeper. Second, bees may have used honeys from a completely different source. What will be a possible way forward to cope with these challenges? In New Zealand, one of the largest exporters of honey bees (Ministry of Finance of Japan, 2021) made DNA-based analysis mandatory for manuka honey for export since 2018 (Kato, 2019; McDonald et al., 2018). Such measures may contribute to high value-added by making it possible to determine the authenticity of honey being produced.

Identification of sources is not exclusively about verifications of authenticity. The measures can be applied to highlight the values of the products. For example, the honey contained DNA from a variety of non-nectar organisms. Such data are instrumental in controlling parasites, pests and infectious diseases. In particular, there were cases where Varroa mite DNA was detected, which may well be a sensitive method of analysis for detection. It was not possible to examine the mites' existence with the naked eye in the hive. As general indicator, the overall number of DNA reads during e-DNA analysis can serve as rough benchmark of the abundance of organisms (di Muri et al., 2020; Pukk et al., 2021). Thus, changes in such reads may serve as early alerts trends of parasites or other diseases in a honey bee hives.

5.3.2. Safety, Biological Conservation, and Community Formation

The implications for the safety are less straightforward and the extents to which e-DNA analysis can contribute to improving safety are rather still limited. As general principle, the analysis can distinguish between different groups of bees, therefore in incidents of nuisances such as stinging and droppings occurs, it may be possible to identify which group caused the damage. However, no research has been conducted in the relevant fields yet, thus, these are subject for future investigation.

The e-DNA analysis has implications for biological conservations as well. Analysis of DNA in pollen from a hive of honeybees kept in central Tokyo showed that it reflected to a certain extent the amount of vegetation present in the surrounding area (Pouilloux, 2019; Tanaka et al., 2020). By identifying the nectar source plants in honey, this may lead to evaluation of potential biodiversity conservation efforts by visualizing the values of the honey through its pollination functions.

In urban areas, there is large number of diverse land managers and there are places which are not freely accessible. Honey bees can transcend such barriers and move freely in the environment and the results of e-DNA can serve as a monitoring indicator of plant biodiversity in urban spaces.

As discussed in the results, the honey from Yamanashi Prefecture, a large amount of *Gaultheria pyroloides* DNA was identified in the honey. However, the commonly known habitat of the tree species is more than 8 km away from the apiary. For a long time, honeybees were believed to fly within a range of two kilometers (Seeley, 2009). Analysis of DNA in pollen collected by bees suggested that bees could fly about 4km (Tanaka et al., 2020). Analysis of the honeybee dances showed that they could fly to nectar sources more than 10 km away, but no evidence was found (Beekman and Ratnieks, 2000). Our result implies that either there is an unrecognized habitat near the apiary, or the bees fly more than 8 km. It remains to be seen which are the cases, but the results demonstrate the high potential of the e-DNA analysis, which may lead to new discoveries useful in conservation biology.

Lastly, the applications of e-DNA have concrete contributions to the community as well. For instance, Meiji University analyzed the phenology of nectar plants around the campus by conducting e-DNA analysis of honey collected from hives set up on campus at various seasonal times through the collaboration with companies and residents who have planted the relevant nectar plants (Omori, 2021). This collaboration promotes active engagements of ordinary citizens in scientific activities.

In Kyodo-no-Mori, Setagaya-ku, Tokyo, people are working together to manage honeybee hives set up on the roof of a housing complex. This is an environmental housing complex with green spaces, where residents gather on weekends to hold small parties after the harvests. Such activities contribute to form community and connect ties amongst residents. While planting nectar plants, the residents also conducted e-DNA analysis of the honey to confirm the effectiveness of the planting. They also sell portions of the harvest at a high price. Such branding and relevant conservations efforts may also contribute to increased values in real estate by promoting greening of the property.

From this study, it is suggested that the e-DNA analysis is a constructive tool that reflects the ecology and behavior of plants and bees themselves, and can support and motivate the background of various environmental initiatives. Such functions are instrumental for community building as described in the cases above.

Chapter 6. Conclusions

This study was conducted to identify whether proper governance exists for urban beekeeping, which has been expanding in recent years. The regulatory elements are analyzed first, and what kind of rules and regulations are needed. This study, which evaluated the current status, problems, and solution policies of urban beekeeping rules using both social and natural science approaches, provides a valuable contribution to the government that manages urban beekeeping, particularly in Japan, where rules and regulations are lacking and existing beekeeping policies are rather weak.

Results of the analyses identified six functions of urban beekeeping, namely: pollination, biological conservation, pest control, safety, apicultural products, and community building. In addition, the benefits and risks of each function were documented. In certain areas of the world (e.g., United States, Australia), where urban beekeeping is currently practiced, the systematic reviews conducted identified the legal and different regulatory items such as “Setbacks” and “Installation of barriers.” While most of these regulations are geared towards ensuring public safety, little scientific evidence was found.

In the case of Japan, there are no legal rules for urban beekeeping, and the legal governance of general beekeeping is weak, making it difficult to collect the information necessary for proper governance. Although, this study was able to document that it was considered appropriate for prefectures to formulate regulations and guidelines on urban beekeeping in the current situation. In addition, guidelines by NGOs, such as beekeeping associations and research institutes, are thought to be effective in formulating rules for local governments.

The condition that regulations of urban beekeeping should take is a balanced view of all six functions in order to maximize the benefits while minimizing the risks of urban beekeeping.

In addition, ecological analysis was conducted so that scientific evidence, particularly those related to setbacks or height of fence installation can be evaluated. It is critical to be able to reflect regional characteristics to respond to the diversity of the local social and/or natural environment based on scientific findings and empirical experiments this study have demonstrated. For example, that the installation of a 1.8m high barrier and a 10m setback are effective in ensuring safety based on the discussions in chapter 4. The flyway was raised by installing a lattice fence. Higher fences can increase the flying height of honey bees. A fence 1 m from the hive was adequately effective at raising the flying height. In order to strengthen the legal governance of urban beekeeping, the adoption of new technologies can be effective as reflected in the application of 3D laser scanner methods in this study, which showed promising results. For instance, this study confirmed that using 3D scanners represents an effective method for measuring small flying insects. Although, more work is needed to provide evidence for at least some of the regulatory items such as the barriers, setbacks, and watering supply.

The analysis of honey using e-DNA was able to identify nectar and pollen source plants. The e-DNA analysis is useful in analyzing the components in honey, and is also likely to contribute in the context of the six functions of urban beekeeping: revealing nectar plants and phenology in urban areas, conservation of urban biodiversity, contribution to ecology and behavior, value addition and authenticity of honey, environmental education, and community building. Furthermore, the results of the analysis enable better understanding of the correlation between the amount of DNA and the volume of existing plants and the general trends of honey origins. The findings of this study can be applied to other cases and contribute to accumulating the scientific evidence for making relevant policies of urban beekeeping.

Future studies could also look into socio-ecological contexts of urban beekeeping, (e.g., Larson et al. 2020; Sponsler and Bratman 2021). Fostering collaborations among different stakeholders (e.g., citizens, research institutions) is instrumental to secure commitments to urban beekeeping in the context of pollinator conservation (Gallay 2018; Nicholls et al. 2020). However, at the local scale, collaborations among different sectors are common challenges in biodiversity monitoring and management practices (Uchiyama and Kohsaka 2019; Shih et al. 2020). Nevertheless, from methodological perspectives, stakeholders' perceptions in urban–rural settings are found to record good appropriate information regarding the environment (e.g., Uchiyama and Kohsaka 2021, Quevedo et al. 2021a; Imai et al. 2018) and effective in providing feedback to management policies (e.g., Kohsaka et al. 2017; Quevedo et al. 2021b; Kohsaka 2010).

References

Akamatsu, E., & Nakamura, J. (2002). Questionnaire survey on "fecal drops of bees" as a new problem of beekeeping in Japan. *Honeybee Science*, *23*(1), 5–11.

Alger, S. A., Burnham, P. A., Boncristiani, H. F., & Brody, A. K. (2019). RNA virus spillover from managed honeybees (*Apis mellifera*) to wild bumblebees (*Bombus* spp.). *PLOS ONE*, *14*(6), e0217822-. https://doi.org/10.1371/journal.pone.0217822

Al-Ghamdi, A., Adgaba, N., Getachew, A., & Tadesse, Y. (2016). New approach for determination of an optimum honeybee colony's carrying capacity based on productivity and nectar secretion potential of bee forage species. *Saudi Journal of Biological Sciences*, *23*(1), 92–100. https://doi.org/10.1016/j.sjbs.2014.09.020

Anderson, D., & Trueman, J. W. H. (2000). Anderson, D. L. & Trueman, J. W. H. *Varroa jacobsoni* (Acari: Varroidae) is more than one species. Exp. App. Acarol. 24, 165-189. *Experimental & Applied Acarology*, *24*, 165–189. https://doi.org/10.1023/A:1006456720416

Askham, B. (2013). Urban buzz. *Sanctuary: Modern Green Homes*, *25*, 76–79.

Baldock, K. C. R. (2020). Opportunities and threats for pollinator conservation in global towns and cities. *Current Opinion in Insect Science*, *38*, 63–71. https://doi.org/https://doi.org/10.1016/j.cois.2020.01.006

Barnett, L. (2011, October 20). *Why London's beekeepers are a growing band | The Independent*. The Indipendent. https://www.independent.co.uk/environment/why-londons-beekeepers- are-a-growing-band-476750.html

Beekman, M., & Ratnieks, F. L. W. (2000). Long-range foraging by the honey-bee, *Apis mellifera* L. *Functional Ecology*, *14*(4), 490–496.

Berquist, M., Bird, A., Dean, M. G., Law, R. B., Lee, S., & Panesar, H. (2012). *Towards a New Approach to Beekeeping Policy in Urban Ontario At the request of Sustain Ontario*. https://sustainontario.com/custom/uploads/2012/12/FINAL-REPORT-Urban-Beekeeping-Policy-in-Ontario-December-2012.pdf

Bruni, I., Galimberti, A., Caridi, L., Scaccabarozzi, D., de Mattia, F., Casiraghi, M., & Labra, M.

(2015). A DNA barcoding approach to identify plant species in multiflower honey. *Food Chemistry*, *170*, 308–315. https://doi.org/10.1016/j.foodchem.2014.08.060

Chen, Y., Why, A., Batista, G., Mafra-Neto, A., & Keogh, E. (2014). Flying insect classification with inexpensive sensors. *Journal of Insect Behavior*, *27*(5), 657–677.

Cheng, T., Xu, C., Lei, L., Li, C., Zhang, Y., & Zhou, S. (2016). Barcoding the kingdom Plantae: New PCR primers for ITS regions of plants with improved universality and specificity. *Molecular Ecology Resources*, *16*(1), 138–149. https://doi.org/10.1111/1755-0998.12438

City News Service. (2015, October 14). *Backyard beekeeping OK'd by City of Los Angeles – Daily News*. Los Angeles Daily News. https://www.dailynews.com/2015/10/14/backyard-beekeeping-okd-by-city-of-los-angeles/

Colorado State Beekeepers Association. (2017). *Best Management Practices for Urban, Suburban and Small-Scale Beekeeping*. http://coloradobeekeepers.org/education/colorado-beekeeping-associations-and-Wellington City Council guidelines for community gardens, 1.

Dakota City, Nebraska Code of Ordinances Chapter 6-Animals, (2018). https://library.municode.com/ne/dakota_city/codes/code_of_ordinances?nodeId=COOR_CH6AN_ARTIIBE

Daniel, S. (2018, March 15). *Why do some Sydney councils encourage urban beekeeping but avoid handling complaints?* ABC Premium News. https://www.abc.net.au/news/2018-03-15/ urban-beekeeping-curious-sydney-why-some-councils-dont-regulate/9492094?nw=0&r=Interactive

Davenport, J. (2012, June 15). *Celebrity beekeepers told to buzz off*. London Evening Standard. https://www.standard.co.uk/news/london/celebrity-beekeepers-told-to-buzz-off-7854420.html

di Muri, C., Lawson Handley, L., Bean, C. W., Li, J., Peirson, G., Sellers, G. S., Walsh, K., Watson, H. v, Winfield, I. J., & Hänfling, B. (2020). Read counts from environmental DNA (eDNA) metabarcoding reflect fish abundance and biomass in drained ponds. *Metabarcoding and Metagenomics*, *4*, 97–112.

Dixon, L. (2012). *Keeping bees in towns & cities*. USA, Timber Press: 2012. https://www.thereallygoodbookshop.com.au/product/1539/Keeping-Bees-in-Towns-and-Cities-

Luke-Dixon

Egerer, M., & Kowarik, I. (2020). Confronting the Modern Gordian Knot of Urban Beekeeping. In *Trends in Ecology and Evolution* (Vol. 35, Issue 11, pp. 956–959). Elsevier Ltd. https://doi.org/10.1016/j.tree.2020.07.012

Feás, X. (2020). Human Fatalities Caused by Hornet , Wasp and Bee Stings in Spain : Epidemiology at State and Sub-state Level from 1999 to 2018. *Biology*, *10*(73). https://doi.org/10.3390/biology10020073

Fontana, P., Costa, C., di Prisco, G., Ruzzier, E., Annoscia, D., Battisti, A., Caoduro, G., Carpana, E., Contessi, A., Dal Lago, A., Dall'olio, R., de Cristofaro, A., Felicioli, A., Floris, I., Fontanesi, L., Gardi, T., Lodesani, M., Malagnini, V., Manias, L., … Segrè, A. (2018). Appeal for biodiversity protection of native honey bee subspecies of Apis mellifera in Italy (San Michele all'Adige declaration). *Bulletin of Insectology*, *71*(2), 257–271.

Forrester, J., Forrester, J., Tennakoon, L., & Staudenmayer, K. (2018a). Mortality, hospital admission, and healthcare cost due to injury from venomous and non-venomous animal encounters in the USA: 5-year analysis of the National Emergency Department Sample. *Trauma Surgery & Acute Care Open*, *3*. https://doi.org/10.1136/tsaco-2018-000250

Forrester, J., Weiser, T., & Forrester, J. (2018b). An Update on Fatalities Due to Venomous and Nonvenomous Animals in the United States (2008–2015). *Wilderness & Environmental Medicine*, *29*. https://doi.org/10.1016/j.wem.2017.10.004

Fujiwara, S., & Murakami, T. (2000). *Japanese honeybees: the practice of native beekeeping* (Japanese Original Honeybee Organization, Ed.). Rural Culture Association Japan. http://ci.nii.ac.jp/ncid/BA4675482X.bib

Gallay, C. (2018). Beeware of the Consequences: The Importance of Urban Apiaries and Environmental ADR. *The Cardozo Journal of Conflict Resolution*, *20*, 417–442.

Garbuzov, M., & Ratnieks, F. L. W. (2014). Lattice fence and hedge barriers around an apiary increase honey bee flight height and decrease stings to people nearby. *Journal of Apicultural Research*, *53*(1), 67–74. https://doi.org/10.3896/IBRA.1.53.1.06

References

Ginza -Mitsubachi-Project. (2008). *Ginza -Mitsubachi-Project*. http://www.gin-pachi.jp/owner

Gratzer, K., Susilo, F., Purnomo, D., Fiedler, S., & Brodschneider, R. (2019). Challenges for Beekeeping in Indonesia with Autochthonous and Introduced Bees. *Bee World*, *96*(2), 40–44. https://doi.org/10.1080/0005772X.2019.1571211

Gross, C. L., Whitehead, J. D., Mackay, E. S. G., Mackay, K. D., Andrew, N. R., & Paini, D. (2019). Interactions between two species of recently-sympatric invasive honeybees: *Apis cerana* induces aggression in *Apis mellifera* during foraging. *Biological Invasions*, *21*(12), 3697–3706. https://doi.org/10.1007/s10530-019-02081-y

Hawkins, J., de Vere, N., Griffith, A., Ford, C. R., Allainguillaume, J., Hegarty, M. J., Baillie, L., & Adams-Groom, B. (2015). Using DNA metabarcoding to identify the floral composition of honey: A new tool for investigating honey bee foraging preferences. *PLoS ONE*, *10*(8), 1–20. https://doi.org/10.1371/journal.pone.0134735

Henry, M., Beguin, M., Requier, F., Rollin, O., Odoux, J.-F., Aupinel, P., Aptel, J., Tchamitchian, S., & Decourtye, A. (2012). A common pesticide decreases foraging success and survival in honey bees. *Science*, *336*(6079), 348–350.

Henry, M., & Rodet, G. (2018). Controlling the impact of the managed honeybee on wild bees in protected areas OPEN. *Scientific Reports*, *8*, 9308. https://doi.org/10.1038/s41598-018-27591-y

Herbertsson, L., Lindström, S. A. M., Rundlöf, M., Bommarco, R., & Smith, H. G. (2016). Competition between managed honeybees and wild bumblebees depends on landscape context. *Basic and Applied Ecology*, *17*(7), 609–616. https://doi.org/10.1016/j.baae.2016.05.001

Hiroshima Prefecture, Livestock Division, Agriculture, Forestry and Fisheries Bureau, (2021). Hiroshima Prefecture Beekeeping Guidelines.

Hoover, S. E., & Ovinge, L. P. (2018). Pollen collection, honey production, and pollination services: managing honey bees in an agricultural setting. *Journal of Economic Entomology*, *111*(4), 1509–1516.

Imai, H., Nakashizuka, T., & Kohsaka, R. (2018). An analysis of 15 years of trends in children's connection with nature and its relationship with residential environment. *Ecosystem Health and Sustainability*, *4*(8), 177–187.

Inoue, M. N., Yokoyama, J., & Washitani, I. (2008). Displacement of Japanese native bumblebees by the recently introduced *Bombus terrestris* (L.) (Hymenoptera: Apidae). *Journal of Insect Conservation*, *12*(2), 135–146. https://doi.org/10.1007/s10841-007-9071-z

Japan Beekeeping Association. (1995). Changes in the beekeeping industry from agriculture, forestry and fisheries statistics. *Honeybee Science*, *16*(2), 85–89. http://ci.nii.ac.jp/naid/120006357823/ja/

Japan Beekeeping Association. (2019). *The history of beekeeping in Japan*. http://www.beekeeping.or.jp/beekeeping/history/japan

Japan Beekeeping Association. (2021). *Beekeeping in Japan*. Japan Beekeeping Association. http://www.beekeeping.or.jp/circumstances/domestic

Kato, Y. (2019). Characteristics of Manuka honey and its functions. *Journal of Home Economics of Japan*, *70*(2), 97–101.

Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences*, *274*(1608), 303–313. https://doi.org/10.1098/rspb.2006.3721

Kohsaka, R. (2010). Developing biodiversity indicators for cities: applying the DPSIR model to Nagoya and integrating social and ecological aspects. *Ecological Research*, *25*(5), 925–936.

Kohsaka, R., Park, M. S., & Uchiyama, Y. (2017). Beekeeping and honey production in Japan and South Korea: past and present. *Journal of Ethnic Foods*, *4*(2), 72–79. https://doi.org/10.1016/j.jef.2017.05.002

Kudler, A. G. (2015, October 15). *Backyard Beekeeping is Finally Legal in Los Angeles*. Curbed LA. https://la.curbed.com/2015/10/15/9911092/backyard-beekeeping-los-angeles

Laboratory of Apiculture and Social Insects. (2013, August 15). *Rise in urban beekeeping in UK may have gone too far, scientists warn*. University of Sussex. http://www.sussex.ac.uk/

broadcast/read/20465

Larson, K. L., Andrade, R., Nelson, K. C., Wheeler, M. M., Engebreston, J. M., Hall, S. J., Avolio, M. L., Groffman, P. M., Grove, M., Heffernan, J. B., Hobbie, S. E., Lerman, S. B., Locke, D. H., Neill, C., Chowdhury, R. R., & Trammell, T. L. E. (2020). Municipal regulation of residential landscapes across US cities: Patterns and implications for landscape sustainability. *Journal of Environmental Management*, *275*, 111132. https://doi.org/10.1016/j.jenvman.2020.111132

le Conte, Y., Ellis, M., & Ritter, W. (2010). Varroa mites and honey bee health: can Varroa explain part of the colony losses? *Apidologie*, *41*(3), 353–363.

Lichterman, C. (2018, August 10). *The People Keeping Bees on Paris's Most Famous Landmarks-Bees make honey on the rooftops of the Notre Dame and Musée d'Orsay*. https://www.atlasobscura.com/articles/urban-beekeeping-in-paris

Lindström, S. A. M., Herbertsson, L., Rundlöf, M., Bommarco, R., & Smith, H. G. (2016). Experimental evidence that honeybees depress wild insect densities in a flowering crop. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1843). https://doi.org/10.1098/rspb.2016.1641

Lorenz, S., & Stark, K. (2015). Saving the honeybees in Berlin? A case study of the urban beekeeping boom. *Environmental Sociology*, *1*(2), 116–126. https://doi.org/10.1080/23251042.2015.1008383

Lu, R., Zhao, X., Li, J., Niu, P., Yang, B., Wu, H., Wang, W., Song, H., Huang, B., Zhu, N., Bi, Y., Ma, X., Zhan, F., Wang, L., Hu, T., Zhou, H., Hu, Z., Zhou, W., Zhao, L., … Tan, W. (2020). Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *The Lancet*, *395*(10224), 565–574. https://doi.org/https://doi.org/10.1016/S0140-6736(20)30251-8

Masaka, K., Sato, T., & Tanahashi, I. (2013). Use of Honey Source Trees in Apiculture: *Journal of the Japanese Forest Society*, *95*(1), 15–22. https://doi.org/10.4005/jjfs.95.15

Matsuzawa, T., & Kohsaka, R. (2021). Status and Trends of Urban Beekeeping Regulations: A Global Review. *Earth 2021, Vol. 2, Pages 933-942*, *2*(4), 933–942. https://doi.org/10.3390/EARTH2040054

Matsuzawa, T., & Kohsaka, R. (2022). Preliminary Experimental Trial of Effects of Lattice Fence Installation on Honey Bee Flight Height as Implications for Urban Beekeeping Regulations. *Land*, *11*(1). https://doi.org/10.3390/land11010019

Matsuzawa, T., Kohsaka, R., & Uchiyama, Y. (2020). *Application of Environmental DNA: Honey Bee Behavior and Ecosystems for Sustainable Beekeeping*. https://doi.org/10.5772/intechopen.92717

Mavrofridis, G. (2018). *Urban beekeeping in Antiquity Grådsko pčelarstvo v antičnosti*. *2*(1), 52–61.

McDonald, C. M., Keeling, S. E., Brewer, M. J., & Hathaway, S. C. (2018). Using chemical and DNA marker analysis to authenticate a high-value food, manuka honey. *Npj Science of Food*, *2*(1), 9. https://doi.org/10.1038/s41538-018-0016-6

Ministry for Primary Industries, N. Z. (2019). *Mānuka honey | MPI | NZ Government*. https://www.mpi.govt.nz/growing-and-harvesting/honey-and-bees/manuka-honey/

Ministry of Finance of Japan. (2021). *Trade Statistics of Japan*. https://www.customs.go.jp/toukei/info/index_e.htm

Ministry of Internal Affairs and Communications. (2013, October 13). *Director-General for Policy Planning (Statistical Standards) | Japan Standard Industrial Classification*. https://www.soumu.go.jp/english/dgpp_ss/seido/sangyo/index.htm

Mitsumori, Y. (2020). An Analysis of Impact of Urban Beekeeping Projects on Community: Ginza Bee Projects brought not only bees, but also a more sophisticated image to Ginza. *2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC)*, 1–7.

Moore, L. J., & Kosut, M. (2013). *Buzz: urban beekeeping and the power of the bee*. New York University Press.

Moriarty, R. T. (2018). Backyard Beekeeping in the Beehive State: Salt Lake City's Beekeeping Regulations, Nuisance Concerns, and the Legal Status of Honey Bees. *Utah Law Review*, *2018*. https://heinonline.org/HOL/Page?handle=hein.journals/utahlr2018&id=247&div=&collection=

Moriyama, H. (2011). Beekeeping changes the city. *Green Power*, *388*, 22–23. http://www.gin-pachi.jp/uploads/general/7e8f6d2508083916dfb5941027fcb979d1fd583d.pdf

Mullins, M. (2018, January 8). *The Buzz in Paris: Rooftop Beehives, Honey and Urban Beekeeping*.

https://bonjourparis.com/food-and-drink/paris-beekeeping-and-honey/

Muranaka, T., Ishii, J., Miyawaki, S., & Washitani, I. (2005). Vascular plants to be designated as Invasive Alien Species according to the Invasive Alien Species Act of Japan. *Japanese Journal of Conservation Ecology*, *10*(1), 19–33. https://doi.org/10.18960/hozen.10.1_19

Nagamitsu, T., Yasuda, M., Saito-Morooka, F., Inoue, M. N., Nishiyama, M., Goka, K., Sugiura, S., Maeto, K., Okabe, K., & Taki, H. (2016). Genetic Structure and Potential Environmental Determinants of Local Genetic Diversity in Japanese Honeybees (*Apis cerana japonica*). *PLoS One*, *11*(11). https://doi.org/10.1371/journal.pone.0167233

Nanetti, A., Bortolotti, L., & Cilia, G. (2021). Pathogens Spillover from Honey Bees to Other Arthropods. *Pathogens 2021, Vol. 10, Page 1044*, *10*(8), 1044. https://doi.org/10.3390/PATHOGENS10081044

National Coroners Information System/NCIS. (2011). *ANIMAL-RELATED DEATHS* (Issue March).

New York City Beekeepers Association. (2018). *NYCBA's Best Practices for Beekeeping*. New York City Beekeepers Association. http://www.bees.nyc/nycbas-best-practices-for-beekeeping

National Institute for Environmental Studies (NIES). (2021). *Invasive Species of Japan --A portal site of alien species of Japan--*. https://www.nies.go.jp/biodiversity/invasive/index_en.html

Noel, A., le Conte, Y., & Mondet, F. (2020). *Varroa destructor*: how does it harm Apis mellifera honey bees and what can be done about it? *EMERGING TOPICS IN LIFE SCIENCES*, *4*(1), 45–57. https://doi.org/10.1042/ETLS20190125

Nunes-Silva, P., Hrncir, M., Guimarães, J. T. F., Arruda, H., Costa, L., Pessin, G., Siqueira, J. O., de Souza, P., & Imperatriz-Fonseca, V. L. (2019). Applications of RFID technology on the study of bees. *Insectes Sociaux*, *66*(1), 15–24. https://doi.org/10.1007/s00040-018-0660-5

Ogihara, M., Yoshiyama, M., Morimoto, N., & Kimura, K. (2020). Dominant honeybee colony infestation by *Varroa destructor* (Acari: Varroidae) K haplotype in Japan. *Applied Entomology and Zoology*, *55*, 1–9. https://doi.org/10.1007/s13355-020-00667-w

Omori, M. (2021). Connecting students with the local environment and people through urban beekeeping. Available here (https://www.meiji-sdgs.jp/articles/efforts/1046/)

Osaka Prefecture, Rules for Enforcement of Ordinance on Regulation of Keeping Bees in Osaka Prefecture, (1968). https://www.pref.osaka.lg.jp/houbun/reiki/reiki_honbun/k201RG00000678.html

Ota, T. (2021). Beneficiary Response to a Provisioning Service produced by Pollinators. *Journal of Human and Environmental Symbiosis*, *37*(1), 65–69. https://doi.org/10.32313/jahes.37.1_65

Paynter, G. (2015). *Review of Legislation, By-laws, Ordinances , Regulations and Guidelines Regarding Urban Beekeeping*. *2015*(7860), 1–7.

Potts, S., Imperatriz-Fonseca, V. L., Ngo, H. T., Biesmeijer, J., Breeze, T., Dicks, L., Garibaldi, L., Settele, J., Vanbergen, A., Aizen, M., Cunningham, S., Eardley, C., Freitas, B., Gallai, N., Kevan, P., Kovács-Hostyánszki, A., Kofi, K., Li, X., Li, J., & Viana, B. (2016). *Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) on pollinators, pollination and food production*.

Pouilloux, L. (2019). *Urban honey beekeeping using hive-pollen to identify urban foraging sites and preferred vegetation communities in Japan* [Université de Liège, Liège, Belgique]. https://matheo.uliege.be/handle/2268.2/7769

Pritchard, D. J. (2016). Grooming by honey bees as a component of varroa resistant behavior. *Journal of Apicultural Research*, *55*(1), 38–48. https://doi.org/10.1080/00218839.2016.1196016

Production Bureau Livestock Department, Ministry of Agriculture, F. and F. of J. (2017). *The current status of beekeeping in Japan*. https://www.maff.go.jp/j/chikusan/kikaku/lin/sonota/pdf/h29hachimeguji.pdf

Pukk, L., Kanefsky, J., Heathman, A. L., Weise, E. M., Nathan, L. R., Herbst, S. J., Sard, N. M., Scribner, K. T., & Robinson, J. D. (2021). eDNA metabarcoding in lakes to quantify influences of landscape features and human activity on aquatic invasive species prevalence and fish community diversity. *Diversity and Distributions*, *27*(10), 2016–2031.

Quevedo, J. M. D., Uchiyama, Y., & Kohsaka, R. (2021a). A blue carbon ecosystems qualitative assessment applying the DPSIR framework: Local perspective of global benefits and contributions. *Marine Policy*, *128*, 104462.

References

Quevedo, J. M. D., Uchiyama, Y., & Kohsaka, R. (2021a). Linking blue carbon ecosystems with sustainable tourism: Dichotomy of urban–rural local perspectives from the Philippines. *Regional Studies in Marine Science*, *45*, 101820.

Quevedo, J. M. D., Uchiyama, Y., & Kohsaka, R. (202b). A blue carbon ecosystems qualitative assessment applying the DPSIR framework: Local perspective of global benefits and contributions. *Marine Policy*, *128*, 104462.

Rahimian, R., Shirazi, F. M., Schmidt, J. O., & Klotz, S. A. (2020). Honeybee Stings in the Era of Killer Bees: Anaphylaxis and Toxic Envenomation. *The American Journal of Medicine*, *133*(5), 621–626. https://doi.org/https://doi.org/10.1016/j.amjmed.2019.10.028

Rahimian, Rombod; Shirazi, F Mazda; Schmidt, Justin O; Klotz, S. A., Rahimian, R., Shirazi, F. M., Schmidt, J. O., & Klotz, S. A. (2020). Honeybee Stings in the Era of Killer Bees: Anaphylaxis and Toxic Envenomation - The American Journal of Medicine. *The American Journal of Medicine*, *133*(5), 621–626. https://doi.org/DOI10.1016/j.amjmed.2019.10.028

Reynolds, D. R., & Riley, J. R. (2002). Remote-sensing, telemetric and computer-based technologies for investigating insect movement: a survey of existing and potential techniques. *Computers and Electronics in Agriculture*, *35*(2), 271–307. https://doi.org/https://doi.org/10.1016/S0168-1699(02)00023-6

Riches, K. J., Gillis, D., & James, R. A. (2002). An autopsy approach to bee sting-related deaths. *Pathology*, *34*(3), 257–262. https://doi.org/10.1080/00313020220131327

Ropars, L., Dajoz, I., Fontaine, C., Muratet, A., Geslin, B. B., Ropars, L., Dajoz, I., Fontaine, C., Muratet, A., & Geslin, B. B. (2019). Wild pollinator activity negatively related to honey bee colony densities in urban context. *PLoS ONE*, *14*(9), 1–16. https://doi.org/10.1371/journal.pone.0222316

Rosenkranz, P., Aumeier, P., & Ziegelmann, B. (2010). Biology and control of *Varroa destructor*. *Journal of Invertebrate Pathology*, *103*, S96–S119. https://doi.org/https://doi.org/10.1016/j.jip.2009.07.016

Rothman, L. (2015). *London's Urban Beekeeping Scene Is Exploding*. https://www.vice.com/en_us/article/z4gd44/londons-urban-beekeeping-scene-is-exploding

Sakamoto, Y., Maeda, T., Yoshiyama, M., Konno, F., & Pettis, J. S. (2020). Differential autogrooming response to the tracheal mite *Acarapis woodi* by the honey bees *Apis cerana* and *Apis mellifera*. *Insectes Sociaux*, *67*(1), 95–102. https://doi.org/10.1007/s00040-019-00732-w

Salkin, P. E. (2012). *Honey , It ' s All the Buzz : Regulating Neighborhood Beehives*. *39*(1), 55–71.

Sanuki, S., Oishi, T., & MIwa, J. (2010). The present state of development of thick growth of trees and vegetaion management in class A rivers. *Advances in River Engineering*, *16*(1), 241–246.

Sasaki, M. (1999). *Wonders of the Japanese honeybee : biology of northernmost apis cerana*. Kaiyusha. http://ci.nii.ac.jp/ncid/BA39867983.bib

Seeley, T. D. (2009). *The wisdom of the hive: the social physiology of honey bee colonies*. Harvard University Press.

Sheppard, W. S., & Meixner, M. D. (2003). *Apis mellifera* pomonella, a new honey bee subspecies from Central Asia. *Apidologie*, *34*(4), 367–375. https://doi.org/10.1051/APIDO:2003037

Shih, W.-Y., Mabon, L., & de Oliveira, J. A. P. (2020). Assessing governance challenges of local biodiversity and ecosystem services: Barriers identified by the expert community. *Land Use Policy*, *91*, 104291.

Shimane Prefecture Beekeeping Guidelines, Agriculture and Livestock Division, Agriculture, Forestry and Fisheries Department, Shimane Prefecture (2020).

Shinkai, R., SPIEGELBERG Maximilian, RUPPRECHT, C., & Tamura, N. (2020). The importance of collecting basic data on beekeeping in Japan: issues and ideas for reform based on an analysis of differences between prefectural application forms for beekeeping registrations. *Sustainable Livestock Production and Human Welfare*, *74*, 921–929.

Shizuoka Prefecture, Livestock Division, Agriculture and Forestry Bureau, Economy and Industry Department, (2013). Shizuoka Prefecture Beekeeping Guidelines.

Skelton, J. (2006). Adventures in Urban Beekeeping. *Briarpatch*, *35*(4), 14–17. https://search.proquest.com/docview/204487081?accountid=12653

Smith, D. (2015, October 14). *Los Angeles passes urban beekeeping law*. Daily News. https://www.dailynews.com/2015/10/14/los-angeles-passes-urban-beekeeping-law/

References

Smith, M. T., Livingstone, M., & Comont, R. (2021). A method for low-cost, low-impact insect tracking using retroreflective tags. *METHODS IN ECOLOGY AND EVOLUTION*, *12*(11), 2184–2195. https://doi.org/10.1111/2041-210X.13699

Sponsler, D. B., & Bratman, E. Z. (2021). Beekeeping in, of or for the city? A socioecological perspective on urban apiculture. *People and Nature*, *3*(3), 550–559. https://doi.org/10.1002/pan3.10206

Stokstad, E. (2018, April 27). *European Union expands ban of three neonicotinoid pesticides*. Science; American Association for the Advancement of Science (AAAS). https://doi.org/10.1126/science.aau0152

Subbarao, K., Klimov, A., Katz, J., Regnery, H., Lim, W., Hall, H., Perdue, M., Swayne, D., Bender, C., & Huang, J. (1998). Characterization of an avian influenza A (H5N1) virus isolated from a child with a fatal respiratory illness. *Science*, *279*(5349), 393–396.

Sugiura, K. (2013). History of the Domestic Animal Infectious Diseases Control Law. *Japanese Journal of Veterinary History*, *50*(1), 1–14.

Sukhdev, P., Wittmer, H., Schröter-Schlaack, C., Nesshöver, C., Bishop, J., ten Brink, P., Gundimeda, H., Kumar, P., & Simmons, B. (2010). *Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*. www.dieaktivisten.de

Tanaka, K., Nozaki, A., Nakadai, H., Shiwa, Y., & Shimizu-Kadota, M. (2020). Using pollen DNA metabarcoding to profile nectar sources of urban beekeeping in Kōtō-ku, Tokyo. *BMC Research Notes*, *13*(1), 515. https://doi.org/10.1186/s13104-020-05361-2

Tauc, M. J., Fristrup, K. M., Repasky, K. S., & Shaw, J. A. (2019). Field demonstration of a wing-beat modulation lidar for the 3D mapping of flying insects. *OSA Continuum*, *2*(2), 332–348. https://doi.org/10.1364/OSAC.2.000332

Terasaki, S., Yoshizaki, H., & Osada, N. (2015). Outbreaks of the European foul brood, quarantine measures, and future issues. *Proceedings of the Tokyo Metropolitan Livestock Health Performance Conference*, 34–38.

Thoms, C. A., Nelson, K. C., Kubas, A., Steinhauer, N., Wilson, M. E., & vanEngelsdorp, D. (2019).

Beekeeper stewardship, colony loss, and *Varroa destructor* management. *AMBIO*, *48*(10), 1209–1218. https://doi.org/10.1007/s13280-018-1130-z

Uchiyama, Y., & Kohsaka, R. (2021). Strategies of Destination Management Organizations in Urban and Rural Areas: Using Text Analysis Method for SWOT Descriptions at Meta-level. *International Journal of Hospitality & Tourism Administration*, 1–19.

Uchiyama, Y., & Kohsaka, R. (2019). Application of the City Biodiversity Index to populated cities in Japan: Influence of the social and ecological characteristics on indicator-based management. *Ecological Indicators*, *v. 106*, 105420--2019 v.106. https://doi.org/10.1016/ j.ecolind .2019.05.051

Uchiyama, Y., Matsuoka, H., & Kohsaka, R. (2017). Apiculture knowledge transmission in a changing world: Can family-owned knowledge be opened? *Journal of Ethnic Foods*, *4*(4), 262–267. https://doi.org/10.1016/j.jef.2017.09.002

Vancouver, C. of. (2013). *City of Vancouver Archives*. *April*, 1–4. http://vancouver.ca/ your-government/city-of-vancouver-archives.aspx

vanEngelsdorp, D., Evans, J. D., Saegerman, C., Mullin, C., Haubruge, E., Nguyen, B. K., Frazier, M., Frazier, J., Cox-Foster, D., Chen, Y., Underwood, R., Tarpy, D. R., & Pettis, J. S. (2009). Colony collapse disorder: A descriptive study. *PLoS ONE*, *4*(8). https://doi.org/10.1371 /journal.pone.0006481

Watson, K., & Stallins, J. A. (2016). Honey bees and colony collapse disorder: A pluralistic reframing. *Geography Compass*, *10*(5), 222–236.

Wilk, B., Rebollo, V., & Hanania, S. (2019). *A guide for pollinator-friendly cities: How can spatial planners and land-use managers create favourable urban environments for pollinators?* https://wikis.ec.europa.eu/display/EUPKH/Pollinator-friendly+cities?preview=/25559581/28869024/Local%20authorities%20Guidance%20document_03-03.pdf

Wong, S. S. Y., & Yuen, K. (2006). Avian influenza virus infections in humans. *Chest*, *129*(1), 156–168.

Wongsiri, S., Chanchao, C., Deowanish, S., Aemprapa, S., Chaiyawong, T., Petersen, S., &

References

Leepitakrat, S. (2000). Honey bee diversity and beekeeping in Thailand. *Bee World*, *81*(1), 20–29. https://doi.org/10.1080/0005772X.2000.11099464

Woodcock, B. A., Isaac, N. J. B. B., Bullock, J. M., Roy, D. B., Garthwaite, D. G., Crowe, A., & Pywell, R. F. (2016). Impacts of neonicotinoid use on long-term population changes in wild bees in England. *Nature Communications*, *7*(1), 12459. https://doi.org/10.1038/ncomms12459

Yamada, Y., Sone, Y., & Furuya, K. (2011). A study on honeybee projects as an activity to create chances to experience and enhance understanding of nature in an urban area. *Journal of The Japanese Institute of Landscape Architecture*, *74*(5), 585–590. https://doi.org/10.5632/jila.74.585

Yokoyama, J., & Inoue, M. N. (2010). Status of the invasion and range expansion of an introduced bumblebee, *Bombus terrestris* (L.), in Japan. *Applied Entomology and Zoology*, *45*(1), 21–27. https://doi.org/10.1303/aez.2010.21

Yoneda, M., Tsuchida, K., & Goka, K. (2008). Ecological Risks of Commercialized Bumblebee and the Invasive Alien Species Act. *Japanese Journal of Applied Entomology and Zoology*, *52*(2), 47–62. https://doi.org/10.1303/jjaez.2008.47

Appendix

Table A. List of the interview data of the local governments in Australia, the United States, and Japan.

Nations	State/Prefecture	Council/Municipality	Date of contact	Responses	Valid answers	Contact method
Australia	New South Wales	-	November 22, 2021	None		e-Mail
	South Australia	-	November 24, 2021	None		e-Mail & Contact form (HP)
	Tasmania	-	November 24, 2021	None, Unable to contact		e-Mail & Phone call
	Victoria	-	November 24, 2021	November 25, 2022	○	Contact form (HP)
	New South Wales	City of Canterbury Bankstown	November 25, 2021	None		e-Mail
	New South Wales	Coolamon Shire Council	November 25, 2021	None		e-Mail
	New South Wales	Kempsey Shire Council	November 28, 2021	None		e-Mail
	New South Wales	Muswellbrook Shire Council	November 28, 2021	December 14, 2021	○	e-Mail
	New South Wales	City of Parramatta Council	November 28, 2021	None		e-Mail
	Queensland	Gold Coast City Council	November 28, 2021	None		e-Mail
	Queensland	Livingstone Shire Council	December 6, 2021	None		e-Mail
	South Australia	Town of Gawler	November 28, 2021	None		e-Mail
	Tasmania	Hobart City Council	November 28, 2021	None		e-Mail
	Victoria	Greater Shepparton City Council	November 28, 2021	None		e-Mail
	Western Australia	Augusta-Margaret River Shire Council	November 28, 2021	None		e-Mail
	Western Australia	Bayswater City Council	November 28, 2021	November 30, 2021	○	e-Mail
	Western Australia	Belmont City Council	November 28, 2021	December 2, 2021	○	e-Mail
	Western Australia	Canning City Council	December 6, 2021	None		e-Mail
	Western Australia	Cottesloe Town Council	November 28, 2021	None		e-Mail
	Western Australia	Gosnells City Council	November 28, 2021	None		e-Mail
	Western Australia	Mundaring Shire Council	November 28, 2021	None		e-Mail

Nations	State/Prefecture	Council/Municipality	Date of contact	Responses	Valid answers	Contact method
	Western Australia	Northam Shire Council	November 28, 2021	None		e-Mail
	Western Australia	Perth City Council	November 28, 2021	None		e-Mail
	Western Australia	Rockingham City Council	November 28, 2021	December 10, 2021	○	e-Mail
	Western Australia	Victoria Park Town Council	November 28, 2021	December 7, 2021	○	e-Mail & Phone call
	Western Australia	Vincent Town Council	November 28, 2021	None		e-Mail
US	Oregon	-	July 17, 2021	July 17, 2021	○	e-Mail
	Alabama	Gadsden	December 1, 2021	Unable to contact		Phone call
	Arizona	Pima County	December 1, 2021	Unable to contact		Phone call
	Arkansas	Bella Vista City	December 1, 2021	None		e-Mail
	Arkansas	Little Rock	December 1, 2021	December 1, 2021	○	e-Mail
	California	Moraga	December 1, 2021	December 2, 2021	○	e-Mail
	Colorado	Castle Pines	December 1, 2021	None		Contact form (HP)
	Connecticut	New Britain	December 1, 2021	None		Contact form (HP)
	Georgia	College Park	December 1, 2021	December 1, 2021	○	Contact form (HP) & Phone call
	Illinois	Belvidere	December 1, 2021	None		Contact form (HP) & Phone call
	Iowa	Decorah	December 3, 2021	None		Contact form (HP)
	Louisiana	Patterson	December 3, 2021	None		e-Mail
	Massachusetts	New Bedford	December 10, 2021	None		e-Mail & Phone call
	Michigan	Grand Haven	December 3, 2021	December 8, 2021	○	Contact form (HP)
	Minnesota	Elk River	December 3, 2021	December 4, 2021	○	Contact form (HP)
	Mississippi	Vicksburg	December 3, 2021	None		Contact form (HP)
	Missouri	Maryland Heights	December 3, 2021	Unable to contact		Phone call

Nations	State/Prefecture	Council/Municipality	Date of contact	Responses	Valid answers	Contact method
	Montana	Great Falls	December 3, 2021	December 8, 2021	○	Contact form (HP)
	Nebraska	Dakota City	December 3, 2021	December 4, 2021	○	e-Mail
	North Carolina	Oak Island	December 3, 2021	None		Contact form (HP)
	Oklahoma	Lawton	December 3, 2021	None		Contact form (HP)
	Rhode Island	East Providence	December 10, 2021	None		e-Mail
	Texas	Killeen	December 3, 2021	December 7, 2022	○	e-Mail
	Virginia	Isle of Wight County	December 10, 2021	None		e-Mail
	Washington	Seattle	December 10, 2021	None		e-Mail
	West Virginia	Ranson	December 3, 2021	None		Contact form (HP)
	Wisconsin	Fitchburg	December 10, 2021	December 11, 2021	○	e-Mail
Japan	Osaka	-	December 18, 2021	December 18, 2021	○	Phone call
	Tokyo	-	December 18, 2021	December 24, 2021	○	Phone call
	Saitama	-	December 18, 2021	December 18, 2021	○	Phone call
	Hokkaido	-	December 18, 2021	December 18, 2021	○	Phone call
	Fukuoka	-	December 18, 2021	December 18, 2021	○	Phone call
	Aichi	-	December 20, 2021	December 23, 2021	○	Phone call
	Akita	-	December 20, 2021	December 20, 2021	○	Phone call
	Yamagata	-	December 20, 2021	December 22, 2021	○	Phone call
	Okinawa	-	December 20, 2021	December 20, 2021	○	Phone call
	Okinawa	Ogimi	December 20, 2021	December 20, 2021	○	Phone call