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Beekeeping Practices and Challenges in the Kingdom of Saudi Arabia: Adoption of New Technologies and Selection of Bee Species

Cover Page Footnote

Ella Poole is an undergraduate at the University of Pennsylvania studying nursing. She is also a beekeeping enthusiast and secretary of the Penn Beekeeping Club. Dr. Heather Sharkey is a professor in the Department of Near Eastern Languages and Civilization at the University of Pennsylvania. She is the faculty sponsor for this research and can be reached at hsharkey@sas.upenn.edu.

I. Introduction

Residents of the Arabian Peninsula have kept bees for nearly 4,000 years, and early Arabic literature recognized the region for its rich beekeeping industry.¹ As of 2011, an estimated 4,000 beekeepers in Saudi Arabia owned 700,000 hives and produced 3,500 tons of honey per year. The work is extremely profitable, with local honey bringing in \$58.87-77.86 per kg, about nine times the current price of honey in the U.S.A.² Saudi demand for honey is high because of its cultural and religious value. Honey is the crown jewel of the traditional Saudi iftar dish, *luqaimat*: balls of fried dough soaked in honey syrup.³ The Qur'an contains an entire *surah*, or chapter about honey, which promotes it as a healthy food with healing properties and adds to its esteem.⁴ In fact, the country imports 15,000 tons of foreign honey each year because its needs are unmet by local production. In 2014, beekeeping households in Saudi Arabia made an average of \$58,937, and that sum usually only constituted supplementary income.⁵ Because of the high domestic demand for honey and its lucrative market, the Saudi government has highlighted beekeeping as an industry that promises growth and improvement of the quality of life in rural communities. In short, the “buzz” about honey in Saudi Arabia is that Saudis value

¹ Alqarni et al. “The indigenous honey bees of Saudi Arabia (Hymenoptera, Apidae, *Apis mellifera jemenitica* Ruttner): Their natural history and role in beekeeping,” *Zookeys* 134 (2011): 83, doi: 10.3897/zookeys.134.1677

² Adgaba et al. “Socio-economic analysis of beekeeping and determinants of box hive technology adoption in the Kingdom of Saudi Arabia,” *Journal of Animal Plant Science* 24, no. 6 (2014): 1876-1884; “National Honey Report.” *United States Department of Agriculture*, October 23, 2020, <https://www.ams.usda.gov/mnreports/fvmhoney.pdf>

³ Eaton, Lorraine. “Adventures in eating: A taste of the Middle East.” *The Virginian- Pilot*. September 25, 2013. https://www.pilotonline.com/food-drink/article_37e21f72-d998-5227-9e49-bb29e5e163ec.html; “The spice is right during Ramadan.” *Gulf Weekly*, September 7, 2008. Gale OneFile: News. https://link.gale.com/apps/doc/A184555366/STND?u=upenn_main&sid=STND&xid=15a56aa7

⁴ Nayik et al. “Honey: its history and religious significance: a review.” *Universal Journal of Pharmacy* 3, no. 1 (2014): 5-8.

⁵ Adgaba et al. “Socio-economic analysis of beekeeping...”

it highly and that beekeeping is a flourishing sector of the agricultural economy with growth potential. Yet, if Saudis agree on the desirability of enhancing local honey production, they do not all agree on how the industry should be advanced.

In particular, certain government officials and academics are seeking to promote industry growth through the adoption of a new hive type—the removable-frame box hive, henceforth called a box hive—and, often, importing bees.⁶ Yet, 71% of Saudi beekeepers still use traditional hives and raise native bees, resisting these plans.⁷ Drawing upon a growing body of work on global beekeeping practices and their ecological implications, I will argue that Saudis should continue to support the keeping of native bee populations because they are better suited to the environment and do not pose a threat to native fauna like foreign bee species. I will also argue that Saudis should develop box hives that better suit their needs and optimized spatiotemporal beekeeping plans.

This paper examines articles by Saudi authors that address the economics of Saudi beekeeping, current opinions and practices of local beekeepers, bee biology and pathology, and the development of novel beekeeping technologies. I will include information from the websites of the Saudi government and the Saudi Beekeepers Cooperative Association (a quasi-governmental organization) to illustrate their involvement in the industry. I will also draw upon a few foundational texts on global beekeeping practices to provide context for the evolution of beekeeping in Saudi Arabia.

I will begin by briefly surveying the history of beekeeping in Saudi Arabia, describing traditional beekeeping practices, and noting the influence of the country's climate and geography. Next, I will introduce the concept of “modern beekeeping” and how it has impacted Saudi beekeeping. I will consider the perspectives of government officials and academics who are actively promoting new practices and the opposing public and academic concerns. I will conclude by

⁶ Alqarni et al. "Performance evaluation of indigenous and exotic honey bee (*Apis mellifera* L.) races in Assir region, southwestern Saudi Arabia." *Saudi Journal of Biological Sciences* 21, no. 3 (2014): 256-264. doi: 10.1016/j.sjbs.2013.10.007.

⁷ Adgaba et al. “Socio-economic analysis of beekeeping...”

suggesting two routes toward “modern beekeeping” that allow for the preservation of native bee populations.⁸

II. A Bee-rief History of Saudi Beekeeping

People in present-day Saudi Arabia began hive beekeeping in 2000 B.C., just 400 years after the Egyptians, who boast evidence of the earliest beekeeping practices.⁹ Despite the regions relatively delayed start, Arab authors writing in the Islamic era noted the prosperity of beekeepers in the Arabian peninsula and their vast knowledge about bees. Arabs in the region recognized the different classes of bees (queens, drones, and workers), understood bee development and behavioral patterns, and called the beehive a *masane’a*, or factory in Arabic, which points to their understanding of bees’ value in honey production.¹⁰ Advanced understanding likely contributed to early Arab success in apiculture.

Only one honeybee species is native to Saudi Arabia: the *Apis mellifera jementica*.¹¹ Traditionally, these bees were kept in hives that were made of earthen materials shaped into pots, cylinders, or logs. The hives were hung or stacked upon one another and were not opened until the honey harvest. Yet, beekeepers did not leave the hives undisturbed. Migratory beekeeping is a crucial part of Saudi apiculture because of extreme temperature changes throughout the year. Beekeepers need to move their bees to provide consistent access to forage.¹² In a

⁸ I would like to briefly explain my interest in a topic as specific as beekeeping practices in Saudi Arabia: I took an eager interest in beekeeping a few years ago and am currently secretary of my university’s beekeeping club.

⁹ Alqarni et al. “The indigenous honey bees...”; Eva Crane, *The world history of beekeeping and honey hunting* (New York: Routledge, 1991), 161.

¹⁰ Alqarni et al. “The indigenous honey bees...”

¹¹ Ansari et al. “Geographical distribution and molecular detection of *Nosema ceranae* from indigenous honey bees of Saudi Arabia.” *Saudi journal of biological sciences* 24, no. 5 (2017b): 983-991. doi: 10.1016/j.sjbs.2017.01.054.

¹² Alqarni et al. “The indigenous honey bees...”

recent interview of beekeepers across the country, 93% of beekeepers reported moving their hives 2-9 times annually.¹³ The cooler southwestern mountains are the ideal area for beekeeping, but even still, beekeepers must travel to warmer coastal regions during the winter. The Saudi climate poses challenges to beekeepers, but the native bees mitigate these problems by being far more heat- and cold-tolerant than imported European bees.¹⁴ Saudi Arabia has a difficult landscape on which to raise bees, but a resilient native species and dedicated beekeepers have persevered.

Saudi Arabia entered the modern era of beekeeping 150 years ago, upon the arrival of Langstroth hives.¹⁵ L.L. Langstroth (1810-1895) was an American clergyman from Philadelphia who is considered the “father of modern beekeeping.” He discovered “bee space,” the ideal width of a crawlspace in a beehive.¹⁶ Any space in a man-made hive that is larger or smaller than a bee species’ preferred size will lead the bees to create their own internal hive structure, making honey extraction more difficult.¹⁷ Langstroth later invented a hive with moveable frames that accommodate bee space.¹⁸ Advantages of moveable frame hives include the ability to inspect the hive internally without damaging it, preserve comb when extracting honey, and produce higher quality honey by not harvesting combs that contain pollen or bee larvae.¹⁹ Other modern beekeeping practices that are facilitated by Langstroth’s hive include treating bee pathologies and queen rearing.²⁰ The spread of Langstroth hives, or box hives, was a watershed moment

¹³ Adgaba et al. “Socio-economic analysis of beekeeping...”

¹⁴ Alqarni et al. “The indigenous honey bees...”; Alqarni et al. “Performance evaluation of indigenous and exotic honey bees...”

¹⁵ Alqarni et al. “The indigenous honey bees...”; Kasangaki et al. “Beehives in the World.” In *Beekeeping for Poverty Alleviation and Livelihood Security*, ed. Rakesh Kumar Gupta et al. (Springer, Dordrecht, 2014), 143.

¹⁶ Kasangaki et al., 128

¹⁷ Kasangaki et al., 143

¹⁸ Kasangaki et al., 128

¹⁹ Kasangaki et al., 144

²⁰ Alqarni et al. “The indigenous honey bees...”

for beekeeping globally and allowed for expanded honey production.²¹ However, only 28.9% of present-day Saudi beekeepers use box hives, with the remainder continuing traditional practices.²² I will now begin to explore the story behind this statistic and the contemporary conflict over adopting modernized beekeeping practices.

III. Modernization Movements

The Saudi government is fairly involved with its citizens' beekeeping practices. A national regulation released in 2010 describes the role of the government in the beekeeping industry: "the Ministry undertakes general supervision over the profession of beekeeping, works to protect it, develops plans, programs and extension services, and cooperates - in order to achieve this - with the relevant authorities."²³ King Saud University (KSU), Saudi Arabia's oldest university (founded in 1957) and one of its largest research universities, is also invested in the nation's apiculture industry. In 2009, the university formed a Chair of Beekeeping Research position to teach the public about beekeeping and the economic value of honey production.²⁴ A study published by researchers at KSU and the Ministry of Agriculture noted that the Saudi government had recently undertaken the task of modernizing the country's beekeeping practices. The government's strategies include funding research on beekeeping practices, education, and loan programs that help beekeepers embrace modern practices.²⁵ The government partners with local organizations for these programs. For example, beekeepers in Al Bahah, a city

²¹ Crane, 161

²² Adgaba et al. "Socio-economic analysis of beekeeping..."

²³ "Beekeeping System," *Bureau of Experts at the Council of Ministries*, March 26, 2010, <https://laws.boe.gov.sa/BoeLaws/Laws/Viewer/9318aba9-8279-4f1c-8454-aa09f1d5e86a?lawId=a5fa054e-a124-4cce-96a2-a9a700f254a0> .

²⁴ "KSU Bagshan Chair for Bee Research Buzzing with Activity." King Saud University. Accessed November 27, 2020, <https://news.ksu.edu.sa/en/node/102069> .

²⁵ Alqarni et al. "Performance evaluation of indigenous and exotic honey bees..."

in western Saudi Arabia, partnered with the Ministries of Social Affairs and Agriculture in 2008 to create the Beekeeper Cooperative Association. One of its primary goals, as described on its website, is to “train and counsel beekeepers, developing their scientific perspective” on apiculture.²⁶ Using these tools, the Saudi government and KSU can promote what they consider the most important modern beekeeping practices: switching from traditional to box hives and, often, switching from using native bees to importing foreign species.

In 2017, Al-Ghamdi and collaborators at KSU published a study that compared the profitability of modern hives and traditional hives to encourage beekeepers to adopt the modern technology. The authors found that box hives produced 75% more honey than traditional hives and that the average net incomes of box hive beekeepers were twice that of traditional beekeepers. They noted that foreign honeybee species are more productive in box hives than native bees. For this reason, the authors posited that “the promotion of box hives and imported bee races must be synchronized.”²⁷ These findings make sense, considering that box hives with moveable frames generally produce more honey than fixed-frame hives. With moveable frame hives, wax combs are preserved during harvest and bees do not need to expend energy in the next season on building new comb, leaving the bees more time and energy to spend producing honey.²⁸

An earlier comparative analysis between the use of native and foreign bees in Asir (a southwestern region that is well suited for the practice) had more ambiguous results. The authors found that the *Apis mellifera carnecia*, Saudi Arabia’s most commonly imported bee, stored more honey than native bees, leaving more honey available for harvest at the end of a season. This finding supports Al-Ghamdi’s team’s assertion that the transition to importing bees is crucial for increasing hive

²⁶ “The basic regulations of the Beekeepers Cooperative Association.” *Beekeepers Cooperative Association- Al Baha*, accessed November 16, 2020, http://bca.saudibi.com/articles/56_%D8%...

²⁷ Al-Ghamdi et al. "Comparative analysis of profitability of honey production using traditional and box hives." *Saudi journal of biological sciences* 24, no. 5 (2017): 1075-1080. doi: 10.1016/j.sjbs.2017.01.007

²⁸ Kasangaki et al., 144

productivity. The study also found that the native species, *Apis mellifera jementica*, is more resistant to cold than the imported species, and the species rears more brood, meaning that their population sizes are much more sustained from year to year, a distinct advantage to keeping native bees.²⁹ In fact, 82% of imported bees do not survive their first year in Saudi Arabia.³⁰

Despite the government and KSU's recent research endeavors and education initiatives, only a minority of Saudi beekeepers have adopted box hives and imported bees. A study conducted in 2014 on Saudi beekeeper practices and perceptions found that younger age and higher education level was correlated with an increased likelihood of using box hives for beekeeping.³¹ This may be because it is easier for those with more education to understand and accept new technology or because these demographics are more familiarized with government education and support programs. But the question of whether moving to box hives and importing bees is the truly educated choice is a complicated one.

IV. Reasons to Resist

In 2014, after the government and KSU had begun their collaborative efforts to promote modern beekeeping, 71.1% of Saudi beekeepers still used traditional hives, and 71.5% kept local bees. Those who stuck with traditional practices cite a few reasons for their resistance: difficulty transporting box hives during migration, the hives' unsuitability for local bees and environmental conditions, and the higher initial capital investment.³² In short, box hives are not designed to meet Saudi beekeepers' needs.

As mentioned before, foreign honeybees are not well suited to the Saudi climate and suffer large losses in numbers each year. A study on Saudi honey bee losses

²⁹ Alqarni et al. "Performance evaluation of indigenous and exotic honey bee..."

³⁰ Adgaba et al. "Socio-economic analysis of beekeeping..."

³¹ Adgaba et al. "Socio-economic analysis of beekeeping..."

³² Adgaba et al. "Socio-economic analysis of beekeeping..."

due to temperature extremes found that the commonly imported *Apis mellifera carnica* and *Apis mellifera ligustica* species have death rates of 92% and 84% per year, respectively.³³ This lines up with Adgaba's team's findings on *Apis mellifera carnica* death rates and is compared to annual death rates of only 46% among the native *Apis mellifera jementica*.³⁴ This, in addition to the findings that native bees rear more brood, suggests that keeping native bees is a much more sustainable choice. Not only would beekeepers not need to reinvest in bees every year, but keeping native bees decreases the risk for the spread of dangerous bee diseases that are associated with importing bees and heightened by importing bees annually.

Importing bees has already led to the spread of bee disease among native bee species in Saudi Arabia. *Paenibacillus larvae* is a bacterium that causes American foulbrood disease, "the most dangerous and contagious of the infectious diseases in bees." Researchers detected it for the first time in native Saudi bees in 2017, after a field survey of major Saudi beekeeping locations. It has also been found in Pakistan, Jordan, and Egypt, and Ansari and his KSU collaborators blame the introduction on the importation of exotic bees that are not quality controlled, especially from Egypt. The researchers argue that authorities need to take immediate steps to limit the disease's spread so that it does not decimate native bee populations.³⁵

Ansari and his team also studied the recent introduction of the *Nosema ceranae* fungal infection to native Saudi bees. A beekeeper reported spores in Riyadh, the country's capital, which prompted the examination of 50 apiaries across the country. The researchers found evidence of the fungus in 58% of hives they studied. Although the exact pathology of the infection is not well understood, it has been

³³ Alatta and Al-Ghamdi. "Impact of temperature extremes on survival of indigenous and exotic honey bee subspecies, *Apis mellifera*, under desert and semiarid climates." *Bulletin of Insectology* 68, no. 2 (2015): 219-222.

³⁴ Adgaba et al. "Socio-economic analysis of beekeeping..."; Alatta and Al-Ghamdi. "Impact of temperature...."

³⁵ Ansari et al. "Diagnosis and molecular detection of *Paenibacillus larvae*, the causative agent of American foulbrood in honey bees in Saudi Arabia." *International Journal of Tropical Insect Science* 37, no. 3 (2017a): 137-148. doi: 10.1017/S1742758417000133

shown to hurt honey productivity, bee survival, brood rearing, pollen collection, and other behaviors. Its impacts are more severe than usual in hot climates like Saudi Arabia. Evidence of the infection was also found in countries that border Saudi Arabia, including Egypt, Israel, Jordan, Iran, and Iraq. The authors again highlighted Egypt as a likely source of the infection.³⁶ Diseases introduced by imported bees can spread widely among native populations before they are detected, as this study demonstrated.³⁷ Since Saudi beekeepers already regularly migrate their bees, which allows bee diseases to spread regionally within the country, they are at heightened risk.³⁸ Beyond deadly disease, introducing foreign bees can create burdensome competition for forage, and forage is already difficult to find for native Saudi bees who must be migrated to avoid its scarcity. Overall, Saudi Arabia's hot and highly variable climate necessitates migration to find forage and makes the country especially susceptible to the hazards posed by importing bees.

Preserving native bee populations is important because of their role as pollinators. Foreign bees may not function in the same way as *Apis mellifera jementica*, and these small pollination differences could have large ripple effects on the local ecosystem and agricultural practices.³⁹ Proponents of "nativism" oppose the importation of foreign species because it contributes to undue human influence on nature and the homogenization of global wildlife. Although these sentiments may just be xenophobia in a naturalistic disguise, the extraordinarily high value of Saudi honey suggests that there may be some value in preserving native species for their historical and cultural value.⁴⁰

³⁶ Ansari et al. "Geographical distribution and molecular detection of *Nosema ceranae*..."

³⁷ Crane, 377; Alqarni et al. "The indigenous honey bees..."

³⁸ Adgaba et al. "Socio-economic analysis of beekeeping..."

³⁹ Sharna and Abrol. "Role of Pollinators in Sustainable Farming and Livelihood Security" in *Beekeeping for Poverty Alleviation and Livelihood Security*, ed. Gupta et al., (Dordrecht: Springer, 2014), 379-411.

⁴⁰ Hettinger, Ned. "Exotic Species, Naturalisation, and Biological Nativism." *Environmental Values* 10, no. 2 (2001): 193-224. <http://www.jstor.org/stable/30301805> .

V. Results and Discussion

Saudi Arabia's apiculture industry has the potential to grow into a highly profitable sector that greatly improves the life of Saudis living in rural regions. The government and academics at KSU are seeking to reach that potential by promoting the use of box hives and importing bees with high honey production rates. Most Saudi beekeepers are resisting these efforts because existing box hives do not meet the country's unique needs. There are also many ecological risks associated with importing bees, primarily the spread of bee diseases. KSU researchers have studied the recent and widespread proliferation of diseases, and some suggest that the government increase regulation of importations to mitigate the risk.⁴¹ I disagree. Increasing numbers of Saudi beekeepers importing bees nearly every year to compensate for their poor adaptation to Saudi climate poses too high of a risk to native bees and the beekeepers that keep them. All these risks could easily be avoided by changing the focus of modernization efforts.

There are modern, technological solutions that would increase honey production without sacrificing native bee populations. One strategy is adapting box hives to Saudi needs. It is possible to modify the original Langstroth box hive to work better with the Saudi climate, regular migration practices, and native bee species. This has already been done in other regions across the globe.⁴² To help the hives handle frequent migration, they can be made lighter weight, more robust, and easier to close.⁴³ Saudi beekeepers complained that the currently available box hives were designed for larger European bees.⁴⁴ The size of the hive and its moveable frames can be adjusted so that the bee space is appropriate for *Apis mellifera jementica*. The thickness or material of the hive walls can be adjusted to help bees thermoregulate despite Saudi Arabia's challenging climate. These last

⁴¹ Ansari et al. "'Diagnosis and molecular detection of Paenibacillus larvae...'"

⁴² Kasangaki et al., 144

⁴³ Adgaba et al. "Socio-economic analysis of beekeeping..."; Crane, 347

⁴⁴ Adgaba et al. "Socio-economic analysis of beekeeping..."

two changes alone could greatly reduce the time and energy that bees spend shaping their hives themselves and thus increase honey production. The Beekeepers Cooperative Association, the quasi-governmental organization mentioned earlier, says on its website that it is “innovating” and “obtaining a product suitable for all sects of bees,” implying that they may be making progress on this front.⁴⁵

Another recent technological innovation that can increase productivity while allowing beekeepers to use native bees is developing optimal spatiotemporal beekeeping plans using geographic information system (GIS) technology. It has been used by KSU researchers in Rawdat-Khuraim, a national park in central Saudi Arabia, and Al-Baha. Researchers study plant forage remotely through satellite images, and a GIS program analyzes and maps the data. With this information, researchers can determine the optimal number and layout of beehives in a given region so, theoretically, all nectar secreted by plants could be retrieved by bees without the bees facing any unnecessary competition, optimizing honey production.⁴⁶

The Saudi government and KSU researchers had the right idea to promote the beekeeping industry by looking for a modern technological solution but the wrong approach. Importing foreign bees can increase honey production, but it also increases the risk of dangerous bee disease spread. Adapting hives to Saudi needs and developing optimized beekeeping plans using GIS technology can increase honey production without the risk. The movement to promote modernized beekeeping practices in Saudi Arabia is still very young, and there is room to

⁴⁵ “The basic regulations of the Beekeepers Cooperative Association.” *Beekeepers Cooperative Association- Al Baha*, accessed November 16, 2020, http://bca.saudibi.com/articles/56_%D8%A7%D9... ”

⁴⁶ Awad, et al. "GIS approach for determining the optimum spatiotemporal plan for beekeeping and honey production in hot-arid subtropical ecosystems." *Journal of Economic Entomology* 112, no. 3 (2019): 1032-1042. doi: 10.1093/jee/toz002.; Adgaba et al. "Determining spatio-temporal distribution of bee forage species of Al-Baha region based on ground inventorying supported with GIS applications and Remote Sensed Satellite Image analysis." *Saudi journal of biological sciences* 24, no. 5 (2017): 1038-1044. doi: 10.1093/jee/toz002.

redirect focus to practices that can improve the livelihoods of the 70% of Saudi beekeepers without harming their native bees.

VI. Summary and Recommendations

Saudi government officials and academics are attempting to grow the Kingdom's beekeeping industry through the paired promotion of box hives and importing foreign bees, but importing foreign bees poses an unsustainable threat to native bees and local ecosystems. Officials and researchers should develop new strategies and technologies that increase honey production while allowing for the preservation of native bee species. These could include developing hives according to native bees' biology and local environmental conditions, selectively breeding native bees for increased productivity, and using GIS technologies, which do not require the use of any specific bee species, to optimize beekeeping practices.

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