Journal of Apitherapy and Nature
e-ISSN: 2667-4734
JAN (2026) 9(1): 37-47 doi: 10.35206/jan.1819708 Review

Divine Design and Biological Precision: Review of Qur'ān Insights and Scientific Discoveries in Honey bee (*Apis mellifera*)

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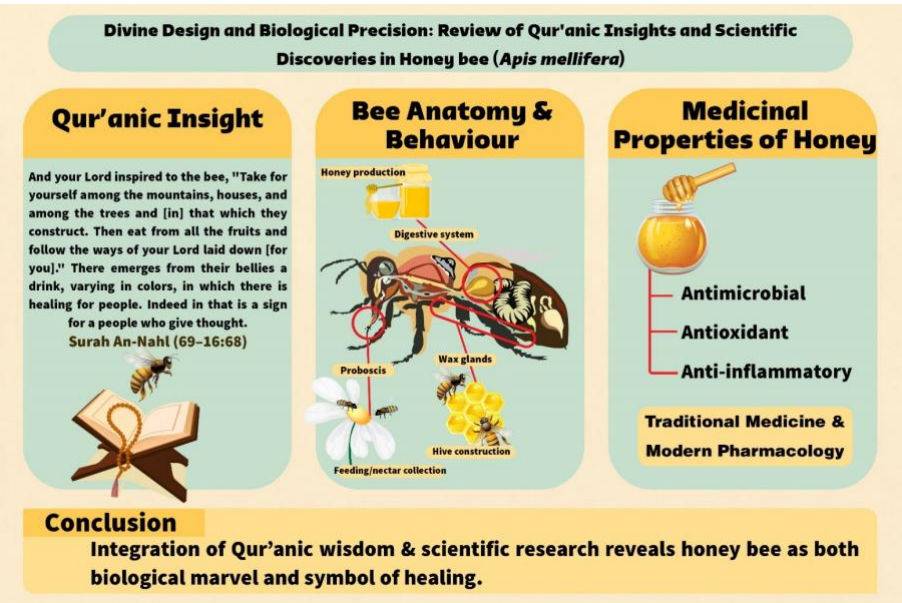
• **Received: 09.11.2025** • **Accepted: 06.03.2026**

Abstract

The honey bee (*Apis mellifera*) represents a remarkable model of biological sophistication and has also been highlighted in religious texts as a symbol of divine wisdom. The Qur'ān, particularly Sūrat al-Naḥl (16:68–69), describes the bee's behavior and the healing properties of honey, prompting continued interest in its scientific relevance. This review aims to explore the relationship between these scriptural insights and contemporary scientific findings on the anatomy of honey bees and the medicinal properties of honey. An interdisciplinary methodology was adopted, integrating perspectives from Islamic exegesis with modern research in pharmacology, biomechanics, and apidology. Current scientific evidence demonstrates that honey bees possess highly specialized anatomical features, including wax glands, wax scales, and an efficient digestive system, all of which contribute to their productivity and survival. Their highly organized hive structure, governed by complex instinctual behaviors refined over evolutionary time, further reflects their biological sophistication. Honey produced through these processes exhibits well-documented antimicrobial, antioxidant, and anti-inflammatory properties, supporting its longstanding use in traditional medicine and its recognition in Islamic sources as a healing substance. Overall, the convergence of empirical scientific research with Qur'ānic descriptions provides a comprehensive understanding of honey bees, highlighting their significance both as subjects of modern scientific study and as indicators of intricate natural design.

Keywords: Apis mellifera, Qur'ān miracles, Honey bee anatomy, Modern biology, Honey production

Garphical Abstract



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1. INTRODUCTION

The Qur'ān Foundation

The Holy Qur'ān contains numerous verses urging humans to reflect upon natural phenomena as signs (āyāt) of Allah's creation. Among these, Sūrat al-Naḥl (The Bee, 16:68–69) provides a detailed account of Honey bee behaviour and honey production:
"And your Lord inspired the bee, saying, 'Build yourselves houses in the mountains and trees and what people construct ﴿68﴾ Then feed on all kinds of fruit and follow the ways made easy for you by your Lord.' From their bellies comes a drink of different colours in which there is healing for people. There truly is a sign in this for those who think ﴿69﴾" Sūrat al-Naḥl (16:68–69) (Ali, 2011)

This passage highlights notable characteristics of Honey bees that correspond with both spiritual insight and scientific observation: Divine inspiration (Waḥy) and innate behavior. Bees demonstrate complex, instinctual behaviors frequently ascribed to divine influence in Islāmic theology (Bucaille, 1980). Innate mechanisms are extensively studied in ethology and neurobiology, uncovering complex genetic and environmental adaptations. Honey bees exhibit architectural precision in hive construction, demonstrating geometric efficiency that optimizes space and structural stability in various environments (Tautz et al., 2008). This phenomenon has been examined in biomimetics and mathematics, illustrating evolutionary optimization principles that align with descriptions in Islāmic exegesis. Honey exhibits therapeutic properties, as contemporary research substantiates its antimicrobial, antioxidant, and anti-inflammatory effects. This aligns with its historical application in traditional medicine and its references in Islāmic texts as a healing substance (Mandal & Mandal, 2011).

Previous scholarship has largely focused on the biological complexity of Honey bees or their theological significance separately, with few studies systematically integrating these perspectives. This review fills the existing gap through a thorough interdisciplinary analysis, integrating interpretations in Islāmic commentaries (tafsīr) with modern scientific literature in apidology, biomechanics, and biochemistry.

Scientific significance: Modern entomology has uncovered astonishing details about Honey bee biology that align with Qur'ān descriptions (Channa et al., 2018). This paper systematically reviews these findings, demonstrating how the Qur'ān's 7th-century insights correspond with 21st-century science.

Objectives: Examine the references to Honey bees in the Qur'ān in light of contemporary biological understanding. Analyze the anatomical and physiological adaptations that facilitate honey production. Assess the therapeutic attributes of bee products as referenced in the Qur'ān.

2. QUR'ĀN PERSPECTIVE ON HONEY BEES

The scientific studies, as well as Islāmic commentators such as Ibn Kaṯīr, al-Qurṭubī and Ebû Bekir İbnü'l-Arabî, indicate that identify two primary theological insights concerning Honey bees in the Qur'ān narrative. First, the concept of divine guidance (Waḥy) is emphasized in Sūrat al-Naḥl (16:68), which states that bees are directed by God to construct their hives and gather provisions. From a theological standpoint, this behavior is viewed as an innate expression of divine inspiration rather than a product of individual or social learning (Alsaeh et al., 2025; Ibn Kaṯīr, 2000; Kaleli & Cinkara, 2019; Putriani et al., 2025; Zubair, 2025). Scientifically, this aligns with findings in ethology and evolutionary biology, which demonstrate that Honey bee behaviors such as comb-building, navigation via solar orientation, and communication through the waggle dance are governed by genetically encoded instincts. These traits have been refined over millennia through natural selection, supporting the idea that such complex behaviors emerge from intrinsic biological programming (Dyer, 1996; Dyer et al., 2002).

Second, the healing properties of honey are underscored in both religious and scientific traditions (Sharaf El-Din et al., 2025). According to a hadith recorded in Ṣaḥīḥ al-Bukhārī (5684) (Al-Bukhari, 1978), the Prophet Muḥammad (PBUH) recommended honey as a remedy for digestive disorders. Contemporary pharmacological research corroborates this assertion, revealing that honey possesses significant antimicrobial activity due to its hydrogen peroxide content, low pH, and phenolic compounds. Furthermore, its prebiotic constituents promote

the growth of beneficial gut microbiota, reinforcing its therapeutic role in gastrointestinal health (Coppola et al., 2025; Yiğit et al., 2024).

This interdisciplinary analysis reveals a compelling alignment between classical Islāmic exegesis and modern scientific disciplines, including apidology, biomechanics, and biochemical pharmacology. By juxtaposing scriptural teachings with empirical evidence, this synthesis fosters a deeper understanding of Honey bees as both theological symbols and biologically sophisticated organisms.

3. ANATOMICAL & PHYSIOLOGICAL MIRACLES

The Honey bee (*Apis mellifera*) possesses a variety of anatomical and physiological adaptations that facilitate its intricate function within the hive and ecosystem. One such adaptation is its unique honey production system. The proboscis, a tube-like tongue (labio-maxillary complex), is highly optimized for the extraction of nectar (Winston, 1991) Fig 1 (A). Upon ingestion, nectar is stored in the honey stomach, where the enzyme invertase catalyzes the hydrolysis of sucrose into glucose and fructose, thereby commencing the honey-making process Fig 1 (B). In addition, beeswax scales are produced by eight wax-secreting mirror glands located on the inner surfaces of the fourth to seventh abdominal sternite segments, and these scales are utilized in the construction of the hive's comb structure (Hepburn et al., 2014; Salama, n.d.; S. Sharma et al., 2024) Fig 1 (C).

The species eusocial organization, a characteristic of advanced insect societies, serves as an additional illustration of biological sophistication. The queen, the sole reproductive female, is sustained by a diet of nutrient-rich royal jelly (Ramadan & Al-Ghamdi, 2012). Workers, sterile females, are responsible for all maintenance, foraging, and defense tasks (Seeley, 2011). Drones, males, are the primary function of the colony and mate with virgin queens (Winston, 1991) Fig 1 (D,E). A healthy colony is composed of three distinct castes.

The biochemical mechanisms that are involved in hive maintenance serve to complement the anatomical and social complexity of the hive. The enzyme glucose oxidase, which is secreted by worker bees, enables the conversion of glucose into hydrogen peroxide, thereby endowing honey with its antimicrobial properties (Nair et al., 2020). Furthermore, bees accumulate and implement propolis, a resinous substance that has been shown to possess antiviral and antibacterial properties (Manginstar et al., 2024), to safeguard the hive from pathogens and sterilize it.

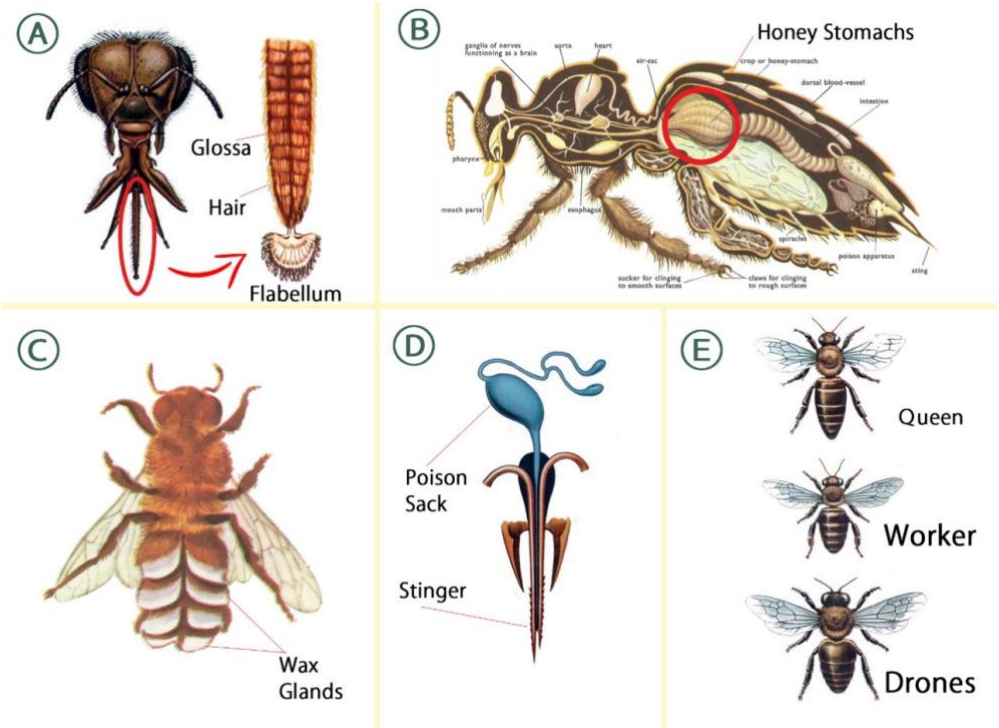

Figure 1 (A) The bee's sucking apparatus. (B) Bee, internal anatomy, showing the honey stomach. (C) A bee in the process of producing wax. Eight little scales of wax are seen coming out of the insect's abdomen, and

they are produced by glands placed between the abdominal segments. (D) Morphological structures that make up a worker's stinger. (E) The bees in a hive are of three kinds: (1) the queen, (2) the female worker and (3) the male drone. © daviddarling, flickr

Bee's legs are endowed with extraordinary adaptations that are essential to their survival and efficacy as pollinators. Pollen baskets (corbiculae) are specialised structures on their hind legs that are used to store pollen in compact masses Fig 2 (A). Initially, pollen is collected by stiff hairs, or scopae, that are situated on the legs and body of the individual before it reaches the baskets. Bees improve the efficiency of transport by combining pollen with nectar to form sticky "pollen pellets". This strategy has been demonstrated to be effective (Ford et al., 1981; Gary, 1992).

Bees possess an extraordinary sensory capacity that is in addition to their mechanical adaptations (Thorp, 1979). Their legs are capable of detecting weak electric fields that are emitted by flowers, which assists in the precise identification of pollen sources. Their foraging accuracy is improved by this electromagnetic sensitivity (Clarke et al., 2013, 2017). Additionally, antenna cleaners are located on the front legs of bees, which are responsible for maintaining sensory cleanliness. These specialised tools enable them to maintain the functionality of their antennae and remove debris, which is crucial for environmental sensing and communication (Schönitzer & Renner, 1984).

Bee eyes are precisely calibrated to their ecological functions, with their visual systems being influenced by their body size and foraging habits Fig 2 (B). Diurnal bees, which are active during the day, depend on high-resolution vision to identify and differentiate flowers (Jander & Jander, 2002). Their larger body size is correlated with an increase in eye size and an improvement in visual acuity, which is an example of isometric scaling. In contrast, nocturnal bees, which forage in low-light conditions, have evolved larger eyes and larger facets to capture more light, sacrificing some resolution for enhanced sensitivity (Warrant, 2008). This adaptation enables them to effectively navigate and forage in dim environments (Berry et al., 2011; Greiner et al., 2004).

Functional demands are also reflected in the shape and structure of bee eyes. The eyes are frequently vertically elongated and contain specialized regions, such as acute zones, which are areas with smaller facets that provide sharper forward vision (Berry et al., 2011). These characteristics facilitate critical behaviors, including precise flower approach and stable flight.

A consistent evolutionary relationship between body size and eye morphology is the underlying factor in all of these adaptations, indicating a strong stabilizing selection. This guarantees that the shared floral niches that bees depend on are optimized for visual performance, underscoring the critical role of vision in their ecological success (Jander & Jander, 2002).

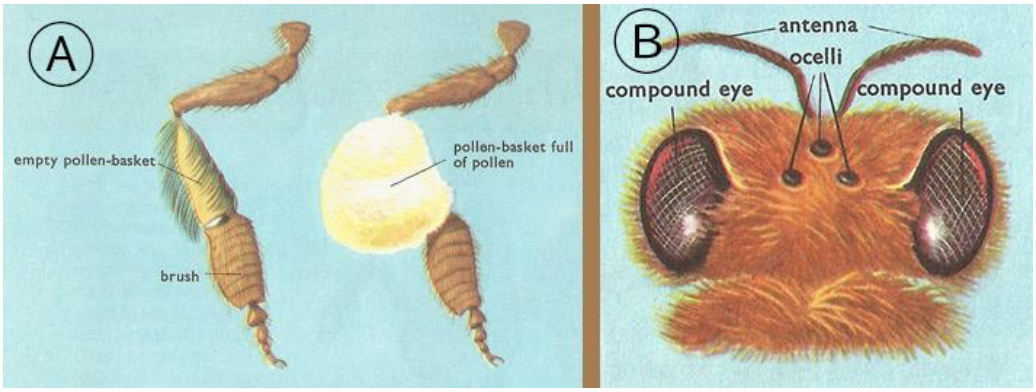

Figure 2 A- Bee legs: the pollen-basket and brush are situated on the third and hindmost pair of legs of the bee. B- A bee's compound eyes and ocelli. © daviddarling

Then comes the miracle of the Qur'ān in the verse "Then eat from all the fruits and follow the ways of your Lord laid down [for you]. There emerges from their bellies a drink, varying in colours, in which there is healing for people. Indeed, in that is a sign for a people who give thought." (Sūrat al-Naḥl16:69) (Ali, 2011) This verse

clearly indicates the numerous changes that occur in the bee's abdomen, which affects the nectar it consumes from the flower, and then it transforms it into honey (Nicolson et al., 2022).

The abdomen of a honey bee is a highly specialized structure that is divided into three primary segments: the propodeum, petiole, and gaster. Each segment is essential to the insect's survival and physiology (De Paula et al., 2022; Liang et al., 2020) Fig 3 (A). The propodeum, which is directly connected to the thorax, enables the bee to manoeuvre its abdomen for essential behaviours such as egg-laying and stinging, while also providing structural integrity and flexibility. The petiole, a narrow, waist-like segment that connects the propodeum to the gaster and improves the bee's abdominal mobility, is the subsequent structure (Stephen et al., 1969). This function is essential for oviposition in queens and defensive actions in workers. The majority of the bee's essential internal organs, such as those involved in metabolism, reproduction, and defence, are located in the gaster, the largest segment (Liang et al., 2019). A complex digestive system that includes the crop (or honey stomach), where nectar is temporarily stored, the midgut, where enzymatic digestion and nutrient absorption occur, and the hindgut, which facilitates water reabsorption and waste excretion, supports metabolic activity within the abdomen (W. Terra, 1988; W. R. Terra, 1988). Collectively, these abdominal structures and systems allow the honey bee to maintain its energy requirements, reproductive capabilities, and survival functions.

The conversion of sugars is the most significant of the chemical reactions that occur in the bee's stomach. In order to convert oligosaccharides and disaccharides (sucrose and maltose) to glucose and fructose by diastase and invertase enzyme activity, bees secrete the enzyme invertase in their honey stomach. The process of nectar ripening is essential for the production of honey. The hypopharyngeal glands, which are situated in the worker bee's head, are the primary secretors of the invertase enzyme (Alaerjani et al., 2022; Sahin et al., 2020). Fig 3 (B, C)

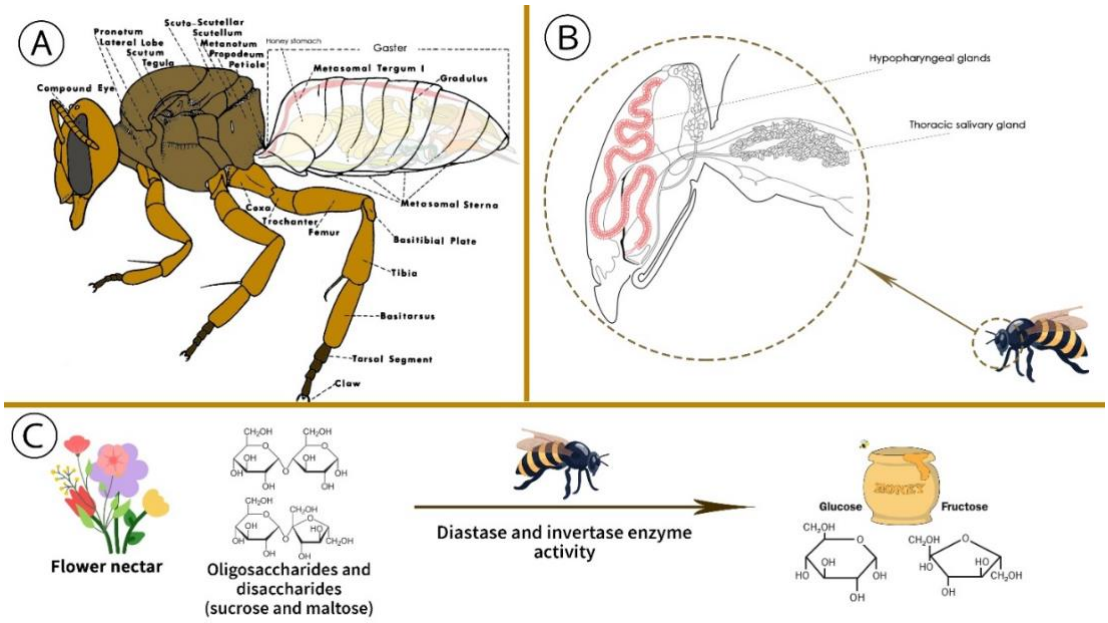

Figure 3 A- The abdomen of a honey bee structure. B- The hypopharyngeal glands structure. C- The conversion of oligosaccharides and disaccharides (sucrose and maltose) to glucose and fructose by diastase and invertase enzyme activity. (B- © Adam Tofilski)

4. SCIENTIFIC VALIDATION OF QUR'ĀN CLAIMS

Modern scientific advancements have become more consistent with the Qur'ān's descriptions, particularly in relation to Honey bees. One example of this is comb architecture, in which the honeycomb's hexagonal design illustrates a mathematically efficient structure. It has been observed that these hexagonal cells optimize storage capacity while minimizing the quantity of wax required, and additionally, this hexagonal architecture enhances the structural strength and mechanical stability of the honeycomb (Karihaloo et al., 2013). The consistent formation of 120° internal angles in the hexagons indicates a degree of geometric precision that may indicate an innate, potentially divinely guided, behavioral blueprint (Eardley, 2009).

The Qur'ān concept of instinctive guidance is further supported by the navigation and communication system of Honey bees, which is another remarkable feature. A series of symbolic movements is the method by which bees convey information about food sources, as per the pioneering work of Nobel laureate Karl von Frisch. The waggle dance encodes the distance and direction of distant food sources (beyond 100 meters) relative to the sun's position, while the circular dance designates resources that are within 50 meters (Preece & Beekman, 2014; Rinderer & Beaman, 1995; Simpson & von Frisch, 1969) Fig 4. The mechanism of bee vibration is that Honey bees accumulate an electric charge during flight and when their body parts are moved or rubbed together. Bees produce an electric field during the waggle dance that is both modulated and constant. The passive antennal movements of stationary bees are induced by both low- and high-frequency components that are emitted by dancing bees, as shown by Coulomb's Law. The interaction between sound and electric fields enhances the effect of electric fields propelling the electrically charged flagella of mechanoreceptor cells. Records from the axons of the Johnston's organ suggest that the organ is sensitive to electric fields. Consequently, it has been suggested that the electric fields that are generated by the surface charge of bees may stimulate mechanoreceptors and may be employed in social communication during the waggle dance (Greggers et al., 2013). This complex mode of communication underscores the Qur'ān's assertion that divine guidance is bestowed upon bees (Qur'ān 16:68-69) by exhibiting a high degree of cognitive and sensory integration.

Additionally, the Qur'ān's assertion that honey has medicinal properties (The Qur'ān 16:69) is corroborated by current biomedical research. In particular, Manuka honey has demonstrated potent antibacterial activity, including efficacy against antibiotic-resistant strains like MRSA (Dahiya et al., 2024). As well as promoting tissue regeneration and reducing inflammation, it also plays a substantial role in wound healing (Salvo et al., 2023; Tashkandi, 2021). The high fructose content of honey makes it a favorable alternative for diabetes management, as it provides sweetness with a lower glycemic impact than refined sugars (Bobiş et al., 2018; Jagua-Gualdrón et al., 2025).

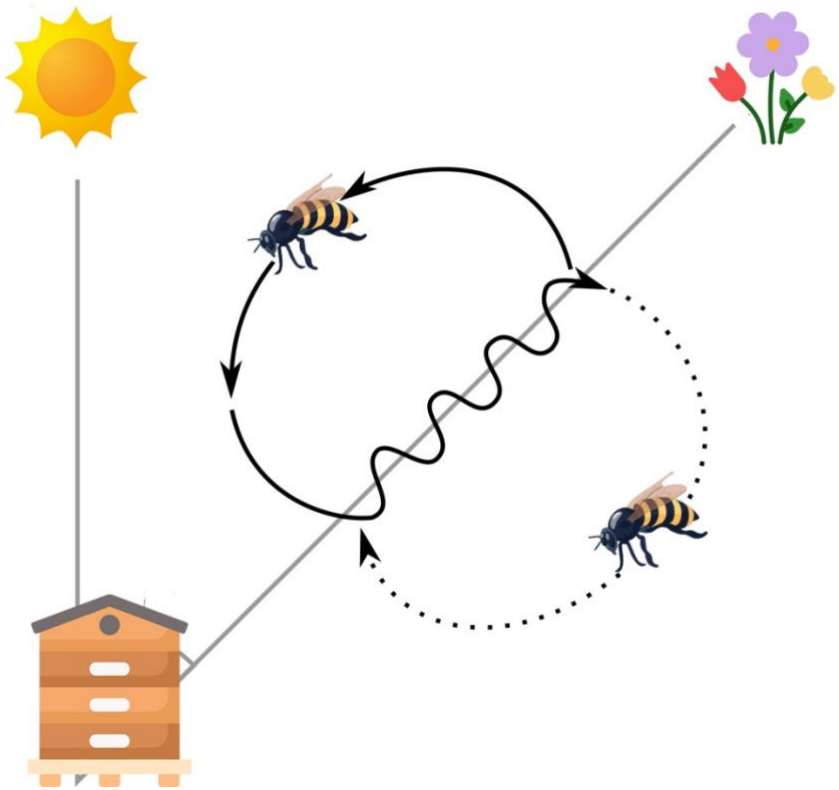

Figure 4 Bee Dance: the direction of the waggle dances the direction in which the bee moves in relation to the hive indicates the direction.

4. 1. The Qur'ān And Scientific Wisdom In Choosing The Locations Of Beehives

The Qur'ān verse "And your Lord inspired to the bee, "Take for yourself among the mountains, houses, and among the trees and [in] that which they construct" (16:68 Sūrat al-Naḥl) was interpreted by early Muslim

scholars, such as Ibn Kaṯīr in the 14th century. What is meant by inspiration in this context is guidance. The bee is directed to establish its residence in the mountains, trees, and structures constructed by humans. With its hexagonal shapes and interlocking forms, the bee's residence is a sturdy structure that ensures the combs are not loose (Ibn Kaṯīr, 2000). The quality and therapeutic efficacy of honey are significantly influenced by its source, whether it be mountainous regions, forests, or farms, as a result of variations in floral diversity, climate, altitude, and environmental purity. This is a scientific interpretation of the verse (Nenasheva & Kozyreva, 2020; R. Sharma et al., 2023).

5. DISCUSSION

The results of this investigation emphasise a significant correlation between contemporary scientific advancements and Qur'ān descriptions of Honey bees. The Qur'ān's emphasis on divine inspiration (Waḥy) as the driving force behind Honey bee behaviour is in alignment with ethological research, which attributes their intricate activities, including comb construction, navigation, and communication, to innate genetic programming that has been refined by evolution. The Qur'ān portrayal of bees as guided creatures is consistent with the biological precision exemplified by the geometric efficiency of hexagonal honeycombs, which are optimised for storage and structural stability.

Additionally, contemporary research has confirmed the therapeutic properties of honey, as evidenced by its efficacy in wound healing, infection control, and metabolic regulation, as cited in the Qur'ān and Hadith. The healing effects of honey are biochemically underpinned by the presence of bioactive compounds, such as phenolic acids, and enzymes like invertase and glucose oxidase. The Qur'ān's prescient insights are not only affirmed by these parallels between scripture and science, but the potential for further interdisciplinary exploration is also stressed.

Nevertheless, the study recognises its inherent limitations, including the necessity of conducting more comprehensive research on the mechanisms that underlie bee behaviour and the medicinal applications of honey. Future research could examine the molecular pathways of honey's bioactive components or investigate the role of environmental factors in hive location selection, as suggested by the Qur'ān.

6. CONCLUSIONS

This review illustrates a compelling synergy between scientific research on Honey bees and Qur'ān teachings. The biological sophistication of *Apis mellifera*, as evidenced by their precision in hive construction and their production of therapeutic honey, is consistent with the concept of divine design. This is evident in their anatomical, physiological, and behavioural adaptations. Modern pharmacology has further validated the Qur'ān's recognition of honey as a healing substance, thereby bolstering its relevance over the course of centuries. This study not only enhances our comprehension of Honey bees but also encourages more profound contemplation of the intersections between faith and natural phenomena by combining theological exegesis with empirical science. Such interdisciplinary approaches can cultivate a more profound understanding of the interplay between scientific inquiry and spiritual wisdom.

AUTHOR CONTRIBUTION

Mohamed F.F Bayomy and Emad Ahmed Fathy Hussein: Conceptualization and methodology, Shahira Hassan Ibrahim Negm: investigation, Ahmed A. Rawwash: resources, Emad Ahmed Fathy Hussein: writing-original draft preparation, Ahmed A. Rawwash: writing-review and editing, Shahira Hassan Ibrahim Negm visualization, Emad Ahmed Fathy Hussein: supervision.

DECLARATIONS

Ethics Approval and Consent to Participate

This study did not involve any human participants or animals. Therefore, ethics committee approval was not required.

Conflict of Interest

The authors declare that there is no conflict of interest.

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