



Food and Agriculture Organization
of the United Nations



وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture



Identification of important local honeybee races in the Kingdom of Saud Arabia (BEE/051/2021/2)

*Strengthening MoEWA's Capacity to implement its Sustainable Rural Agricultural Development
Programme (2019-2025) (UTF/SAU/051/SAU)*

**Food and Agriculture Organization of the United Nations
Riyadh, Kingdom of Saudi Arabia**

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1 Summary

In the Sustainable Rural Agriculture Development Project of the Kingdom of Saudi Arabia (KSA), beekeeping and honey production sector has been identified as one of the promising commodities with development potential in southwest regions of the country. The aim of this study was to identify important honeybee races used by beekeepers in the project target regions to initiate and implement appropriate interventions targeting these major honeybee races.

The scope of the work was to identify and map the types of honeybee races used by beekeepers in the target project areas based on rapid reconnaissance field survey supported with literature reviews. Accordingly, extensive review of pertinent literatures on morphometric and genetic analysis of the local honeybees was made. The field survey was made through direct interviewing of experienced beekeepers and group discussions. Moreover, random inspections of sufficient honeybee colonies samples were made and professional phenotypic assessments on the morphological and behavioral characteristics of the bees were conducted. Furthermore, the coordinates of areas where ancient and isolated cave apiaries (with pure local bee race) were taken. Finally, the preliminary distribution of the important honeybee races of the target regions was mapped.

Based on phenotypic assessments and responses of beekeepers it was found that in the target regions beekeepers are using two types of honeybee races, the indigenous (*Apis mellefera jemenitica*) and exotic bees being a hybrid between *Apis mellifera carnica* and *Apis mellifera lamarckii* from Egypt. Since the imported bees are perishing serving only for on honey harvest season their availability is only on seasonal bases during the flowering of some major honey source plants in Spring and Autumn.

The different literature reviews on morphometric, genetic and behavioral studies, reported that the indigenous honeybee race *A. m. jemenitica* of Saudi Arabia is different form *A. m. jemenitica* of Africa. The literatures further confirmed the presences of three different ecotypes of the local honeybee race at different ecological regions of the country. The professional field assessments on phenotypic and behavioral characteristics of the local bees, clearly showed that the local bees are very small in body size and are very calm and gentle which confirmed the literature findings on the peculiarity of the indigenous honeybee race (*A. m. jemenitica*) of Saudi Arabia, from that of the African populations which are very aggressive.

Regarding their distribution, both races are found in almost all parts of the project target regions (Aseer, Jazan, Al-Baha, Makkah, Al-Madinah and Hail) (Fig. 6). However, the imported bees are very rare or absent in Jazan region. Moreover, during the survey several isolated and permanent cave apiaries were found where local pure bees are kept and conserved since many centuries (Fig. 5 and 6). The bees from such apiaries are the true sources of pure local bees so it is recommended to register and preserve such apiaries together with the traditional management practices as important hot spot areas for conservation of the local honeybee race.

According to the random sample survey study, from the total of 50 interviewed beekeepers 39 (78 percent) of them from the above six target regions preferred to keep the local bees for their better adaptation to the local environmental conditions (Annex 1). From these, 33 beekeepers (66 percent) of them keep only local bees. Seventeen (34 percent) of beekeepers keep imported bees, of which 11 (22 percent) of them keep imported bees only and a few of them keep both, imported and local bees simultaneously (Annex 1). All the 8 interviewed beekeepers from Jazan and 84 percent out of the 19

beekeepers from Aseer keep local bees (Annex 1). Relatively more beekeepers 14 out of 23 (61 percent) of the interviewed beekeepers from Al-Bha, Makkah, Hail and Al-Madina were keeping imported bees. According to the Saudi Arabia's Ministry of Environment, Water and Agriculture 2020 report the trends of importation of exotic bees is increasing from 0.76 million in 2017, to 1.97 and 1.3 million in 2018 and 2019 respectively. Finally, the possible threats associated with the importation of exotic bees (genetic dilution) and approaches to minimize the impacts, and strategies for conservation of local bees such as isolation of areas for local bees, registering and protecting of permanent (cave) apiaries and restriction of importing of package bees with adult drones have been suggested.

2. Study area and methodologies

Since the scope of the study was just to identify and map the types of honeybee races used by beekeepers in the project target regions, the study was based on rapid reconnaissance field survey supported with literature reviews. It is not based on morphometric and genetic analysis. Information on morphometric and genetic analysis is well documented for honeybee race found in the country.

Literature review: Extensive literature reviewing on the indigenous bees (*A. m. jemenitica*), its population variability and geographical distribution across the Arabian Peninsula and Africa were assessed. Moreover, similarities and variations among the different populations, their adaptation mechanisms to the various ecological factors and surviving strategies have been reviewed and summarized. In addition, the behavioral characteristics (gentleness, migration, reproductive swarming tendencies and nest volume of *A. m. jemenitica* of Saudi Arabia have been reviewed and summarized. Moreover, the morphometric and genetic characteristics of the local honeybee race have been reviewed and presented. The information obtained from literature reviewing have been used to correlate the field phenotypic and behavioral assessments of the bees.

Field survey: The types of honeybee races, used in the target regions (Aseer, Jazzan, Al-Baha, Makkah, Al-Madinah and Hail) were assessed through interviewing of beekeepers and visual phenotypic observation of the honeybees in the beekeeper's apiaries. Accordingly, a survey was made in the above six target regions and in 17 representative governorates of the regions (Annex 1). From each governorate 2-5 beekeeper's apiaries were visited and interviewed based on checklist prepared for this purpose. The major points raised include what types of bee race used, presence and degree of importation of exotic bees, their preferences towards local and imported bees, reasons of choosing a particular race, migratory beekeeping practices, presence of permanent apiaries (absence of migration) if any, presence of areas designated or isolated for local bees if any and others were included.

Moreover, in each apiary 3-5 honeybee colonies and a total of 138 bee colonies were randomly chosen and assessed based on visually inspection of the phenotypic characteristics of the worker bees (Annex 1). The typical phenotypic features of the local bee race such as their body size, body pigmentation pattern, and behavioral aspects: calmness and gentleness were assessed and recorded. Moreover, digital pictures of the bees were taken and used for comparisons among the bees within and among apiaries, governorates, and regions. The phenotypic observations were complemented with comprehensive reviewing of published study result reports that specifically made on the local honeybee race (Section 3).

In addition, information on ancient and permanent cave apiary sites which are situated in mountain escarpments mostly from Al-Madinah Regions were visited. Since the bees from such sites are not migrating at all and have been remained isolated for centuries, the probability of the bees in such apiaries to be pure local honeybee race is very high. Moreover, such mountain escarpments are not accessible to introduce the imported bees, hence the chance of hybridizing of the bees in these apiaries is low. Hence the bee colonies in such pocket apiaries considered as pure local bees and the coordinates of some the cave apiary sites were taken and mapped for further follow-up (Fig. 5 and 6).

Moreover, areas those have been remained dominantly with local bees and free from or with rare introduction of exotic bees were also identified with the help of local beekeepers and the respective

regional and governorate focal persons and such areas also mapped as possible areas of pure local bees (Fig. 6). In addition, information on areas where exotic bees are introduced and widely used have been obtained and recorded with the help of beekeepers and the staff of the Ministry of Environment Water and Agriculture (MEWA). Finally, the preliminary distribution map of areas where only local bees and areas where both local and exotic bees are existing were mapped for future follow-up activities (Fig. 6).

3. Result and discussion

3.1. Honeybee races found in Kingdom of Saudi Arabia based on literature review

More than 20 000 species of bees are reported to exist in the world, among which only 8 species are recognized to produce honey and are called honeybee species. Among the honeybee species the most popular one is *Apis mellifera* (the western honeybee) which is widely used all over the world. *Apis mellifera*, consists of 31 sub species (geographical races) and of which 15 are found in Europe, 11 in Africa and 5 in Middle East and Asia (Engle, 1999). The indigenous honeybee, *Apis mellifera jemenitica* is one of those sub species. In the Kingdoms of Saudi Arabia (KSA), beekeeping is majorly practiced using two types of honeybee races, the indigenous bees (*Apis mellifera jemenitica*) and exotic hybrid bees (a cross of *A. mellifera carnica* and *A. mellifera lamarckii*) imported from Egypt.

3.1.1 Population of *A. m. jemenitica*

The indigenous bee race *A. m. jemenitica* is well known for its best adaptation to the semi-arid and desert conditions of the country. *Apis m. jemenitica* is the only race of *A. mellifera* that occurs naturally in both Africa and Asia. In Africa, *A. m. jemenitica* is distributed in the Sahel, tropical climatic zone below the Sahara and north of the wetter, tropical Africa extending from East Coast of Africa to West Coast of Africa (Ruttner, 1988; Hepburn and Radloff, 1998). The Asian populations of *A. m. jemenitica* distributed in the Arabian Peninsula (Saudi Arabia, Yemen and Oman). Despite the morphological similarities of the race across such wide range of geographical distribution areas, the presence of morphometric and behavioral variations among the different populations within and among the regions have been well reported (Dutton *et al.*, 1981; Karpowicz, 1989; Hepburn and Radloff, 1998; Amssalu *et al.*, 2004; Al-Ghamdi *et al.*, 2013).

Among the *A. m. jemenitica* population of the Arabian Peninsula, significant variations within close geographical region have been reported. Dutton *et al.* (1981) based on measuring of morphometric characters reported two widely separated populations of *A. m. jemenitica* population from the northern and southern Oman. They also noted the presence of variations between Yemeni and Omani populations. Moreover, the presence of contradicting color variations within and among *A. m. jemenitica* populations of Omani honeybees have been reported (Dutton *et al.*, 1981; Karpowicz, 1989). Such morphological variations could be the result of long years ecological adaptation. The *A. m. jemenitica* of the Arabian Peninsula race is known to cope well with long dry periods, brief flowering intervals, temperatures of up to 40 °C, and annual rainfall of just 50-100 ml (Ruttner, 1988). In the recent survey in the region, we observed the local bees surviving a temperature of 50 °C. One of the adaptation mechanisms of the race is limiting its brood and adult bee population size during long dearth period not to put its colony at high risk under erratic rainfall and unpredictable weather conditions of the region. Such behavior is a good surviving strategy for the race to survive harsh periods.

3.1.2 Behavioral characteristics *A. m. jemenitica* of Saudi Arabia

Apis m. jemenitica is well known for its fast population build up which is an adaptive feature in semi-arid habitat where rainfall and flowering periods are very short. Moreover, Alqarni (1995) reported a higher tendency for reproductive swarming, in the *A. m. jemenitica* population of Saudi Arabia than in the imported Carniolan bees, and a maximum of 16 queen cells/colony was reported for the month of October. Unlike the African population, there is no migratory tendencies in *A.m. jementitica* population of Saudi Arabia. Moreover, the race in Saudi Arabia is reported to be so gentle and it does not sting even after provocation (Alqarni, 1995) and can be easily managed even without proper protection. *Apis m. jemenitica* of Saudi Arabia is reported to build 25 percent more worker brood cells per unit area than the European honeybee races (Al-Ghamdi, 2005). Generally, the race occupies less nest volume (20 liter) and builds 25 percent more brood cells per dm² than number of cells on embossed wax foundation designed for European bee races (Nuru *et al.*, 2016).

3.1.3 Morphometric and genetic characteristics of the local bee race

Morphometrically, *A.m. jementitica* is the smallest race of *Apis mellifera* species and it is readily identifiable by its small body size and yellow abdomen with grey to brown bands. The various morphometric and genetic analysis of honeybees of Saudi Arabia confirmed that the bees are belong to *A. m. jemenitica* of the Arabian Peninsula. However, within this population the presence of three ecological types (ecotypes) has been reported to occur in the target regions (Jazan, Aseer, Al-Baha, Makkah, Al-Madina and Hail) (Al-Ghamdi *et al.*, 2012). According to this study, the honeybees from Hail are belongs to one of the ecotypes and the honeybees from Madinah to Makkah are belong to the second ecotype and the third ecotype was found from Al-Baha, Asir to Jazan up to Yemeni boarder.

Moreover, according to the morphometric study of Al-Attal *et al.* (2014) the presence of two major cluster groups were reported in which most of the samples from KSA fall into *A. m. jemenitica* population the Arabian Peninsula while the other group was closer to *A. m. litorea* of East Africa. The genetic study of Al-Attal *et al.* (2014), revealed the presence of three different haplotypes that coexist with in the same geographical region. The same study indicated that honeybee samples from Asir, Al-Bahah and Al-Taif exhibited similarities in the sequences of the COI–COII intergenic regions. The study further confirmed that, most of the Saudi honeybee haplotypes clustered with the O (the Middle East) bee lineage.

The current MEWA (2021) unpublished report on morphometric study of the honeybee race of Saudi Arabia indicated the presence of two distinct cluster groups of honeybees. Cluster one includes the honeybees form the southern region (Najran, Jazan, Baha and Makkah) and the honeybee samples from the northern regions of Saudi Arabia (Madina and Tabuk) grouped in to the second cluster group. It is noticed that the cluster groups reported in different studies are not consistently confirming each other. Since the entire honeybee colonies > 95 percent in the country are continuously migrating (by beekeepers in search of better bee forage) 9 times/annum from north to south and east to west and vise-versa, it is hard to designate specific honeybee population with specific geographical region or ecologies as pure ecotype. This could be the reasons for the absence of conformity of the cluster groups of the honeybee populations among the different study reports.

The same MEWA (2021) study report which was based on mt DNA analysis reported the presence of three ecotypes or evolutionary groups of honeybees of Saudi Arabia. Group one represents honeybees from the northern parts of Saudi Arabia (Al-Madina and Tabuk and few from Taif) and are very similar to the Syrian honeybee. Group two was the very common and occurs in southern region of the kingdom Makkah, Al-Baha and Aseer. The honeybee samples from Jazan and Najran form the third ecotype and it is belonging to A lineage (African origin). In the current morphometric and genetic analysis of the local honeybees, the occurrences of hybridizations of local bees with exotic bees and its extent was not reported which is an important area that needs to be investigated in the future.

3.1.4 Imported hybrid bees

The imported hybrid bees are coming from Egypt, and it is a hybrid of European origin Carniolan honeybee (*Apis mellifera carnica*) and African origin bee, *Apis mellifera lamarckii* from Egypt. The imported bees have been used in the country for more than three decades. Because, of the high price of locally produced honey, many people are attracted to be involve in beekeeping as sideline or part time business or fulltime occupation in Saudi Arabia. Because of its relatively cheap price and its more readily availability than the local bees, the demand for imported honeybee colonies is very high. The imported bees are preferred by some beekeepers because of their fast establishment in box hives, comb construction, high hording tendency, fast in collecting and storing nectar and even sugar syrup. As a result, the demand for imported bees is very high and the country imports more than one million package bees annually. According to the Saudi Arabia's Ministry of Environment, Water and Agriculture 2020 report the trends of importation of exotic bees is increasing from 0.76 million in 2017, to 1.97 and 1.3 million in 2018 and 2019 respectively. In 2019 alone, the country imported 1.3 million package bees with total value of SAR 130 million. Beekeepers with imported bees only are not dedicated year-round beekeepers, they bring the bees only on peak flowering periods of some major honey source plants and they discard them after honey harvest.

The most limitation of the imported bees is their low adaptation to the harsh environmental conditions of Saudi Arabia. Most of the imported bees die soon after the first honey harvest and the remaining also gradually vanish in second honey harvest season (Al-Ghamdi and Nuru, 2013). The possible factors for death of the imported bee colonies could be due to lack of adaptation to the new environment. The imported bees may continue to follow behavioral rhythms that are similar to those of their original homeland and the residual effect of prior environmental experience "aftereffects", which may be critical for the survival of the bees in extremely different environments. The physiological, morphological, and behavioral characters (phenotypic plasticity) of the imported bees may not be suitable for the arid climatic conditions of the country. The other possible factors for the death of imported bees could be lack of interest by beekeepers to maintain the imported colonies after honey harvest in which most of the beekeepers with imported bees abandon the bees. This is because the high maintenance cost of the imported bees in long dearth period which might be higher or equal to the purchasing cost of new package bees during the flowering period. Though beekeeping with imported bees is not sustainable in long term bases, the comparative profitability of maintaining of imported colonies over seasons versus purchasing of new colony every honey flow season has to be investigated.

The imported bees are believed to carry and disseminate different honeybee diseases (*Nosema apis*, *Nosema ceranae*, *Varroa destructor* and others) in the country. Moreover, the mass importation of exotic bees is believed to pose a risk on genetic erosion to the indigenous bee race as result of possible hybridization that ultimately deteriorate the adaptability and disease resistance potentials of the local bees. In this regard some intermediary type of bees bigger than the local and smaller than the imported bees have been observed in some apiaries, but it is difficult to conclude as hybrid without having genetic and morphometric analysis of such bees. The Government of Saudi Arabia is working hard to minimize the dependency of the country on importation of exotic bees, though focusing more on mass local queen rearing and colony multiplications to satisfy the local honeybee colonies demands.

3.2 Phenotypic characteristics of the local bees based on field assessment

The local bees are easily identifiable from that of imported bees by their phenotypic and behavioral characteristics. In terms of body size, the local bees are typically small compared to the imported bees (Fig. 1) and they are slender with tapered abdomen. In this regard *A. m. jemenitica* of Arabian Peninsula has been reported as the smallest honeybee races of *Apis mellifera* (Ruttner, 1988). Within the local bees two morphologically distinct bees were observed in Al-Madina Region. One is very small and slender compared to the other. However, the two types of bees were found within the same apiary and not restricted to certain geographical regions.



Fig. 1. Relative body size variations between the local and imported bees

Color

In terms of color two distinct colors were observed in local bees. The first group was darker color with dominantly black abdominal segment with light brown strips that gives the bees zebra color (Fig. 2 A). The other group was dominantly yellow, with yellow abdominal segments (Fig. 2B). It was noticed that the intensity of yellow color was varied from individual to individuals within the same colony. Some of the bees were more yellow, up to the fourth abdominal segment while others were only one to two abdominal segments. The presence of color variations from dark brown to very dark grey and very intense yellow were reported for the same Omani population of *A. m. jemenitica* (Dutton *et al.*, 1981; Karpowicz, 1989).

Fig. 2. Colors of the local honeybee top (A) dark to dark-brown, bottom (B), more yellow

Temperament

Behaviorally, all the local bees inspected were very calm and were remaining quietly settled on the comb without having the tendency to fly while they were inspected (Fig. 3A). Calmness is one of the desired behaviors of honeybees by beekeepers and it is one of the parameters in selection and genetic improvement of honeybee colonies. Moreover, most of the inspected local honeybee were very gentle without sign of attacking or stinging during opening the hives and inspection even without smoker and protectives. Moreover, the bees were not stinging even when we were scooping them in bar hands (Fig. 3B). This agrees with the findings of Alqarni (1995) who reported the *A. m. jemenitica* of Saudi Arabia as so gentle that it does not sting even after provocation. Gentleness is also one of the best desirable characteristics of the bees and it is one of the parameters in selection and breeding programme of honeybees. Based on their body size, pigmentation and temperament conditions the observed bees in the target regions are *A. m. jemenitica* of Saudi Arabia and are totally different from the African *A. m. jemenitica* populations and are readily distinguishable from the imported bees which are relatively large in body size.



Fig. 3. *A. m. jemenitica* bees (A) indicates the calmness (settling quietly on the comb) and (B) gentleness without stinging even after provocation

3.3 Phenotypic characteristics imported bees

The imported bees are widely used in many parts of the country without having distinctive preferred geographical areas. However, beekeepers from Hail, Al-Baha and Makkah regions use more imported bees than local bee race. The imported bees are easily identifiable mainly by its significantly larger body size (Fig. 1 and 4). Moreover, the imported bees are darker in color with little or no yellow abdominal segments as that of local bees (Fig. 4).



Fig. 4. Imported bees relative body size and darker abdominal pigmentation

Behaviorally the imported bees are gentle and have no tendency of stinging during hive manipulation. Since the imported bees are surviving only for less than 2 months during peak flowering seasons, there is no such longtime management practices of imported bees. Since the bees are imported as temporary work force (sometime only workers without queen) to collect nectar at any places and the imported bees have no distinct ecological region, and there is no study report on the morphometric characteristics of the bees as one of the geographical races in the Kingdom of Saudi Arabia. Since the bees perish soon after a honey harvest, they do not attain the strength to undergo reproductive swarming, hence their tendency towards reproductive swarming is not documented under Saudi Arabia conditions.

4.3 Beekeeper's views towards different honeybee races

Beekeepers with their long years of experiences working with the bees, they easily differentiate the types of races they use, describing them well phenotypically and behaviorally. According to the sample survey result, out of 50 interviewed beekeepers 39 (78 percent) preferred to keep the local bees for their better adaptation to the local environmental conditions. From these, 33 beekeepers (66 percent) of them keep only local bees. Seventeen (34 percent) of beekeepers keep imported bees, of which 11 (22 percent) of them keep imported bees only and 6 of them keep both, imported and local bees simultaneously (Annex 1). All the 8 interviewed beekeepers from Jazan and 84 percent out of the 19 beekeepers from Aseer keep local bees (Annex 1). Relatively more beekeepers 14 out of 23 (61 percent) of the interviewed beekeepers from Al-Bha, Makkah, Hail and Al-Madina were keeping imported bees.

Most of beekeepers with imported bees are commercial and semicommercial and they are managing large numbers of bee colonies. The colony holding size of beekeepers with imported bees is varying from 70 to 2 000 with average holding size of 661 colonies per beekeeper which is much more than colonies holding size of beekeepers with local bees (Annex 1).

Beekeepers from Jazan and Aseer are demanding the local government to restrict the introduction of imported bees to these regions. As far as the demand is coming from most of the beekeepers in these regions, the areas can be designated for local bees only and some formal enforcement can be applied to prevent the introduction of the exotic bees to the area. This can contribute for conservation strategy of the local bees. From the field assessment and interviewing of beekeepers it was noticed that all

beekeepers in the target regions migrate their colonies from place to place for better forage and to escape harsh seasons.

Beekeepers with imported bees are not dedicated to keep bees year-round and they are focusing to make quick money through importing mass package bees during the peak flowering periods of some major honey source plants. After the honey harvest the bees abandoned or ignored without feeding and eventually die. It was observed the presence of conflict of interests between beekeeper with local and imported bees. The major reason of the conflict is due to resource competition for bee forages. Moreover, since the exotic bees transported with feed stress conditions without any feed reserve in their nests, they are aggressively robbing the stored resources from the nest of local bees especially upon their arrival. Moreover, beekeepers with imported bees harvest all the honey stored by exotic bees without leaving any reserve and the bees become very starved and inclined to rob the stored resources from local bees. The other general fear is that the importation of exotic bees may hybridize the local bees that may ultimately affect the genetic composition of the local bees. Because of minimum introduction of imported bees, honeybees from Jazan regions are expected to be pure local bees than other regions.

As the information given by the Al-Madinah Region Ministry of Environment, Water and Agriculture office, the presences of many isolated and permanent cave apiaries with more than 1000 bee colonies are reported to exist in many locations of Al-Madina Region (Fig. 5). As random sample we have visited five such apiaries (Fig. 5). These apiaries were there for many centuries without interference of human migration. Moreover, due to inaccessibility, such apiaries are not affected by the introduction of exotic bees. The bees in such apiaries are undoubtedly pure indigenous bees and can serve as the sources of pure bees for breeding, selection and conservation of the local bees. Such areas and practices should be formally registered, and beekeepers should be encouraged to preserve such heritages. Honey coming from such beekeeping practices should be registered in Geographical Indication and get better price incentives for their conservation efforts.

Based on reviewing of the available literatures, field phenotypic and behavioral assessments on the morphological features (body size and abdominal segment colors) and behaviors of the bees (calmness and gentleness) and considering the confirmations of beekeepers; it was possible to identify and map the distribution of the two races of bees found in the target regions (Fig. 6). The map also indicates where permanent cave apiaries with local bees are found and areas where no or rare importation exotic bees exist and areas where both local and imported bees are found simultaneously (Fig. 6). However, the occurrence of the imported bees is on seasonal bases, only during Spring and Autumn where some honey source plants are flowering. The imported bees are not available at all in Summer and Winter seasons.



Fig. 5. Permanent cave apiaries which estimated to be more than 500 years old, top close up of the apiaries with modified nest and bottom right the cave apiary from far and left climbing to the nest during the field survey

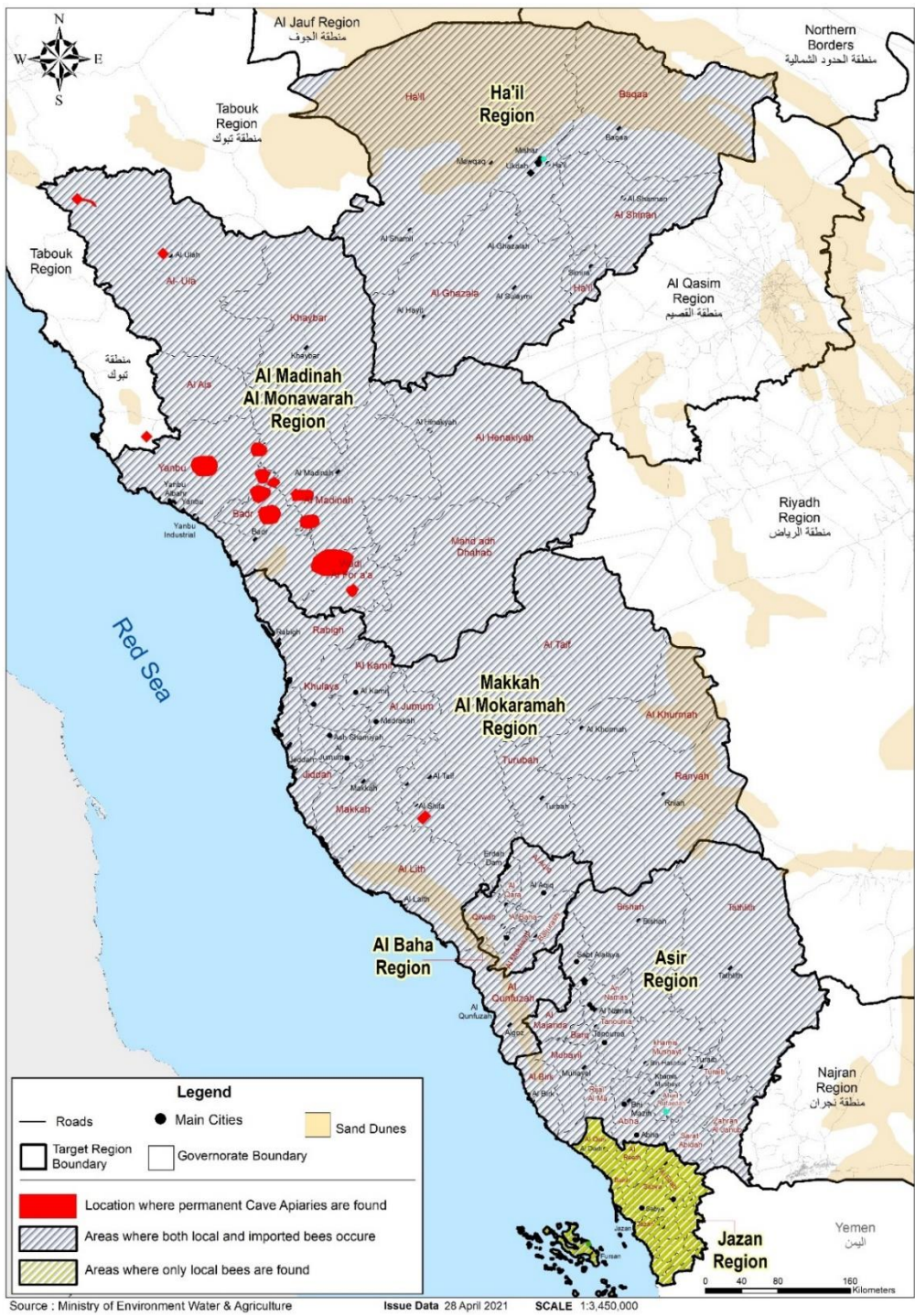


Fig. 5. The current distribution map of local and imported bees in target regions and the location of permanent cave apiaries

5. Factors contributing for low hybridization of local bees with imported bees

The probability of occurrence of hybridization of the local bees with exotic bees cannot be totally ruled-out because of mass importation of package bees with thousands of adult drones annually. However, so far there is no genetic, morphometric and behavioral studies conducted and reported for the occurrences of hybridization. Under Saudi Arabia conditions because of the way the imported bees managed and associated their short lifespan it is possible to hypothesize that the probability of occurring of hybridization in local bees is low. Moreover, there are factors such as: stress, temporal and spatial barriers that may contribute to minimize the probability of hybridization of local bees with imported drones. Some of the possible assumed factors for the occurrences of low hybridization in local bees are:

Stress: Honeybee drones are very delicate and sensitive to minor stress. The imported package bees arrive suffocated with very stress conditions with starved drones and the worker bees further deprive the drones to feed and they start to die very quickly (Fig. 7). The photo in Fig. 7 shows the heap dead drones in front of newly established imported package bees' colony. As result of the transporting and starvation stress the chance of surviving of imported drones for long enough time to mate with the local virgin queen is very low.



Fig. 7. Mass deaths of drones (only) in front of newly imported and established package bee colonies

Temporal variations: The imported bees are not coming during the major reproductive period of the local bees which is mainly takes place between January to March mainly in Thihama (lowland plains) where there are plenty of pollen source plants that contribute for brood rearing and subsequent reproductive swarming of local colonies. In this regard beekeepers with imported bees do not usually bring exotic bee colonies to Thihama for pollen collection and the chance of mating of the local bees virgin queens with imported drones is very low.

Spatial variations: In most areas there are agreed rules among beekeepers to keep imported bees and local bees in separate locations (wadis). So, the chance of mating of imported drones with local virgin

queen is very low. Moreover, during honey collection periods even if there is a chance to keep local bee colonies closer with imported bees, the local bees are not in their reproductive period and there will not be emerging of virgin queens and the chance of mating with exotic drone is very low.

However, this hypothesis should be verified through conducting genetic and morphometric analysis of the local bees to assess the degree of introgression of exotic genes in local bees through conducting nuclear DNA marker tests. So far there was no study conducted that explicitly indicates the presence or absence of genetic hybridizations and its extent. Such types of study are important to make appropriate policy measures on the importation and management of exotic bees and to develop conservation strategies for local bees based on scientific results and facts.

6. Strategies for conservation of local bee race

The importation of exotic bees to the Kingdom of Saudi Arabia have been practiced for more than three decades. The trend of importation is gradually increasing from 0.76 million in 2017 and reached 1.3 million by 2019 (MEWA, 2020). Such mass importation of package bees has imposed threats to the sustainability of the beekeeping industry of the country. One of the threats is introduction and dissemination of several honeybee diseases. The other fear is genetic dilution of the local bees because of possible hybridization with exotic bees and the high dependency of the industry with imported bees.

The decision and implementation of the total banning of the importation of exotic bees may take time until the country able to satisfy the local honeybee colony demands through strengthening the capacity of the queen rearing centers and able to rear and distribute local queens. Therefore, as long-term plan, it is necessary to have strategies on how to conserve the indigenous honeybees, protecting them from hybridization with exotic bees. Some of the suggested conservation strategies are:

6.1 Demarcating of areas for local bees

To conserve the pure local bees and to minimize the chance of its hybridization with exotic bees it is very important to designate certain geographical areas for local honeybees only and strictly ban the introduction of exotic bees to such designated areas. Once such areas are designated exit and re-entering of any types of bees should be prohibited. Under Saudi Arabia conditions it is very difficult to keep bees throughout the year without migrating from place to place in search of better forages and also to escape harsh seasons. In relation to this, areas that will be designated for local bee's conservation should be large enough and should have different ecologies that allow the movement of the bees within designated territory. In this regard, at initial stage designation of Aseer and Jazan regions together, for conservation of the local bees would be an appropriate because the ecological diversities of the two regions will allow beekeepers to migrate their colonies in different seasons within demarcated territories.

As assessed from the recent situation analysis most of the beekeepers from Aseer and Jazan regions are preferred to keep local bee colonies and they are strongly against the introduction of exotic bees to their regions. If it is the interest of most of beekeepers, it will be easy to implement the banning of the introduction of exotic bees to demarcated areas and to restrict also the exit and re-entry of any bees from demarcated areas.

However, beekeepers from such regions should be encouraged for their efforts of keeping the local bees for the sake of conservation and sustainable use of the indigenous bees on the expenses of losing advantages of having chance to migrate their colonies out of their regions and for not keeping exotic bees which are the source of making quick money. The encouragement can be registering, labeling (Geographical Indication of the honeys from such area) and promoting of their honeys to get fair and better prices from consumers. Moreover, creating sustainable markets for their bee products, supporting those beekeepers in accessing the markets, strengthening and supporting existing beekeepers' associations and focusing on sustainable use and development of the local bees should be taken into consideration. In addition, providing of training for beekeepers ranging from good beekeeping practices to professional marketing are very important.

6.2 Registering and protecting of permanent or cave apiaries

In many parts of Al-Medina Region and others, there are many isolated and permanent cave apiaries for many centuries (Fig. 5 and Fig. 6). Since the bees in such apiaries are not migrating and not accessible to be hybridized with imported bees, they are the true sources of pure indigenous bees. So, all such apiaries should be registered and mapped as hot spot areas for conservation of the local bees. Beekeepers practicing such an ancient type of beekeeping should be recognized and encouraged through promoting their honeys as GI products. Moreover, creating sustainable markets for their bee products, supporting those beekeepers in strengthening the existing beekeepers' associations and focusing on sustainable use and development of the local bees should be taken into consideration. In addition, providing of training for beekeepers on good beekeeping practices and integration of beekeeping with natural resource conservation of the area are very important. In this regard beekeeping practices with permanent apiaries (without migration) can be sustainable only if the natural resources (vegetations) of the areas are conserved. Moreover, such types of beekeeping practices can be integrated with tourism to serve the sites as destination for "Api-tourism" and to support the local beekeeping communities.

6.3 Restriction of importing of package bees with adult drones

Sometimes it was observed that significant proportion of the imported package bees are drones. Drones do not contribute for honey collection rather it is a burden for a colony with too many drones. So, there should be restriction of having drones in the imported package bees. This can be easily checked at ports through visual observation of the package bees. The exporters can easily sieve out all drones using queen excluder before putting the bees in packaging box. If the package bees are coming without drones and since most of the package bee colonies are perishing after the honey harvest without having the chance to rear another drone such practice can serve to minimize the chance of hybridization and conservation of the local bees.

7. Recommendation

- 1.** Conducting genetic and morphometric analysis of the local bees to assess the degree of introgression of exotic genes in local bees and refined mapping their distribution is very important to take appropriate intervention measures.
- 2.** Demarcating of areas or regions for local bees, and value addition and marketing of specific bee products from such areas, creating the legal framework are very important to encourage beekeepers with indigenous bees and to ensure the sustainability of the beekeeping in the long term.
- 3.** Registering and protecting of permanent or cave apiaries and value addition and marketing of specific bee products from such apiaries, creating legal framework and integration of such beekeeping practices with natural resources conservation areas and Api-tourism are very important.
- 4.** Restriction of importing of package bees with adult drones and creating the legal framework should be taken into consideration.
- 5.** Hygienic standards for importing of exotic bees, strengthening boarder quarantine systems and creating legal framework are important.
- 6.** Strengthening the capacity of mass rearing and distribution of indigenous honeybee queens to satisfy the local demands is very important to minimize the heavy dependency of the country on exotic bees.

8. References

- Al-Attal, Y., Alsharhi, M., Al-Ghamdi, A., Al-Faify, S., Migdadi, H. & Ansari, M.** 2014. Characterization of the native honeybee subspecies in Saudi Arabia using the mtDNA COI–COII intergenic region and morphometric characteristics, *Bulletin of Insectology* 67 (1).
- Al-Ghamdi, A. & Nuru, A.** 2013. Beekeeping in Kingdoms of Saudi Arabia: opportunities and challenges. *Bee World International Bee Research Association* Vol. 90 (3) 54-57 pp.
- Al-Ghamdi, A.A.** 2005. Comparative study between subspecies of *Apis mellifera* for egg hatching and sealed brood percentage, brood nest temperature and relative humidity. *Pakistan Journal of Biological Sciences* 8(4): 626-630 pp.
- Al-Ghamdi, A., Nuru, A., Khanbash, M.S. & Smith, D.R.** 2013. Geographical distribution and population variation of *Apis mellifera jemenitica* (Ruttner). *Journal of Apicultural Research* Vol. 52 (3): 124-133 pp. (2013) DOI 10.3896/IBRA.1.52.3.03.
- Al-Ghamdi, A., Alsharhi, M., Alattal, Y. & Nuru, A.** 2012. Morphometric diversity of indigenous Honeybees, *Apis mellifera* (Linnaeus, 1758), in Saudi Arabia. (Insecta: Apidae). *Journal of Zoology in Middle East* Vol. 57 97-104 PP.
- Alqarni, A.S.** 1995. Morphometrical and biological studies of the native honeybee race *Apis mellifera* L.; the carniolan *Apis mellifera carnica* Pollmann and their F1 hybrid. MSc Thesis, King Saud University, Riyadh, Saudi Arabia, 143 pp. [Google Scholar]
- Amssalu, B., Nuru, A., Sarah, R. & Hepburn, R.** 2004. Multivariate morphometric analysis of honeybees (*Apis mellifera*) in Ethiopia region *Apidology* 35 71 -81 PP.
- Dutton, R.W., Ruttner, F., Berkeley, A. & Manley, M.J.D.** 1981. Observations on the morphology, relationships and ecology of *Apis mellifera* of Oman. *Journal of Apicultural Research* 20: 201-214 pp.
- Engel, M.S.** 1999. The Taxonomy of Recent and Fossil Honeybees (Hymenoptera: Apidae; *Apis*), *Journal of Hymenoptera Research* 8(2) 165-196 pp.
- Hepburn, H.R. & Radloff, S.E.** 1998. *Honeybees of Africa*. Springer-Verlag; Berlin, Germany. 370 pp.
- Karpowicz, J.** 1989. Beekeeping with *A. m. jemenitica*: modernity in traditionalism. *Bee World* 70: 19-35 pp.
- MEWA.** 2020. MEWA, General Administration of quarantine 2020 annual report.
- Nuru, A., Al-Ghamdi, A.A., Awraris, G., Yilma, T., Answer, A., Aansari, J., Mohammed, A., & Deepak, S.** 2016. Natural nest characteristics of *Apis mellifera jemenitica* (Hymenoptera; Apidae) and its implications in frame hive adoption. *Journal of Animal and Plant Science* 26(4).
- Ruttner, F.** 1988. *Biogeography and taxonomy of Honeybees*. Springer-Verlag; Berlin, Germany. 284 pp.

Annex 1. Regions, governorates, and beekeeper's apiaries with numbers of local and imported bees and number of colonies inspected

Serial number	Region	Governorate	Codes of respondents	Number of local bee colonies per beekeeper	Number of imported bee colonies per beekeeper	Total number of colonies/ beekeeper	No. of colonies inspected per beekeeper's apiary
1	Aseer	Abha	001	60		60	3
2	Aseer	Abha	002	250		250	3
3	Aseer	Rjal Almaa	003	300		300	3
4	Aseer	Rajal Alma	004	650		650	3
5	Aseer	Rajal Alma	005	100		100	
6	Aseer	Rajal Alma	006	250		250	
7	Aseer	Rajal Alma	007	700		700	3
8	Aseer	Rajal Alma	008	200		200	
9	Aseer	Rajal Alma	009	300		300	3
10	Aseer	Rajal Alma	010	355		355	
11	Aseer	Abha	011	40		40	
12	Aseer	Rajal Alma	012	300		300	3
13	Asser	Abha	013	700		700	
14	Aseer	Abha	014	15	70	85	4
15	Aseer	Khamis Mushait	015	500		500	4
16	Asser	Abha	016	25		25	3
17	Aseer	Khamis Mushait	017	200	300	500	5
18	Aseer	Rajal Alma	018	300	650	950	
19	Aseer	Namas	019	300		300	4
20	Jazan	Al-Edabi	020	51		51	3
21	Jazan	Al-Edabi	021	700		700	3

22	Jazan	Sabya	022	550		550	4
23	Jazan	Al-Edabi	023	140		140	3
24	Jazan	Sabya	024	48		48	3
25	Jazan	Dhamad	025	212		212	4
26	Jazan	Dhamad	026	70		70	4
27	Jazan	Al Edabi	027	300		300	
28	Makkah	Maysan	028		1000	1000	5
29	Makkah	Al-Taif	029		2000	2000	3
30	Makkah	Al-Taif	030	500		500	3
31	Al-Baha	Al Mandaq	031	1500		1500	3
32	Al-Baha	Baljarshi	032	1500	700	2200	3
33	Al-Baha	Baljarshi	033	1800		1800	
34	Al Baha	Al Mekhwah	034	1200		1200	3
35	Al-Baha	Baljarshi	035	1800		1800	
36	Al-Bhaha	Baljarshi	036	200	1500	1700	4
37	Al-Bhaha	Baljarshi	037		100	100	3
38	Al-Bhaha	Baljarshi	038		600	600	3
39	Al-Bhaha	Al Mekhwah	039		1000	1000	4
40	Al-Bhaha	Al Mekhwah	040	250		250	3
41	Al-Bhaha	Al Aqeeq	041	500		500	5
42	Al-Madinah	Al-Madina	042	30		30	
43	Al-Madinah	Al-Madinah	043	63		63	3
44	Al-Madinah	Al-Madinah	044	350	150	500	4
45	Al-Madinah	Al-Ess	045		200	200	4
46	Al-Madinah	Al-Ess	046		200	200	4
47	Hail	Al Shnan	047		70	70	4
48	Hail	Al Shnan	048		200	200	4

49	Hail	Hail	049		1000	1000	4
50	Hail	Hail	050		1500	1500	4
Average colony holding size per beekeeper by race					443.8	661.18	570.98
Total number of beekeepers by bee race type					39(78%)	17(34%)	
Beekeepers keep only imported bees						11(22%)	
Beekeepers keep only local bees					33 (66%)		
Total number of bee colonies inspected							138



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