The Journal of Animal & Plant Sciences, 24(6): 2014, Page: 1876-1884
ISSN: 1018-7081

SOCIO-ECONOMIC ANALYSIS OF BEEKEEPING AND DETERMINANTS OF BOX HIVE TECHNOLOGY ADOPTION IN THE KINGDOM OF SAUDI ARABIA

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ABSTRACT

Despite the extensive beekeeping practices in Saudi Arabia, relevant information related to socio-economic profiles of beekeeping and factors affecting the adoption of improved beekeeping technologies were lacking. To understand these conditions, 182 beekeepers from five regions were interviewed using exhaustive questionnaires and the data were analyzed using descriptive statistics and logistic model. The study revealed that still 71.1% of the honeybee colonies in the country are kept in traditional hives and the adoption of box hives have been observed to be significantly influenced by the beekeeper's socio-demographic profiles. Education level had positively influenced the adoption of box hive, which could be due to the fact that education increases knowledge, accesses to information and easily understanding of the technology. The less acceptance of box hive was also implicated with its unsuitability to the biology and ecology of the local bees, which may indicate lack of consideration of these factors in selection and adoption of the technology. The majority (71.5%) of the respondents keep local bees for their better adaptability and 82% of the imported hybrid bees reported to die after one honey-harvesting which could be due to lack of adjustment to the new environment as result of the residual effect of the behavioral rhythms of their original homeland. The majority (93%) of beekeepers reported to migrate their colonies 2-9 times per annum which is important to exploit resources available at different seasons and ecologies. The average annual productivities of colonies were 6.64±5.64kg and 3.69±2.62 kg honey/colony/annum for box and traditional hives, respectively. The average price of locally produced honey is high and varies from $58.87 to $77.86/kg and this has contributed to attract and sustain many people in the beekeeping business. The average annual household earnings from beekeeping was relatively high ($58,937.6), and contributes to an average of 29.67 ±28.95% of the total annual income of beekeepers which show that beekeeping plays a significant role in increasing and diversifying the incomes of rural communities. The major constraints of beekeeping in the country as outlined by beekeepers are absence of rain, shortage of bee forage and honey bee enemies. To enhance the development of the subsector: a strong extension and research supports; consideration of the biology and ecology of the local race in selection and adoption of beekeeping technologies; focusing on conservation and rehabilitation of vegetation with integration of beekeeping; establishing of colony multiplication center and conserving of the indigenous honeybee race would be very important.

Key words: beekeeping, socio-economic, box hive, adoption, honey production, *Apismelliferajemenetica*, Saudi Arabia.

INTRODUCTION

Beekeeping is traditionally a longstanding and environmentally friendly agricultural activity in Saudi Arabia. This activity contributes to the country's economic and social development by providing sustainable additional income and self-employment opportunities for approximately 5,000 household beekeepers in the Kingdom (Al-Ghamdi, 2010). There are an estimated one million honeybee colonies in Saudi Arabia. The major types of honeybee races used in the country are the indigenous honeybees *Apismelliferajemenitica* and the imported hybrid bees, *Apismelliferacarnica*. Approximately 9,000 tons of honey is produced annually in the country (Al-Ghamdi, 2007). However, this production is far from self-sufficient (Al-Ghamdi, 2010). Honey is a highly valued product in Saudi Arabian culture and religion, and the country is one of the largest honey-consuming countries in the world. As a result, the demand for honey is high, and the country imports approximately 15,000 tons of honey annually to fill the gap in demand (CDSI, 2010). Saudi Arabia is the fourth largest honey buyer country next to EU, USA and Japan (USDA, 2013).

In many parts of the world where crop growing is difficult or impossible because of insufficient or intermittent rainfall or where other rural livelihood options are limited, beekeeping is an alternative means of generating income to improve the quality of life of rural communities. Beekeeping is less affected by erratic rainfall conditions than the growing of annual crops, as honeybees can produce honey following any opportunistic rainfall and subsequent flowerings (Clauss,

1983). A significant proportion of the land in the Kingdom is ragged, mountainous, and arid to semiarid, which is climatically not ideal for farming (Al-Shayaa *et al*., 2012) and has little potential for other agricultural activities but can be best used for beekeeping.

Despite the presence of attractive honey prices and its high market demands, a large proportion (70%) of Saudi Arabia's beekeeping industry continues to rely on traditional beekeeping methods (Al-Ghamdi, 2010). As a result, the production and productivity of beekeeping are generally low. To improve the production and productivity of beekeeping it is important to adopt improved beekeeping technologies. Adoption is a decision of individual or groups accept to use recommended ideas, practices or technologies over a reasonably long periods (Feder*et al*. 1985, Dasgupta, 1989). Moreover, it is a complex process which may influenced by different socio-economic factors (Workneh *et al*., 2008) and may also by environmental conditions.

So identification of factors that influencing the adoption of technologies, either positively or negatively, are important for policy makers, researchers and development practitioners to suitably modify the approach or/and the technology to improve its up taking by end users (Workney, *et al*. 2008). In this regard many studies have shown that a careful diagnosis of honey production systems significantly contributes to identifying major constraints of the subsector and to increase honey production and incomes of beekeepers in sustainable ways (Vural and Karaman, 2009; Gidey and Mekonen, 1998). Moreover, study that focused on identifying constraints and opportunities, able to demonstrate the existing beekeeping production systems and come up with recommendations for both research and development interventions (Keralem *et al*. 2006). In addition, the study of Workneh, *et al*., (2008) that focused on identification of determinants of the adoption of improved box hive technology, they able to pinpoint the major factors influencing its adoption.

Despite the extensive beekeeping practices in Saudi Arabia, there is little information related to honey production systems, constraints of the subsector, factors affecting the adoption of beekeeping technologies the socio-economic profiles of beekeepers and the role of beekeeping in household income generation and diversification. Thus, it was essential to assess the beekeeping production system as whole and identify determinants of improved beekeeping technology adoption and major constraints of the subsector.

MATERIALS AND METHODS

Study sites and sampling techniques: The study was conducted in the Kingdom of Saudi Arabia by considering five representative regions: Al-Baha, Hail, Jazan, Madinah, and Taif. Purposive sampling technique was employed to identify the target population of the study area. Accordingly, the required data were collected between April, 2012 – December, 2012.

Data collection: Accordingly, in this study, exhaustive questionnaires were prepared and used to generate all relevant information regarding the beekeeping production systems of the sampled regions. To explore the general overview of the subsector, an initial brief survey was conducted following participatory rural appraisal (PRA) approaches. Subsequently, the questionnaires were pretested and adjusted based on the feedback obtained from the group and finally data was collected by interviewing of sample respondents. Accordingly, from the lists of beekeepers in the respective regional agricultural offices, an average of 36 beekeepers (ranging from 30-46 per region) and total of 182, volunteer beekeepers were randomly selected.

The major information that was generated include: the socio-economic profiles of beekeepers; honeybee colonies holding size/beekeeper; the types of honey bee races used; and the average honey yield per hive, per harvest, and per annum. Moreover, the types of hives (log or box) used, their preferences, reasons of preferences and the determinants of box hive adoption, were assessed. Furthermore, the financial returns of beekeeping, the annual household net incomes from beekeeping and its share of the total annual income of beekeepers were estimated. The major constraints of beekeeping and the major honeybee enemies and diseases according to their degree of importance were also recorded. Moreover, the marketing of bee products and the prices of different types of honey by region and by botanical origin were recorded and compared. Finally, the types of management practices that are used to handle bee colonies were considered.

Statistical analysis: Descriptive statistics were used to analyze the quantitative data. Pair-wise ranking technique was used to determine the preferred types of technology by users and to identify and prioritize the major beekeeping constraints. Moreover, matrix ranking was applied to identify the reasons for the respondents' preferences for one technology type over another. A rank score was also calculated for each variable to screen the major constraints perceived by beekeepers. Besides the technological and environmental factors that might influence the adoption of box hive, the role of some socio economic profiles of beekeepers in determining the adoption of box hives were also analyzed using logistic model by comparing adopters and non-adopters. The data that generated were analyzed using SPSS version 18 (2009).

RESULTS AND DISCUSSION

The results were based on the responses of 182 beekeepers who owned a total 63,951 bee colonies, (45,987 in traditional hives and 17,964 in box hives), with an annual average honey production of 288.3 tons.

Socio-economic profiles of beekeepers: The study revealed that the average age of the beekeepers was 46.58 ± 10.50 years, with a range of 22-70 years. Only 5.49% of the beekeepers were younger than 30 years old, 18.13% were between the ages of 30 and 40, and the remaining 76.37% were over 40 years old. The age distribution of beekeepers is generally within the active working age. However, the proportion of young people involved in beekeeping is low, which may be due to the presence of alternative job opportunities in the country. Regarding their experience in the business, the respondents had an average of 18.18 ± 10.69 years of experience, with a range of 1-50 years of working practice with honey bees. Moreover, 76.24% of the beekeepers had at least 10 years of experience (Table 1). The average family size of the interviewed beekeepers was 8.32 ± 4.49 members, which was larger than the national average family size of 5.84 (Table 1). Regarding their educational backgrounds, 40.7% had studied in higher learning institutes (diploma to PhD), 24.7% had attended secondary school, 26.9% had completed primary school, and the remaining 7.7% were illiterate. The large proportion of the respondents have formal education and adoption of improved beekeeping technology, such as box hives, had significant positive correlation ($r = 0.35$, $N = 180$, $P < 0.0001$) with their educational levels. The experience of beekeeper was positively correlated with the use of traditional hives ($r = 0.21$, $N = 179$, $P = 0.004$), which indicate older people have less interest to adopt box hives.

Table 1. Some socio-economic characteristics of beekeepers in the sampled regions

Region	No. of respondents	Age	Family size	Beekeeping experience	% of formal education
Madinah	30	47.87 ± 8.31	8.57 ± 4.48	19.40 ± 8.30	96.67
Hail	30	43.90 ± 8.45	6.73 ± 2.35	11.13 ± 7.96	100
Taif	31	45.74± 11.44	9.57 ± 5.75	22.74 ± 9.93	83.9
Jazan	45	45.29 ± 11.88	8.50 ± 4.97	14.76 ± 9.72	95.56
Baha	46	49.45 ± 10.56	8.26 ± 4.06	22.33 ± 11.80	90.91
Total	182	46.58 ± 10.50	8.32 ± 4.49	18.18 ± 10.69	93.41

Honeybee colony holding size and types of races used: The honeybee colony holding size of the beekeepers ranges from five to 3000, with a mean of 351.38 ± 365.26 (Table 2). Among these beekeepers, 24.73% hold less than 100 colonies, 58.98% of the beekeepers hold between 101 and 500 colonies, 16.48% of them hold between 501 and 1000 colonies, and the remaining 3.85% hold more than 1,000 colonies. Generally, the average holding size is a semi-commercial and economic size to sustain the business.

The majority (71.5%) of the respondents keep local bees, 19.2% prefer to keep imported hybrid bees, and the remaining respondents (9.3%) keep both types of races. The reasons for the higher preferences for the local bees, as explained by 68% and 21.3% of the respondents, were for their more adaptive and productive, values respectively, than imported hybrid bees within the same environmental situation in the region. Some of the adaptive characteristics of local bees are:- their ability to withstand different forms of environmental stress and to survive long dry periods with little or no rainfall for more than years (Ruttner, 1988). The adaptability of local bees may stem from their long years of ecological adaptation and environmental selection in the region. In addition to their small body size, and their small colony populations (Ruttner, 1988) may have been selected for environmental reasons to avoid risks resulting from the harsh and unpredictable climate conditions of the region. The better adaptation and performance of *A. m. jemenitica* than imported bees in the hot and arid climatic conditions of Saudi Arabia have been reported (Alqarni *et al*. 2006, 2011 &Abou-Shaara *et al*. 2012). However, maintenance feeding and moving colonies frequently in pursuit of better forage are some of the challenges of beekeeping in the region.

In this survey, the beekeepers reported that, approximately 82% of imported hybrid bees die after one honey-harvesting season for reasons that are not yet certain. The possible factors for death of the imported colonies could be perhaps lack of adjustment to the new environment. This agrees with the Avetisyan's hypothesis, colonies that are moved from one region to another may continue to follow behavioral rhythms that are similar to those of their original homeland (Johanssons and Johanssons, 1979). Alternately, this phenomenon may be a residual effect of prior environmental experience "after effects" (Sheeba *et al*. 2002), which may be critical for survival in extremely different environments. Moreover, the physiological, morphological, and behavioral character of imported bees may not be suitable for the

arid climatic zone of the region. In this regard, the adaptability range or phenotypic plasticity of European evolved bees (*A. m. carnica* (hybrid) in the arid climatic conditions of Saudi Arabia must to be investigated.

Table 2. Honeybee colony holding size of beekeepers by regions and hive types

Region	No. of respondents	Traditional hive owned	Box hive owned	Average honeybee colonies/household
Madinah	30	200.70 ± 211.36	87.20 ± 129.14	287.90 ± 244.42
Hail	30	49.00 ± 188.72	209.00 ± 254.70	258.00 ± 297.10
Taif	31	255.32 ± 250.88	69.61 ± 128.15	324.94 ± 276.69
Jazan	45	333.02 ± 269.06	62.22 ± 167.67	395.24 ± 308.72
Baha	46	339.02 ± 524.39	89.56 ± 166.55	428.59 ± 529.17
Total	182	252.67 ± 346.53	98.70 ± 179.04	351.38 ± 365.26

Types of beehives used and determinants of box hive adoption: The current study revealed that both traditional and box hives are used in the Kingdom. However, there is a greater preference for the use of traditional hives; 62.4% of the respondents continue to use local hives, whereas 37.6% use box hives. Of all of the honeybee colonies owned by the respondents, 71.1% are kept in local hives. The major reasons for the low adoption rate of box hives as beekeepers opinion were difficulty of transporting box hives during migration of honeybee colonies; its unsuitability for local bees in the existing environmental conditions and high costs in degree of importance. Moreover, lack of training and extension supports, unavailability, lack of awareness were also mentioned as factors.

In addition, the role of some socio economic profiles of beekeepers in determining the adoption of box hives were assessed using logistic model, and the analysis indicated that, 75 % of the total variation for the adoption of box hive was explained by logistic model. The χ^2 result also showed that the parameters were significantly different from zero at P<0.01 for adopting box hive. Moreover, the model correctly predicted sample size of 70.9 % and 77.9% for adopters and non-adopters, respectively. The explanatory variables that fit the model: family size, age, education level were found to be significant as hypothesized. The explanatory socioeconomic variables that were significantly influencing the adoption of box hive were family size, age and education level. Family size and education levels were positively influencing the adoption of box hives while age of beekeepers was negatively influencing (Table, 3).

Table 3. Logistic regression for factors influencing adoption of box hive

variables	B	S.E.	Wald	df	Sig.	Exp(B)
experience	0.013	.025	.265	1	.606	.987
family size	0.125	.063	3.898	1	.048**	.882
age	-0.061	.030	4.244	1	.039**	1.063
education level	1.230	.255	23.261	1	.000***	3.423
Constant	-5.871	1.464	16.077	1	.000	.003

-2 log likelihood = 141.013, χ^2 = 38.254***;*,**,*** significant at p<0.1, p<0.05, and p<0.01, (n=137)

Despite the higher productivity of colonies in box hives, the low adoption rate of the technology, as mentioned by beekeepers, may result from its unsuitability for local bees. The inappropriateness of the box hive (which was designed for the European bee population size) may stem from its volume incompatibility with the population size of local bees in different seasons in the region. Balancing population size with the amount of stored food in the hive and hive volume were reported as important to the survival of a colony (Wright, 2003). Moreover, the local bees are the smallest races of *Apismellifer* (Ruttner, 1988), and their brood cell diameter and cell depth are expected to be smaller than those of European bees. Therefore, the foundation sheet and the bee space developed for European bees may not suit to the body size of the local bees and may not allow them to perform well in this type of box hive.

Success in beekeeping primarily results from the utilization of improved beekeeping technologies that are suitable for local bee types and conditions (Hepburn and Radloff, 1998). These conditions may generally indicate, the importance of considering the biology and ecology of the bees in selection and adoption of technologies.

Besides the technological and biological factors; the socio-demographic conditions of beekeepers observed to play significant role in the adoption of technologies. As hypothesized, education influences the adoption of

improved box hive positively and significantly at P<0.01 %. The odds in favor of adopting improved box hive increased by a factor of 3.423 for beekeepers who had more education level. The possible reasons for more adoption of box hives by beekeepers with higher educational backgrounds, could be that education may increases access to information and their knowledge to understand the technology more. The result is also supported by earlier studies (Workneh et. al., 2008; Workneh, 2011).

As expected, family size influences adoption of improved box hive positively and significantly at P<0.05 %. The odds in favor of adopting improved box hive increased by a factor of 0.882 for beekeepers who had more family size. This could be due to the fact that farmers with large family size might significantly adopt the technology more, to satisfy the need of their family. As, anticipated that young people adopt the improved box hive more than elders. The influence of age in adoption of box hive is statistically negatively significant at P>0.05. The odds in favor of adopting improved box hive increased by a factor of 1.063 for beekeepers who are young people. Empirical study revealed that young are more flexible in deciding for change than aged people (Motamed and Singh, 2003).

Honeybee colony management practices: The seasonal shortages bee forages cause 93% of beekeepers to move their honeybee colonies from place to place in search of better forage and favorable climatic conditions. The frequency of annual migration varies from 2 to 9 with a mean of 5.05 ± 3.16/annum (Table 4). The interviewed beekeepers reported that they move their colonies primarily during the flowering periods of the *Ziziphusspina-christi* (Sidr), *Acacia origena* (Talh), *Acacia tortilis* (Sumra), *Acacia ehrenbergiana* (Salam), *Acacia asak* (Dahiana), and *Lavendula* species, in order of importance based on their honey production potential. In arid zones with brief flowering periods that primarily occur following rain showers; migrating of colonies is the major aspect of bee management practices for efficiently exploiting the available floral resources, both for the maintenance of colonies and for honey production. Variations in the availability of floral resources among locations and the exploitation of honey flow by shifting colonies from one region to the other have been reported (Thomas *et al*., 2001). In addition to flower scarcity, extreme weather conditions, such as hot summers in lowlands and cold winters in highlands, force beekeepers to move their colonies. The variations in temperature and rainfall are the key factors influencing beekeeping practices in Saudi Arabia (Alqarni*et al*., 2011), and stationary beekeeping is rare and does not appear to be economically feasible. Similarly, migratory beekeeping has been reported to be more profitable than stationary beekeeping in India (Sharma and Bhatia 2001).

Despite extensive migratory practices in the region, there are no rules for maintaining of optimum distance of 2-3 miles which known as a standard distance among apiary sites (Grout, 1949). Generally, in the area there is high trend of keeping large number of colonies up to 600 in a single apiary without considering the carrying capacity of the area. These have been resulted overcrowding and declining of honey yields. Serious declining of yield per colony as a result of overcrowding were reported earlier (Khanbash, *et al*. 2008).

Honey production and productivity of colonies: According to the responses of the interviewed beekeepers, the average productivities of colonies in traditional and box hive are 1.25 ± 1.11 kg and 2.26 ± 1.88 kg per harvest, respectively (Table 4). Given the average annual honey harvesting frequency of colonies (3.05 ± 1.13/annum), the overall annual productivity of colonies in box hives was 6.64 ± 5.64 kg/colony/annum with a range of 1-37 kg, and the yield differs significantly among regions ($F = 5.59$, $df = 4$, $P < 0.01$). The overall annual productivity of colonies in traditional hives was 3.69 ± 2.62 kg/colony/annum with a range of 0.5-20 kg, but it does not differ significantly among regions ($F = 1.12$, $df = 4$, $P = 0.352$). A group comparison using multiple comparisons showed variations among the regions in the annual productivity of box hives but not in traditional hives (Table 4). The interviewed beekeepers produce an average of 1587.72 kg (932.35 kg from traditional hives and 655.37 kg from box hives) of honey per beekeeper/annum. The major honey types produced in the regions were *Ziziphusspina-christi* (Sidr), *Acacia origena* (Talah), *Acacia tortilis* (Sumra), and other types of honey such as Lavendula, *Acacia asak* (Dahiana).

Despite the low average honey yield per harvest, the annual honey yields per colony of 3.69 ± 2.62 kg and 6.64 ± 5.64 kg in repeated harvest for local and box hives, respectively, are relatively good. These yields may increase depending on the frequency of migration and subsequent harvests. However, Abdulaziz (2012) has reported an average annual honey yield of 5.8 kg and 9 kg for local and box hives, respectively, for the Al-Baha region. These findings indicate variations in the annual average yield from year to year and place to place. Generally, the average colony holding size of beekeepers (351.38 ± 365.26) and the total honey production per apiary (1587.72 kg/annum) are relatively high, which is economic size to maintain the business.

Table 4. Frequencies of colony migration and honey harvesting and productivity by hive types in the sampled regions.

Region	Frequency of colony migration/year	Frequency of honey harvest per year	Productivity (kg) of traditional hive/harvest	Productivity (kg) of box hive/harvest	Annual productivity (kg)/ traditional hive	Annual productivity (kg)/ box hive
Baha	5.91 ± 3.29	3.39 ± 1.05	0.92 ± 0.59	1.56 ± 0.47	3.70^{a} ± 1.39	5.56^{a} ± 2.41
Hail	3.55 ± 3.53	3.07 ± 1.11	0.74 ± 0.62	1.62 ± 1.40	2.00^{a} ± 2.12	4.29^{a} ± 1.94
Jazan	4.24 ± 2.12	2.91 ± 0.82	1.25 ± 0.75	3.19 ± 2.27	3.67^{a} ± 2.13	9.00^{ab} ± 7.49
Madinah	4.14 ± 1.74	3.03 ± 1.61	1.27 ± 0.74	2.83 ± 2.19	3.19^{a} ± 1.23	7.39^{ab} ± 4.41
Taif	6.87 ± 3.40	2.81 ± 1.08	1.74 ± 1.95	3.76 ± 2.84	4.35^{a} ± 4.57	13.57^{b} ± 12.46
Cumulative average	5.05 ± 3.16	3.05 ± 1.13	1.25 ± 1.11	2.26 ± 1.88	3.69 ± 2.62	6.64 ± 5.64

Different letters in the columns indicate significant differences between locality means in the annual productivity per colony at $P < 0.05$.

The productivity of box hive per harvest was twice than that of traditional hives, this is perhaps because of the use of better management practices, such as providing wax foundation sheets, recycling of drawn-out combs after honey extraction, and performing inspectionsto encourage higher productivity of the colony. Better honey storing of colonies in box hives with foundation sheet has been reported (Al-Ghamdi, 2005). Moreover, the possible advantage of increasing the overall average honey yield of colonies in box hives over traditional hives has been well documented in Nigeria (Fadare*et al*. 2008). In this regard, to enhance the production and productivity of beekeeping, the adoption of box hives with necessary modifications, considering the biology and ecology of local bees would be important.

Price of honey: The majority (59.3%) of the beekeepers sell their honey directly to consumers. There is a large price disparity among the different types of honey within the region and within the same types of honey among regions. Generally, *Ziziphusspina-christi* honey commands high prices across all regions, with a range of 257.1 ± 37.4 - 376.4 ± 111.3SR and a mean of 292.0 ± 85.7SR (Table 5). The overall price among different types of honey differs significantly within the regions, except in the Madinah region (Baha: $F = 13.37$, $df = 3$, $P< 0.001$; Hail: $F = 5.21$, $df = 3$, $P< 0.01$; Jazan: $F = 126.71$, $df = 3$, $P< 0.001$; Madinah: $F = 0.22$, $df = 3$, P = 0.884; Taif: $F = 15.11$, $df = 3$, $P < 0.001$). Moreover, the overall price of similar types of honey differs significantly among the regions (Sidr: $F = 8.29$, $df = 4$, $P< 0.001$; Talh: $F = 11.45$, $df = 4$, $P< 0.001$; Sumra: $F = 14.82$, $df = 4$, $P< 0.001$; others: $F = 20.26$, $df = 4$, $P< 0.001$).

Table 5. Price (SR/Kg) comparison within the same types of honey among regions

Region	Sidr (*Zizphusspina-christi*)honey	Talh (*Acaicaorigina*) honey	Sumra (*Acacia tortilis*) honey	Other honey
Baha	275.58^{a} ± 52.75	215.12^{a} ± 42.20	214.50^{a} ± 64.41	290.00^{ac} ± 90.68
Hail	376.39^{b} ± 111.30	300.21^{b} ± 78.37	331.25^{ab} ± 117.92	238.33^{a}±135.14
Jazan	257.13^{a} ± 37.35	196.43^{a} ± 57.06	174.34^{d}± 39.87	79.88^{b} ±39.32
Madinah	296.00^{a} ± 98.33	298.42^{b} ± 107.72	336.67^{be} ± 168.30	321.25^{ac} ±289.30
Taif	315.68^{ab} ± 117.23	224.17^{a} ± 53.56	256.04^{ac} ± 40.73	390.00^{c} ±111.57
Average price	291.99 ± 85.73	244.47 ± 78.05	234.21 ± 101.11	218.88±182.60

* 3.75SR = 1USD; Different letters in the columns indicate significant differences in mean honey prices per kg among different localities at $P < 0.05$.

The result revealed that most respondents are motivated to produce mono-floral honey to supply consumers with high-quality honey either in the form of comb honey or extracted and packed for various levels of demand. However, beekeepers obtain better prices from comb honey, as consumers are willing to pay higher prices for this honey, which is believed to be free of adulteration (personal communication).

Domestic consumers highly prefer locally produced honey over imported honey and are willing to pay five to eight times more money. The average prices of locally produced honey are 17 times higher than the average price of honey in the US ($3.36/kg) (USDA,

2013).The high price of locally produced honey could be related to the high promotional activities, cultural and religious values in society. Moreover, the subjective choices of consumers for local honeys, its scarcity, and the relatively high incomes of middle- and upper-class consumers who can afford to buy expensive honeymay have contributed for its high price. The high price of honey has increased the circulation of money from urban people with a relatively high standard of living to rural people with a relatively low standard of living. Moreover, the high prices of locally produced honey encourage many people to become involved in the beekeeping business. The majority of honey producers sell their products directly to consumers based on personal communication and this indicate that honey market is not efficient or not well organized and reportedly as one of the challenges of producers.

Production cost and net income of honey production: The overall average total production cost and net income per beekeeper from honey production were 52,397.29 and 221,016SR per annum, respectively. The results in Table 6 show that the highest average annual earnings were recorded in the Taif region (334,296SR), while the lowest (159,007SR) Madinah. In addition to family labor, most beekeepers hire at least one to two employees and a total of 191 permanent and 112 temporary laborers from other countries were working in beekeeping activities.

This study shows that beekeeping contributes an average of 29.67 ±28.95% of the annual income of beekeepers in the studied regions. However, this contribution varies from 1% to 100%. There are regional differences in the role of honey production with respect to total household income per annum. Honey production contributes as much as 46.09 ± 30.64% to the total household income in the Al-Baha region and as little as 13.11 ± 12.07% in Madinah (Table 6). Generally, the results show that beekeeping is a profitable business in the Kingdom of Saudi Arabia.

The annual average share of income from beekeeping (29.67 ± 28.95%) in relation to beekeepers' total annual income indicates that beekeeping plays a significant role in increasing and diversifying the incomes of rural communities and provides a means of self-employment opportunities. This finding is consistent with the report of Al-Ghamdi (2010), who reported that beekeeping is the main source of income for 5,000 households in the Kingdom.

Table 6. Average cost of production and net annual income of beekeeping ventures per apiary

Region	Fixed cost (A)	Variable cost (B)	Total production cost (A +B) = C	Gross annual income from honey sale (D)	Annual net income from honey sell (D-C)	Average %annual share of income from beekeeping
Baha	37341.96	13351.19	50693.15	322386.15	271693	46.09
Hail	20026.30	14140.69	34166.99	220999.99	186833	20.43
Jazan	31285.68	31332.56	62618.24	218545.24	155927	34.77
Madinah	30416.97	17684.81	48101.78	207108.78	159007	13.11
Taif	44127.29	16646.77	60774.06	395071.06	334297	22.21
Total average	33004.56	19392.73	52397.29	273413.29	221016	29.67

Major constraints of beekeeping: The interviewed beekeepers prioritized the major beekeeping constraints in degree of importance as: absence of rain, shortage of bee forage and bee enemies. Moreover, extreme temperatures, honeybee diseases, poor bee product marketing, pesticides and lack of training were also mentioned as important constraints of the subsector. Moreover, among the major honeybee enemies of the study areas; honeybee-eater birds, wasps (*Vespa orientalis*), wax moths and varroa mites were also reported as economically important in their degree of importance. It is reported that a large number of honeybee colonies are lost every year in the studied regions. According to the beekeepers report 24.65% of their colonies were lost in 2012. The major factors for loss of colonies as perceived by the beekeepers, were a shortage of honeybee forage, diseases, pesticides, honeybee enemies, and extreme temperatures.

The absence or inadequate rainfall and subsequent scarcity of the bee forage are very important problem to the subsector, which could be due to the general climate changes in the region. Optimum nectar flow is promoted by adequate rainfall prior to flowering period (Akangaamkum *et al*. 2010). A decreasing trend of precipitation by 47.8 mm and an increase in mean ambient air temperature by 0.60°C per decade were reported for Saudi Arabia (Almazroui, *et al*. 2012). These changes might have contributed to declining soil moisture, soil organic matter and rising temperatures, and an increase in aridity of the area which undoubtedly directly and indirectly contributed for the scarcity of bee forages.

In addition, honeybee diseases, like varroa mites is important both in its degree of damage and wide distribution. These infestation may be due to movement and close contact of large number of colonies like: large scale importation of package bees, extensive migratory practices, placing of large number of (up to 600) colonies/apiary and absence of reasonable distances between apiaries. The endangering of indigenous race through disease infestation as result of continuous importation of package bees have been reported (Al-Ghamdi, *et al*. 2013). Honeybee enemieslike: Bee-eater birds, and wasps are the most important enemies of honeybees in the country, and both are difficult to control because they not only eat bees in apiaries but also eat them while foraging flowers in the field. Bee- eater birds are very important because the regions are the main route for these seasonal migratory birds and occur in large groups in two seasons when they move from north to south and south to north. In general in most tropical countries honeybees enemies are reported to be more important (Yirga*et al*. 2012, Awraris*et al*. 2012). The overall effects of such challenges are reported to manifest in low production and poor yields of colonies (Akangaamkum *et al*. 2010).

Conclusion and recommendations: Despite many challenges, beekeeping is a viable business that contributes significantly to increasing and diversifying the income of many rural households in the Kingdom. Moreover, beekeeping provides a means of supplementary business and self-employment opportunities for many families. To enhance the development of the subsector, the following areas should be considered: A strong extension and research supports to enhance the development; consideration of the biology and ecology of the local race in selection and adoption technology; conservation and rehabilitation of vegetation with integration of beekeeping; organizing of beekeepers for efficient marketing of bee products; establishing of colony multiplication center and multiplying, distributing and conserving of the indigenous honeybee race would be very important.

Acknowledgements: This study was financially supported by the NSTIP Strategic Technologies Program project number 11-AGR1749-02 in the Kingdom of Saudi Arabia. So the authors would like to acknowledge NSTIP for its financial and technical supports.

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