J. Myanmar Acad. Arts Sci. 2021 **Vol. XIX. No.3**

STUDY ON BEEKEEPING OF TWO QUEENS SYSTEM ON EUROPEAN HONEYBEE *APIS MELLIFERA* LINNAEUS, 1758 IN MAGWAY REGION*

Nyo Nyo Lwin[1], Thein Thein Htay [2], Myo Myo Aye[3]

Abstract

Number of cells containing on the colony structures such as open, seal, egg and empty showed very drastic changes. Seal cells were recorded that too highest condition as 33.47% as well as open cells 15.3% in 2Queen beehive 2, respectively. Especially, high condition of seal cells was recorded as 15.23% in Control2. Relation of honey production with mean weather conditions in experiments and control were recorded. Honey production was showed highly statistically significant difference as ($p < 0.001$) between double-queen and single-queen colonies. Pollen production level was no statistically significant difference as ($p > 0.05$) for double-queen colonies compared to the single-queen during the study period. Within each queen systems, production of honey and pollen were recorded statistically significant difference as ($p < 0.05$), respectively. The large weight honeys were recorded as hive number 1, 2 and 3 of single-queen and double-queen systems during the sunflower seasons. Especially, as 39.8% in hive number 3 was recorded the highest stored honey in single-queen system and as 37.3% in hive number 2 was recorded the highest weight honey in double-queen system. Within one queen system as well as two queen system, production of honey and pollen were recorded statistically significant difference as ($p < 0.05$) with ANOVA HSD test in terms of number of combs occupied by nectar and pollen. Honey production cost difference indicates that was showed higher production costs for managing single-queen colonies compared to double queen colonies as well as pollen production cost

Keywords: Honeybee, Two queens system, Life stages and bee products

Introduction

Honeybees are the main insects which help in pollination of different species of plants. Honeybees are beneficial to both agriculture plant and most wild plants as pollinator. For mankind they provided a lot in agriculture, medicine and food (Sawyer, 1981).

They are major agricultural pollinators around the world and are the keystone pollinators in tropical ecosystems. Pollination has been considered a keystone process to ecosystem function through the facilitation of both plant and animal diversity (Suwannapong *et al*., 2012).

A colony of honeybee consists of a queen, several thousand workers and in a certain season of the year- a few hundred drones. Among the members of the colony there is a division of labour and specialization in the performance of biological functions.

The queen, a true mother bee, is the only female that is completely developed sexually. In the colony, she is found in the area of the brood nest. The developmental time of the queen, 16 days, is the shortest. Workers are females that are not fully developed sexually. They do the work of the colony and maintain it in good condition. Workers have special structures and organs which are associated with the duties they perform. The adult worker emerges from the cell 21 days after the egg is laid. Drones, the males of the colony, are produced from unfertilized eggs. The body of the drone is larger than that of the worker or queen. The eyes are large and cover practically the whole head. The developmental period of drones is 24 days (Yadav *et al*., 2017).

The presence of one queen in a colony of bees is generally considered normal. The beekeeper, however, may frequently find mother and daughter queens laying eggs in the colony.

[1] Professor/Head, Department of Biology, Yangon University of Education
[2] Associate Professor, Department of Zoology, West Yangon University
[3] Associate Professor, Department of Biology, Yangon University of Education
[*] Best Paper Award Winning Paper in Zoology(2020)

Establishing a two-queen colony is based on the harmonious existence of two queens in a colony unit.

The two-queen system has been recommended as a way to increase honey production without increasing the number of colonies operated. Bee population becomes high, due to the combined efforts of two queens, and there was grave danger of overcrowding. The two-queen colonies required regular manipulation, and serious difficulties arose when they were neglected. Super requirements increased greatly during a heavy honey flow, and it was almost impossible to give each unit enough supers (Gilbert, 1940).

Taking these facts into consideration, the present work was conducted with the following objectives.

- to investigate the beekeeping of two queens system in Pwint Phyu Township, Magway Region
- to compare the life stages and bee products between one queen and two queen systems

Materials and Methods

Study site

Beekeeping site was selected in Pwint Phyu Township, Magway Region located at latitude 20° 27'23.48" N and longitude 94°49' 29.91" E. The study area has active blooming seasons in which pollen and nectar are available for the bees (Plate. 1).

Study period

The study was carried out during October, 2017 to March, 2018.

Experimental Colony Set Up

Three normal beehive colonies were composed of one queen, about one hundred drones and about 9000 workers bee. Three sets of two-queen beehives (2QH1, 2QH2, 2QH3) were prepared by two brood chambers bottom hive which each bottom hive consist four frames and super hive which includes six seal frames as only honey collection combs (Plate. 2).

These colonies were maintained in nuclei to achieve standard hive colony size and bee colonies were transferred to moveable frame hives and managed under the same conditions and brought to the uniform strength. Three colonies were selected and allocated to the single-queen system colony management and another three selected and allocated to the two-queen system colony management. Selection of the colonies was conducted at random. These selected colonies were used and no treatment shift occurred during the study period.

Two queen system of beekeeping, each brood chamber of bottom hive was placed by one honey or pollen comb, open brood comb, two combs of seal as well as one mated queen. Especially, queen excluder was covered between bottom hive and super hive. After three days, experimental design of double queen beehive was checked to know the conditions of queen bee and inside the beehive. At the same time, three beehives with each of one queen were designated as the control experiment.

Collection of Data

Weekly data collection was made at apiary. Especially, life stages and bee products were recorded. Weather parameters such as maximum and minimum temperature and relative humidity were also recorded to relate the changes of bee products throughout the study period. Meteorological data were obtained from Department of Meteorology and Hydrology, Magway Region.

Statistical Analysis

Honey and pollen data was compared by using t-test between one and two-queen management systems. Relations of bee products and bee calendar were subjected to ANOVA- HSD test over the period data both one and two-queen management systems. Cost benefit analysis was performed on the bases of investment cost on value of amount of honey produced under each system. SPSS (Statistical Package for Social Science) version 25 was conducted.

Identification

The honeybees were identified according to the methods described by Bingham (1897).

Pwint Phyu Township, Magway Region

Plate 1 Map of study site (Source: Google Earth, 2018)

A. Sets of two queens beehives (2QH)

B. One queen beehives

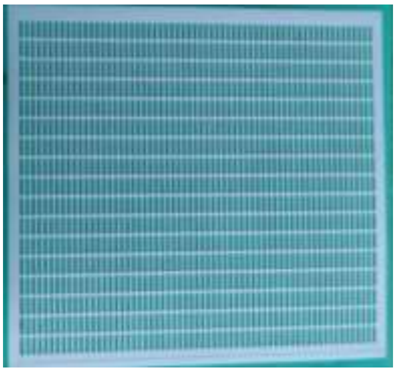
C. Apiary

D. Food source plant of honeybee

Plate 2 Beekeeping of two queen system

A.Smoker

B. Bee Veil



C. Queen Excluder

D. Hive Tool

E. Digital Thermometer

F. Hygrometer

Plate 3. Equipment

Results

Comparison on the life stages of honey bee between experiments and control

Seal cells were recorded that too highest condition as 33.47% as well as open cells 15.3% in 2Queen beehive 2, respectively. Life stages of honey bee were recorded as available condition of egg, open, seal and empty in control bee hives. Especially, high condition of seal cells were recorded as 15.23% in Control2 (Fig 1 and Table 1).

Table 1 Mean of comparison on the life stages of honey bee between experiments and control

Proportion (%)	Bee Hives					
	Control1	2QH1	Control2	2QH2	Control3	2QH3
Egg (%)	2.49	3.13	2.16	3.07	1.4	1.95
Open (%)	8.5	14.56	7.3	15.3	5.27	12.94
Seal (%)	11.68	20.67	15.23	33.47	11.5	21.15
Empty (%)	1.5	30.39	1.3	20.02	2.01	39.42

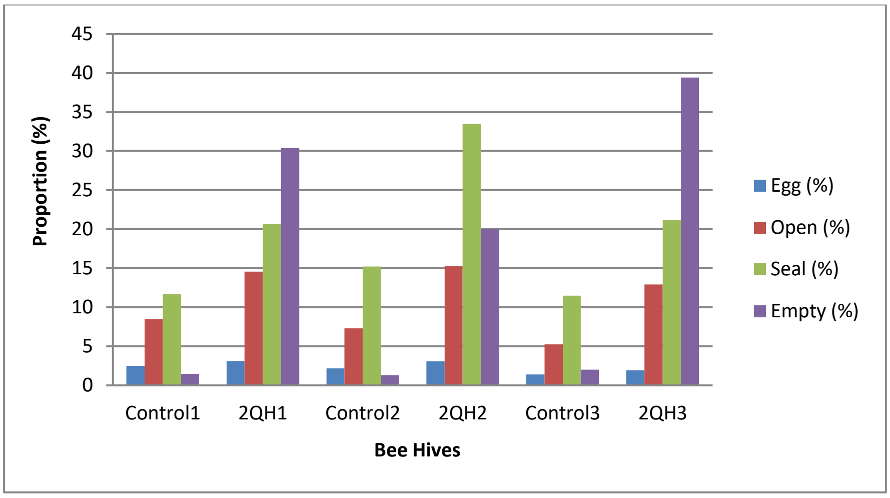


Figure 1 Mean of comparison on the life stage of honeybee between experiments and control

Relation of honey production with mean weather conditions in experiments and control

Honey production was too high weight as 23.8 kg in 2Queen hive 2 (2QH2) and 23.47kg, 25.22kg, 24.05kg in 2Queen hive 3 (2QH3) when level temperature about 30˚C were recorded in December and January. And them, pollen condition was high as 2.5kg in 2Queen hive 1(2QH1) and 2Queen hive 3 (2QH3) were also recorded in December (Fig 2,3 and Table 2, 3).

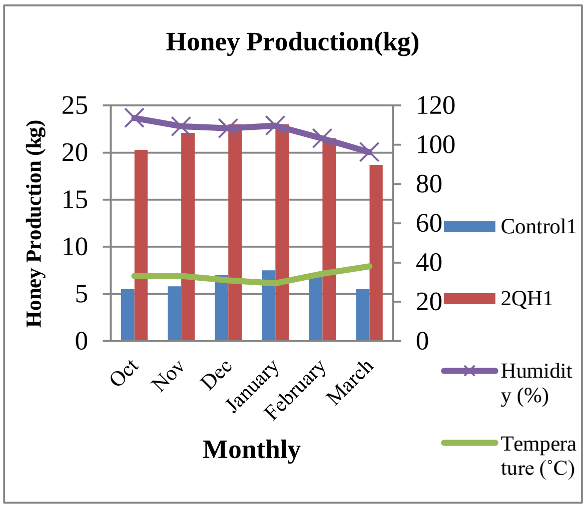
When humidity conditions between 75% to 80%, honey production was too high in both 2Queen beehive 1 and 2Queen beehive 2 as well as high condition of pollen production in these two hives (Fig 2,3 and Table 2, 3).

Table 2 Relation of Honey production with mean temperature and humidity in experiments and control

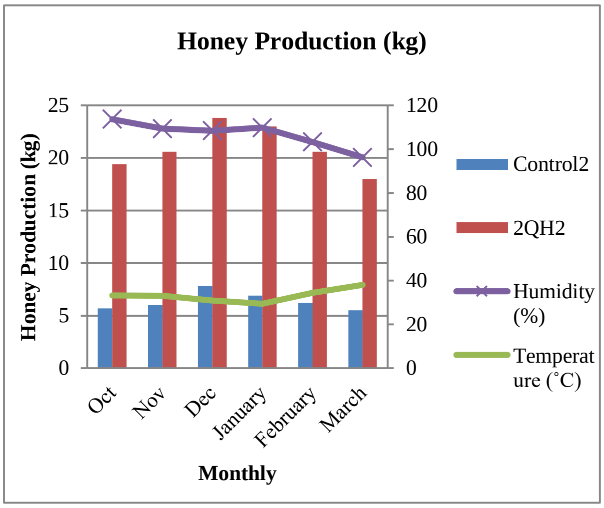
Bee Hives	Honey Production (kg)					
	Oct	Nov	Dec	January	February	March
Control1	5.5	5.8	7	7.5	6.8	5.5
2QH1	20.3	22.1	23	23	21.5	18.7
Control2	5.7	6	7.8	6.9	6.2	5.5
2QH2	19.4	20.6	23.8	23	20.6	18
Control3	6.5	7.2	9	8.8	7.8	5.4
2QH3	21.5	23.47	25.22	24.05	22	19.45
Temperature (˚C)	33.25	33.12	30.86	29.47	34.3	37.98
Humidity (%)	80.42	76.2	77.52	80.29	68.96	58.21

Table 3 Relation of Pollen production with mean temperature and humidity in experiments and control

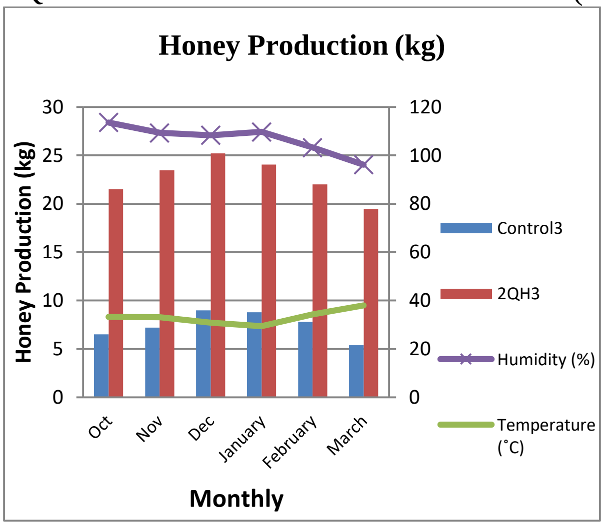
Bee Products / Bee Hives	Pollen Production (kg)					
	Oct	Nov	Dec	January	February	March
Control1	0.5	1.69	2	1.5	0.7	0
2QH1	1.3	1.5	2.5	1.8	1.2	0
Control2	0.5	1.5	2.1	1.5	0.5	0
2QH2	1.5	1.8	2.1	2	1.5	0
Control3	0	1.75	1.98	1.3	0.5	0
2QH3	1.2	2.3	2.5	1.6	1.7	0
Temperature (˚C)	33.25	33.12	30.86	29.47	34.3	37.98
Humidity (%)	80.42	76.2	77.52	80.29	68.96	58.21



(A) Control 1 and 2QH1

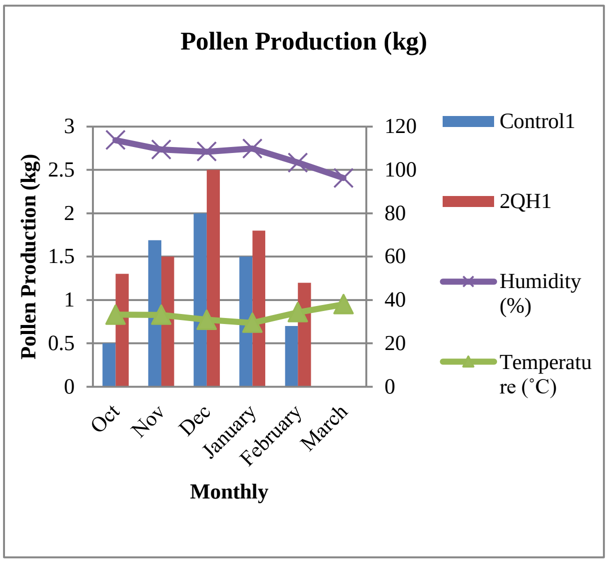


(B) Control 2 and 2QH2

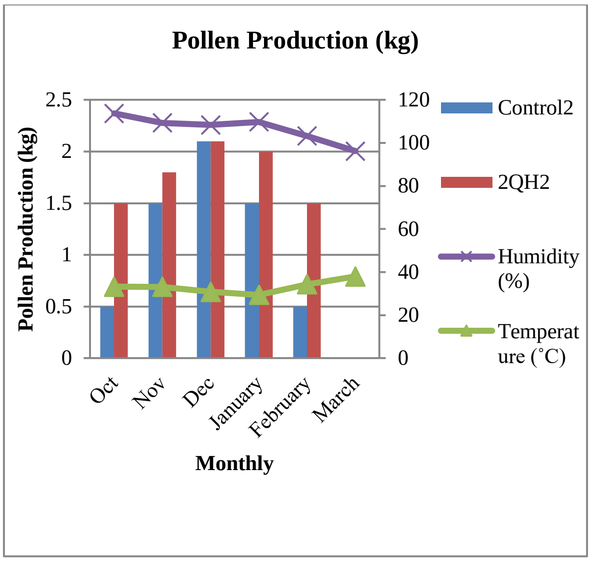


(C) Control 3 and 2QH3

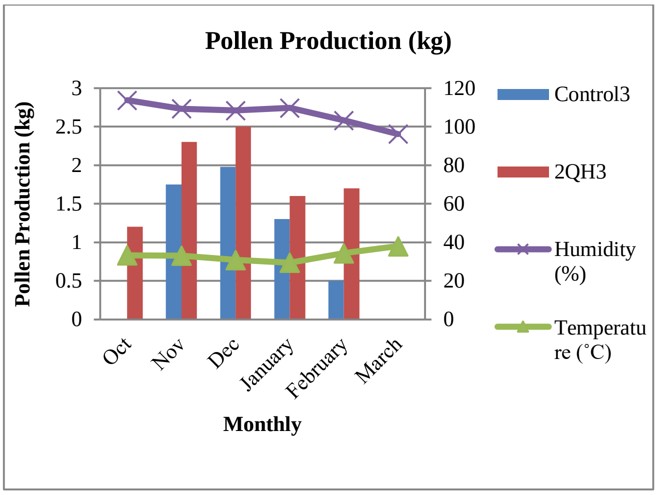
Figure 2 Relation of honey production with mean weather conditions in experiments and control



(A) Control 1 and 2QH1



(B) Control 2 and 2QH2



(C) Control 3 and 2QH3

Figure 3 Relation of pollen production with mean weather conditions in experiments and control

Comparison on the production of Honey and Pollen in Experiments and Control

Two-queen colonies produced more honey than single-queen colonies ($p < 0.001$), with t-test, with a mean of 21.65 ± 2.0 kg and a mean of 6.72 ± 1.1 kg for two-queen and one-queen colonies, respectively (Fig 4 and Table 4). The honey production level was statistically significant difference both queen systems owing to the differences in the amount of nectar available during the study period.

Two-queen colonies produced more weight of stored pollen than one-queen colonies were no statistically significant difference ($p > 0.05$), with a mean of 1.47 ± 0.78 kg and a mean of 1.00 ± 0.77 kg for two-queen colonies compared to the one-queen during the active season as shown in Fig 4 and Table 4.

Investigation on the bee products within one-queen and two-queen colonies

Within one queen system as well as two queen system, production of honey and pollen were recorded statistically significant difference as ($p < 0.05$) with ANOVA HSD test in terms of number of combs occupied by nectar and pollen.

The large weight honey was recorded as 38.1%, 38.6% and 39.8% in hive number 1, 2 and 3 of single-queen system during the sunflower seasons. Especially, as 39.8% in hive number 3 was recorded the highest stored honey. For double-queen management systems, the high weight honey was recorded that 35.8%, 37.3% and 36.3% in hive number 1, 2 and 3 during the sunflower seasons. Especially, as 37.3% in hive number 2 was recorded the highest weight honey in double-queen system.

In single-queen hives, the large weight pollen was recorded as 54.8%, 59.0% and 59.3% in hive number 1, 2 and 3 during the sunflower seasons. Especially, as 59.3% in hive number 3 was recorded the highest weight pollen. For double-queen management systems, the high weight pollen was recorded that 51.8%, 46.1% and 44.1% in hive number 1, 2 and 3 during the sunflower seasons. Especially, as 51.8% in hive number 1 was recorded the highest stored pollen in double-queen system.

T-test (Honey products of two-queen and one-queen system)

Group Statistics

	Method	N	Mean	Std. Deviation	Std. Error Mean
Honey	Q1	18	6.7167	1.13098	.26657
	Q2	18	21.6494	2.00341	.47221

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Honey	Equal variances assumed	6.073	.019	-27.538	34	.000	-14.93278	.54226	-16.03478	-13.83078
	Equal variances not assumed			-27.538	26.836	.000	-14.93278	.54226	-16.04572	-13.81984

T-test (Pollen products of two-queen and one-queen system)

Group Statistics

	Method	N	Mean	Std. Deviation	Std. Error Mean
Pollen	Q1	18	1.0011	.77228	.18203
	Q2	18	1.4722	.78351	.18468

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pollen	Equal variances assumed	.891	.352	-1.817	34	.078	-.47111	.25930	-.99808	.05586
	Equal variances not assumed			-1.817	33.993	.078	-.47111	.25930	-.99809	.05586

Table 4 Comparison on honey and pollen products between experiments and control

Bee Hives / Bee Products	Average Production (kg)/Colony/month					
	Control1	**2QH1**	**Control2**	**2QH2**	**Control3**	**2QH3**
Honey	6.35	21.43	6.35	20.9	7.45	22.615
Pollen	1.69	3.75	1.22	2.53	1.32	3.48

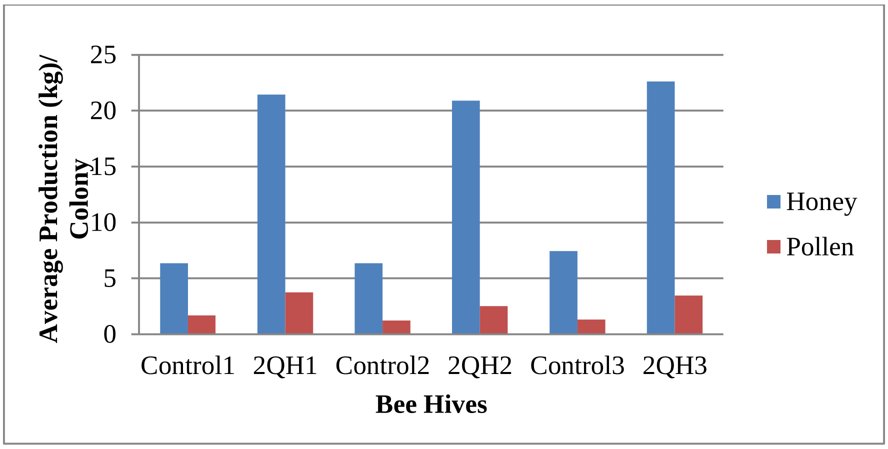


Figure 4 Comparison on the honey and pollen products between experiments and control

ANOVA HSD test in two-queen and one-queen systems

ANOVA[a]

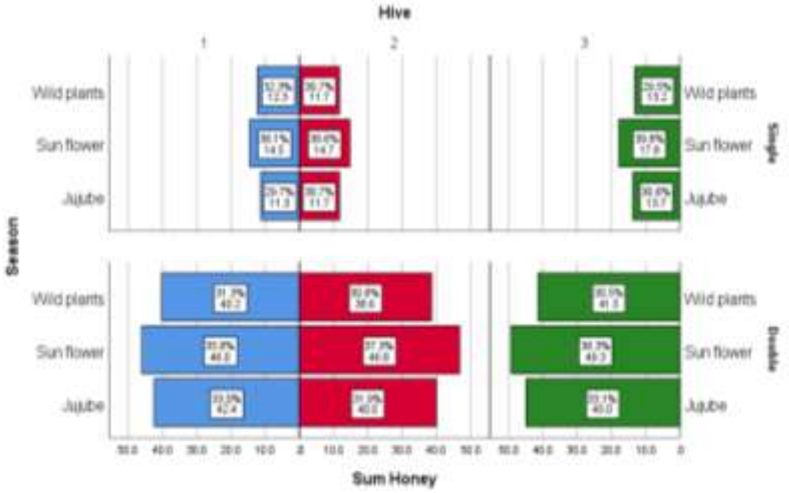
		Sum of Squares	df	Mean Square	F	Sig.
Honey	Between Groups	11.243	2	5.622	8.030	.004
	Within Groups	10.502	15	.700		
	Total	21.745	17			
Pollen	Between Groups	6.280	2	3.140	12.203	.001
	Within Groups	3.859	15	.257		
	Total	10.139	17			

a. Queen_No = Single

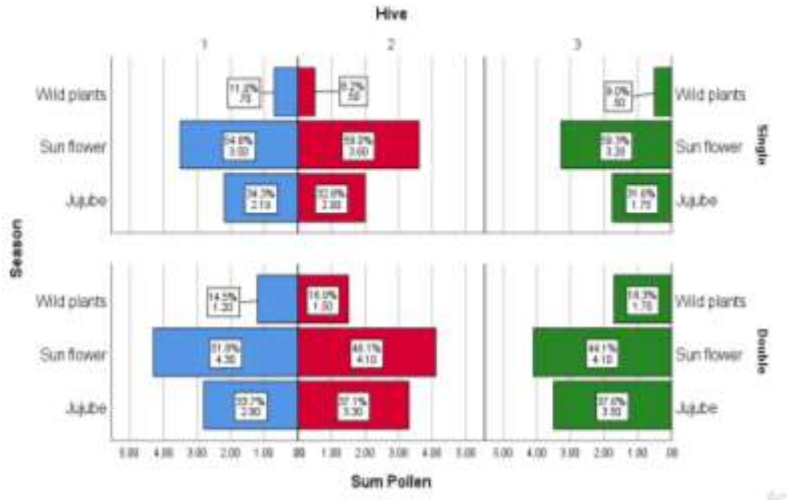
ANOVA[a]

		Sum of Squares	df	Mean Square	F	Sig.
Honey	Between Groups	41.272	2	20.636	11.481	.001
	Within Groups	26.960	15	1.797		
	Total	68.232	17			
Pollen	Between Groups	5.614	2	2.807	8.733	.003
	Within Groups	4.822	15	.321		
	Total	10.436	17			

a. Queen_No = Double



(A) Honey



(B) Pollen

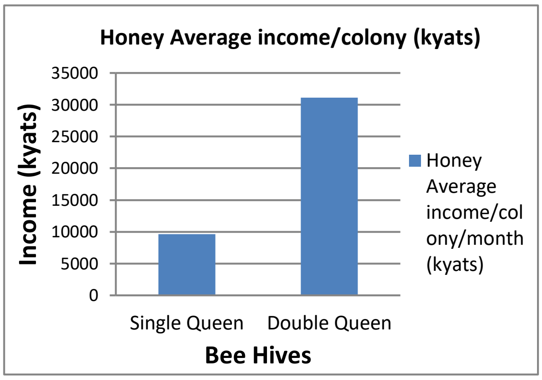
Managing income cost for double-queen and single-queen colonies

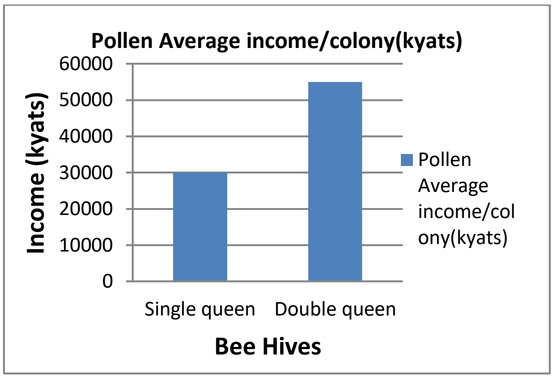
The average production cost of honey per month was over thirty thousand kyats for the double-queen colonies as well as over nine thousand kyats for the single colonies (Fig 5 and Table 5). The average production cost of pollen per month was about fifty five thousand kyats for the double-queen colonies as well as over thirty thousand kyats for the single colonies (Fig 5 and Table 5).

Honey production of two-queen system Pollen production

Table 5 Differences income cost honey and pollen from double queen and single queen colonies

Bee Hives	Honey Average income/colony/month(kyats)	Pollen Average income/colony/month(kyats)
Single queen	9660	30000
Double queen	31120	55000





(A) Honey (B) Pollen

Figure 5 Average income cost per colony per month between products of double-queen colonies and single-queen colonies

Discussion

Two-queen system offers labor advantages, lower cost per kilogram of honey produced, better quality produce, less swarm problem of bees. There is established fact about high positive correlation between bee colony population and honey yield, there is information related to how a double-queen system affects different variables of beekeeping under Magway conditions.

The two-queen system is an intensive management system designed to produce the largest possible honey crop per hive unit. The honey yield reflects the colony capacity to use the nectar supply and is affected by population, size, race or strain of bees, incidence of disease, and management (Moeller, 1976).

Honey production was showed highly statistically significant difference as ($p < 0.001$) between double-queen and single-queen colonies. The numbers of nectar and pollen combs in double-queen colonies were larger than that of single-queen colonies during the blooming seasons. Honey production potential per individual bee was greater for double-queen system colonies compared to the single-queen colonies. However, the pollen production level was no statistically significant difference as ($p > 0.05$) for double-queen colonies compared to the single-queen during the study period.

During study period, within each queen systems, production of honey and pollen were recorded statistically significant difference as ($p < 0.05$), respectively. The large weight honeys were recorded as hive number 1, 2 and 3 of single-queen and double-queen systems during the sunflower seasons. Especially, as 39.8% in hive number 3 was recorded the highest stored honey in single-queen system and as 37.3% in hive number 2 was recorded the highest weight honey in double-queen system. The result indicates that peak brood rearing activity coincides with higher honey and pollen stores, which later on are converted to maximum number of worker bees during the active honey harvesting seasons.

Honey production cost difference indicates that was showed higher production costs for managing single-queen colonies compared to double queen colonies as well as pollen production cost difference indicates that there were recorded higher production costs for managing single-queen colonies compared to double-queen colonies. From a financial analysis point of view, current study result showed that use of double queen colonies is more profitable than managing single-queen colonies in Myanmar beekeeping.

The lower production cost mainly resulted from savings from labor, beeswax, and feeding. Moeller (1976, quoted in Valle *et al*., 2004) reported that 50% more labor time is required for two-queen colonies than for one-queen colonies, indicating two-queen colonies needed less total labor per kg of honey produced. Valle *et al*. (2004) reported that only 24% more labor cost was required than what is needed for single-queen colonies.

During study period, seal cells were recorded that too highest condition as 33.47% as well as open cells 15.3% in 2Queen beehive 2, respectively. Life stages of honey bee were recorded as available condition of egg, open, seal and empty in control bee hives. Development of colony structure and food sources of double queen beehives were investigated to be depend on weather conditions especially to the proper condition of temperature and humidity.

Conclusion

The two-queen system is an intensive management system designed to produce the largest possible honey crop per hive unit if available to favourable conditions on weather and bee food sources. For the promotion of beekeeping, a beekeeper can easily get a pure honey for commercial products in small scale or large scale. The two-queen system is a constitutional management system to produce bee populations and to protect waste of larvae. Small scale beekeeping provide good livelihood suitable for rural people to eradicate poverty.

This research of breeding high quality of queen bee by two-queen system techniques that one can apply to promote the quality of Myanmar honey product. We also recommend that two-queen colonies should be studied in other potential beekeeping areas of Myanmar by involving more representative numbers of colonies for validating the system further.

As part of the research study, the proposer believes that this work will contribute to Department of Apiculture, Ministry of Agriculture, Livestock and Irrigation and local beekeepers in Myanmar. The two-queen system is a viable and insured method that bee breeders and beekeepers can rely on for that purpose. Two-queen system of beekeeping will create new job opportunity and extra income.

Acknowledgements

I would like to thank Dr Pyone Pyone Aung and Dr Kay Thwe Hlaing, Pro-rectors, Yangon University of Education for their permission to work throughout my study period. Especially, I am greatly indebted to U Soe Naing, Deputy Director, Department of Apiculture, Magway Region for his good advises. Many special thanks to U Myo Chit, Research Officer, Department of Apiculture, Magway Region and the staffs of Apiculture Department for their kind help during my study period. Especially, I would also like to thank Chairperson and All Executive Committee of the Myanmar Academy of Arts and Science for their good advises.

References

Bingham, C.T., (1897). *The fauna of British India Including Ceylon and Burma, Hymenoptera. Vol. I. Wasps and Bees*. Taylor and Francis, London, xxix+577 pp., 4 pls.

Doolittle, G.M., (1889). Scientific Queen-rearing. Wicwas Press, Ithaca, NY., ISBN-10: 1878075241.

Gilbert, C.H., (1940). The Two-Queen Hive and Commercial Honey Production. *University of Wyoming Agricultural Experiment Station Bulletin,* 239:1-16.

Moeller, F.E., (1976). Two Queen System of Honey Bee Colony Management. Washington, D.C.

Sawyer, R.W., (1981). *Pollen identification for beekeepers.* University College Cardiff Press, Cardiff, U.K.

Suwannapong, G., Eiri, D.M. and Benbow, M.E., (2012). Honeybee communication and pollination, New Perspectives in Plant Protection, Prof. Ali R. Bandani (Ed.).

Valle, A. G. G., Guzmán-Novoa, E., Benítez, A. C., & Rubio, J. A. Z. (2004). Efecto del uso de dos reinas en la población, peso, producción de miel y rentabilidad de colonias de abejas (Apis mellifera L.) en el altiplano mexicano The effect of using two honey bee (Apis mellifera L.) queens on colony population, honey product. Téc Pecu Méx, 42(3), 361–377.

Yadav, S., Kumar, Y. and Jat, B.L., (2017). *Honeybee diversity, Castes and Life Cycle*. Omkar (ed.), Industrial Entomology.