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STUDIES ON THE LIFE CYCLE AND MORPHOMETRICS OF HONEYBEES, *APIS MELLIFERA ADANSONII* (HYMENOPTERA: APIDAE) IN A MANGROVE AREA OF LAGOS, NIGERIA.

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ABSTRACT

The life cycle of the honeybee, *Apis mellifera adansonii*, was studied in mangrove area by monitoring the developmental stages and morphology of the castes. It was observed that the fate of the eggs were predetermined at the onset leading to drones, queens or workers. It was also established that the three different castes (drone, queen and worker) exhibit similar patterns of complete metamorphoses. The mean developmental period of the drone from egg to adult stage was the longest (24.97±1.77 days, n = 60) followed by that of worker (20.22 ± 2.20 days, n = 60) and the queen (15.5 ± 2.08 days, n = 60) in that order. The body length and head capsule width varied within the different castes. The general pattern of the studied life cycle of *A. mellifera adansonii* in Mangrove area of Lagos is similar to *A. mellifera scutellata* and Africanized *A. mellifera* studied in other regions. It was concluded that the knowledge of the life cycle of *A. mellifera adansonii* by bee farmers in their locality may enhance their apicultural practices for better productivity.

Key words: Honeybees, Caste Differentiation, Larval Instar Determination, Life Cycle and Apiculture.

INTRODUCTION

Honeybees (Hymenoptera: Apidae) are social insects with a unique feature of division of labour. In different parts of the world, different species and subspecies of honeybees are cultured to produce honey and beeswax (Seegeren *et al.,* 1996 and Ojeleye, 1999). The dwarf honeybees, *Apis florae* Fabricius (1787) are generally found in warm climatic region. It builds single comb-nest around twigs of shrubs or trees in the open. They are commonly domesticated in countries such as Oman, Pakistan, India, Sri Lanka, Indonesia and Southeast Asia. Another species of honeybees domesticated in countries such as Pakistan, India, Sri Lanka including Philippines and China is *Apis dorsata* Fabricius (1793) commonly called the giant honeybee or the rock bee. The species construct single comb-nest built on rock or branches of trees. Their nests occur singly or in groups on a single tree (Seegeren *et al.,* 1996 and Ojeleye, 1999).

Apis cerana Fabricius (1793) the oriental honeybees, is commonly found in tropical, subtropical and temperate zones of Asia, USSR, China, Korea and Japan. They construct parallel multiple-comb nests with bee space in between the combs in dark enclosures such as caves and hollowed tree trunks. Another species of honeybee is *Apis mellifera* Linnaeus (1758) which is commonly domesticated in Europe, Africa, Middle East of Asia and America. They construct multiple-comb nests in dark cavities in the same way as *Apis cerana*. There are subspecies of *Apis mellifera* which include *Apis mellifera intermissa* Von Buttel-Reepen (1906) (Tellian bees) which are common to North Africa. They are found in north of the Sahara from Libya to Morocco. *Apis mellifera lamarckii* Cockerell (1906) (Egyptian bees) are found in Egypt and Sudan and they have almost similar behavioural pattern with *Apis mellifera interrmissa*. In Kenya, *Apis mellifera scutellata* Lepeletier (1836) (East African bees) are commonly domesticated. *Apis mellifera monticola* Smith (1961) (mountain bees) are found in Tanzania while *Apis mellifera capensis* Eschscholtz (1822) (cape bees) are common in South Africa.

Apis mellifera adansonii Latreille (1804) (West African bees) is another subspecies of *Apis mellifera* commonly found in West Africa including Nigeria (Seegeren *et al.*, 1996, Ojeleye, 1999 and Fasasi, 2008).

Honeybee colony is composed of the reproductive queen, whose developmental duration ranges from 15 to 17 days, several hundred drones and 30,000 to 75,000 domestic worker bees (sterile females) with developmental duration of 20 22 days and 23 27 days respectively. The queen lays the eggs and coordinates the activities of the colony while the drones mate the queen and the workers carry out domestic duties such as nectar and pollen collection, feeding the queen, cleaning, guarding and ventilating the hive, building combs and making honey (Mace, 1976, Ikediobi *et al.*, 1985, Delaplane, 1997 and Ojeleye, 1999).

Apis mellifera adansonii is presently the only subspecies found in Nigeria and it is mainly domesticated in local artificial hives (Basket hives, Skept hives, Drum hives, Clay pot hives and Gourge hives) for honey and beeswax production by few traditional bee-keepers (Ayoade, 1977 and Malaka and Fasasi, 2005). The most serious problem associated with bee-keeping in West Africa, specifically Nigeria, is the bee itself. *A. mellifera adansonii* is very aggressive and difficult to manage because it has the propensity to abscond (Ikediobi *et al.*, 1985, Crane, 1990 and Ojeleye, 1999). In Kenya, Shi *et al.* (2003) studied colony management and Queen rearing in Kenyan honeybees, *A. mellifera scutellata,* and observed that grafting method used for queen rearing in European races of *A. mellifera,* can also be used for *A. mellifera scutellata*. Shi *et al.* (2003) suggested that colony development and queen rearing can be accomplished with *A. mellifera scutellata* if their temperament can be improved upon and managed. Kostarelou-Damianidou *et al.* (1995) reported that proper understanding of the life cycle of the bee, *Apis mellifera macedonica,* enhance requeening of the colony of the species every two or three years. In Nigeria, however, bee-keeping is recently gaining the attention of Nigerian Entomologists through intensive research to improve honey and beeswax production. There is very scanty documented information on the biology of *A. mellifera adansonii* in relation to honey and beeswax production and its management in the country (Ikediobi *et al.,* 1985, Ojeleye, 1999, Fasasi and Malaka, 2005 and Fasasi, 2008). Most of the publications on bee-keeping in Nigeria were on the economic uses of honeybees, honey, beeswax and other bee products (Malaka and Fasasi, 2005 and Fasasi, 2008). The comparative analysis of bee-keeping and crop production in Adamawa State and southern parts of Nigeria creates awareness on bee-keeping as vocational job for the youth in the wake of unemployment in the country. Most of the publications available on reproductive biology, bio-ecology of honeybees are in advanced countries and some parts of Africa (e.g. Ghana and East Africa). Therefore, there is the need for adequate and sustainable scientific research on the reproductive cycle and behaviour of *A. mellifera adansonii* in Nigeria. This will encourage the growth of commercial apiaries for increased honey production in Nigeria.

MATERIALS AND METHODS

Study Site

The study was carried out at the Biological Garden in University of Lagos, Akoka Campus, Lagos. The garden has an estimated area of about 802 acre. The University of Lagos, Akoka Campus, is located between latitude 06^{0} 30´15´´N and 06^{0} 31´ 20´´ N and longitude 003^{0} 23´ 05´´E and 003^{0} 24´ 20´´E.

Culture of honeybees

Honeybees were reared and cultured in single-chambered artificial beehives called Langstroth beehives constructed with hardwood (*Terminalia macroptera* Guill et Perr. black afara) with iron roofing sheets. The beehives measured 475mm, 400mm and 475mm in length, width and height respectively and were placed on 500mm high platforms. Four honeybee colonies (Honeybee cultures) were established by attracting bees into the beehives using paste of 70ml of honey and 35g of granulated sugar enclosed in perforated

Petri-dishes placed in each beehive. Thereafter, five replicate hives, forming what is referred to as honeybee colonies, were similarly set up for the experiment.

Study of life cycle stages of Honeybees

The colonies of *A.mellifera adansonii* in the five beehives (5 replicates) were allowed to stabilize for 1½ years before life cycle studies began. In each of the beehives, there are ten frame bars for both honey and young broods in the brood chamber. In the same brood chamber, broods were displaced and removed from six frame bars which served as empty brood frame bars for new or prospective progeny. In this same brood chamber, were placed another set of four frame bars, each without broods but with honey-filled combs totaling ten frames per replicate. Following this, 18 months old queen of same colony was retained and placed on a brood frame bar in order to start off laying of fresh eggs. The beehive was inspected and observed every 24 hrs for egg laying activities of the 18 months old queen. First batch of eggs laid were observed daily from the day when the eggs were first laid until adult stage was attained. During observation, each life cycle stage was identified whenever it occurred. In addition, the duration of each of the stages was noted. Larval samples (20 per replicate) of different castes were taken from each of the replicates at 24 hrs intervals for morphometric measurements (body length and head capsule width) using a micrometer fitted on stereoscan microscope at varying magnification for a period of 30 days.

RESULTS

The 18 months old queen was observed to lay her eggs sequentially into the six empty brood combs starting with the first brood comb present in the single-chambered beehive, avoiding the four honey combs with honey that served as food for the new workers. The creamy, ovoid shaped eggs destined to be workers, drones and queens were more aggregated at the centre, periphery and vertical edges of the honeycombs respectively.

Developmental Stages of Apis mellifera adansonii:

The egg destined to be queen has the shortest diameter (2.40 ± 0.45mm) compared to that of the worker (2.5 ± 0.4mm) and the drone (2.6 ± 0.3mm) respectively (Table 1). The egg destined to be queen has the shortest duration of development (1.66 ± 0.61days) compared to that of the drone (3.07 ± 0.20days) and worker (3.04 ± 0.19days) respectively (Table 2). It was observed that the three castes of *A. mellifera adansonii* passed through four larval instars and they are sessile without changing their positions until pupation in each of the comb cell.

First instar: The body length and head capsule width of the first instar larva of the drone was higher (Body length: 8.87 ± 1.03mm; head capsule width: 3.48 ± 0.24mm) than that of the queen (Body length: 6.78 ± 0.97mm; head capsule width: 3.00 ± 0.09mm) and the worker (Body length: 5.33 ± 0.91mm; head capsule width: 2.48 ± 0.15mm) respectively (Table 1). The 1st instar larvae of the queen have the shortest duration of development (1.71 ± 0.36days) followed by that of the drones (2.82 ± 0.20days) and workers (2.86 ± 0.23days) respectively (Table 2).

Second instar: The second instar larva of the drone has body length and head capsule width (Body length: 12.47 ± 1.46mm; head capsule width: 4.80 ± 0.29mm) which was more than that of the queen and worker by 1.3 and 1.74 times in body length and 1.20 and 1.40 times in head capsule width respectively (Table 1). The second instar larva of the drone has the longest developmental duration (3.87 ± 0.26days) which was 1.8 and 1.2 times longer than that of the queen and the workers respectively (Table 2).

Third instar: The body length and head capsule width of the 3rd instar larva of the drone (Body length: 16.88 ± 1.95mm; head capsule width: 6.80 ± 0.24mm) was 1.3 and 1.7 times in body length and 1.2 and 1.45 times in head capsule width than that of the queen and the worker respectively (Table 1). The developmental duration of 3rd instar larva of the drone (4.01 ± 0.26days) was longer than that of the queen and the worker by 2.0 and 1.1 times respectively (Table 2).

Fourth instar: The body length and head capsule width of the 4th instar larva of the drone was 23.29 ± 2.64mm and 8.8 ± 0.29mm respectively which

Table 1: Comparative Morphometrics of Developmental Stages in the Life Cycle of *Apis mellifera adansonii* in Mangrove Area of Lagos

(Ranges are in parenthesis, : Standard deviation, *GR: Growth ratio).

Developmental Stages	**Castes of *A. mellifera adansonii* (mm)**					
	Drone n = 50		**Queen n = 50**		**Workers n = 50**	
	Body length $\bar{x}$ **± S.D**	**Head capsule Width** $\bar{x}$ **± S.D**	**Body length** $\bar{x}$ **± S.D**	**Head capsule Width** $\bar{x}$ **± S.D**	**Body length** $\bar{x}$ **± S.D**	**Head capsule Width** $\bar{x}$ **± S.D**
Eggs	2.6 ± 0.3	-	2.4 ± 0.5	-	2.5 ± 0.4	-
	(2.3 - 3.0)		(2.0 - 2.9)		(2.1– 2.9)	
1st instar	9.0 ± 1.0	3.5 ± 0.2	6.8 ± 1.0	3.00 ± 0. 1	5.3 ± 0.9	2.5 ± 0.2
(Uncapped broods)	(7.9 – 10.0)	(3.2 – 3.7)	(5.8 – 7.8)	(2.9 - 3.1)	(4.4 – 6.2)	(2.3 – 2.6)
2nd instar	12.5 ± 1.5	4.8 ± 0.3	9.4 ± 1.4	4.0 ± 0.1	7.2 ± 1.2	3.5 ± 0.2
(Uncapped broods)	(11.0-13.9)	(4.5 – 5.1)	(8.0 - 10.7)	(3.9 – 4.2)	(5.9 – 8.3)	(3.2 – 3.7)
		*GR: 1.37		*GR: 1.33		*GR: 1.40
3rd instar	16.9 ± 2.0	6.8 ± 0.2	13.3 ± 1.1	5.5 ± 0.2	10.2 ± 1.8	4.7 ± 0.3
(Capped broods)	(14.9 – 18.8)	(6.6 – 7.0)	(12.2 – 14.4)	(5.4 – 5.7)	(8.4 – 12.0)	(4.4 – 5.0)
		*GR: 1.42		*GR: 1.38		*GR: 1.34
4th instar	23.3 ± 2.7	8.8 ± 0.3	18.0 ± 2.7	7.7 ± 0.2	13.5 ± 2.2	6.6 ± 0.4
(Capped broods)	(20.7 – 25.9)	(8.5 – 9.1)	(15.2 – 20.7)	(7.5 – 7.9)	(11.3– 15.7)	(6.3 – 7.0)
		*GR: 1.29		*GR: 1.40		*GR: 1.40
Pupa	20.3 ± 1.4	7.8 ± 0.6	18.3 ± 0.5	7.2 ± 0.3	18.0 ± 1.4	6.7 ± 0.8
	(18.9 – 21.7)	(7.2 - 8.4)	(17.8 – 18.7)	(6.9 – 7.4)	(16.7– 19.4)	(5.9 – 7.5)
Adult	19.7 ± 0.2	-	18.3 ± 0.5	-	17.0 ± 1.3	-
	(19.5 – 19.9)		(17.8 – 18.7)		(15.7 –18.3)	

Table 2: Mean Duration of Stages of *Apis mellifera adansonii* in Mangrove Area of Lagos (Ranges are in parenthesis, : Standard deviation).

Developmental Stages	Castes of *A. mellifera adansonii* (days).		
	Drones	Queens	Workers
Eggs	3.07 ± 0.20	1.66 ± 0.61	3.04 ± 0.19
	(2.87 – 3.27)	(1.05 - 2.27)	(2.84 – 3.23)
1st instar (uncapped broods)	2.82 ± 0.20	1.71 ± 0.36	2.86 ± 0.23
	(2.62 – 3.02)	(1.35 - 2.07)	(2.63 – 3.09)
2nd instar (uncapped broods)	3.87 ± 0.18	2.11 ± 0.37	3.25 ± 0.48
	(3.69– 4.05)	(1.74 – 2.48)	(2.77 – 3.73)
3rd instar (capped broods)	4.01 ± 0.26	2.02 ± 0.29	3.60 ± 0.36
	(3.75 – 4.27)	(1.73 – 2.31)	(3.24 – 3.96)
4th instar (capped broods)	4.29 ± 0.45	3.09 ± 0.29	2.46 ± 0.33
	(3.84 – 4.74)	(2.8 – 3.38)	(2.13 – 2.79)
	6.91 ± 0.48	4.91 ± 0.16	5.01 ± 0.61
Pupa	(6.43 – 7.39)	(4.75 – 5.07)	(4.40 – 5.62)
Total (Egg – Adult)	24.97 ± 1.77	15.5 ± 2.08	20.22 ± 2.20
	(23.2 – 26.74)	(13.42 – 7.58)	(18.22 - 22.42)

was more by 1.3 and 1.7 times in body length and 1.1 and 1.3 times in head capsule width than that of the queen and worker respectively (Table 1). The 4th instar larva of the drone has developmental duration of 4.29 ± 0.45days which was 1.4 and 1.7 times more than that of the queen and worker respectively (Table 2).

Pupa stage: The body length and body width of the pupa of the drone was 20.30 ± 1.41mm and 7.80 ± 0.64mm respectively. The pupa of the queen has body length of 18.28 ± 0.46mm and body width of 7.15 ± 0.25mm, while the pupa of the worker has body length of 18.02 ± 1.35mm and body width of 6.70 ± 0.78mm (Table 1). The pupation period of the drone was 6.91 ± 0.48days which was more than that of the queen and the worker by 1.41 and 1.38 times respectively (Table 2).

The adult stage: The body length of the drone was 19.70 ± 0.16mm which was 1.1 and 1.2 times higher than that of the queen and the worker respectively (Table 1). It was observed that the adult queen, drone and worker bees exhibited different developmental periods with different morphometric measurements due to the caste differentiation in consonance with division of labour within the colony. The drone has the longest developmental duration (24.97 ± 1.77days), followed by that of the worker (20.22 ± 2.20days) and the queen (15.50 ± 2.08days) from egg to adult stage (Table 2).

DISCUSSION

The analyses of the head capsule width measurements in caste broods showed that the honeybees passed through four larval instars with mean growth ratios of 1.38, 1.36 and 1.37 for workers, drones and queens respectively. This conforms to Dyar's rule (1.2 1.4) (Dyar, 1890). However, it is worthy of note that the total developmental period spent at each stage as well as morphometric measurements differed between each caste. In this work it was found that the queen has the shortest total developmental duration from egg to adult stage, despite her long life span of over 1½ years, followed by that of the worker and the drone in an ascending order. This was similar to the study of *A. mellifera scutellata* in Kenya and Africanized *A. mellifera* in Europe as reported by Shi *et al.* (2003) and Silva *et al.* (2006).

The queen is possibly the most important caste in the bee colony in the sense that she is responsible for reproducing other castes and therefore responsible for the perpetuation of other castes in the colony. This important role of the queen which has to do with establishment and maintenance of the colony may have provided the reason why selection pressure over time brought about this observed fast development. Certainly the queen that matures within the shortest possible time will be better positioned to ensure the establishment, expansion and survival of the colony in the environment. Furthermore, this short developmental characteristic will also allow the colony whose queen died accidentally or through predation to replace the queen within the short period of 13 14 days in time to arrest the decline of castes in the affected colony, thereby making ecological succession more likely. This argument is made stronger by the fact that the next most useful caste namely the worker responsible for defense and gathering food have developmental period that is slightly longer than that of the queen but shorter than that of the drone whose only function is to fertilize the queen, a function that does not require too many males within the colony.

It also stands to reason that the queen and worker have short development for the following other reasons: (a) when the colony loses the queen, the colony loses focus and coordination of colony members (other castes) and the whole colony is disturbed. So the lost queen needs to be replaced by new virile queen within the shortest possible time for the colony to maintain their social behaviour. (b) For the workers, their life span is very short within the range of 18 - 22 days which was similar to the results of Smith (1953 and 1958), Mace (1976), Tribe and Fletcher (1977a and b), Shi *et al.* (2003) and Silva *et al.* (2006). Because through short life span, there is need for quick generation turnover in this regard, short developmental period may be an advantage. This is probably the reason why the workers spent short period in the study.

The results of the morphometric study of the three different castes of *A. mellifera adansonii* showed that the drone with dark broad abdomen has large body size than the queen and the worker in descending order respectively which conformed to the report of Smith (1953 and 1958), Mace (1976), Tribe and Fletcher (1977a and b), Shi *et al.* (2003) and Silva *et al.* (2006). The worker needs the small portable body size to be efficient in terms of manoeuver to defend and gather food from flowers in every nook and corners in the wild. However, worker bees have the largest population to meet up with the enormous colony tasks. The drone with the largest body size only feeds and gathers energy over a long period of time for mating the queen during the nuptial flight only and probably die on that mission. The queen has larger body size than that of the worker bee because she uses most of the accruing resources to produce eggs needed in the colony.

The results obtained from the studied mangrove area of Lagos conform to that observed by Tribe and Fletcher (1977a and b) in Britain using Africanized *A. mellifera*, Shi *et al.* (2003) in Kenya using *A. mellifera scutellata* and Silva *et al.* (2006) in Brazil using Africanized *A. mellifera*. Therefore, it is not surprising that the general pattern of the studied life cycle of *A. mellifera adansonii* in Mangrove area of Lagos is similar to those of *A. mellifera scutellata,* and Africanized *A. mellifera*. This indicates that the difference in eco-regions and / or vegetation does not matter since the findings are similar to those of previous researchers. However, understanding the life cycle stages of *A. mellifera adansonii* in mangrove areas by bee-keepers may enhance colony propagation, proper maintenance and management of honeybee colonies for better yield.

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