International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 15-09-2021, Accepted: 30-09-2021, Published: 16-10-2021
Volume 6, Issue 5, 2021, Page No. 189-195

Maternal age induced changes in the reproductive traits of the bruchid beetle, *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae)

Md Anisur Rahman*, Fatema-Tuz-Zohora, Moni Krishno Mohanta, Ananda Kumar Saha, M Habibur Rahman
Department of Zoology, Faculty of Biological Sciences, University of Rajshahi, Rajshahi, Bangladesh

Abstract

Maternal age means the mother's age during reproduction which has a great impact on reproductive traits of different animals. The influence of maternal age on some reproductive traits of *Callosobruchus chinensis* (L.) like fecundity, duration of immature stage, adult emergence and adult longevity was evaluated in the present study. The fecundity for younger mother 26.50±6.55, older mother 12.96±4.14, and oldest mother 10.46±3.75 revealed that the values were decreased significantly ($F_{2,147}$=150.60; P<0.01) with the increase of maternal age. The duration of immature stages were 20.42±0.56 days for younger, 22.91±1.10 days for older, and 23.36±0.69 days for oldest showed significant increase ($F_{2,104}$=134.25; P<0.01) where oldest mothers had offspring with longest length of egg-adult development. The adult emergence value (64.40±22.05) was highest in oldest mother while the younger and older mother had the values as 60.99±21.76 and 33.23±23.84 which were significantly different ($F_{2,102}$=20.06; P<0.01). The life span (in days) of males from younger mother was 8.50±1.08, older mother was 8.40±0.84 and oldest mother was 7.20±1.22 showed a gradual decrease ($F_{2,27}$=4.63; P<0.05). Similar consequences were found in females from younger mother, older mother and oldest mother (11.60±1.42 days, 9.60±1.26 days and 8.00±1.05 days; $F_{2,27}$=20.52; P<0.01). Mated males were with less life span comparing to unmated males (5.86±0.63 days, 8.20±0.42 days; t=33.28, P<0.001) and similar pattern was in mated females and unmated females (7.08±0.77 days, 11.40±1.34 days; t=7.82, P<0.001). The increase of reproductive age of mother decreased the values of reproductive traits. The stronger responses to reproductive traits indicated that they were much more sensitive to senescence than that of offspring from older or oldest mothers. Thus, the present results suggested that maternal senescence is indicative to population dynamics and trans generational selection on these traits might lead to evolution in Coleopteran species.

Keywords: maternal age, traits, senescence, population dynamics, selection, evolution

Introduction

The phenotypic developments of offspring influenced by environmental effects which can enter indirectly to the developing organisms through parents are referred to as paternal and maternal effects [5, 32]. The quality and quantity of parental investment are influenced by these effects which is an area of interest to evolutionary biologists [17]. This investment may be either from parents that increase the offspring survival or may be genetic, leading to changes in phenotype or genotype of the offspring [37].

Maternal age is the time during which an insect oviposit egg and nowadays it is well known that it has impact on the life traits of different species. Paternal (father) mitochondria occasionally got incorporated into eggs during fertilization [4] and sperm of older fathers carry more deleterious mutations than sperm of younger males [8]. Therefore, paternal age generally has little effect on the composition of the egg or the phenotype of his offspring [10].

Maternal age or trans generational effect influences offspring quality in many insects [36, 38, 50, 33] and it is reported that the number of eggs decreases in Coleoptera [51, 13], phenotypes generally decline with increasing offspring age [15, 20]. In *Drosophila*, carry over to later generation [16] and viability in larvae [39, 21, 16], ecological and evolutionary consequence [22], egg hatch and life span in *Callosobruchus maculatus* [10, 13], maternal size influences egg quality of reef fish [7], maternal effects on offspring size, growth and survival in the desert tortoise [35] growth and immune reaction in birds [43], parental age effects on offspring lifetime reproductive success [6], reduced fitness in progeny from old parents [44]. The older mothers have lower hatching success, higher mortality and slower development than those from eggs laid by younger mothers [11]. Offspring from older mothers tend to have shorter adult life span [10] and similar results were found in rotifer [25, 47], nematodes [23], insects [39] and even humans [14].

It was reported that maternal age did not affect the male offspring fitness traits of the Pacific field cricket *Teleogryllus oceanicus* [49]. Maternal effects affect fitness of future generations of oviparous parasitic wasp *Eupelmus vuilleti* [34]. Populations of aphids *Myzus persicae* (Hemiptera) from every three maternal age groups were incremental type and the offspring of younger and middle-aged mothers had a regular reproductive period [3]. The phenotype of the offspring from old, small and large mothers of zig-zag ladybird beetle (*Menochilus sexmaculatus*) was not influenced by maternal age rather was adaptive strategy [45].

Studies on maternal effects on a number of genetically determined characteristics or traits in *Callosobruchus maculatus* revealed that older mothers had smaller eggs and lower hatch rate than younger mothers, and offspring of older mothers had lower egg-to-adult survivorship and took longer to develop to adult [51, 11, 13, 48]. In *Callosobruchus chinensis* egg sizes, unitary egg sizes, egg number and reproductive effort decreased significantly with maternal age [51]. It was found that females reared at low density were heavier and laid larger eggs than those reared at high density, and development time decreased with egg mass [52]. The reproductive traits of *C. chinensis* and *C maculatus* were influenced by gamma radiation [40, 18], by carbofuran [42] and nanoparticles [41] in *C. maculatus*. However, none of these studies described the detailed effects of maternal age on reproductive traits *viz.* fecundity, duration of immature stages, adult emergence and adult longevity of *C. chinensis*. Thus, the present study was aimed to evaluate the changes of reproductive traits induced by maternal age of *C. chinensis* (L.) (Coleoptera: Bruchidae).

Materials and Methods

Experimental insect

Experiments were conducted in the Genetics and Molecular Biology Laboratory, Department of Zoology, University of Rajshahi, Rajshahi-6205, Bangladesh. The pulse beetle *Callosobruchus chinensis* (L.) commonly known as the adzuki bean weevil belonging to the order Coleoptera under the family Bruchidae was used in this experiment.

Procurement of fresh seeds and sources of test insects

Fresh lentil (*Lens esculenta* L.) seeds were purchased from local markets of Rajshahi City Corporation and *Callosobruchus chinensis* infested seeds were collected from IBSc (Institute of Biological Sciences) Laboratory, Third Science Building at Rajshahi University in Bangladesh. Infested seeds were served as stock culture of the test species.

Materials used

Plastic containers were used to carry both types of lentil seed to the laboratory. The beetles from infested seeds were reared in Petri-dishes for mass culture. Each glass vial with cotton ball was used to keep single egg with single seed to collect virgin male and female and after mating to lay eggs by females.

Preparation of food medium

Voracious larvae fed lentil seeds as food during their developmental time and after emerging as adults either males or females they were aphagous. The seeds were cleaned by using hands and sieves and carefully sun dried once a day under sunlight (30-35^{0}C) for 3-4 hours for three days schedule.

Collection of experimental beetles

To collect virgin females and males infested seeds were separated and kept single seed with single egg in single vial. Daily observations were done until the day of emergence. For single pair mating the male beetle allowed to a female or vice-versa in the glass vial.

Releasing test species on fresh seeds

Just after mating the mated male and female beetles were released as single pair on a glass vial with fresh lentil seeds and a culture was maintained in the laboratory at 28±2°C temperature and 80±5% relative humidity. They were exposed to 12L: 12D regimen throughout the study period.

Formation of age group

Mothers for first 24 hours of egg laying or 1st day are treated as younger or 1st day mothers, next to first 24 hours or 2nd day are treated as older or 2nd day mothers and next to second 24 hours or 3rd day are treated as oldest or 3rd day mothers. The next to 3rd day, mothers were very weak and egg laying was discontinued and as all did not lay eggs they were negligible for counting and thus discarded in this experiment.

Experimental design

50-60 lentil seeds were placed in each vial for oviposition by each female**.** The experiment was conducted with parental unmated 10 pairs (10 males and 10 females) and mated 50 pair (50 males and 50 females) adult beetles. The unmated males and females (parental) were used to estimate unmated parental adult longevity whereas the parental adult longevity for mated males and females were estimated from the mated 50 pairs of younger or 1st day parents. These mated 50 pairs were used for the determination of fecundity and of them 36 pairs were for duration of immature stages and of them 35 pairs were for percentage of adult emergence. Adult offspring 30 pairs were used to determine adult longevity (10 pairs @ younger, older and oldest mothers or 1st, 2nd and 3rd consecutive days). In parental beetles, mated males were compared with unmated males (50:10) and similarly for females (50:10) for the evaluation of survival competence. The egg(s) with seeds were collected and counted for 24 hours intervals of oviposition by each mother for three days (first 24 hours, 2nd 24 hours and 3rd 24 hours) schedule and thus they were grouped as younger, older and oldest mothers. During the collection of eggs, the insects of a pair were separated from the seeds by using an aspirator. The fecundity, duration of immature stage, adult emergence, and adult longevity reproductive traits were determined and they were as follows.

Fecundity

Fecundity means the total number of eggs laid by a female during her life time. Laid eggs on seeds were counted as fecundity from 1st day (younger mother), 2nd day (older mother) and 3rd day (oldest mother) of oviposition. The seeds from three different days were placed in three separate glass vials and kept them for next observation until the first one emergence.

Duration of immature stages

The time from oviposition to adult emergence was designated in this experiment as duration of immature stage. So, the duration includes the incubation, *i.e.* the time (day) of larval and pupal periods collectively.

Percentage of adult emergence

Each seed with egg was separated and kept in individual glass vial after 10 days of incubation. The adult emergence meant how many insects were emerged from total eggs of each day and counting was continued for first three consecutive days. The percentage of adult emergence in all experimental replicates was calculated by using the following formula-

$$\text{Percentage of adult emergence (\%)} = \frac{100 \times total\ emergence}{total\ seed\ with\ egg}$$

Adult longevity

Adult (male & female) longevity is the duration between emergence of an adult and its death. The progenies (10 pairs; 10 males and 10 females) from mated males and females for each day in a three day regimen (1st, 2nd and 3rd) were used to estimate the adult longevity. Unmated or control 10 pairs (10 males and 10 females) and mated 50 pairs (50 males and 50 females) were used to estimate parental adult longevity. The survivability either increased or decreased due to different reproductive ages of mother, male and female progenies were compared separately from younger (1st day), older (2nd day) and oldest (3rd day) females. Comparisons were also made between mated males and unmated males (50 and 10) and mated females and unmated females (50 and 10) in parental line to check the longevity increase or decrease of the test species.

Statistical analysis

Descriptive statistics was employed to ascertain mean values of different genetic traits. One way analysis of variance (ANOVA) for fecundity, duration of immature stage, percentage of adult emergence and student's t-test for parental adult longevity were carried out to compare differences of means from younger, older and oldest mothers. Significant difference of means were separated by using Fisher's least significant difference (LSD) at $p<0.05$, 0.01, and 0.001.

Results

Fecundity

The fecundities of *Callosobruchus chinensis* from first three consecutive days (1st day, 2nd day and 3rd day mother) revealed that the number of eggs per female was highest in younger and middle in older and lowest in every oldest mother (Fig. 1). The mean values of fecundity were 26.50±6.55 for 1st day, 12.96±4.14 for 2nd day and 10.46±3.75 for 3rd day and analysis of variance (ANOVA) showed significant difference among them ($F_{2,147}=150.60$; $P<0.01$) (Table 1).

Duration of immature stage

The duration of immature stages of test insects presented here as developmental days (Fig. 2) where the mean values from the first three consecutive days (younger, older and oldest mother) were 20.42±0.56 days, 22.91±1.10 days, and 23.36±0.69 days. It revealed that the highest mean values were found in 3rd day egg and lowest in first day of oviposition and they were significantly different ($F_{2,104}=134.25$; $P<0.01$) (Table 1).

Percentage of adult emergence

The percentages of adult emergence of *C. chinensis* presented in Fig. 3. The mean values were 60.99±21.76 for 1st day or younger mother, 33.23±23.84 for 2nd day or older mother and 64.40±22.05 for 3rd day or oldest mother (Table 1) were statistically significant ($F_{2,102}=20.06$; $P<0.01$).

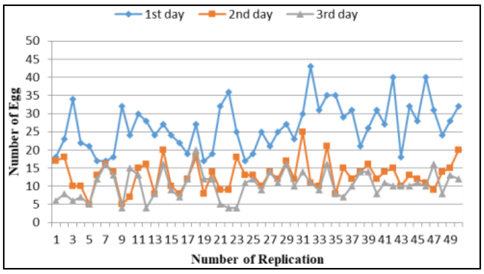

Fig 1: Fecundity of *C. chinensis* (L.) from younger (1st day), older (2nd day) and oldest (3rd day) mothers.

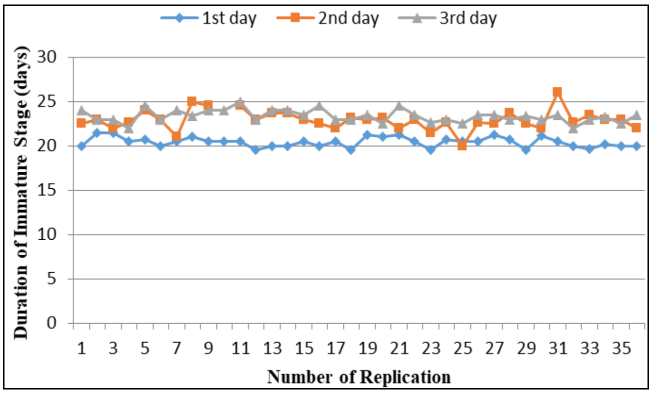

Fig 2: Immature stages (developmental days) of *C. chinensis* (L.) from younger (1st day), older (2nd day) and oldest (3rd day) mothers.

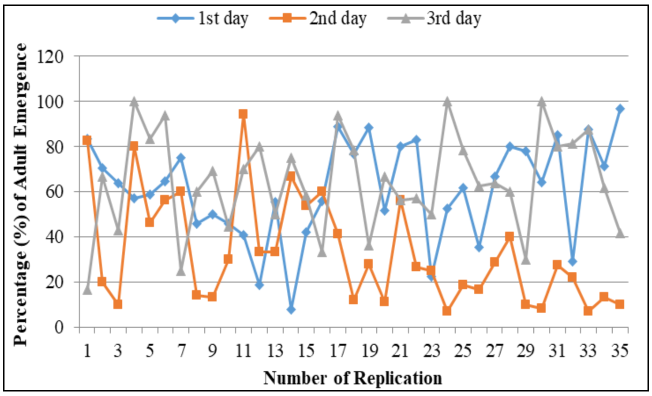

Fig 3: Percentages (%) of adult emergence from younger (1st day), older (2nd day) and oldest (3rd day) mothers of *C. chinensis* (L.).

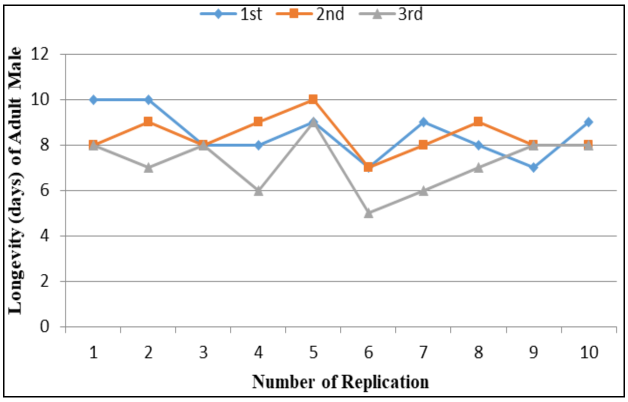

Fig 4: Longevity of offspring adult male beetles from younger (1st day), older (2nd day) and oldest (3rd day) mothers of *Callosobruchus chinensis* (L.).

Adult longevity

The adult longevity of the virgin male and female beetle (offspring) presented in Fig. 4 and 5 and the male from different mothers showed various survivability (8.50±1.08, 8.40±0.84 and 7.20±1.22 days; $F_{2,27}=4.63$; $P<0.05$) and female showed similar pattern (11.60±1.42, 9.60±1.26 and 8.00±1.05 days; $F_{2,27}=20.52$; $P<0.01$) (Table 1). The parental adult longevity (Fig. 6) of the mated and unmated males showed the values were 5.86±0.63 days and 8.20±0.42 days ($t=33.28$; $P<0.001$) (Table 2) and the longevity of the mated and unmated females (Fig. 7) showed the values were 7.08±0.77 days and 11.40±1.34 days which were significantly different ($t=7.82$; $P<0.001$) (Table 2).

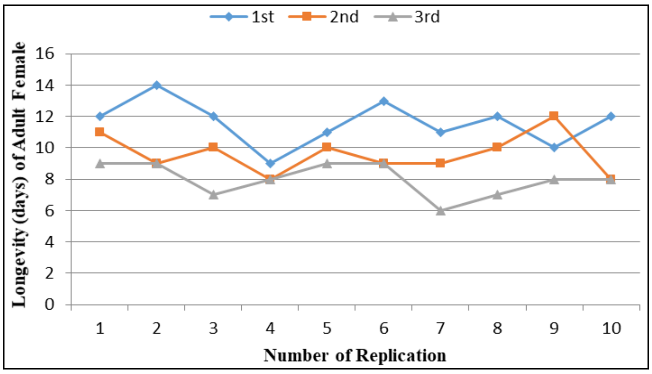

Fig 5: Longevity of offspring adult female beetles from younger (1st day), older (2nd day) and oldest (3rd day) mothers of *Callosobruchus chinensis* (L.).

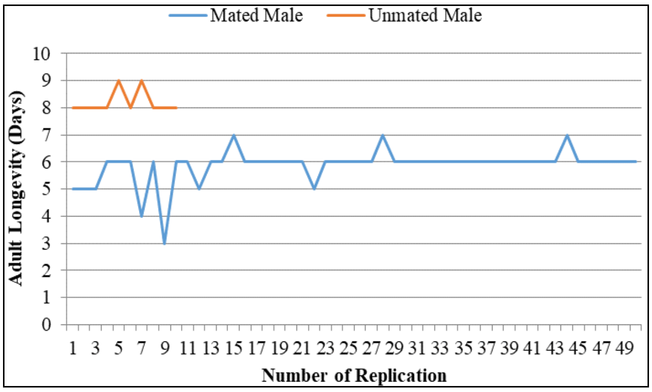

Fig 6: Longevity of parental mated and unmated adult male *Callosobruchus chinensis* (L.).

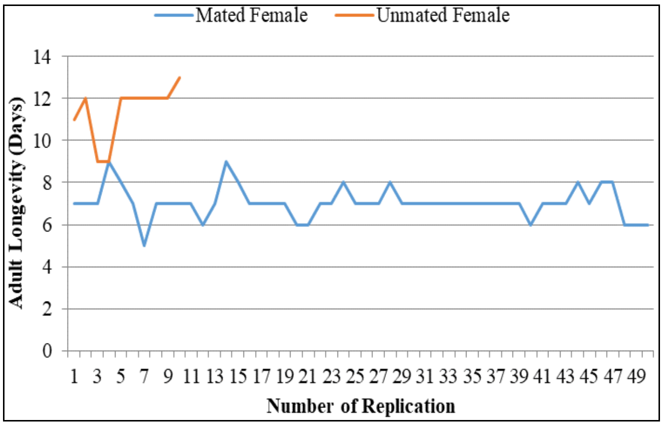

Fig 7: Longevity of parental mated and unmated adult female *Callosobruchus chinensis* (L.).

Table 1: Descriptive statistics (M±Sd) and analysis of variance (ANOVA) of reproductive traits of offspring from younger, older and oldest mothers of *Callosobruchus chinensis* (L.).

Maternal age & F-value	Reproductive traits				
	Fecundity (M±Sd)	Immature stage (M±Sd) (Days)	Adult emergence (%) (M±Sd)	Adult Longevity (Days) (off spring)	
				Male (M±Sd)	Female (M±Sd)
1st Day (Younger)	$26.5^{a}\pm6.55(50)$	$20.42^{a}\pm0.56(36)$	$60.99^{a}\pm21.76(35)$	$8.50^{a}\pm1.08(10)$	$11.60^{a}\pm1.42(10)$
2nd Day (Older)	$12.96^{b}\pm4.14(50)$	$22.91^{b}\pm1.10(36)$	$33.23^{b}\pm23.84(35)$	$8.40^{b}\pm0.84(10)$	$9.60^{b}\pm1.26(10)$
3rd Day (Oldest)	$10.46^{c}\pm3.75(50)$	$23.36^{c}\pm0.69(36)$	$64.40^{c}\pm22.05(35)$	$7.20^{c}\pm1.22(10)$	$8.00^{c}\pm1.05(10)$
F-value	150.60**	134.25**	20.06**	4.63*	20.52**

Mean values with different superscripts (a, b, c) are statistically significant (* = P<0.05, ** = P <0.01; all values are at 2 df). Figures in the parenthesis are for number of replications.

Table 2: Descriptive statistics (M±Sd) and students's t-test of longevity of mated and unmated parent beetles *Callosobruchus chinensis* (L.).

Virginity	Sex	Number of replication	Longevity (Days) (M±Sd)	t-value
Mated	♂	50	$5.86^{a}\pm0.63$	33.28***
Unmated	♂	10	$8.20^{b}\pm0.42$	
Mated	♀	50	$7.08^{a}\pm0.77$	7.82***
Unmated	♀	10	$11.40^{b}\pm1.34$	

*** = P<0.001; Values are at 48 df.

Discussion

Maternal effects have the potential to affect population dynamics (vital rates) and evolution [54] and we examined the influences of maternal age on different reproductive traits *i.e.* fecundity, duration of immature stage, adult emergence and adult longevity in *Callosobruchus chinensis* (L.).

The freshly emerged adult beetles in parental line took part in copulation after emergence and laid eggs and they were counted consequently keeping a 24 hour interval until 72 hours (1st day, 2nd day and 3rd day). The fecundity was higher in 1st day eggs (younger mother) and then second (older mother) was followed by third day (oldest mother) and they were significantly different. The highest fecundity of adult female *C. chinensis* was 54 eggs [1] whereas it was 8.4, 9.2 and 7.2 for 1st, 2nd and 3rd day [2]. The average fecundity was 37.04 for 5 females [46], 87.07 to 100.33 eggs for 10 days [19]. Female aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) average total fecundities were 26.08 for younger, 37.63 for middle, and 21.18 for older [3]. The present study revealed that first day, *C. chinensis* (younger female) laid highest number of eggs, decreasing gradually and at 3rd day females (oldest female) laid lowest number of eggs. So, the present results showed a day dependent (senescence) decrease in fecundity which conformed the findings of several workers [31, 53, 29, 26]. The highest value of fecundity in first day and then gradual decline may be for physiological limitations in the ability of females to produce more eggs [51].

The time in between egg laying and adult emergence was duration of immature stage in this experiment and it was 21.94±0.34 days [40], 14 days [2], 29.00 to 31.00 in different pulses [19]. In case of aphid the younger, middle and older females showed 6.76, 6.54, and 6.63 days in *Myzus persicae* [3]. The maternal age delayed the nymphal development in *Podisus maculiventris* [27]. *Galleria mellonella* (Lepidoptera: Pyralidae) showed reverse developmental pattern *i.e.* development time decreased with the increase of maternal age [24]. Here, we found that the older mother laid few number eggs and took comparatively longer duration of immature stages by following a sequence *i.e.* 1st Day <2nd Day <3rd Day (younger mother<older mother<oldest mother) which was in agreement with the reports of several workers [40,18,11]. The difference in developmental period might be different for age, sex, temperature within the *C. chinensis* and in different species along with species diversity.

The developing larva passed a long incubation period and eventually emerged out from the seeds which constituted adult emergence. In *C. chinensis* it was 85% [2], 78.00 to 90.33% [19] and the average adult emergence was 26.68 [46] whereas in field cricket *Teleogryllus oceanicus*, young mothers had more offspring [49]. The development rate of offspring from older mothers in *Callosobruchus maculatus* (Coleoptera: Bruchidae) was significantly lower than those of offspring from younger mothers [13]. The present results showed the percentages of adult emergence 60.99±21.76 for 1st day, 33.23±23.84 for 2nd day and 64.40±22.05 for 3rd day did not support the works done by workers mentioned aforesaid. The effects of parental age on offspring viability or lifespan are negative [26] but sometimes inconsistent [30] also. The older females laid larger eggs with lower hatching success than those from younger mothers [11] did not support the findings of our present study. Fitness and fertility rendered first day eggs' emergence with a high percentage (%) and decreased in 2nd day. The oldest mothers (3rd day) with lowest number of eggs of this experiment rendered highest emergence because of higher measure of immune competency [49] and higher egg mass [45]. It may be for maximum energy accumulation in the eggs of older female (3rd Day) but made them less fecund. Thus, less number of eggs got high rate of emergence was similar with the reports of Yanagi and Miyatake [51].

Life spans of the offspring produced by younger, middle-aged and older mothers of *M. persicae* were 9.71, 13.12, and 8.78 days [3]. In *A. nerii*, the offspring lifespan differences between the younger and older mothers were 9.3% and older mothers produce offspring with short life expectancy [54]. Female *C. chinensis* longevity was always more than male through parental, F_1 and F_2 generation [40, 18]. In case of *C. maculatus* the male longevity was found to be shorter than female [42] and vice-versa [41]. Male and female *C. chinensis* had 5.40 days and 6.40 days as longevity [2]; 9.8 days and 12.6 days in chickpea for 24 hours [9] and male 8.90 to 10.90 days and female 8.90 to 10.90 days [19].

The adult longevity of males for first three days of the present study showed older the mothers less survival the offspring and in case of female it was with similar pattern (Table 1). The offspring of older mothers have mostly shorter adult life spans than those of younger mothers [28, 12] which may be due to an accumulation of genetic abnormalities in eggs as mothers age [8]. Again Fox *et al.* [10] reported that offspring of older mothers of *Callosobruchus maculatus* live longer than offspring of younger mother and offspring lifespan was greater for male offspring than for female offspring. The longevity decreased with maternal age increase [24]. The present study also revealed that mated male species had shorter lifespan compared to unmated males (5.86±0.63 days< 8.20±0.42 days) and same patterns found in female (mated 7.08±0.77 days<unmated 11.40±1.34 days) (Table 2) in parental generation. It indicated that unmated males and females were superior to mated species might be not to invest their energy before reproduction. Offspring longevity was decreased with the increase of mother's age and males were inferior to females in every case (Table 1). Females either unmated or mated showed larger life span with comparing that of males of *Callosobruchus chinensis* which was consisted with the reports of Fox *et al.* [10].

Conclusion

The viability of the reproductive traits of females *C. chinensis* depended on the age at breeding time *i.e.,* younger females had good reproductive attributes than the older and oldest ones. In the present experiment, the senescence (age increase) of mothers (*C. chinensis*) showed decreased potentialities that caused changes in values of reproductive traits. Thus, the maternal age of *C. chinensis* suggested that it has the indicative influence on population dynamics and the selection on these traits might lead to evolution in Coleopteran species.

Acknowledgements

The authors are thankful to the Honorable Chairman of the Department of Zoology, University of Rajshahi, Bangladesh for providing the laboratory facilities.

References

1. Ahad MA, Sayed MA, Siddiqui MN, Haque MM. Evaluation of some indigenous plant extracts against pulse beetle, *Callosobruchus chinensis* L. (Bruchidae: Coleoptera) in stored green gram *Vigna radiata* (L.). Global Journal of Medicinal Plant Research,2012:1(1): 33-41.
2. Bashir MA, Alvi AM, Bibi R, Ahmad T, Naz H. Reproductive potential and development of Callosobruchus chinensis on legumes and cereals commodities. Science Letters,2015:3(2):122-127.
3. Birgucu AK, Bayindir-Erol A. Maternal age effect on biology of Aphids: a lifetable approaches. Fresenius Environmental Bulletin,2018:27(11):7470-7478.
4. Birky CW. The inheritance of genes in mitochondria and chloroplasts: laws, mechanisms, and models. Annual Review of Genetics,2001:35:125-148.
5. Bonduriansky R, Head M. Maternal and paternal condition effects on offspring phenotype in *Telostylinus angusticollis* (Diptera: Neriidae). Journal of Evolutionary Biology,2007:20:2379-2388.
6. Bouwhuis S, Vedder O, Becker PH. Sex-specific pathways of parental age effects on offspring lifetime reproductive success in a long-lived seabird. Evolution,2015:67(7):1760-1771.
7. Carter AB, Carton AG, McCormick MI, Tobin AJ, Williams AJ. Maternal size, not age, influences egg quality of a wild, protogynous coral reef fish *Plectropomus leopardus*. Marine Ecology Progress

Series,2015:529:249-263. https://doi.org/10.3354/meps11277.

8. Crow IF. The high spontaneous mutation rate: is it a health risk? Proceedings of the National Academy of Sciences of the USA,1997:94:8380-8386.
9. Fatiha RA, Kada R, Khelil MA, Pujade-Villar J. Biological control against the cowpea weevil (*Callosobrus chinensis*; Coleoptera; Bruchidae) using essential oils of some medicinal plant. Journal of Plant Protection Research,2014:54(3):211-217.
10. Fox CW, Bush ML, Wallin WG. Maternal age affects offspring lifespan of the seed beetle, *Callosobruchus maculatus*. Functional Ecology,2003:17:811-820.
11. Fox CW, Dingle H. Dietary mediation of maternal age effects on offspring performance in a seed beetle (Coleoptera: Bruchidae). Functional Ecology,1994:8:600-606.
12. Fox CW. Maternal and genetic influences on egg size and larval performance in a seed beetle (*Callosobruchus maculatus*) multigenerational transmission of a maternal effect. Heredity,1994:73(5):509-517.
13. Fox CW. The influence of maternal age and mating frequency on egg size and offspring performance in *Callosobruchus maculatus* (Coleoptera: Bruchidae). Oecologia,1993:96:139-146.
14. Gavrilov LA, Gavrilova NS, Semenova VG, Evdokushkina GN, Krun’ko VN, Gavrilova AL *et al*. Maternal age and lifespan of offspring. Doklady Akademii Nauk,1997:354(4):569-572.
15. Heath DD, Fox CW, Heath JW. Maternal effects on offspring size: variation through early development of chinook salmon. Evolution,1999:53:1605-1611.
16. Hercus MJ, Hoffmann AA. Maternal and grandmaternal age influence offspring fitness in *Drosophila*. Proceedings of the Royal Society of London,2000:267:2105-2110.
17. Hunt J, Simmons LW. Maternal and paternal effects on offspring phenotype in the dung beetle, *Onthophagus taurus*. Evolution,2000:54:936-941.
18. Islam MS, Rahman MA, Laz R. Manipulation of reproductive potential in the pulse beetles *Callosobruchus* spp. (Coleoptera:Bruchidae) by gamma irradiation. University Journal of Zoology, Rajshahi University,2001:20:17-24.
19. Jaiswal DK, Raju SVS, Vani VM, Sharma KR. Studies on life history and host preference of pulse beetle, *Callosobruchus chinensis* (L.) on different pulses. Journal of Entomology Research,2019:43(2):159-164
20. Jann P, Ward I. Maternal effects and their consequences for offspring fitness in the Yellow Dung Fly. Functional Ecology,1999:13:51-58.
21. Kern S, Ackermann M, Stearns SC, Kaweeki TJ. Decline in offspring viability as a manifestation of aging in *Drosophila melanogaster*. Evolution,2001:55:1822-1831.
22. Kirkpatrick M, Lande R. The evolution of maternal characters. Evolution,1989:43:485-503.
23. Klass MR. Aging in the nematode *Caenorrhabditis elegans*: major biological and environmental factors influencing lifespan. Mechanisms and Ageing and Development,1977:6:413-429.
24. Koç Y, Sönmez E. Impact of maternal age on performance of the progeny in *Galleria mellonella* (L., 1758) (Lepidoptera: Pyralidae). Turkiye Entomoloji Dergisi,2021:45(1):33-40. DOI: http://dx.doi.org/10.16970/entoted.682212
25. Lansing AI. A nongenetic factor in the longevity of rotifers. Annals of the New York Academy of Sciences,1954:57:455-464.
26. Lansing AI. A transmissible, cumulative, and reversible factor in aging. Journal of Gerontology,1947:2:228-239.
27. Legaspi JC, O'Neil JR. Developmental response of nymphs of *Podisus maculiventris* (Heteroptera: Pentatomidae) reared with low numbers of prey. Environmental Entomology,1994:23(2):374-380.
28. Lind MI, Berg EC, Alavioon G, Maklakov AA. Evolution of differential maternal age effects on male and female offspring development and longevity. Functional Ecology,2015:29:104-110.
29. Mishra G, Omkar O. Influence of parental age on reproductive performance of an aphidophagous ladybird, *Propylea dissecta* (Mulsant). Journal of Applied Entomology,2004:128(9-10):605-609.
30. Monaghan P, Maklakov AA, Metcalfe NB. Intergenerational transfer of ageing: parental age and offspring lifespan. Trends in Ecology & Evolution,2020:35(10):927-937.
31. Montoya LR, Farfan JN. Natural selection and maternal effects in life history traits of *Brevicoryne brassicae* (Homoptera: Aphididae) on two sympatric closely related hosts. Florida Entomologist,2009:92(4):635-644.
32. Mousseau TA, Fox CW. The adaptive significance of maternal effects. Trends in Ecology & Evolution,1998:13:403-407.
33. Mousseua TA, Dingle H. Maternal effects in insect life histories. Annual Review of Entomology,1991:36:511-34.
34. Muller D, Giron D, Desouhant E, Rey B, Casas J, Lefrique N *et al*. Maternal age affects offspring nutrient dynamics. Journal of Insect Physiology,2017:101:123-131.
35. Nafus MG, Todd BD, Buhlmann KA, Tuberville TD. Consequences of maternal effects on offspring size, growth and survival in the desert tortoise. Journal of Zoology,2015:297:108-114.
36. Newcombe D, Moore PJ, Moore AJ. The role of maternal effects in adaptation to different diets. Biological Journal of the Linnean Society,2015:114(1):202-211.
37. Omkar JS, Kumar G. Effect of prey quantity on reproductive and developmental attributes of a ladybird beetle, *Anegleis cardoni*. International Journal of Tropical Insect Science,2010:30(1):48-56.
38. Plaistow SJ, Shirley C, Collin H, Cornell SJ, Harney ED. Offspring provisioning explains clone-specific maternal age effects on life history and life span in the water flea, *Daphnia pulex*. The American Naturalist,2015:186(3):376-389. MED: 26655355
39. Priest NK, Mackowiak B, Promislow DE. The role of parental age effects on the evolution of aging. Evolution,2002:56:927-935.
40. Rahman MA, Islam MS. Gamma radiation induced changes on several reproductive potentials in *Callosobruchus chinensis* (L.) and *C. maculatus* (F.) (Coleoptera: Bruchidae). Bangladesh Journal of

Genetics and Biotechnology,2005:6(1,2):23-28.

41. Rahman MA, Parvin A, Khan MSH, War AR, Lingaraju K, Prasad R *et al*. Efficacy of the green synthesized nickel-oxide nanoparticles against pulse beetle, *Callosobruchus maculatus* (F.) in black gram (*Vigna mungo* L.). International Journal of Pest Management, 2020. DOI:10.1080/09670874.2020.1773572
42. Rahman MA, Sabiha S. Efficacy of carbofuran against pulse beetle *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in black gram (*Vigna mungo* L.) seeds. Journal of Entomology and Zoology Studies,2018:6(2):2480-2486.
43. Saino N, Ambrosini R, Martinelli R, Moller AP. Mate fidelity, senescence in breeding performance, and reproductive trade-off in the barn swallow. Journal of Animal Ecology,2002:71:309-391.
44. Schroeder J, Nakagawa S, Rees M, Mannarelli ME, Burke T. Reduced fitness in progeny from old parents in a natural population. Proceedings of the National Academy of Sciences of the United States of America,2015:112(13):4021-4025.
45. Singh S, Mishra G, Omkar. Maternal body size and age govern reproduction and offspring phenotype in the zig-zag ladybird beetle (Menochilus sexmaculatus). Canadian Journal of Zoology,2021:99(2):97-105.
46. Thakur DR, Devi B. Biopesticidal efficacy of *Berberis lycium* Linnaeus and *Cannabis sativa* Linnaeus against *Callosobruchus chinensis* Linnaeus (1758) (Coleoptera: Bruchidae). Journal of Insect Science,2016:29(1):227-232.
47. Verdone-Smith C, Enesco HE. Maternal age and lifespan do not influence longevity in the rotifer *Asplanchna brightwelli*, Experimental Gerontology,1982:17:263-266.
48. Wasserman SS, Asami T. The effect of maternal age upon fitness of progeny in the southern Cowpea weevil, *Callosobruchus maculatus*, Oikos,1985:45(4):191-196.
49. Wilson JD, Anner SC, Murphy SM, Tinghitella RM. Consequences of advanced maternal age on reproductive investment by male offspring. Journal of Orthoptera Research,2020:29(1):71-76. https://doi.org/10.3897/jor.29.39228.
50. Wilson K, Graham RI. Transgenerational effects modulate density-dependent prophylactic resistance to viral infection in a lepidopteran pest. Biology Letters,2015:11:20150012. http://dx.doi.org/10.1098/rsbl.2015.0012.
51. Yanagi S, Miyatake T. Effects of maternal age on reproductive traits and fitness components of the offspring in the bruchid beetle, *Callosobruchus chinensis* (Coleoptera: Bruchidae). Physiological Entomology,2002:27:261-266.
52. Yanagi S, Tuda M. Interaction effect among maternal environment, maternal investment and progeny genotype on life history traits in *Callosobruchus chinensis*. Functional Ecology,2010:24:383-391.
53. Zehnder CB, Hunter MD. A comparison of maternal effects and current environment on vital rates of *Aphis nerii*, the milkweed-oleander aphid. Ecological Entomology,2007:32:172-180.
54. Zehnder CB, Parris MA, Hunter MD. Effects of maternal age and environment on offspring vital rates in the oleander aphid (Hemiptera: Aphididae). Environmental Entomology,2007:36(4):910-917.