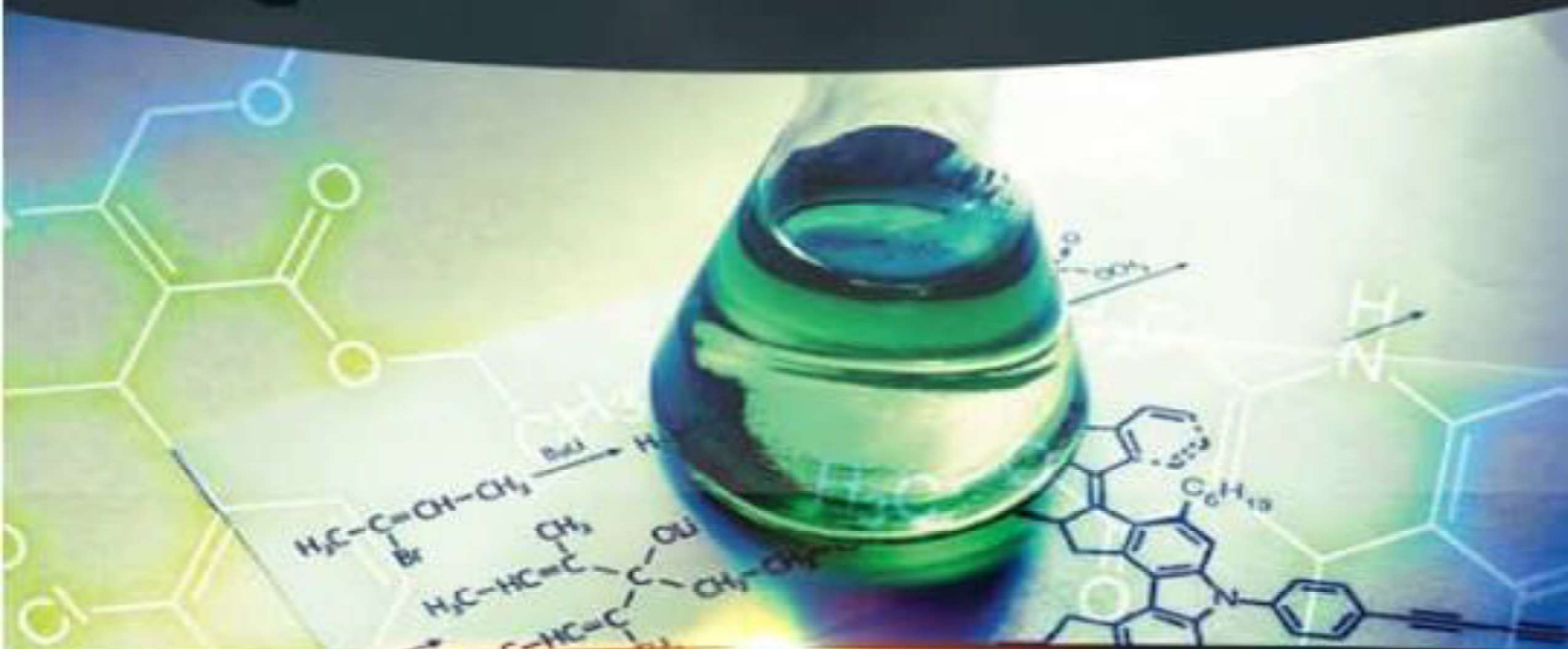
FACULTY OF NATURAL SCIENCES,
Ibrahim Badamasi Babangida University, Lapai, Niger State.

2nd FACULTY OF NATURAL SCIENCES ANNUAL CONFERENCE (FONSAC 2021)



Theme:

CATALYZING NATIONAL ECONOMIC RECOVERY IN POST-COVID-19 ERA THROUGH INNOVATIVE RESEARCH

Book of Proceedings

Date : Monday 30th August to Thursday 2nd September, 2021
Venue: University Auditorium IBB University Lapai, Niger State

Influence of Day-Length Conditions on Immature Fitness Attributes of *Aedes aegypti* (Diptera: Culicidae)

*[1]Sule B. U., [1]Ukubuiwe A. C., [1]Olayemi I. K., [2]Salihu I. M., [1]Sodangi C. J. & [3]Ukubuiwe C. C.

[1]Department of Animal Biology, Federal University of Technology, Minna, Niger State
[2]Biological Science Department, IBB University, Lapai, Niger State
[3]Department of Microbiology, Federal University of Technology, Minna, Niger State

*Corresponding Author's email: sulebright1109@gmail.com, phone No: 08038251346

ABSTRACT

Photoperiod is the amount of light and darkness in a 24 hour clock is a physical factor affecting the physiology and behaviour of insects. This study investigated the influence of day-length on developmental attributes of *Aedes aegypti*. Eggs gotten from the wild were incubated in the laboratory. Day old larvae were exposed to five photoperiod regimens; 0, 6, 13 (control), 18 and 24 hour of light (hL). Rearing of immature stages and other entomological variables were monitored following standard protocols. Results revealed significant effects of photoperiod on all parameters measured. Total larval and total immature development ranged from 7.87±1.88 to 16.29±4.53 days and 9.67±1.94 to 18.08±4.48 days respectively, while average larval and average immature survivorship ranged from 94.08±4.25 to 99.46±0.87 and 94.71±3.88 to 98.38±1.44 %. This study showed photoperiod had significant effect on immature duration and survivorship of *Ae. aegypti.*

Keywords: *Aedes aegypti,* Day-length, Survivorship.

INTRODUCTION

Aedes aegypti originates from Africa but today are seen in all regions of the both developed and underdeveloped places worldwide (Powell and Tabachnick, 2013). In Sub-Sahara Africa where yellow fever epidemics and other aboviral diseases have had serious effects on human, they are the major cause of relative incidence of disease and mortality (Morrison *et al.,* 2008; Marcondes and Ximenes, 2015). The vector of these diseases constantly exposed to varying physical factor that significantly influence the physiology, behaviour and development (Delinger and Yocum, 2019).

Among these physical factor is photoperiod; defined as the amount of light available within a 24 hour clock (Gillot, 2005; Shi *et al.,* 2017). The number of hour of light and darkness L:D or hours of light (hL), has great influence on insects physiology (Saunders, 2012). It give rise to knowledge about yearly changes received and processed by mosquitoes, resulting to differences in developmental indices (Yee *et al.,* 2012; Lacour *et al.,* 2014; Armbruster, 2016). Day length variations serves as signal for changes in ecosystem and insects have what it takes to detect these changes before it arrives allowing

Sule B. U., Ukubuiwe A. C., Olayemi I. K., Salihu I. M., Sodangi C. J. & Ukubuiwe C. C. (2021). Influence of Day-Length Conditions on Immature Fitness Attributes of *Aedes aegypti* (Diptera: Culicidae). 2nd Faculty of Natural Sciences Annual Conference. IBB University Lapai held between 30th August to 2nd September 2021. Pp 213-219

them to make necessary responses (Denlinger *et al.,* 2017). More so, variations occur in insect's developmental indices due to the fact that photoperiodic response is species specific (Ukubuiwe *et al.,* 2018).

Knowledge about the right biological and physiological activities exhibited by species of insect to changes in photoperiod is vital in the development of a potent control protocols, particularly for medically important insect pest.

METHODOLOGY

Sourcing and Handling of Aedes egg

Ovitraps (plastic troughs of 400 mL capacity) half-filled with distilled water lined with white cloth inwardly were set in the wild and monitored daily for collection of eggs. Oviposited eggs were retrieved by removing the white cloth from the ovitrap as eggs are attached to the cloth. Retrieved eggs were transferred to the Insectary unit Animal Biology Department, Federal University of Technology, Minna, Niger State for incubation.

Simulation and Maintenance of Day-length Regimens

Simulation and maintenance of photoperiod regimens followed the method of (Ukubuiwe *et al*., 2018) while mosquitoes were reared as described by Olayemi and Ande (2009). Five photoperiod durations 0, 6, 13, 18 and 24 hours of light (hl) were simulated by varying the duration by which mosquitoes are exposed to light. The test mosquitoes were exposed to this light variation from larval stage through to adulthood.

Rearing of Experimental Mosquitoes

Eggs were introduced into six (6) replicate troughs (100 mL capacity) at twenty five (25) eggs/ trough and monitored until hatching. Hatched larvae were introduced into a separate rearing trough at 4 mL water per larva and fed with yeast every day and the water changed everyday until pupation as described by Ukubuiwe *et al.* (2016).

Influence of day-length conditions on Immature Fitness Attributes of *Ae. aegypti* Duration of development

This represented the time taken for an immature stage to transform to another immature stage. The mosquitoes were monitored twice (6 am and 6 pm) every day, the time and numbers of immature life stages that transform to the next stage (LI-IV), pupa stage and adult was taken note respectively (Ukubuiwe *et al.,* 2016).

Immature survivorship

This is the proportion of mosquitoes at the start of a life stage that effectively enters the next stage. It was determined for immature life stages expressed in percentages and computed using the formula described by Ukubuiwe et al. (2018).

$$S_i = (n_i/n_{i-1}) \times 100$$

Si = survival rates in instars stage i in percentage; ni is the number of larvae entering instars stage i and ni-1 the number of larvae that entered the preceding instar stage.

Data Analysis

Data generated from the independent study were processed into means and standard deviation using Microsoft Office Excel 2016. Variables from various regimens were compared for significant difference using one-way and two-way analysis of variance (ANOVA) as appropriate with means separated using Duncan Multiple

Range Test (DMRT). Differences in mean were considered to be significant at $P<0.05$

RESULTS AND DISCUSSION

Results

Influence of day-length on duration of immature development (days) of *Aedes aegypti*

Analyses showed significant ($p<0.05$) effect of photoperiod in developmental time exhibited by larvae at different photoperiod regimen from L1 to LIV. There was no significant ($p>0.05$) effect in total larval duration from 0, 6, 13 and 18 hours of light (hL). Immature reared at shorter day lengths 0, 6 and 13 hl displayed fast developmental rate as they took short time for their development, while 18 and 24 hl took longer time for their development (Table 4.1). The range of values for immature development are L1 0.71±0.18 to 1.31±0.17 days; L2 0.79±0.31 to 1.32±0.31 days; L3 1.41±0.53 to 4.39±2.27 days; L4 4.69±1.74 to 9.55±3.98 days and pupa 1.54±0.38 to 1.90±0.10 days, respectively (Table 1).

These variations in larval and pupa duration of development led to a significant ($p<0.05$) difference in total larval and immature duration for the species. Total larval development ranges from 7.87±1.88 to 16.29±4.53 days andtotal immature development ranges from9.67±1.94 to 18.08±4.48 days, respectively (Table 1)

Influence of day-length on immature survivorship (%) of *Aedes aegypti*

Analyses revealed significant ($p<0.05$) effect of day-length conditions on survival rate of immature life stages of the species except at second larva instar (LII). Average larval survivorship of those exposed to 0, 6, 13 and 18 hL show no difference but at 24 hL, there was significant difference as survival rate was low. At the pupa stage, there was no significant ($p>0.05$) effect of day-length on survivorship. The range of values for the survivorship of larva instars and pupa stage are L1 97.96±3.31to 100.00±0.00 %; LII 97.17±3.11 to 100.00±0.00 %; LIII 88.61±17.65to 100.00±0.00%; LIV87.73±8.51 to 98.41±2.47 % and pupa 94.05±4.25to 97.22±4.30 %, respectively (Table 2).

Average larval and average immature survivorship also varied significantly ($p<0.05$) with range of values 94.08±4.25to 99.46±0.87 % and 94.71±3.88 to 98.38±1.44 %, respectively (Table 2).

Table 1 Effect of Photoperiod on Duration (Days) of Immature Development of *Aedes aegypti*

Photoperiod (hL)	First larva instar (L1)	Second larva instar (L2)	Third larva instar (L3)	Fourth larva instar (L4)	Total Larval Duration	Pupal Stage Duration	Total Immature Duration
0	$0.71\pm0.18^{a*}$	0.79 ± 0.31^{a}	1.41 ± 0.53^{a}	4.90 ± 1.60^{a}	7.87 ± 1.88^{a}	1.81 ± 0.11^{b}	9.67 ± 1.94^{a}
6	1.11 ± 0.25^{b}	0.83 ± 0.17^{a}	1.84 ± 0.65^{a}	4.69 ± 1.74^{a}	8.47 ± 2.31^{a}	1.54 ± 0.38^{a}	10.01 ± 2.01^{ab}
13	0.72 ± 0.19^{a}	0.89 ± 0.18^{ab}	1.61 ± 0.71^{a}	5.53 ± 1.58^{a}	8.74 ± 2.14^{a}	1.78 ± 0.11^{b}	10.52 ± 2.11^{ab}
18	1.31 ± 0.17^{b}	1.32 ± 0.31^{c}	2.07 ± 0.69^{a}	6.55 ± 1.67^{a}	11.24 ± 1.50^{a}	1.90 ± 0.10^{b}	13.14 ± 1.83^{b}
24	1.18 ± 0.33^{b}	1.18 ± 0.30^{bc}	4.39 ± 2.27^{b}	9.55 ± 3.98^{b}	16.29 ± 4.53^{b}	1.79 ± 0.63^{b}	18.08 ± 4.48^{c}

*Values in a column having same superscript are not significantly different at $P\leq0.05$

Values are expressed as Mean±SD

Table 2:Effect of Photoperiod on Immature Survivorship (%) of *Aedes aegypti*

Photoperiod (hL)	First larva instar (L1)	Second larva instar (L2)	Third larva instar (L3)	Fourth larva instar (L4)	Total Larval Duration	Pupal Stage Duration	Total Immature Duration
0	$100.00\pm0.00^{b*}$	100.00 ± 0.00^{a}	100.00 ± 0.00^{b}	97.83 ± 3.49^{b}	99.46 ± 0.87^{b}	94.05 ± 4.25^{a}	98.38 ± 1.44^{b}
6	97.96 ± 3.31^{a}	97.79 ± 3.53^{a}	98.48 ± 2.36^{ab}	98.41 ± 2.47^{b}	98.16 ± 1.41^{b}	96.81 ± 3.66^{a}	97.89 ± 0.66^{b}
13	100.00 ± 0.00^{b}	97.17 ± 3.11^{a}	100.00 ± 0.00^{b}	97.55 ± 4.29^{b}	98.68 ± 0.85^{b}	94.20 ± 5.24^{a}	97.78 ± 0.73^{b}
18	100.00 ± 0.00^{b}	98.55 ± 3.55^{a}	96.70 ± 5.17^{ab}	97.53 ± 9.74^{b}	98.19 ± 3.41^{b}	95.91 ± 6.57^{a}	97.74 ± 1.85^{b}
24	100.00 ± 0.00^{b}	100.00 ± 0.00^{a}	88.61 ± 17.65^{a}	87.73 ± 8.51^{a}	94.08 ± 4.25^{a}	97.22 ± 4.30^{a}	94.71 ± 3.88^{a}

*Values in a column having same superscript are not significantly different at $P\leq0.05$

Values are expressed as Mean±SD

DISCUSSION

Effects of day-length conditions on development of *Aedes aegypti* mosquitoes

From this study, immature development of mosquitoes reared under day-length ≤ 13hLspent shorter day for their development while day-length ≥18 hL spent longer time for their development. This is similar to what was observed by Kollberg *et al.*, (2013) in pine sawfly (*Neodiprion sertifer*) and Ukubuiwe *et al*. (2018) in *culex quinquefasciatus.*The faster growth rate at (13 hL) in this study is same as observed by Lopatina *et al*. (2011) in carabid beetle (*Amara communis*).

On a contrary, Bradshaw and Holzapfel (1975) reported rapid growth rates at long light duration for *Toxorhynchites rutilus* and retarded development during short duration. Chocorosqui and Panizzi (2003) also reported longer developmental time in shorter day-length for *Dichelops melacanthus*. These contradictions may be due to the fact that different species respond differently to photoperiod.

The fast growth rate by mosquito reared under shorter photoperiod might be physiological or behavioural responses to beginning of rainy season, a season having short day length mostly (Leimar, 1996). Wet season favours mosquito development simply because relative humidity is high and breeding sites available, hence mosquito species' population increases. The danger of larvae been flooded during the wet season might have triggered the fast developmental rate and short light duration might have favoured feeding by immature stage, hence increase accumulation of teneral reserve for pupation (Kollberg *et al*, 2013). Furthermore, longer developmental time experienced for longer light duration might either be stress and diapause-related physiological stimulus (Lopatina *et al*., 2011).

Effects of day-length conditions on survivorship of *Aedes aegypti*

From this study, day-length ≤ 13 hL recorded higher survival rate while ≥18 hL survived less. This finding is similar to the work of Ukubuiwe *et al* (2018) in their study accessing the effect of photoperiod on survivorship of *Culex quinquifasciatus.* High survivorship observed at shorter day-length indicates that they are favourable for mosquito survivorship. Mathias *et al*. (2006) reported differently to photoperiod responses of *Wyeomyia smithii*, *Polyommatus icarus* and *Anopheles quadrimaculatus*. According to Kollberg*et al*. (2013), immature survivorship of European pine sawfly (*Neodiprion sertifer*) is not dependent of photoperiod. The differences observed in the present study with others could be due to the fact that photoperiod is species specific.

CONCLUSION

This study showed that photoperiod had significant effect on immature developmental indices measured. Further, rate of development is fast at short day-length also survivorship is high at short day-length suggesting that short day-length favoured development and survivorship. This information gotten from this study is vital in developing a robust control strategy.

Acknowledgement

Our deepest appreciation goes to the Management and Staff members of the Department of Animal Biology, Federal University of Technology and Entomology Sentinelof the department for providing a conducive environment for the study.

REFERENCES

Armbruster, P.A. (2016). Photoperiodic diapause and the establishment of *Aedesalbopictus*(Diptera: Culicidae) in North America. *Journal of medical entomology*, *53*(5), pp.1013-1023.

Bradshaw, W.E. and Holzapfel, C.M. (1975). Biology of tree-hole mosquitoes: photoperiodic control of development in northern *Toxorhynchitesrutilus* (Coq.). *Canadian Journal of Zoology*, *53*(7), pp.889-893.

Chocorosqui, V.R. and Panizzi, A.R. (2003). Photoperiod influence on the biology and phenological characteristics of *Dichelopsmelacanthus* (Dallas, 1851) (Heteroptera: Pentatomidae). *Brazilian Journal of Biology*, *63*(4), pp.655-664.

Costanzo, K.S., Schelble, S., Jerz, K. and Keenan, M. (2015). The effect of photoperiod on life history and blood-feeding activity in *Aedes albopictus* and *Aedesaegypti* (Diptera: Culicidae). *Journal of Vector Ecology*, *40*(1), pp.164-171.

Denlinger, D. L., and Yocum, G. D., (2019). Physiology of heat sensitivity. In *Temperature sensitivity in insects and application in integrated pest management* (pp. 7-53). *CRC Press*.

Denlinger, D.L., Hahn, D.A., Merlin, C., Holzapfel, C.M. and Bradshaw, W.E. (2017). Keeping time without a spine: what can the insect clock teach us about seasonal adaptation?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1734), p.20160257.

Gillott, C. 2005. Entomology. 3rd Ed. *Springer publishing*, pp 500-511.

Kollberg, I., Bylund, H., Schmidt, A., Gershenzon, J. and Bjoerkman, C. (2013). Multiple effects of temperature, photoperiod and food quality on the performance of a pine sawfly. *Ecological Entomology*, *38*(2), pp.201-208.

Lacour, G., Vernichon, F., Cadilhac, N., Boyer, S., Lagneau, C. and Hance, T. (2014). When mothers anticipate: effects of the prediapause stage on embryo development time and of maternal photoperiod on eggs of a temperate and a tropical strains of *Aedes albopictus* (Diptera: Culicidae). *Journal of Insect Physiology*, *71*, pp.87-96.

Leimar, O. (1996). Life history plasticity: influence of photoperiod on growth and development in the common blue butterfly. *Oikos*, pp.228-234.

Lopatina, E.B., Kipyatkov, V.E., Balashov, S.V. and Kutcherov, D.A. (2011). Photoperiod-temperature interaction-a new form of seasonal control of growth and development in insects and in particular a Carabid Beetle, *Amara communis* (Coleoptera: Carabidae). *Journal of Evolutionary Biochemistry and Physiology*, *47*(6), pp.578-592.

Marcondes, C.B. and Ximenes, M.D.F. (2015). Zika virus in Brazil and the danger of infestation by *Aedes* (Stegomyia) mosquitoes. *Revista da SociedadeBrasileira de Medicina Tropical*, *49*, pp.4-10.

Mathias, D., Reed, L.K., Bradshaw, W.E. and Holzapfel, C.M. (2006). Evolutionary divergence of circadian and photoperiodic phenotypes in the pitcher-plant mosquito, *Wyeomyiasmithii*. *Journal of biological rhythms*, *21*(2), pp.132-139.

Morrison, A.C., Zielinski-Gutierrez, E., Scott, T.W. and Rosenberg, R. (2008). Defining challenges and proposing solutions for control of the virus vector *Aedes aegypti*. *Public Library of Science medicine*, *5*(3), p.e68.

Olayemi, I.K. and Ande, A.T. (2009). Life table analysis of *Anopheles gambiae* (Diptera: Culicidae) in relation to malaria transmission. *Journal of Vector Borne Diseases*, *46*(4), pp.295-299.

Powell, J.R. and Tabachnick, W.J. (2013). History of domestication and spread of *Aedes aegypti*-a review. *Memórias do Instituto Oswaldo Cruz*, *108*, pp.11-17.

Saunders, D.S., 2012. Insect photoperiodism: seeing the light. *Physiological Entomology*, *37*(3), pp.207-218.

Shi, L., Vasseur, L., Huang, H., Zeng, Z., Hu, G., Liu, X. and You, M. (2017). Adult tea green leafhoppers, *Empoascaonukii* (Matsuda), change behaviors under varying light conditions. *Public library of science one*, *12*(1), p.e0168439.

Ukubuiwe, A.C., Olayemi, I.K. and Jibrin, A.I. (2016). Genetic variations in bionomics of *Culexquinquefasciatus* (Diptera: Culicidae) mosquito population in Minna, North Central Nigeria. *International Journal of Insect Science*, *8*, 9-15

Ukubuiwe, A.C., Olayemi, I.K., Omalu, I.C.J., Arimoro, F.O., Baba, B.M. and Ukubuiwe, C.C. (2018). Effects of varying photoperiodic regimens on critical biological fitness traits of *Culexquinquefasciatus* (Diptera: Culicidae) mosquito vector. *International journal of insect science*, *10*, p.1179543318767915.

Yee, D.A., Juliano, S.A. and Vamosi, S.M. (2012). Seasonal photoperiods alter developmental time and mass of an invasive mosquito, *Aedesalbopictus* (Diptera: Culicidae), across its north-south range in the United States. *Journal of medical entomology*, *49*(4), pp.825-832.