**ORIGINAL ARTICLE**

# The Effect of Electric Shocks Produced by Various Amperes and Voltages on Larvae of *Anopheles arabiensis* Patton and *Culex quinquefasciatus* Say (Diptera, Culicidae).

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## Abstract:

This study was carried to determine the response of *Anopheles arabiensis* and *Culex quinquefasciatus* larvae when exposed to electric shocks. Karkoug village was chosen for collection of *Anopheles* and *Culex* mosquitoes (larvae). The collected larvae were immediately transferred to the University of Gezira, Faculty of Engineering and Technology, Basic Science Laboratory, where the tests were run. The electric shocks were performed by using a current of 1, 2, and 3 amperes by using a power supply (Popular, PE-23005, Made in India). The voltages used in each experiment were, 20, 30, 40, 50, and 60 volts. The duration of the electric shock was 2 minutes. These tests were repeated for three times and the average was subjected to probit analysis. The results showed that, changing of the electric current from 1, 2 to 3 amperes was associated with the decreases of Lethal Electric Shocks of 50% of the population form 31.468, 26.488 and 27.357 volts, respectively on *Anopheles* larvae, while they were 29.04, 28.58, and 25.65 volts, on *Culex* larvae. *Culex* larvae were more susceptible to the electric shocks than *Anopheles* larvae. The electric shocks also shortened the life span of the produced adults of both *Culex* and *Anopheles*. Also, the electric shocks induced a state of sterility (fail to reproduce) on the subjected species.

## Introduction:

The malaria parasites are transmitted through the bite of *Anopheles* mosquito, it has been recognized that knowledge of the mosquito biology, physiology and behavior, are major importance to use the proper tool for malaria control. Simple technique of reducing mosquito survival, such as spraying interior wall surfaces with residual insecticides, have in some countries led to control of malaria or greatly reduced its public health importance (David and Herbert, 2002).

White (1991) and Robyn (2009) reviewed more details concerning the biology and physiology of mosquitoes. Many scientists like Haddow (1942) and Service (1977) have reviewed the ecology and behaviour of mosquitoes. Medical importance of mosquitoes was well reviewed by White (1989 and 1974); El Safi (1994); El Safi and Haridi (1986), and Brown (1986).

In Wad Medani area, insecticides application for mosquitoes proved to be effective and feasible as a control method. However, by 1980, many anopheline species were reported to be resistant to one or more insecticides, such as dieldrin, organophosphate and carbamates. Organochlorines (DDT) failed to give satisfactory control of *Anopheles arabiensis* Patton in Wad Medani area early in the 1970s, and then organophosphates (Malathion and Fenitrothion) were introduced in 1975, supplemented by some larvicides on a weekly basis program from 1976 till 1982 (El Safi, 1994).

A device for catching roaches and other insects utilizing an electric shock to catch or kill such insects is disclosed. An electrical integrated circuit utilizing automatic on and off switching is used to enable roaches and insects to enter the device and then periodically shock them and kill them. The design provides safety, efficiency and lower cost without environmental pollution thereby permitting use around small children and pets. The device includes a cover which permits roaches and insects into the device and which includes openings that are sufficiently small to prevent entry of a child's hand or a pet's paws. When the cover is removed, a microswitch automatically cuts the electrical circuit off. The device includes a housing in which is located a conical downwardly and inwardly sloping surface on which is carried a helical pair of conductors connected to the electrical circuit. When a voltage pulse is applied to across the conductors, any roaches or other insects which are in contact with the conductors are shocked and fall downwardly toward the bottom of the cone, which opens into a container partially filled with water to drown the insects (Boddingtons.com, 2009).

**Objective:**

This study was intended to determine the response of *Anopheles arabiensis* and *Culex quinquefasciatus* larvae when exposed to electric shocks by using a current of 1, 2, and 3 amperes and voltages of 20, 30, 40, 50, and 60 volts.

## Materials and Methods:

### 1. The Study Area

Karkoug village (located at the North-west of Wad Medani City) was selected for sampling *Anopheles* and *Culex* mosquitoes larvae. The collected larvae were immediately transferred to the University of Gezira, Faculty of Engineering and Technology, Basic Science Laboratory, where the tests were run.

### 2. Collection and Maintenance of Mosquitoes

Larvae of *Anopheles* and *Culex* spp were collected with sufficient amounts of breeding water (resulted from leakage of the irrigation canals), by means of dipping. The collected aquatic predators were immediately removed by using a plastic dropper. The larvae were put in two rearing dishes (about 2 liter size); one for *Anopheles* and the other for *Culex*. The larvae were fed on yeast formulation. The pupae were transferred to the adults' cage. The emerged adults were fed on sugar solution (5% sugar solution); in addition to that, females were also fed on blood meal (from a shaved-back rabbit that was fixed in a small cage within the mosquito's adult cage). Rearing and maintenance of the first generation mosquito larvae followed WHO (1980).

### 3. The bioassay of the experiments

Experiments were started by preparing six plastic dishes (size of more than 1000 ml). Randomly selected samples of each mosquito larvae (20 of the third and early fourth instars of the first generation) of *Anopheles* and *Culex* were introduced to these dishes, which were 80% filled with tap water. Five dishes were used for treatment of larvae, whereas the sixth was used for control. The electric shocks were performed by passing the conducting wires of the -ve and the +ve (without being contacted to each other) of the power supply into the bottom of each of the prepared dishes, then the power supply was calibrated at a specific current and voltage, and then was switched-on. Three experiments were run in this work. The first was performed by using an electric shock at 1 ampere, the second at 2 amperes, whereas in the third test, an electric shock at 3 amperes was performed. The voltages used in each of the three experiments were, 20, 30, 40, 50, and 60 volts. The duration of the electric shock was kept for 2 minutes (starting period) by using a stop watch. These tests were repeated for three times. The survived larvae were reared in a special cage till they reached the adult stage. The produced adults were fed with sugar solutions and blood meals, and then the life cycle of the produced generation was subjected to a study.

### 4. Calculations and Statistics

The objective of the statistical calculations was to determine the proper voltages sufficient to produce death in larvae. The dead larvae were those which cannot move when touched with needle, or those which cannot rise to the surface within a reasonable period of time (Busvine, 1971). After electric shock, the treated larvae were let for 30 minutes before the number killed (% mortality) of each *Anopheles* and *Culex* larvae were counted. The mortality data (in each of the three experiments) in corresponding to the voltages used were submitted to a probit statistical analysis by using Excel program 2007. Also the durations of the eggs, larvae, pupae, and adults of the produced generation were counted.

## Results and Discussion:

### 4.1. The effect of 1 ampere electric shocks on *Anopheles* and *Culex* larvae:

When the power supply was adjusted at 1 ampere, the voltages of 20, 30, 40, 50 and 60 volts, resulted in mortalities of 41.65, 45, 46.65, 63.35 and 78.35%, respectively on *Anopheles*, while they were 37, 50, 60, 70, and 80% on *Culex* larvae, following the same order of voltages. The test was repeated for three times and the mean mortality was calculated for the tested voltage. The highest voltage (60 volts) resulted in 78.35% mortality on *Anopheles* larvae, while it was resulted in 80% on *Culex* larvae. From the statistical analysis, the obtained data resulted in LES that produce 50% mortality on the tested population was 31.467 and LES 95 was 237.576 volts, on *Anopheles* larvae, while they were 29.04 and 141.07 volts, respectively, on *Culex* larvae, as was shown in table(1).

The R-square was 0.739 on *Anopheles* tests, which considered being less than that of *Culex* larvae (0.976). *Culex* larvae proved to be more homogeneous towards the voltages used at one ampere than *Anopheles*.

### 4.2 The effect of 2 amperes electric shocks on *Anopheles* and *Culex* larvae:

In this experiment, the power supply was adjusted at 2 amperes. The voltages of 20, 30, 40, 50 and 60 volts, resulted in corrected mortalities of 41.65, 48.35, 70, 70 and 75 %, respectively on *Anopheles*, while they were 37, 50, 65, 70, and 80% on *Culex* larvae, following the same order of voltages. The tests were also repeated for three times. The highest voltage 60 volts resulted in 75 % mortality on *Anopheles* larvae, while it was resulted in 80% on *Culex* larvae. From the statistical analysis, the obtained data resulted in LES 50 of 26.488 and LES 95 of 180.288 volts, on *Anopheles* larvae, while they were 28.58 and 136.94 volts, respectively, on *Culex* larvae, as was shown in table (2).

The R-square was 0.908 on *Anopheles* tests, which was considered being less than that of *Culex* larvae (0.987). *Culex* larvae proved to be more homogeneous than *Anopheles* towards the voltages used at 2 amperes scale.

**Table (1): The effect of 1 ampere electric shocks on *Anopheles* and *Culex* larvae:**

| Dose | | % Mortalities | |
|---|---|---|---|
| | | On *Anopheles* larvae | On *Culex* larvae |
| Voltage | Log-volt | | |
| 20 | 1.301 | 41.65 | 37 |
| 30 | 1.477 | 45 | 50 |
| 40 | 1.602 | 46.65 | 60 |
| 50 | 1.692 | 63.35 | 70 |
| 60 | 1.778 | 78.35 | 80 |
| Control | - | 0 | 0 |
| Data analysis | | | |
| Regression equation | | Y= 2.202 + 1.868 X | Y= 1.505 + 2.389 X |
| LES 50 | | 31.467 volts | 29.04 volts |
| LES 95 | | 237.576 volts | 141.07 volts |
| SE (X) | | 0.6406 | 0.215 |
| SE (Y) | | 1.0124 | 0.340 |
| R-square | | 0.739 | 0.976 |

**Table (2): The effect of 2 amperes electric shocks on *Anopheles* and *Culex* larvae:**

| Dose | | % Mortalities | |
|---|---|---|---|
| | | On *Anopheles* larvae | On *Culex* larvae |
| Voltage | Log-volt | | |
| 20 | 1.301 | 41.65 | 37 |
| 30 | 1.477 | 48.35 | 50 |
| 40 | 1.602 | 70 | 65 |
| 50 | 1.692 | 70 | 70 |
| 60 | 1.778 | 75 | 80 |
| Control | - | 0 | 0 |
| Data analysis | | | |
| Regression equation | | Y= 2.198 + 1.969 X | Y= 1.491 + 2.410 X |
| LES 50 | | 26.488 volts | 28.58 volts |
| LES 95 | | 180.288 volts | 136.94 volts |
| SE (X) | | 0.3611 | 0.162 |
| SE (Y) | | 0.5707 | 0.256 |
| R-square | | 0.908 | 0.987 |

**4.3 The effect of 3 amperes electric shocks on *Anopheles* and *Culex* larvae:**

In this experiment, the power supply was adjusted at 3 amperes. The voltages of 20, 30, 40, 50 and 60 volts, resulted in corrected mortalities of 41.65, 51.65, 60, 65 and 71.65 %, respectively on *Anopheles*, while they were 45, 50, 65, 71.7, and 80% on *Culex* larvae, following the same order of voltages. The test was also repeated for three times. The highest voltage (60 volts) resulted in 71.65 % mortality on *Anopheles* larvae, while it resulted in 80% on *Culex* larvae. From the statistical analysis, the obtained data resulted in LES 50 of 27.357 and LES 95 of 291.068 volts, on *Anopheles* larvae, while they were 25.65 and 156.23 volts, respectively, on *Culex* larvae, as was shown in table (3).

The R-square was 0.9925 on *Anopheles* tests, which was considered being more than that of *Culex* larvae (0.947). *Culex* larvae proved to be less homogeneous towards the voltages used at 3 amperes than *Anopheles*.

The increase of the electric current from 1, 2 to 3 amperes was associated with the decreases of LES 50 form 31.468, 26.488 to 27.357 volts, respectively on *Anopheles* larvae, while they were 29.04, 28.58, and 25.65 volts, on *Culex* larvae, following the same order. *Culex* larva was obviously more susceptible to the electric shocks than *Anopheles*, according to the LES 50's and 95's. Also, 3 amperes proved to be the best opportunity electric current.

The values of R-square were 0.739, 0.908 and 0.9925, respectively, on *Anopheles* larvae, while those of *Culex* were 0.976, 0.987, and 0.947 following the same sequence. Also, at three amperes electric shocks the homogeneity was decreased and the LES 95 was increased in *Culex* larvae, compared to the two amperes electric shocks experiments results. The same occurred to *Anopheles* larvae, except that, the homogeneity was also increased.

**4.4 The effect of electric shocks on the life cycle of *Anopheles* and *Culex*:**

Table (4.4) showed the life span of the larvae, pupae and adults in the control and treated groups. Control groups showed durations of 1-3, 2-3, and 14-21 days on both the *Culex* and *Anopheles* larvae, pupae and adults, while the survived groups showed durations of 1-3, 2-3, 1-3 days on both the *Culex* and *Anopheles* larvae, pupae and adults. These findings showed the effect of electric shocks on shortening the life span of the produced adults of both *Culex* and *Anopheles*. Also, the produced adults of both *Culex* and *Anopheles* failed to produce eggs. These results mean that the electric shocks induce a state of sterility on the subjected species.

**Table (3): The effect of 3 amperes electric shocks on *Anopheles* and *Culex* larvae:**

| Dose | | % Mortalities | |
|---|---|---|---|
| | | On *Anopheles* larvae | On *Culex* larvae |
| Voltage | Log-volt | | |
| **20** | 1.301 | 41.65 | 45 |
| **30** | 1.477 | 51.65 | 50 |
| **40** | 1.602 | 60 | 65 |
| **50** | 1.692 | 65 | 71.65 |
| **60** | 1.778 | 71.65 | 80 |
| **Control** | - | 0 | 0 |
| **Data analysis** | | | |
| **Regression equation** | | Y= 2.705 + 1.597 X | Y= 2.055 + 2.09 X |
| **LES 50** | | 27.357 volts | 25.65 volts |
| **LES 95** | | 291.068 volts | 156.23 volts |
| **SE (X)** | | 0.0801 | 0.286 |
| **SE (Y)** | | 0.1266 | 0.452 |
| **R-square** | | 0.9925 | 0.947 |

**Table (4.4): The duration (in days) of the larval, pupal and adults' stages of control and treated *Anopheles* and *Culex* larvae**

***a) Anopheles spp***

| | Larvae | Pupae | Adults |
|---|---|---|---|
| **Control** | 1-3 | 2-3 | 14-21 |
| **Survived** | 1-3 | 2-3 | 1-3 |

***b) Culex spp***

| | Larvae | Pupae | Adults |
|---|---|---|---|
| **Control** | 1-3 | 2-3 | 14-21 |
| **Survived** | 1-3 | 2-3 | 1-3 |

## Discussion:

In similar principle, Electric flyswatters (sometimes called mosquito bats, racket zappers, or zap rackets) are hand-held devices that resemble badminton rackets or tennis rackets, which became popular worldwide in the late 1990s. The handle contains a battery-powered high-voltage generator. The circuit is composed of an electronic oscillator, a step-up transformer and a voltage multiplier, similar to the circuit in an electroshock weapon, but with much lower power (Miller, 2015).

The grid of the flyswatter is electrically charged to a voltage of between 500 and 1500 V DC, activated by pressing and holding a button. When the electrically conductive body of a fly nearly bridges the gap between electrodes, a spark jumps through the fly. A capacitor attached to the electrodes discharges during the spark, and this initial discharge usually stuns or kills the fly. If the button is still pressed, the continuous current will roast and kill the fly. Many flyswatters have a three-layer grid to prevent people from touching both electrodes. The outermost grids or rods are at the same electrical potential, and are open enough to allow an insect to contact the inner charged grid. Most electric flyswatters conform to electrical safety standards for humans: A limit on the charge stored in the capacitor. A discharge of less than 45 µC is considered safe, even in the unlikely scenario that the current from a flyswatter would be flowing from one arm to the other arm, partly through the heart. This means that the capacitor of a 1000 V flyswatter should be less than 45 nF. Due to this precaution for humans, the initial shock is usually inadequate to kill flies, but will stun them for long enough that they can be disposed of. A limit on the current after the initial discharge. The maximal continuous current of most flyswatters is less than 5 mA. This current is safe, even when flowing from one arm to the other arm of a human (brighthubengineering.com, 2011).

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