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Genotoxicity Assessment of an Organophosphate Insecticide, Ethion Employing Mosquito Genome (*Diptera: Culicidae*)

Lovleen Marwaha[1,2*]

[1]Department of Zoology, Mosquito Cytogenetics Unit, Panjab University, Chandigarh,
[2]Department of Zoology, School of Biotechnology and Biosciences, Lovely Professional University, Phagwara, India;
lovleenmarwaha@gmail.com

Abstract

The preferential motives of the present exploration are attributed to the genotoxicity evaluation of an organophosphate pesticide, ethion on the heredity material of *Culex quinquefasciatus*, exposed to sublethal aliquot, LC_{20}, for the continuation of 24 h, implementing two *in vivo* approaches viz., the testicular chromosomal aberrations analysis and dominant lethal test (DLT). Mutagenic, as well as clastogenic consequences of ethion on germinal chromosomes were observed, specifically through relatively elevated incidences of nondisjunctions during pole-wise movement of chromosomes, excessively condensed heterochromatinizations regions, chromosomal fusions due to stickiness, aneuploidy eventually by expressed by hypoploidy, lags of whole or chromosomal fragments and furthermore, pole to pole extended chromosomal bridges, in comparison to control population, with statistical corresponding values 26.03 ± 15.5 in treated stock as against 12.67 ± 3.8 in control groups. For DLT, treated male imagoes were allowed to crossmate with normal females to procure egg rafts and enhanced percentage frequency of unhatched eggs corresponds to value 12.39 ± 3.00 in treated stocks as correlated to 4.23 ± 1.12 in control stocks. Subsequently, statical examination of procured data, from both executed parameters, demonstrated significant outcomes, when scrutinized through Student's *t*-test ($P < 0.05$). The overall conclusion indicated that the induced genotoxicity of ethion in germinal chromosomes could be the probable reason for dominant lethality observed during DLT.

Keywords: Chromosomal Aberrations and Dominant Lethal Test, *Culex quinquefasciatus*, Ethion, Germinal Chromosomes

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1. Introduction

The implementation of pesticides has escalated the economic potential, through generation of excessive food commodities and by controlling vector-borne diseases; but at the same time, corresponding synthetic formulations contaminate ecological components and possess detrimental consequences to living organisms as indicated by different investigations, attributed to the genotoxicity, acute and chronic toxicity, mutagenicity, teratogenicity, reproductive, and cancerous devastates.[1,2] Moreover, aforementioned chemicals, possess harmful consequences on human health including immune suppression, hormone disruption, diminished intelligence, and reproductive abnormalities together with congenital defects as indicated by numerous cytotoxicity evaluation studies.[3-5] Subsequently, the genotoxicity assessment of corresponding formulations has eventually become a crucial conductive aspect that should be executed before, actual applications of such chemicals in the agricultural fields, to ascertain recommended exposure doses, which cause lethality to specific pest species, without additional ill consequences on other species of living organisms, prevailing in a particular ecosystem. Considering the particular cognition, the present investigation has been executed to evaluate genotoxicity of ethion, employing genomic components of common house mosquito, *Culex quinquefasciatus.* Furthermore, additional motivational factor for execution of present exploration

* *Author for correspondence*

is; despite certain *in vitro* and *in vivo* investigations which provide profound insights to drastic chronic genotoxic characteristics and other ill consequences of the concerned organophosphate chemical on different test models, but only limited exploration has been conducted on evaluation of clastogenic and cytotoxic responses on germinal genetic imprints and their impacts on subsequent generations. For this study, exclusive criterion considered was analysis of diverse chromosomal behavior during cell division in gonidial cells of treated male pupae and the subsequent impact on viability of succeeding progencies of treated individuals, correlated with pesticide exposure.

Ethion (O,O,O',O'-Tetraethyl S,S'-methylene bis-phosphorodithioate), member of organothiophosphate family of the organophosphate insecticides, moderately persistent, nonsystemic, and broad spectrum insecticide, registered for commercial purposes in 1965 and is nowadays extensively employed to regulate mites, leafhoppers, maggots, and foliar feeding larvae on a wide variety of food, fiber, and ornamental crops; additionally, practiced on extensive categories of greenhouse crops, lawn, fiber, and ornamental crops. Particular organophosphate pesticide is a highly to moderately toxic compound, persistent continuation, in a particular environment depending upon climatic conditions. Half-life period is 1.3–8 weeks. Environmental protection Agency (EPA), on the basis of toxicity of the concerned compound, designated it, as Class II formulation.

Ethion, a potent insecticide, primarily inhibit acetylcholinesterase enzyme (AChE), required for breaking acetylcholine neurotransmitter molecules into choline and acetate group. The reaction is accomplished through carbamylation of a hydroxyl group of serine moiety, in the active site of this esterase. Thereafter, blockage of AChE, results in accumulation of acetylcholine neurotransmitter at the synaptic junction, eventually prompting continuous stimulation of nerve impulses, consequently, resulting in hyperexcitation, wherein voluntary muscles become twitched, ultimately the insects are killed.

Currently, diverse types of biomarkers are employed to assess the deleterious consequences of different environmental mutagens, on genetic imprints and reproduction potential of an enormous variety of experimental models by adopting diversified experiment innovation. Correspondingly, mosquito genome is quite an efficient analytical material for genotoxicity assessment for disparate environmental contaminants. Mosquito genome is extensively employed in various evaluation explorations and in such conductive research innovations, elicited percentage frequency of characteristic chromosomal aberrations, positively correlated with exposure limits, in comparison to natural response rate, were considered as exclusive criterion to evaluate, the cytotoxicity of suspected chemicals.[6-8] Therefore, to achieve present research objectives of genotoxicity assessment exploration, common house mosquito, *C. quinquefasciatus* (2*n* =6) is used as a test organism, considering specific peculiarities including easy availability, adaptability to laboratory conditions, and short life span. Furthermore, it has small diploid number of chromosomes (2*n* =6). Additionally, mosquito genome has been convinced ideal analytical tool during present investigation, as it provided characteristics exceptional quality temporary squash preparations of germ cell chromosomes and oviposit eggs in the form of egg rafts.

Therefore, during present exploration, the genome of aforementioned, experimental model was implemented to analyze mutagenicity evaluation of ethion on germinal imprints conjointly, with consequences on the viability of succeeding generation. Compilation of procured data from treated stocks in germinal chromosomes analysis and Dominant Lethal Test (DLT), respectively ascertained, a statistically elicited frequency of chromosomal malformations and enhanced percentage frequency of unhatched eggs in comparison with controls, eventually witnessed the clastogenicity intrinsic of organophosphate pesticide, ethion.

2. Materials and Methods

2.1 Test Organism

For the accomplishment of the targeted objectives, common house mosquito, *C. quinquefasciatus*, taxonomically contemplated as a member of the *Culex pipiens* species complex, is taken as test organism. It is to evaluate cytotoxic, as well as, clastogenic characteristics of ethion, at sublethal exposure extent. To execute the targeted motives, gravid females of *C. quinquefasciatus* were captured with the assistance of appropriate mouth aspirator, from the cattle sheds of the village Nada Sahib, approximately 20 km southeast of Chandigarh. The captured mosquitoes were enmeshed in conventional mosquito rearing cages fabricated from mosquito net cloth and were repositioned consequently, such compounds comparatively, only escalate toxicity of synthetic formulations. to insectary

under controlled temperature and humidity. Before colonization, the accomplishment of species identification was done by transferring each gravid female imago, separately to different test tubes and examining each with 5X magnification hand lens, considering appropriate identification key.[9] Thereafter, the mosquitoes oviposit egg rafts in water filled petridishes, already placed in the breeding cages at 25 ± 1°C, 70 ± 10% humidity and 12 h/12 h photoperiods. The rearing of larvae, hatched from egg rafts, was accomplished by sprinkling powdered protein-rich diet, made from dog biscuits and yeast extract mixed in 6:4 ratio, on surface of rearing medium which was changed daily to avoid scum formation. Thus, colonization of *C. quinquefsciatus* was accomplished in insectary.

2.2 Selected pesticide

Ethion belongs to organothiophosphate family of organophosphate insecticide, with International Union of Pure and Applied Chemistry name O,O,O',O'-Tetraethyl S,S'-methylene bis-(phosphorodithioate), CAS number 563-12-2, molecular formula $C_9H_{22}O_4P_2S_4$ and molecular weight 384.5. Its chemical structure is elucidated in [Figure 1]. For execution of present exploration, a packet of 100 ml available under trade name ethion (M/S Krishi Rasayan Exports Ltd., India) was procured from market and was used as such, reason being, the main motive of this investigation was the examination of clastogenic concomitantly mutagenic characteristics of the aforementioned commercial formulation, which is really going to field. Numerous investigations dealing with pesticides indicated discrepancy concerning mutagenicity between active and inert ingredients. Furthermore, fundamental conclusion snapped from these considerations specifies that genotoxicity generally occur due to increased toxicity of formulation compared to pesticide technical grade. Corresponding investigations also manifested, that inert ingredients are supplemental toxic than mutagenic, consequently, such compounds comparatively, only escalate toxicity of synthetic formulations.

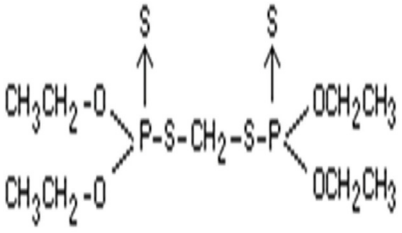


Figure 1. Elucidation of chemical structure of ethion[31].

2.3 Statistical Analysis of Value LC_{20}

The fundamental criterion for computing LC_{20} was mortality of fourth instar larvae, exposed to serial dilution concentrations of stock solution ethion (1%) for 24 h. Corresponding concentrations of serial dilution were formulated by adding aliquots of the stock solution in distilled water. To experiment respective concentrations, 3 replicates of 20 larvae were maintained concurrently, with individual controls under controlled conditions of the laboratory. The mortality of larvae was monitored after 24 h and exclusively, larvae whose bodies were absolutely devoid of the exuvie were recorded as alive. On the basis of mortality of larvae in each set, the accurate value of LC_{20} was calculated by probit analysis.[9] Considering present investigation, the corresponding value of LC_{20} was 14.45 nl/ml [Figure 2] for *C. quinquefasciatus*. The mortality in the control group was taken to be the natural response rate.

2.4 Exposure to Pesticide and Methodology Adopted

For execution of present explorations viz., germinal chromosomal study and DLT, fourth instar larvae of *C. quinquefasciatus* were exposure to statistically analyzed LC aliqout, for 24 h, subsequently, exposed larvae were transferred to distilled water, reared by feeding on protein-rich diet. Furthermore, the testicular chromosomal aberrations analysis was executed, by repeating the parameter in three discrete sets (triplicates). In each discrete set, exposed male pupae were sacrificed for temporary squash preparations, by following standard methodology,[10] with appropriate modification, essentially through dilution of stain and duration of staining; likewise, controls were also maintained concurrently with them. Afterward, quality preparations obtained from all sets were carefully scrutinized, and photographed under digital phase contrast microscope.

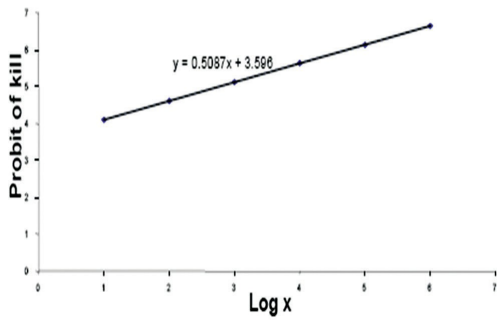


Figure 2. Relationship between the probit of kill and doses of ethion for *Culex quinquefasciatus.*

Furthermore the procured complications were carefully discerned for discrete abrupt genetic abnormalities, represented exclusively in the form of chromosomal aberrations. While in DLT, consequently to hatching, both male and female adult mosquitoes were nurtured by implanting cotton pads immersed in 10% sucrose solution. Peculiar criteria difference between male imago and females is, former possess large palps and feathery antennae. Sequentially, males treated with the pesticides were allowed to cross mate with normal females under optimum conditions of the breeding cage; simultaneously, parallel controls were also maintained with them. To replenish blood meals to copulated females, a mouse entrapped in wire mesh was placed daily in breeding cages. Furthermore, the females who had taken blood meals were identified by their black abdomen. Thereafter, within succeeding 2 or 3 days, gravid females laid eggs in water-filled petri dishes in the breeding cages; subsequently oviposited egg rafts were allowed to hatch in controlled specifications of biochemical oxygen demand incubator. Afterward, the hatched eggs were examined under suitable magnification of Bausch and Lomb binocular microscope, criterion considered was an egg with open opercula were considered as hatched, and eggs with closed opercula were counted as unhatched.

2.5 Statistical Analysis

The ascertained data from both *in vivo* adopted parameters were arithmetically scrutinized by computing the values of the percentage frequency, mean, and standard deviation, discretely for respective aberration an in aggregate separately. Likewise, for DLT, the induced dominant lethality was determined on the basis of percentage frequency of unhatched eggs by using the consecutive description:

$$\text{Percentage frequency of unhatched eggs} = \frac{\text{Number of unhatched eggs in one egg raft x 100}}{\text{Total number of eggs in one egg raft}}$$

The procured complications were scrutinized for statistical analysis and to discern the significance of induced genotoxicity of ethion, in correlation with control groups, Student's *t*-test was applied.

3. Results

3.1 Germinal Chromosome Aberration Analysis

The present *in vivo* germinal chromosomes examination discerned, the inductive prospective of ethion, eventually through different characterized chromosomal malconformations, influencing the structural integrity concurrently the numerical proportionality of genetic elements, in pesticide-exposed *C. quinquefasciatus* pupae [Figure 3]. The structural disfigurements differentiated predominately through nondisjunctions of chromatid at anaphase, excessively condensed heterochromatin domains, chromosomal fusions due to stickiness, lags

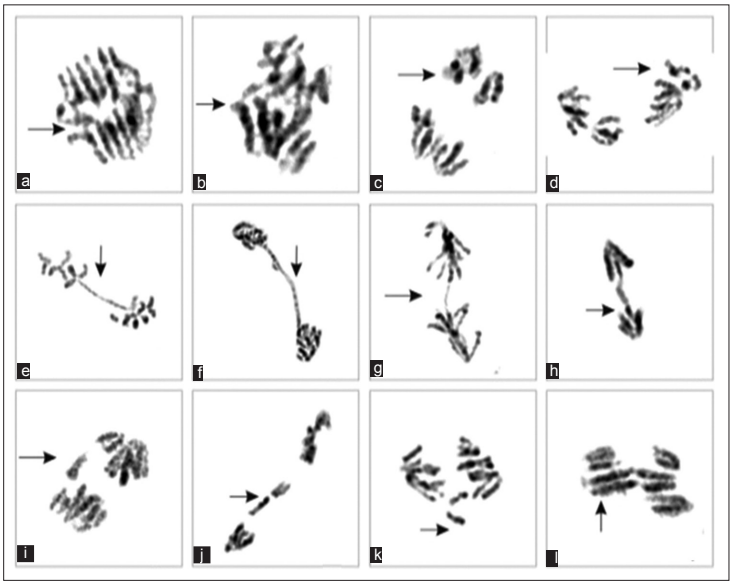


Figure 3. Structural and numerical abnormalities in ethion exposed germinal chromosomes (a and b) nondisjunction; (→) (c and d) induced heterochromatinization (→); (e-h) chromosomal bridge (→); (i-k) lags during anaphase (→); (l) aneuploidy (→).

of fragmented or entire chromosome during anaphase conjointly pole-to-pole extended chromosomal bridges with corresponding percentage frequency of 22.55, 28.43, 3.92, 9.8, and 9.8, respectively, whereas, the numerical impairments were predominately represented by aneuploidy essentially hypoploidy, with percentage frequency of 1.96. Furthermore, in control stocks, only nondisjunction together with heterochromatinizations were discerned, with respective percentage frequency of 17.65 and 19.61 [Figure 4], subsequent to arithmetic scrutiny of procured compilations, the corresponding values were found to be 26.03 ± 15.5 in treated groups as correlated to 12.67 ± 3.8 in control stocks [Table 1].

3.2 Dominant Lethality Analysis

Whereas, another *in vivo* genotoxicity evaluation parameter, DLT, considered the discrepancy between percentage frequency of unhatched eggs in treated and control stocks [Figure 5a and b], as fundamental criterion for analysis of the mutagenic consequences of corresponding synthetic formulation. Compilation elucidated the elicited percentage frequency of unhatched eggs in treated individuals as compared to normal population [Figure 6], with statistical corresponding values 12.39 ± 3.00 in treated groups as against 4.23 ± 1.12 in control stocks [Table 2].

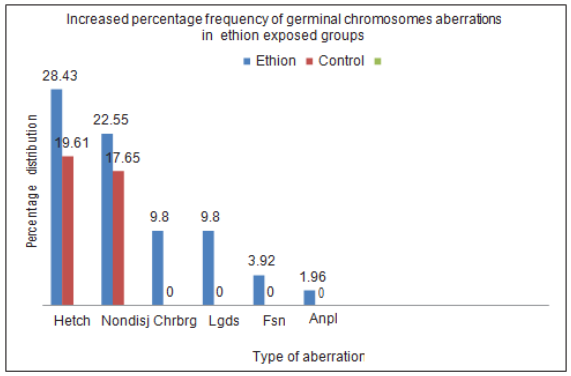


Figure4. Percentage distribution of chromosomal aberrations in germinal chromosomes of ethion treated and control groups. The gross procured compilations, elucidated here, emphasized the mutagenic instinct of ethion, predominantly represented through, heterochromatinization, subsequently followed by anaphasic disjunction failure, chromosomal bridges and lags, fusions and cells with aneuploid condition. (Hetch=Heterochromatinization, Nondisj=Nondisjunction, Chrbrg=Chromosomal bridge, Lgds=Laggards, Fsn=Fusion, Anpl=Aneuploid).

The significance of induced genotoxicity due to pesticide exposure correlated to chromatin behavior during cell division, conjointly with repercussions on viability of succeeding progeny, was discerned through implication of Student's *t*-test and outcomes were found statistically significant ($P < 0.05$), in both the executed parameters.

4. Discussion

The astoundingly elicited percentage frequency of structural configurations was ascertained in germinal chromosomal examination of treated stocks, eventually expressed through chromatid disjunctions failure during pole-wise movement at anaphase, excessively nonsynchronized condensation of chromatin, telomeric fusions due to stickiness, laggards consequenced, due to fragmentation or the lag of entire chromosome, conjointly with pole-to-pole extended chromosomal bridges, resulting due to stretching of the chromosomal segments, whereas, numerical malformations were represented predominately through aneuploidy, exclusively through hypoploidy. Moreover, the aforementioned synthetic formulation demonstrated cytotoxicity, predominately in the form of condensed heterochromatised regions, among all encounted

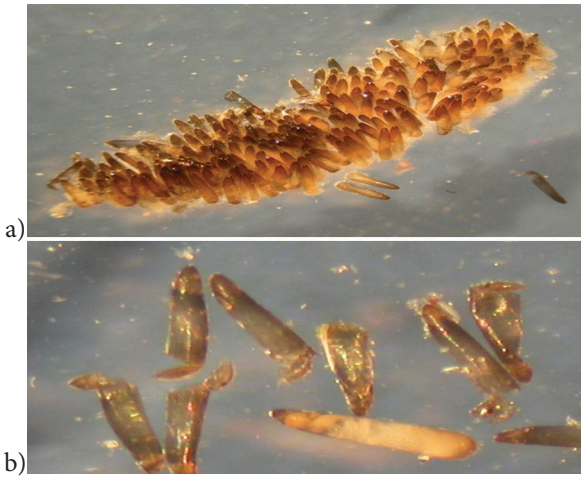


Figure 5. (a) Egg raft of *Culex quinquefaciatus* showing unhatched egg (•→); (b) Eggs with open (→) and closed opercula (•→) - in ethion treated stock of *Culex quinuefasciatus.*

Table 1. Statistical analysis of various structural and numerical chromosomal aberrations recorded in germinal chromosomes of control and ethion treated stocks of *Culex quinquefasciatus*

Nature of stock	Mean±SD							t
	Nondisjunction	Heterochromatinization	Fusion	Aneuploidy	Laggard	Chromosomal bridge	Total	
Control	6.00±1.73	6.67±2.07	-	-	-	-	12.67±3.8	3.38
Treated	7.67±4.50	9.67±3.51	1.34±1.53	0.67±1.15	3.34±2.30	3.34±2.51	26.03±15.5	

df=4, P<0.05. SD = Standard deviation, df = Degree of freedom

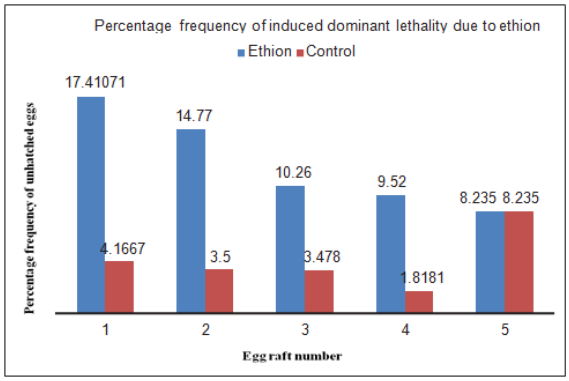


Figure 6. Percentage frequency of dominant lethality induced in ethion treated and control stocks of *Culex quinquefasciatus*. The percentage frequency of unhatched eggs represents the induced dominant lethality due to devastate repercussions of concerned pesticide.

Table 2. Statistical analysis of dominant lethality in control and ethion treated stocks of *Culex quinquefasciatus* in terms of percentage frequency of unhatched eggs

Type of stock	Mean of percentage frequency	SE	t
Control	4.23	1.12	4.31
Treated	12.39	3.00	

df=8, P<0.05. df = Degree of freedom, SE = Standard error

chromosomal aberrations, whereas least incidences of aneuploidy were discerned. Comprehensive conclusion illustrated, the evidently enhancement gross percentage frequency of different types of chromosomal anomalies in germinal chromosomes of pesticide-exposed groups, whereas certain chromosomal abnormalities, primarily chromatid fusions, lags during anaphase, chromosomal bridges and cells with aneuploid condition, were particularly observed only in pesticide-exposed groups, furthermore not even a singular occurrence of concerned deviations was discerned in control groups. Equivalent occurrence frequencies were scrutinized for the incidence of chromosomal bridges together with laggards in pesticide-treated groups, furthermore, statistics, indicated the significant induction of genotoxicity of the organophosphate pesticide.

Comprehensive statistical conclusion specifies the dominance of heterochromatinization, in comparison to other types of aberrations manifested in the germ cell chromosomes of ethion- treated stocks. Heterochromatin consists of noncoding, condensed, highly repetitive satellite sequences produced due to particular proteins, including silent information regulator proteins in yeast and heterochromatin protein 1 (HP1), Su(var) 3–7 and origin recognition complex proteins, in higher eukaryotes. In mouse 3T3 fibroblasts, heterochromatinization was stipulated to happen due to the impedance of functional activities of HP1 protein; the specific responsible protein which, usually accomplishes the methylation of histone H3 at lysine 9 (MeH3K9) and histone deacetylation.,[11]Moreover, in *Arabidopsis* the phenomenon of heterochromatinization was concluded to happen due to particular attribution of protein variant in methylation 1, which prompting irregularity due to over condensation of the chromatin material.[12]Furthermore, during an investigation on the process of aging in humans, heterochromatinization was found to consequence due to decreased activity of functional expression of certain reparative enzymes.[13] Precise discussion given here ascertained the mutagenic instinct of ethion on functional aspects of specific proteins could be a possible reason for excessive incidentation of heterochromatinization during present investigation.

Subsequent to heterochromatinization during present exploration, nondisjunctions were additionally prominent abnormalities, eventuated to happen due to normal disjunction failure at the time of anaphase. Normally, the back-to-back association of participating homologues forming bivalents, helps in their orientation toward the opposite poles, and ensures their segregation and movement to opposite poles. But in the absence of proper pairing and orientation, the segregation can be anomalous, ultimately leads to nondisjunction of chromosomes.[14-16]In an investigation concerning the consequences of pesticides viz., benomyl and isopropyl-3-chlorophenyl carbamate on Aspergillus *nidulans*, concluded that the interference with

the organization of spindle apparatus, ultimately resulted in the induction of nondisjunction.,[17]Furthermore, another examination, considered the concerned phenomenon in mice germinal chromosomes, exposed to chloral hydrate and claimed the manifestation occurred due to spindle disruption.[18]Whereas, an investigation; *in vitro* human lymphocytes culture, analyzed that nondisjunction consequenced due to certain chemicals comprising colchicine, carbendazim, mebendazole, nocodazole, and methyl methanesulphonate, was exclusively due to spindle inhibition, attributable to lack of proper organization of spindle fibers.[19]To summarize, the conclusion depicted, ethion might possess tendency to effect spindle organization, therefore, spindle disruption characteristics, ultimately resulted in escalating the incidence of nondisjunction.

Additionally, chromosomal laggards in the form discrete chromatin fragment or lag of whole chromosomes, and furthermore, pol-to-pole extending chromosomal bridges, were quite more pronounced in the ethion-treated stocks. Numerous investigations, executed to discern the mutagenic attributes of discrete mutagens by implementing various conventional innovations, using specific biomarkers and by adopting different test organisms, affirmed the causative factors for laggards and chromosomal bridges as abnormal spindle fibers organization. [20,21]Concluding remarks; the disrupt spindle organization could be a possible reason for the elicited incidence of nondisjunction, laggards and chromosomal bridges in ethion- exposed groups correlated to natural population. The reason for, incidences of chromosomal fusions and aneuploidy, ascertained during present investigation, could be the drastic consequences, happened during the interaction of ethion with germinal genetic material of exposed organisms.

Present investigations on the genotoxic repercussions of organophosphate pesticide, ethion, employing genomic contents of *C. quinquefasciatus*, were further proceeded by implimenting DLT, the second *in vivo* parameter of the study. Numerous investigators implemented concerned methodology to discern the genotoxic evaluation of discrete mutagens. The evaluations include, radiations conjointly tretamine (2,4,6-tris(I-aziridinyl)-striazine) on *Cocftliomyia ftominivorax* were perceived to induce dominant lethal consequences, due to chromosome breaks in mature sperms and oocytes,[22]whereas, DLT conducted on rats, attributed to assess detrimental consequences of two chemosterilants (tris(1- aziridinyl)phosphine oxide) and (tris(2-methyl-1-aziridinyl) phosphine oxide), indicated that translocations conjointly with aneuploidy, occurred in germinal chromosomes, as responsible criterion for dominant lethality. [23]Deltamethrin pesticide was discerned to cause the devastating consequences on mice exclusively represented through production of oligospermia, chromosomal nondisjunction concomitantly clastogenic events as stimulating factor for the actuation of dominant lethality [24] whereas, a separate experimentation considered, the dacarbazine pesticide, caused significant lethality in mice which occurred primarily due chromosomal translocations and ultimately consequenced embryonic deaths. [25]During present investigation through DLT, ethion induced statistically significant dominant lethality by reducing viability of F_1 generation of exposed parents, as specified by considerably elicited percentage frequency of unhatched eggs in treated stocks, therefore, it may be possible that induced genotoxicity in germ cell chromosomes, represented eventually through elevated percentage frequency of diverse chromosomal malformations could be the possible reason for induced lethality in subsequent progeny.

Furthermore, certain explorations procurable in literature concerned with clastogic and cytotoxic effects of concerned pesticide on the reproductive potentiality of diverse test organisms discerned ethion triggered teratogenicity in rat eventually resulted in delayed ossification of bones in fetus at concentration of 2.5 mg/kg, [26]whereas at concentration 500 mg/kg/day, it drastically affects reproductive potential. Additional document about mutagenic attributes of ethion discriminated the cytotoxicity of corresponding pesticide has caused disparate categories of chromosomal malformations in chick bone marrow cells.[27]Moreover, an examination concluded that the mutagenic characteristics of ethion implementing bone marrow assay and concluded it as causative agent for formation of micronuclei in mice. [28]Furthermore, drastically decreased RNA/DNA ratio in *Bombyx mori*, was due to imparted formation of nucleic acid content, which subsequently diminished the transcription phenomenon and sequentially lead to reducing protein contents,[29] Likewise, in a recent exploration, ethion was interpreted to possess, prospective cytotoxic consequences on mitotic division in *Allium cepa* root tip cells, and induced discrete chromosomal malformations, predominantly represented through scattered prophase, nonsynchronized condensation of chromosome, disturbed prophase, equatorial plate shifting, sticky chromosomes,

and C-metaphase conjointly with sticky metaphase, which consequenced due to the interference of ethion with the conventional procedure of mitosis in exposed cells.[30]

5. Conclusion

The results of present exploration indicated that ethion induced drastic consequences, predominately by induction of statistically significant characteristics, structural chromosomal malformation, heterochromatinization, which could be due to devastates of aforementioned compound on functional aspects of certain specific proteins, whereas inductive tendency to generate nondisjunction could be due to malformed spindle organization. To summarize, during present exploration the possible reason discerned is that the respective aspects of cytotoxic and clastogenic instinct of ethion to provoke characteristics structural and numerical chromosomal malformations during the process of spermatogenesis, could be due to genotoxic instinctivity of aforementioned chemical on genetic material. Afterward, corresponding genetic aberrations could have consequenced, the impedance of viability of F_1 generation of treated parents, and induced statistically significant frequency of unhatched embryo during DLT. Concluding remarks, discerned that at sublethal aliquot, LC_{20} level, ethion demonstrated clastogenic and mutagenic properties. Therefore, suggested aspects are to execute the evaluation of the genotoxicity potential of corresponding formulated pesticide on extensive levels to find out appropriate exposure limits before recommending its more commercial applications in diverse fields.

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Conflicts of interest

There are no conflicts of interest.

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