Ayurveda Sahiti Prabha's

International Journal of Ayurvedic Medicine

ISSN No: 0976-5921

Research Article

Comparative analysis of *Lantana camara* Linn Leaf and Flower extracts on Pupation Site Preference and Developmental Rate in Epileptic Para^{bss1} *Drosophila melanogaster* mutant

Mahesh Venkatesh[1]*, Harini B P[2]

1. PhD Scholar, Department of Zoology, J.B.Campus Bangalore University, Bengaluru-560056, India.
2. Professor, Department of Zoology, J.B.Campus Bangalore University, Bengaluru-560056, India.

Received: 25-10-2025 Accepted: 21-06-2026 Published: 30-06-2026

Abstract

Background: Pupation site selection represents a critical behavioral adaptation in holometabolous insects, directly influencing survival and reproductive success. Plant-derived bioactive compounds have been shown to modulate various aspects of insect behavior and development, thus a study was undertaken to know the effects of Pupation site selection and Developmental rate of *Lantana camara* aqueous extracts on epileptic mutant para^{bss1} *Drosophila m*. Objective: This study investigated the effects of variable concentrations of (leaf and flower extracts) on Pupation site selection preference and developmental rate in epilpeptic para^{bss1} *Drosophila m.* under controlled laboratory conditions. Methods: Experimental bottles were divided into four distinct spatial regions (R1-R4) to assess pupation site preferences across different treatment groups which include variable *Lantana camara* aqueous leaf extracts and flower extracts, diseased condition para^{bss1}, and control treatments of *Drosophila m.* wild type. Developmental rate studies monitored egg-to-adult development time across all life stages at 22°C using standardized corn flour media mixed with variable extracts. Results: Flower extracts altered pupation site preference; leaf extracts accelerated development. The inverse relationship suggests distinct phytochemical constituents in each extract drive their specialized efficacy. Neither extract was effective across both parameters, reflecting their unique chemical compositions. Conclusions: Plant-derived bioactive compounds significantly influence both pupation site selection and developmental rate in epilpeptic Para^{bss1} *Drosophila m.*, with flower extracts demonstrating concentration-dependent efficacy patterns and leaf extracts showing moderate developmental acceleration effects compared to controls.

Access this article online

Website: https://ijam.co.in

DOI: https://doi.org/10.47552/ijam.v17i2.6671

Keywords: *Drosophila melanogaster*, *Lantana camara*, Pupation site preference, Plant extracts, Bioactive compounds, Developmental rate

Introduction

The remarkable life cycle of *Drosophila melanogaster* larvae, characterized by three successive molts and culminating in metamorphosis, represents one of nature's engaging developmental transitions. At the end of the third instar, the steroid hormone ecdysone triggers wandering behavior, initiating a critical phase in which larvae actively search for suitable sites to undergo their approximately five-day metamorphosis (1). In Cyclorrhaphan flies like *Drosophila*, this transformation is uniquely protected by the puparium, a hardened case formed from the retained and modified final larval cuticle that shields the developing pupa from environmental threats.

Understanding the environmental determinants of pupariation site choice has emerged as an important area of investigation in *Drosophila* research. Pupation site preference (PSP) represents a core adaptive behavior in holometabolous insects, directly impacting survival during the vulnerable immobile pupal stage (2). This complex behavioral trait is shaped by an intricate interplay of internal and external factors. Biotic variables such as sex, larval density, locomotor activity, developmental timing, and digging behavior converge with abiotic elements including temperature, humidity, moisture, photoperiod, and pH significantly influence pupariation decisions (3-9). The interactions between larvae whether conspecific or heterospecific, substantially modulate site selection, while genetic factors underscore the heritable nature of this behavior across numerous *Drosophila* species (10-13).

Pupal adhesion is crucial for *Drosophila* survival, as it prevents predation during metamorphosis (14). The site selection and

*** Corresponding Author:**
Mahesh Venkatesh
PhD Scholar, Department of Zoology,
J.B.Campus Bangalore University,
Bengaluru-560056, India.
Email Id: mahesh31v92@gmail.com

adhesion process relies heavily on chemically mediated interactions. Developmental exposure to conspecific chemical cues shapes future site choices through species-specific signaling molecules (15), with the olfactory system serving as the primary sensory modality through which larvae detect and respond to congeners in fluctuating environments (16, 17). Compelling experimental evidence underscores the centrality of olfaction in pupal site selection: wild-type larvae preferentially pupate on substrates carrying conspecific odors, whereas mutants defective in odor co-reception select sites randomly (17). Once an appropriate site is selected, molecular factors enable successful pupation. Salivary gland secretion (Sgs) genes constitute a functional group essential for substrate attachment during metamorphosis, encoding adhesive proteins that are deposited as "glue" by third instar larvae at the onset of puparium formation (18). These secretions are expelled through the mouthparts by swollen salivary glands and rapidly harden upon air contact, producing a firm bond that anchors the pupa to the substrate (19). Ecological and competitive contexts further influence pupation choice. Intraspecific crowding within cultures, or the presence of heterospecifics in natural settings, can generate stress and alter pupation decisions, with environmental conditions such as strain type, substrate texture, temperature, and humidity all shaping this behavior (20). Quantitative assessments reveal that most *Drosophila* species prefer the growth medium for pupation, while a smaller proportion pupate on alternative surfaces such as glass or cotton (21). The larval decision-making process regarding pupation sites carries major survival consequences, highlighting both its adaptive significance and behavioral plasticity (22).

Environmental factors interact with diet to further modulate developmental outcomes. Temperature-dependent developmental dynamics in *Drosophila* have been documented extensively, with embryogenesis demonstrating remarkable robustness across temperature ranges, though with notable interspecific variation in sensitivity (23, 24). At reduced temperatures (<15°C), flies display dietary shifts from yeast-based to plant-based nutrient sources, with plant-derived lipids enhancing cold survival (25, 26). Diet strongly impacts metabolism, physiology, behavior, and lifespan, and altered nutritional environments can reconfigure developmental and reproductive outcomes in *Drosophila* spp. (20, 24).

Plant-derived extracts exert diverse, species-specific, and concentration-dependent influences on the *Drosophila* lifecycle (27, 28). Aqueous extracts of *Boerhavia diffusa* (BDAE) protect against toluene-induced reproductive toxicity by maintaining fertility, fecundity, and egg hatching through enhanced antioxidant enzyme activity (29). In contrast, *Euphorbia guyoniana* induces larval lethality and disrupts pupal development and courtship behavior (30), while *Lepista nuda* reduces reproductive output and longevity by suppressing ecdysone, juvenile hormone, and vitellogenin production (31). Extracts of beetroot, black currant, blue-berry, sour cherry, and *Catharanthus roseus* exhibit biphasic, dose-dependent effects with contrasting outcomes at low versus high concentrations (31-33). These varied outcomes are mechanistically linked to antioxidant regulation (29), endocrine disruption (31), and behavioral impairment (30).

Plant-based medicines have gained prominence as alternatives to allopathic treatments due to their reduced side effects and capacity to improve health, including as immuno-modulators for immune-related diseases. *Drosophila* has correspondingly emerged as a valuable model for evaluating plant-derived substances, given that most developmental and cell signaling pathways, along with 75% of human disease-related genes, are conserved between *Drosophila* and humans, facilitating pharmacological investigation of plant-derived components (28, 34).

The para^{bss1} mutant of *Drosophila m.* is a valuable genetic model for epilepsy research, harboring a gain-of-function mutation (L1699F) in the *paralytic* (*para*) voltage-gated sodium channel gene that produces seizure-like behavior and severe locomotory deficits characterized by intense muscle contractions and subsequent paralysis (35-37). This mutation affects the "paddle motif" of homology domain IV, altering voltage dependence of channel inactivation and rendering neurons hyperexcitable (36, 37). Among all bang-sensitive mutants in *Drosophila*, para^{bss1} exhibits the most severe phenotype and lowest seizure threshold (37, 38). These motor impairments can significantly compromise larval navigation and pupation site selection. As the primary deficit could be more of locomotory rather than sensory distinct from the well-established role of olfaction in wild-type pupation site selection (16, 17) this mutant is well-suited for investigating whether therapeutic interventions can restore motor function and thereby enable normal site selection behavior.

Lantana camara has emerged as a promising source of neuroprotective compounds, with recent studies demonstrating antiepileptic efficacy comparable to sodium valproate in kainate-induced epilepsy models, reducing seizures, memory impairment, and anxiety through GABA modulation, antioxidant activity, and neuroinflammation reduction (39). The plant contains diverse bioactive compounds including triterpenes, flavonoids, phenylpropanoids, and iridoid glycosides with well-documented anti-inflammatory, antioxidant, and neuroprotective properties (40, 41).

Against these backgrounds, the present study investigates the comparative influence of *L.camara's* aqueous leaf and flower extracts on pupation site preference and developmental timing in para^{bss1}epileptic *Drosophila m.* model.

Materials and methods

Experimental Organisms

Two *Drosophila m.* strains were employed in this study: the epileptic para^{bss1} mutant as the diseased control-1 and the Oregon-K strain as the wild-type control-2. Both strains were maintained on standard corn flour medium at 22±1°C with controlled relative humidity under 12:12 hr light: dark photoperiod.

Plant Extract Preparation

Only fresh and young, healthy plant parts (flower and leaf) were chosen for the experiment. The collected plant parts were cleaned thoroughly to remove unwanted debris, such as dust, hidden insects, caterpillars, and spiders from leaves and the inflorescence. Flowers and leaves procured were shade-dried (42). The dried plant parts were separately powdered and stored in airtight containers.

Based on an earlier study (43), in which continuous Soxhlet extraction using aqueous and other solvents, combined with phytochemical screening, identified the aqueous extract as the efficacious fraction and this extract was selected for all biological experiments in the present study.

Pupation Site Selection Assay

Experimental bottles (15 cm height, 3 cm diameter) were divided into four distinct regions (R1 to R4) of equal height (3.75 cm each). Each region was marked externally for identification. Height of the media bottle was found to be 15cm and the bottle

was divided into four different quadrants; Region 1: pupations near the cotton plug, Region 2: pupations near the cotton plugs middle region (in between the cotton plug and the middle region), Region 3: pupations near the medias middle region (in between the media and the middle region), Region 4: pupations near the media.

Prior to bioassay experiments, a preliminary acute toxicity study was conducted to determine the safe concentration range of aqueous *L.camara* flower and leaf extracts in *Drosophila m.* culture media. Based on the No Observed Adverse Effect Level (NOAEL) established from the toxicity assessment, three experimental concentrations 500 mg, 1500 mg, and 3500 mg per 100 mL of fly culture media were selected, facilitating a systematic investigation of concentration-dependent biological effects on PSP activity and developmental timing in $para^{bss1}$ mutants.

Treatment groups included: a. Leaf extracts: L-LOW (500 mg), L-MID (1500 mg), L-HIGH (3500 mg) b. Flower extracts: F-LOW (500 mg), F-MID (1500 mg), F-HIGH (3500 mg) c. Controls: Diseased condition: $para^{bss1}$ untreated and *Drosophila m.* OK strain wild-type.

Aqueous extracts were dissolved directly into 100 mL of standard corn flour media at the specified doses. About 10 males and 10 females were introduced into treatment bottles containing the extract-supplemented media. Adults were allowed to mate and oviposit for 5 days before removal. Each concentration had 4 replicates (4 bottles with 20 flies in each bottle). Pupation site selection and developmental rate were monitored daily.

Developmental Rate Analysis

The same bottles were used to analyze developmental rates. Development was monitored at 22±1°C, recording egg stage duration, larval stage duration, pupal stage duration and total egg-to-adult development time. Observations were conducted in the evening daily, and development times were recorded for each treatment group.

Data Analysis

Pupation efficacy was calculated as the total mean pupated to each region. Developmental timings were recorded and analyzed across treatment groups.

Results

Pupation site preference was assessed across four equidistant regions (R1–R4, each 3.75 cm) of a 15 cm experimental bottle containing 20 epileptic flies per bottle with two bottles per group (n=40). R1 represented the topmost region near the cotton plug and R4 represented the bottommost region adjacent to the food media. Pupation in R1 was used as the primary indicator of treatment efficacy, R2 as supporting evidence of upper zone climbing recovery, R3 as the bulk pupation zone and R4 as the indicator of locomotor impairment. Data are expressed as mean ± SE of two replicates.

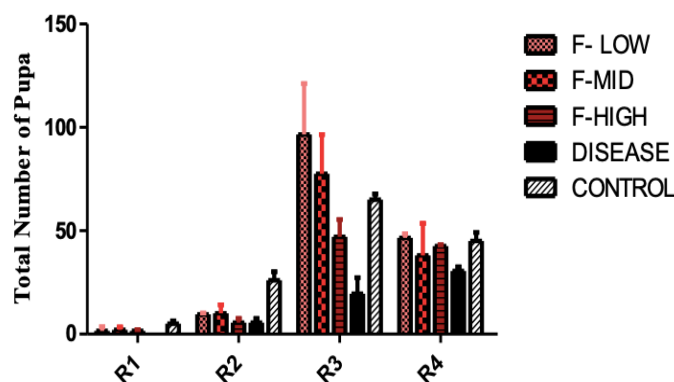
The *Drosophila m*. control group recorded Peak mean pupation in R3 (65.00 ± 2.00), followed by R4 (45.00 ± 3.00), R2 (26.00 ± 3.00) and R1 (5.00 ± 1.00). The presence of pupation across all regions including R1 in the healthy control group reflects full locomotor competence and serves as the benchmark for this study.Untreated epileptic fly recorded peak mean pupation concentrated in R4 (30.50 ± 1.50), followed by R3 (19.50 ± 5.50) and R2 (5.50 ± 1.50). Pupation in R1 was completely absent (0.00 ± 0.00), reflecting the severely compromised locomotor ability of epileptic larvae and their inability to climb to the topmost region of the bottle (35,36).

Flower low dose treated epileptic flies recorded peak mean pupation in R3 (96.50 ± 17.50), followed by R4 (46.50 ± 1.50), R2 (9.50 ± 0.50) and R1 (1.50 ± 1.50). The presence of pupation in R1 and elevated R2 values in this group indicate restored upper zone climbing ability in treated epileptic larvae. Flower mid dose treated epileptic flies recorded peak mean pupation in R3 (77.50 ± 13.50), followed by R4 (38.00 ± 11.00), R2 (10.00 ± 3.00) and R1 (2.00 ± 1.00). Pupation in R1 and R2 in this group further confirms the restoration of climbing ability in treated epileptic flies. Flower high dose treated epileptic flies recorded peak mean pupation in R3 (47.00 ± 6.00), followed by R4 (42.50 ± 0.50), R2 (5.50 ± 1.50) and R1 (1.50 ± 0.50). Pupation in R1 was recorded in this group as well, indicating that even at the highest flower dose; treated epileptic larvae retained the ability to reach the topmost region.

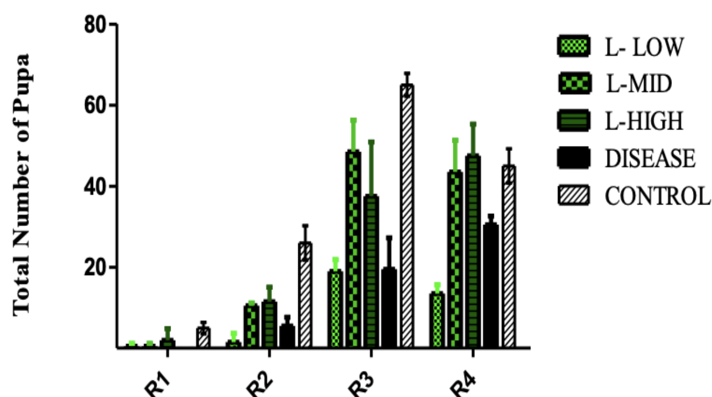
Leaf low dose treated epileptic flies recorded the peak mean pupation in R3 (19.00 ± 2.00), followed by R4 (13.50 ± 1.50), R2 (1.50 ± 1.50) and R1 (0.50 ± 0.50). A small but present mean pupation in R1 indicates a marginal restoration of climbing ability at this dose. Leaf mid dose treated epileptic flies recorded peak mean pupation in R3 (48.50 ± 5.50), followed by R4 (43.50 ± 5.50), R2 (10.50 ± 0.50) and R1 (0.50 ± 0.50). Elevated R2 pupation and the presence of R1 pupation in this group reflect a meaningful degree of upper zone locomotor recovery. Leaf high dose treated epileptic flies recorded peak mean pupation in R4 (47.50 ± 5.50), followed by R3 (37.50 ± 9.50), R2 (11.50 ± 2.50) and R1 (2.00 ± 2.00). Notably, this group recorded the highest R1 mean among all leaf treated groups (2.00 ± 2.00) alongside elevated R2 values, indicating upper zone climbing recovery despite the shift in bulk pupation toward R4.

Overall, R1 consistently recorded the lowest mean pupation across all groups, confirming that upward migration to the topmost region remained largely unachieved regardless of treatment (35). The clear progression from R4 dominant pupation in untreated epileptic flies, through partial R3 recovery in leaf treated groups, to strong R3 dominant pupation exceeding control values in flower low and mid dose groups, demonstrates a treatment and dose dependent gradient of locomotor restoration with flower phytocompounds showing markedly superior efficacy over leaf phytocompounds across all dose levels.

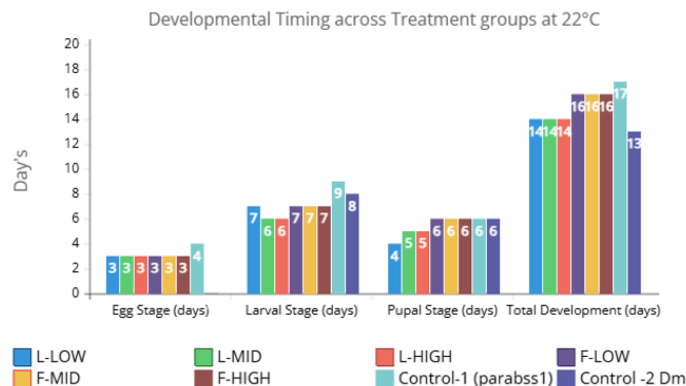
Graph1: Pupation Site Preference of Flies across varying concentrations of Flower Extracts



Graph 2: Pupation Site Preference of Flies across varying concentrations of Leaf Extracts



Graph 3: Developmental timing of Flies at three different stages across treatment groups



Developmental studies revealed accelerated development in treated groups, with leaf extract treatments showing reduced total development time (14-17 days) followed by flower extract treatment showed (16-18 days) compared to untreated controls (17-20 days).

Developmental Rate Analysis

Developmental timing data for all treatment groups are expressed as Mean of two independent replicates respectively.

Egg Stage Development

Egg development showed relatively consistent timing across most treatments (3-4 days), with notable exceptions in the wild-type strain (0-1 days) and untreated para^{bss1} controls (4-5 days). The accelerated egg development in wild-type strain suggests genetic optimization for rapid embryogenesis, while extended development in untreated controls may reflect metabolic consequences of the genetic mutation compared to the normal fly used in the study.

Larval Stage Dynamics

Larval development exhibited the greatest variation among treatments, ranging from 6 days (L-MID, L-HIGH) to 9 days (untreated para^{bss1}). Leaf extract treatments consistently showed reduced larval development time compared to controls, suggesting nutritional or metabolic enhancement effects (24). Flower extract treatments showed intermediate larval development times (7 days), indicating different modes of action compared to leaf extracts.

Pupal Stage Patterns

Pupal development times ranged from 4-5 days (L-LOW) to 6-7 days (F-treatments, Control1-untreated para^{bss1}, Control 2-wild-type). The shorter pupal development in leaf extract treatments suggests accelerated metamorphic processes, possibly through enhanced protein synthesis or altered hormonal regulation.

Total Development Time

Overall development time showed significant treatment effects, with leaf extract treatments achieving the shortest total development time (14-17 days) compared to untreated para^{bss1} controls (17-20 days) Graph 3. This represents a 15-30% reduction in generation time, which could have significant implications for population dynamics and fitness (26).

Phytochemical profiling of *L.camara* aqueous flower and leaf extracts, as reported in our earlier study, revealed the presence of carbohydrates, cardiac glycosides, and flavonoids across both extracts. Saponins and oxalates were detected exclusively in leaf extracts, representing an extract-specific phytochemical distinction (43). Quantitative RP-HPLC analysis confirmed flavonoid contents of 12.81 mg/g and 11.254 mg/g in aqueous flower and leaf extracts, respectively. DPPH-based antioxidant assessment yielded IC_{50} values of 0.479 mg (aqueous flower) and 0.453 mg (aqueous leaf), demonstrating notable antioxidant efficacy in both fractions (43).

Discussion

The present study demonstrates the therapeutic potential of *L.camara* extracts in ameliorating the motor deficits and developmental delays characteristic of the para^{bss1} epileptic *Drosophila m.* genetic model. The superior efficacy of flower extracts compared to leaf extracts in restoring pupation site selection behavior likely reflects extract-specific accumulation of bioactive compounds (27, 28), consistent with the evolutionary diversification of plant secondary metabolites across different extracts. The most significant finding is the restoration of pupation site selection behavior in epileptic mutants. Untreated para^{bss1} larvae exhibited severe locomotor problems characterized by intense muscle contractions during seizures and subsequent paralysis (35), which disrupted normal movement and compromised their ability to navigate to appropriate pupation sites. The inability of untreated para^{bss1} mutants to reach the uppermost region (R1) of experimental bottles directly reflects to these motor impairments associated with dysfunctional voltage-gated sodium channels (35). This interpretation is supported by the well-documented association between seizure susceptibility and altered larval locomotion or peristaltic wave frequency in bang-sensitive *Drosophila* mutants as reviewed (47).

Treatment with *L.camara* extracts restored the ability of para^{bss1} mutants to access upper regions across experimental bottles, with treated larvae demonstrating heterogeneous distribution patterns across regions R1 to R4 similar to wild-type flies. This spatial distribution pattern suggests that bioactive compounds in *L. camara* extracts ameliorated the locomotory deficits sufficiently to enable normal navigational behavior. While the precise molecular mechanism remains to be elucidated, the restoration of motor function indicates that *L. camara* compounds may either compensate for sodium channel dysfunction or activate alternative neural pathways that bypass the genetic defect (35).

The differential efficacy between flower and leaf extracts in restoring pupation behavior reflects distinct phytochemical profiles, with flower extracts likely harboring higher concentrations of neuroactive compounds (43). The concentration-dependent response patterns further indicate that specific bioactive molecules interact with neural function in a dose-responsive manner, consistent with the documented variation in secondary metabolites including triterpenes, flavonoids, phenylpropanoids, and alkaloids across different plant extracts (40, 41, 44).

The absence of early developmental acceleration in flower extract-treated para^{bss1} mutants is consistent with the distinct phytochemical composition of the aqueous flower fraction documented in our earlier study (43). Unlike the leaf extract, the aqueous flower extract lacks saponins, and fats and oils compounds exclusively detected in leaf fractions that might collectively create a unique phytochemical environment capable of modulating developmental signaling pathways. Although the aqueous flower extract contained a higher flavonoid content and marginally superior antioxidant capacity compared to the leaf extract these properties appear to direct its biological activity predominantly toward neuroactive and neuroprotective functions. These contrasting phytochemical profiles thus provide a compelling mechanistic basis for the extract-specific and outcome-specific biological effects observed between flower and leaf extracts of *L. camara*.

Plant extracts significantly accelerated larval development, with leaf extract treatments showing the most pronounced effects (14-17 days total development) compared to flower extracts (16-18 days) and untreated para^{bss1} controls (17-20 days), respectively. This acceleration may suggest enhanced metabolic efficiency through improved nutritional absorption, enzyme activity, or optimized developmental signaling pathway regulation (24). In contrast, the absence of accelerated developmental timing in flower extract-treated groups is consistent with the distinct phytochemical composition of the aqueous flower fraction (43), which lacks phytocompounds exclusively present in leaf extracts. The superior developmental acceleration by leaf extracts despite their efficacy in restoring pupation behavior suggests that different bioactive compounds exert distinct physiological effects. Leaf extracts may contain compounds that enhance general metabolism and nutrient utilization, promoting faster growth and development through metabolic pathways (24).

The utilization of *Drosophila m.* para^{bss1} genetic variant offers distinct advantages over conventional rodent models for screening plant-derived therapeutic compounds. While systematic reviews have illustrated the antiepileptic potential of plant compounds in rats and mice using kindling models (39), these acquired seizure paradigms do not address underlying genetic deficits. The genetic tractability and conservation of neurological pathways in *Drosophila* enable investigation of plant-derived compounds in a genetically defined epileptic model.

The para^{bss1} mutation specifically disrupts voltage-gated sodium channel function through a missense mutation in the paddle motif of the fourth homology domain (35-37), making this model valuable for identifying compounds that either restore proper ion channel kinetics or compensate for genetic deficiencies through alternative molecular pathways. Importantly, para^{bss1} phenotypes can be ameliorated by antiepileptic drugs, though not completely suppressed, resembling pharmacologically resistant epilepsies such as Dravet syndrome (37, 38, 45). The successful restoration of both motor function and developmental rate in this genetic model suggests that *L. camara* extracts contain bioactive compounds capable of overcoming the functional consequences of sodium channel mutations, potentially through modulation of downstream neural circuits or parallel compensatory mechanisms similar to those observed with other plant-derived neuroprotective agents (46).

Conclusion

This investigation reveals the therapeutic potential of *L. camara* aqueous extracts in ameliorating locomotory deficits and developmental alterations in the epileptic *Drosophila m.* para^{bss1} mutant model. The primary objective of this study was to comparatively assess the efficacy of flower and leaf extracts in modulating these physiological parameters, and the findings consistently demonstrate extract-specific biological outcomes attributable to their distinct phytochemical compositions (43).

Flower and Leaf extracts demonstrated better efficacy in restoring pupation behavior, with treated para^{bss1} mutants exhibiting a dose-dependent recovery of R1region wall pupation a behavior requiring sustained coordinated larval crawling that is characteristically impaired in seizure-susceptible *Drosophila* mutant (47). The restoration of appropriate pupation site selection in flower and leaf extract-treated groups is interpreted as an indirect functional indicator of improved locomotory capacity, consistent with the well-documented association between locomotory and peristaltic wave alterations in bang-sensitive para^{bss1} mutants , as reviewed by Stilwell et al., 2006; Graham et al., 2016; Streit et al., 2016 (47).

It is acknowledged, however, that direct quantification of seizure frequency, and larval crawling assay, or peristaltic wave frequency was not conducted in the present study, and conclusions regarding locomotory restoration are therefore presented with appropriate caution as inferential, pending direct behavioral and electrophysiological corroboration. The flavonoid contents and antioxidant property in both flower and leaf along with other phytochemicals likely underlie the neuroactive efficacy, potentially modulating voltage-gated Na^+ channel function or associated neural signaling pathways disrupted in para^{bss1} mutants.

Leaf extracts, in contrast, exerted a more pronounced influence on developmental timing; with treated mutants exhibiting better accelerated progression through successive developmental stages compared to flower treatments, control and untreated. This extract-specific effect is mechanistically consistent with the distinct phytochemical profile of the leaf fraction notably the exclusive presence of, fats and oil along with the substantial flavonoid content (43) and few other class of phytocomponents that might have governed the developmental transitions in the treated *Drosophila* mutants.

Collectively, these findings establish the differential but complementary bioactivity of *L. camara* flower and leaf extracts as modulators of neurological function and developmental physiology in an genetic epilepsy model, with both flower and leaf extracts emerging as the more potent neuroactive fraction and leaf extracts demonstrating slightly greater influence over developmental timings. The distinct secondary metabolite compositions of the two plant extracts (43) appear to mediate these complementary therapeutic outcomes through independent but synergistic phytochemical mechanisms.

Future investigations employing direct larval locomotion tracking, peristaltic wave frequency analysis, electroconvulsive seizure assays, and electrophysiological recordings as systematically characterized for seizure-susceptible *Drosophila* mutants (47) will

be essential for providing direct behavioral and mechanistic corroboration of the locomotory restoration inferred in the present study. Complementary molecular and biochemical approaches aimed at identifying specific bioactive compounds responsible for the observed neuroactive and developmental effects will further advance the understanding of plant-based therapeutic interventions for genetic epilepsy disorders, and may ultimately inform the development of novel antiepileptic compounds with improved efficacy and reduced side effects relative to current pharmacological treatments.

Comparative Performance Summary

Both flower and leaf extracts exhibited significant and biologically meaningful effects on evaluated parameters, though with differential efficacy profiles. Flower extracts demonstrated preferential activity toward pupation site preference disruption, while leaf extracts showed enhanced capacity for developmental acceleration. The apparent inverse relationship between PSP efficacy and developmental acceleration suggests that distinct phytochemical constituents present in each extract type may be responsible for their respective biological activities. Neither extract type emerged pharmacologically efficacious across both parameters; rather, each demonstrated specialized efficacy patterns reflecting their unique chemical composition and the differential susceptibility of the target *Drosophila* mutants to specific bioactive compounds present in flower versus leaf extracts.

Acknowledgments

The authors wish to thank the Al-Mighty God and express gratitude to the Department of Zoology, Bangalore University for providing the facility to carry out the work and Special thanks to Dr. Rizwan Sharieff for his statistical advice and support. Mahesh.V wishes to express his profound gratitude to his Well-wisher -Dr M. Jayashankar.

Conflict of interest: The Author's declare no Conflict of Interest

References

1. Schwedes C.C, Carney G.E. Ecdysone signaling in adult *Drosophila melanogaster*. J. Insect Physiol. 2012; 58(3); 293-302
2. Lindstedt C, Murphy L, Mappes J. Antipredator strategies of pupae: how to avoid predation in an immobile life stage? Phil. Trans. R. Soc. B. 2019; 374; 20190069
3. Sokal, R. R., Ehrlich, P. R., Hunter, P. E., and Schlager, G. Some factors affecting pupation site of *Drosophils.Ann. Entomol. Soc. Am.* 1960. 53:174–182.
4. Ramniwas S, Kumar G. Pupation site preference selection in *Drosophila jambulina*. Ethol. Ecol. Evol. 2019; 31(4); 301-312
5. Fogleman J.C, Markow T.A. Behavioral differentiation between two species of cactophilic *Drosophila*. II. Pupation site preferences. Southwest. Nat. 1982; 27(3); 315-320
6. Pandey M.B, Singh B.N. Effects of biotic and abiotic factors on pupation height in four species of *Drosophila melanogaster*. Indian J. Exp. Biol. 1993; 31; 912-917
7. Hodge S, Campbell-Smith R, Wilson N. The effect of resource acidity on the development of *Drosophila melanogaster* larvae. Entomologist. 1996; 115; 129-139
8. Hodge S, Caslaw P. The effect of resource pH on pupation height in *Drosophila melanogaster* (Diptera: Drosophilidae). J. Insect Behav. 1997; 11; 47-59
9. Beltrami M, Medina-Munoz M.C, Arce D, Godoy-Herrera R. *Drosophila melanogaster* pupation behavior in the wild. Evol. Ecol. 2010; 24; 347-359
10. Beltrami M, Medina-Munoz M.C, Del Pino F, Ferveur J.F, Godoy-Herrera R. Chemical cues influence pupation behavior of *Drosophila simulans* and *Drosophila buzzatii* in nature and in the laboratory. PLoS ONE. June 2012; 7(6); e39393
11. Bauer S.J, Sokolowski M.B. Autosomal and maternal effects on pupation behavior in *Drosophila melanogaster*. Behav. Genet. 1988; 18; 81-97
12. Bauer S.J, Sokolowski M.B. A genetic analysis of path length and pupation height in a natural population of *Drosophila melanogaster*. Can. J. Genet. Cytol. 1985; 29; 334-340
13. Garcia-Florez L, Casares P, Carracedo M.C. Selection for pupation height in *Drosophila melanogaster*. Genetica. 1989; 79; 155-160
14. Borne F, Prigent S.R, Molet M, Courtier-Orgogozo V. *Drosophila* glue protects from predation. Proc. Biol. Sci. March 31, 2021; 288(1947); 20210088
15. Beltrami M, Medina-Munoz M.C, Del Pino F, Ferveur J.F, Godoy-Herrera R. Chemical cues influence pupation behavior of *Drosophila simulans* and *Drosophila buzzatii* in nature and in the laboratory. PLoS ONE. June 21, 2012; 7(6); e39393
16. Del Pino F, Jara C, Pino L, Godoy-Herrera R. The neuro-ecology of *Drosophila* pupation behavior. PLoS ONE. July 17, 2014; 9(7); e102159
17. Raman B, Ito I, Stopfer M. Bilateral olfaction: two is better than one for navigation. Genome Biol. 2008; 9(3); 212
18. Beckendorf S.K, Kafatos F. Differentiation in the salivary glands of *Drosophila melanogaster*: characterization of the glue proteins and their developmental appearance. Cell. 1976; 9; 365-373
19. Da Lage J.L, Thomas G.W.C, Bonneau M, et al. Evolution of salivary glue genes in *Drosophila melanogaster* species. BMC Evol. Biol. 2019; 19; 36
20. Bezerra Da Silva C, Park K.R, Blood R.A, et al. Intraspecific competition affects the pupation behavior of spotted-wing *Drosophila* (*Drosophila suzukii*). Sci. Rep. 2019; 9; 7775
21. Vandal N.B, Siddalingamurthy G.S, Shivanna N. Larval pupation site preference on fruit in different species of *Drosophila.* Entomol. Res. 2008; 38; 188-194
22. Singh D, Kumar G, Ramniwas S. Pupation site preference (PSP) variation in cold adapted, warm adapted, and generalist *Drosophila* species. Acta Ecol. Sin. 2022; 43
23. Chong J, Amourda C, Saunders T.E. Temporal development of *Drosophila* embryos is highly robust across a wide temperature range. J. R. Soc. Interface. July 2018; 15(144); 20180304
24. Koyama T, Texada M.J, Halberg K.A, Rewitz K. Metabolism and growth adaptation to environmental conditions in *Drosophila*. Cell Mol. Life Sci. November 2020; 77(22); 4523-4551
25. Brankatschk M, Gutmann T, Knittelfelder O, Palladini A, Prince E, Grzybek M, Brankatschk B, Shevchenko A, Coskun U, Eaton S. A temperature-dependent switch in feeding preference improves *Drosophila* development and survival in the cold. Dev. Cell. September 24, 2018; 46(6); 781-793
26. Knoblochova D, Dharanikota M, Galikova M, et al. Temperature-dependent dynamics of energy stores in *Drosophila.* BMC Biol. 2024; 22; 272
27. Thankur M, Gupta D. Effect of different plant extracts on reproduction of fruit fly *Bactrocera tau* (Walker). Biopestic. Int. June 2012; 8(1); 32-37
28. Pratomo A.R, Salim E, Hori A, Kuraishi T. *Drosophila* as an animal model for testing plant-based immunomodulators. Int. J. Mol. Sci. November 26, 2022; 23(23); 14801

29. Benil P.B, et al. Prophylactic efficacy of *Boerhavia diffusa* L. aqueous extract in toluene induced reproductive and developmental toxicity in *Drosophila melanogaster*. J. Infect. Public Health. 2020; 13(2); 177-185
30. Lila C, et al. Toxical effect of *Euphorbia guyoniana* aqueous extracts (Euphorbiaceae) on mortality, larval development and sexual behavior of *Drosophila melanogaster* (Diptera: Drosophilidae). J. Bioresour. Manag. 2022; 9(1)
31. Huang Y, et al. Diets supplemented with different solvents extracts of Lepista *nuda* alters longevity and fecundity, and the expression of related genes in *Drosophila melanogaster* (Diptera: Drosophilidae). J. Econ. Entomol. 2024; 118(1); 403-415
32. Magoss E, Mos L, Szoke-Kovas Z, Szoke-Kovas R, Vigh S, Pribac C, Czapar M, Olah C. Plant extracts affect dose-dependently the hatching rate of *Drosophila melanogaster* but do not induce chromosome loss and/or aneuploidy. Anal. Univ. Oradea Fascicola Ecotoxicol. Zooteh. Tehnol. Ind. Aliment. 2012; 11B; 399-404
33. Shameema K, Anand P.P, Vardhanan Y.S. Protective effect of *Catharanthus roseus* plant extracts against endosulfan and its isomers induced impacts on non-targeted insect model, *Drosophila melanogaster* and live brain cell imaging. Comp. Biochem. Physiol. C Toxicol. Pharmacol. February 2021; 240; 108916
34. Victor Atoki A, Aja P.M, Shinkafi T.S, Ondari E.N, Adeniyi A.I, Fasogbon I.V, et al. Exploring the versatility of *Drosophila melanogaster* as a model organism in biomedical research: a comprehensive review. Fly. 2024; 19(1)
35. Kroll J.R, Saras A, Tanouye M.A. *Drosophila* sodium channel mutations: contributions to seizure-susceptibility. Exp. Neurol. December 2015; 274(Pt A); 80-87
36. Parker L, Padilla M, Du Y, Dong K, Tanouye M.A. *Drosophila* as a model for epilepsy: bss is a gain-of-function mutation in the para sodium channel gene that leads to seizures. Genetics. January 2011; 187(2); 523-534
37. Fischer F.P, Karge R.A, Weber Y.G, Koch H, Wolking S, Voigt A. *Drosophila melanogaster* as a versatile model organism to study genetic epilepsies: an overview. Front. Mol. Neurosci. February 16, 2023; 16; 1116000
38. Parker L, Howlett I.C, Rusan Z.M, Tanouye M.A. Seizure and epilepsy: studies of seizure disorders in *Drosophila*. Int. Rev. Neurobiol. 2011; 99; 1-21
39. Venkatesh M, Harini B.P, Jayashankar M. *Lantana camara* Linn: unveiling a reservoir of novel antiepileptic compounds through systematic review. Int. J. Ayurvedic Med. 2025; 16(3); 600-605
40. Ramirez J, Armijos C, Espinosa-Ortega N, Castillo L.N, Vidari G. Ethnobotany, phytochemistry, and biological activity of extracts and non-volatile compounds from *Lantana camara* L. and semisynthetic derivatives -an updated review. Molecules. February 12, 2025; 30(4); 851
41. Amoah V, Atawuchugi P, Jibira Y, Tandoh A, Ossei P.P.S, Sam G, Ainooson G. *Lantana camara* leaf extract ameliorates memory deficit and the neuroinflammation associated with scopolamine-induced Alzheimer's-like cognitive impairment in zebrafish and mice. Pharm. Biol. 2023; 61(1); 825-838
42. Ebadi M.T, Azizi M, Sefidkon F, Ahmadi N. Influence of different drying methods on drying period, essential oil content and composition of *Lippia citriodora* Kunth. J. Appl. Res. Med. Aromat. Plants. 2015; 2(4); 182-187
43. Mahesh V, Harini B.P. Phytochemical profiling, HPLC analysis, and antioxidant activity of *Lantana camara* flower and leaf extracts. Pharmacogn. Res. 2025; 17(3); 947-954
44. He A, Chadha S, Saruchi, Kumar V. Phytocompound profiling and GC-MS analysis of *Lantana camara* leaf extract. J. Indian Chem. Soc. 2024; 101(11); 101379
45. Reynolds E.R, Stauffer E.A, Feeney L, Rojahn E, Jacobs B, McKeever C. Treatment with the antiepileptic drugs phenytoin and gabapentin ameliorates seizure and paralysis of *Drosophila* bang-sensitive mutants. J. Neurobiol. February 2004; 58(4); 503-513
46. Elufioye T.O, Berida T.I, Habtemariam S. Plants-derived neuroprotective agents: cutting the cycle of cell death through multiple mechanisms. Evid. Based Complement. Alternat. Med. 2017; 2017; 3574012
47. Mituzaite J, Petersen R, Claridge-Chang A, Baines R.A. Characterization of seizure induction methods in *Drosophila*. eNeuro. 2021; 8(4); ENEURO.0079-21.2021. https://doi.org/10.1523/ENEURO.0079-21.2021

*****