



Developmental Biology and Morphometric Traits of *Ariadne merione* Affecting Castor (*Ricinus communis*)

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ABSTRACT

Background: The larva of *Ariadne merione*, commonly known as the Common Castor Butterfly, is a voracious feeder of *Ricinus communis* (castor plant), significantly reducing crop yield. Due to the scarcity of updated information on its lifecycle and morphometrics, this study was conducted in 2023 to understand its developmental stages and identify vulnerable phases for pest management.

Methods: Eggs collected from the field were reared on castor leaves, monitored daily, and data on lifecycle, growth, and behaviour were recorded and analyzed.

Result: The durations of the egg, first, second, third, fourth, fifth instar, and pupal stages were 2.022 ± 0.839 , 2.422 ± 0.499 , 2.156 ± 0.475 , 2.444 ± 0.586 , 2.622 ± 0.650 , 3.867 ± 0.786 , and 5.500 ± 0.762 days, respectively. Morphometric measurements recorded were: Egg- 1.261 ± 0.134 mm diameter; first instar- 2.618 ± 0.286 mm length, 0.613 ± 0.092 mm width; second instar- 4.554 ± 0.660 mm length, 1.311 ± 0.228 mm width; third instar- 8.341 ± 1.294 mm length, 2.736 ± 0.402 mm width; fourth instar- 11.751 ± 3.125 mm length, 3.62 ± 0.922 mm width; fifth instar- 19.322 ± 3.290 mm length, 5.201 ± 0.789 mm width; pupa- $18.208 \pm .095$ mm length, 6.347 ± 0.320 mm width. The larvae became intensive feeders from the third instar, causing severe damage such as extensive defoliation. Therefore, control measures should be initiated from the neonate stage to minimize yield loss.

Key words: *Ariadne merione*, Common castor butterfly, Lifecycle, Morphometric analysis, *Ricinus communis*.

INTRODUCTION

Castor (*Ricinus communis*) is a valuable non-edible oilseed crop belonging to the family Euphorbiaceae (Patel *et al.*, 2024). It is widely cultivated in tropical and subtropical regions and is characterized as a xerophytic and heliophilous plant. Morphologically, it is a perennial herb with simple, denticulate leaves, a deep taproot system and monoecious flowers that lack petals. Its spiny green fruits enclose hard brown seeds, which contain ricin-a toxic ribosome-inactivating protein. In addition to its toxicity, castor possesses notable medicinal properties and the oil extracted from its seeds has a distinctive chemical composition that supports diverse pharmaceutical and industrial applications (Orji *et al.*, 2018). Castor oil is utilized as a lubricant, pain reliever, polymer precursor, purgative and varnish (Abomughaid *et al.*, 2024; Ribeiro *et al.*, 2016).

Despite its economic importance, castor cultivation is severely affected by numerous insect pests, among which *Ariadne merione* is of growing concern. (Srinivasa Rao *et al.*, 2012; Srivastava and Kumar, 2016). Commonly known as the Common Castor Butterfly, *A. merione* belongs to the family Nymphalidae. Its larvae feed voraciously on castor leaves, earning the species its common name. The adult butterfly is orange with distinctive brown wavy lines. Historically regarded as a minor pest, *A. merione* has recently emerged as a significant threat to castor crops. Field observations indicate that its activity begins in September, peaks in October and declines by December (Singh *et al.*, 1980). This shift in pest status underscores the need for

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continuous monitoring and detailed knowledge of its biology and population dynamics.

Understanding the lifecycle of an insect pest is crucial for identifying vulnerabilities that can be exploited for effective control (Belluco *et al.*, 2023). For instance, the biometric characteristics of *Earias insulana* and *Earias vittella*-key pests affecting okra-were examined under controlled laboratory conditions. This investigation aimed to gain insights into their biological and ecological traits, serving as a foundation for developing effective pest management strategies (Sheoran *et al.*, 2023).

In light of this, the present study was undertaken in 2023 to document the lifecycle and morphometric characteristics of *A. merione* in detail. Eggs were collected from natural field conditions and reared under controlled laboratory settings until adult emergence. Throughout rearing, daily observations were recorded to document each

developmental stage from egg through successive larval instars to pupation along with precise morphometric measurements (length and width) for each stage. The objective was to identify critical weak points in the pest's lifecycle where interventions could be most effective.

Given the paucity of recent, detailed information on *A. merione* biology, this study aims to fill an important literature gap by providing updated and comprehensive data on its developmental stages and morphometrics, thereby supporting the development of more targeted and timely pest management strategies.

MATERIALS AND METHODS

Eggs of *Ariadne merione* were collected from Kanyakumari district, Tamil Nadu, India (8.0844° N, 77.5495° E) between January 2023 and March 2023. The work was carried out at Department of Zoology, Madras Christian College, Chennai. Each egg was placed in an individual container to prevent cannibalism. After hatching, the larvae were reared on fresh castor (*Ricinus communis*) leaves at room temperature until adult emergence. Fresh leaves were supplied at 24-hour intervals and any faecal waste or unconsumed foliage was removed during each feeding. To maintain leaf freshness, the petiole was wrapped with water-soaked tissue paper. Larvae were observed twice daily to record growth, moulting, instar progression and behavioural patterns (Fig 1). The study relied on direct observation of moulting events and preserved exuviae for stage classification. The number of larval instars was determined by the presence of exuviae, with the moulted head capsule serving as the primary indicator for instar transitions (Sonune *et al.*, 2010). This method was adopted because the larvae consume the moulted body skin, leaving only the head capsule as a reliable marker for stage identification (Fig 2).

Morphometric measurements, including larval length and width, were recorded daily using a Thermisto TH-M61 Digital Vernier Callipers. Upon pupation, each pupa was placed in a separate container to minimize disturbance. The duration from pupation to adult emergence was documented and newly emerged butterflies were released

back into their natural habitat. All recorded data were statistically analyzed using Microsoft Excel to calculate mean values and standard deviations (Deepti and Pathma, 2023; Suryanarayana *et al.*, 2015; Sharifi and Zarea, 1970). All laboratory procedures were conducted in accordance with institutional biosafety guidelines to ensure safe handling of biological specimens.

RESULTS AND DISCUSSION

Life cycle and feeding behaviour

Adult females preferentially oviposit on *Ricinus communis* plants growing in calm, unpolluted environments, actively avoiding sites exposed to pollution. The eggs of *Ariadne merione* are laid singly never in clusters on the underside of castor leaves, with each leaf typically bearing between one and five eggs. The eggs are white, opaque and covered with fine spikes. They are spherical in shape with a distinct central depression and have a mean diameter of 1.261 ± 0.134 mm. The average incubation period from oviposition to larval emergence was 2.022 ± 0.839 days. Prior to hatching, the eggs develop distinct black spots and after emergence, the empty eggshell becomes transparent (Srivastava and Kumar, 2016) (Fig 3).

Larva

There were five larval instars in the development of *Ariadne merione* butterfly. All instars were characterized by green colouration and feeds on the moulted skin.

First instar

The newly hatched first instar larvae of *Ariadne merione* measured 2.618 ± 0.286 mm in length and 0.613 ± 0.092 mm in width. This stage lasted for an average of 2.422 ± 0.499 days. First instar larvae exhibited relatively low feeding activity, restricting their damage to the scraping of the leaf epidermis, which resulted in fine, whitish feeding trails on the leaf surface. Upon emergence movement was limited and larvae typically remained close to the hatching site, feeding intermittently. With progressive growth, the larvae became markedly more active and mobile (Fig 4).

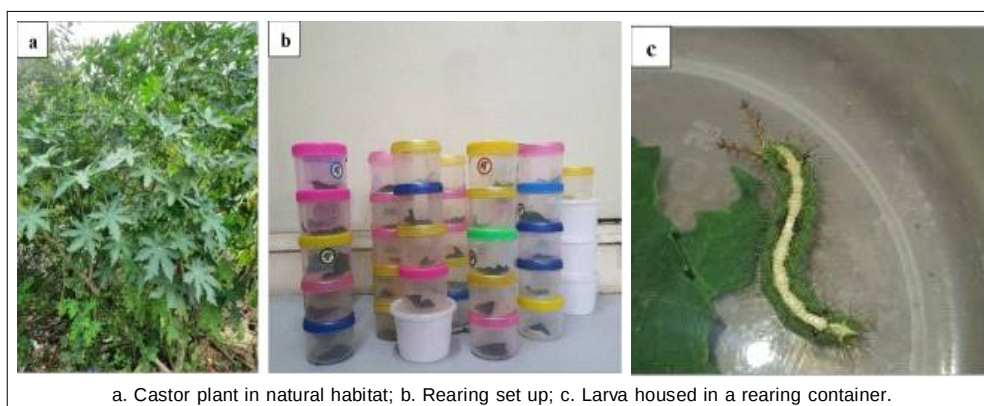


Fig 1: Rearing setup for *Ariadne merione* (Common Castor Butterfly).

Second instar

The second instar larvae, measuring 4.554 ± 0.660 mm in length and 1.311 ± 0.228 mm in width, persisted for 2.156 ± 0.475 days. At this stage, feeding activity increased and larvae began to consume softer parenchymatous



Fig 2: Molted head skin of *Ariadne merione* (common castor butterfly).

tissues between veins, leaving behind fine veins intact. The body coloration and spination became more distinct, aiding in camouflage against the host foliage (Fig 5).

Third instar

The third instar larvae attained a length of 8.341 ± 1.294 mm and a width of 2.736 ± 0.402 mm, with the stage lasting 2.444 ± 0.586 days. This instar marked the transition to voracious feeding behaviour. Larvae consumed large areas of the leaf lamina, creating irregular holes and in heavily infested plants, significant portions of the photosynthetic surface were lost. Feeding was both diurnal and nocturnal and larvae became more mobile, dispersing to adjacent leaves (Fig 6).

Fourth instar

The fourth instar stage lasted 2.622 ± 0.650 days, with larvae measuring 11.751 ± 3.125 mm in length and 3.621 ± 0.922 mm in width. Feeding intensity further increased and larvae were capable of stripping entire leaf blades, leaving only the midribs and major veins intact. By this stage, the larval body appeared more robust and defensive behaviours, such as curling when disturbed, were more pronounced (Fig 7).

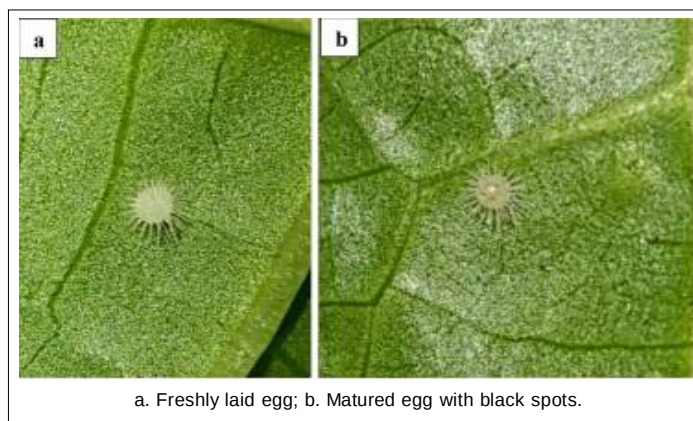


Fig 3: Egg of *Ariadne merione* (common castor butterfly).

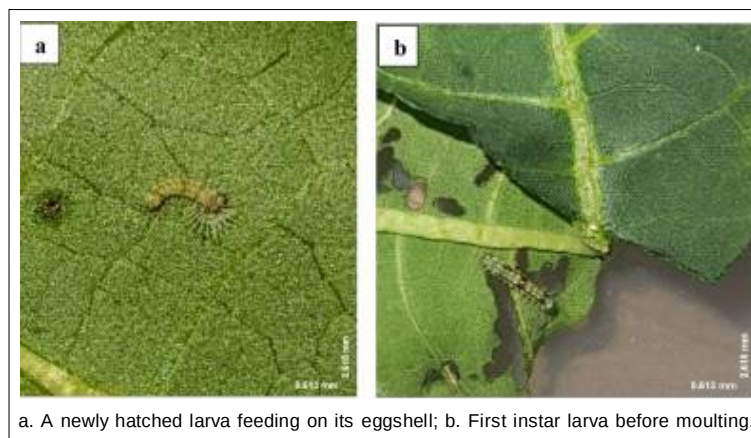


Fig 4: First instar larva of *Ariadne merione* (common castor butterfly).

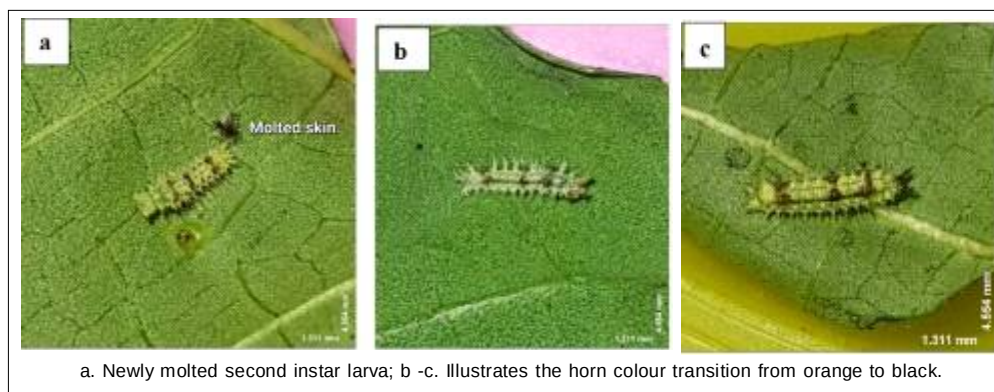


Fig 5: Second instar larva of *Ariadne merione* (common castor butterfly).



Fig 6: Third instar larva of *Ariadne merione* (common castor butterfly).



Fig 7: Fourth instar larva of *Ariadne merione* (common castor butterfly).

Fifth instar

The fifth instar was the longest larval stage, lasting 3.867 ± 0.786 days. Larvae at this stage reached 19.322 ± 3.290 mm in length and 5.201 ± 0.789 mm in width. They were intensive feeders, capable of causing complete defoliation in localized infestations. Feeding damage was severe, with

leaves either skeletonized or entirely consumed, drastically reducing the photosynthetic capacity of the host plant. The body coloration was darker and larvae displayed more active movement, often moving between plants in search of food (Fig 8).

Pupa

Upon completion of the larval period, pupation occurred. The pupae measured 18.208 ± 1.095 mm in length and 6.347 ± 0.320 mm in width and the pupal stage lasted 5.500 ± 0.762 days. Pupae were typically attached to stems or the undersides of leaves using a silk girdle and cremaster. After the pupal duration, adults emerged and were subsequently released into their natural environment (Fig 9).

Following eclosion, the newly emerged adult butterfly remains stationary with its wings fully spread for several hours, allowing the wings to dry and harden before initiating flight. The dorsal (upper) surface of the wings displays a bright orange background intricately patterned with fine brown lines. The body is slender, with the head, thorax and abdomen exhibiting a matching orange coloration.

In contrast, the ventral (under) surface of the wings is predominantly brown, adorned with reddish-brown wavy transverse lines, providing camouflage when the butterfly rests with wings closed. Sexual dimorphism is evident: males can be distinguished from females by the presence of a distinct white brand on the hindwings. In lepidopteran terminology, a "brand" refers to a specialised patch of androconia scales a secondary sexual characteristic in male butterflies. These androconia scales function in pheromone dissemination, assisting in courtship communication. In *A. merione*, the brand is associated with minute pheromone-emitting organs on the hindwing, from which the scent is dispersed during mating interactions (Darragh *et al.*, 2017) (Fig 10).

The developmental duration and morphometric traits of egg and larval instars were presented in the Table 1, 2 and Fig 11, 12.

A pictorial key for the field identification of different developmental stages of *Ariadne merione* (Common Castor Butterfly) was provided (Table 3).

According to Crimmins *et al.*, (2020), a comprehensive understanding of the developmental stages of an insect pest is fundamental to designing timely detection and control strategies. Such knowledge enables interventions to be applied at the most vulnerable points in the pest's life cycle, thereby reducing crop losses and improving overall yield. Also, accurate identification of pest instars plays a pivotal role in enhancing integrated pest management (IPM) strategies, particularly through instar-specific biocontrol interventions. Morphometric benchmarks enable rapid field-level differentiation of larval stages, allowing pest managers to time biological control

measures more effectively. Since early instars are generally more vulnerable to parasitoids and microbial agents, targeting these stages can improve control efficacy while minimizing insecticide use. Moreover, the observed morphological variation across instars supports selective monitoring and tailored interventions, reinforcing the practical utility of instar-wise susceptibility data in real-world IPM programs (Wang *et al.*, 2022).

In this context, the present study was undertaken to document the complete life cycle, growth patterns and behavioural traits of the common castor butterfly (*Ariadne merione*), a significant defoliator of *Ricinus communis*.

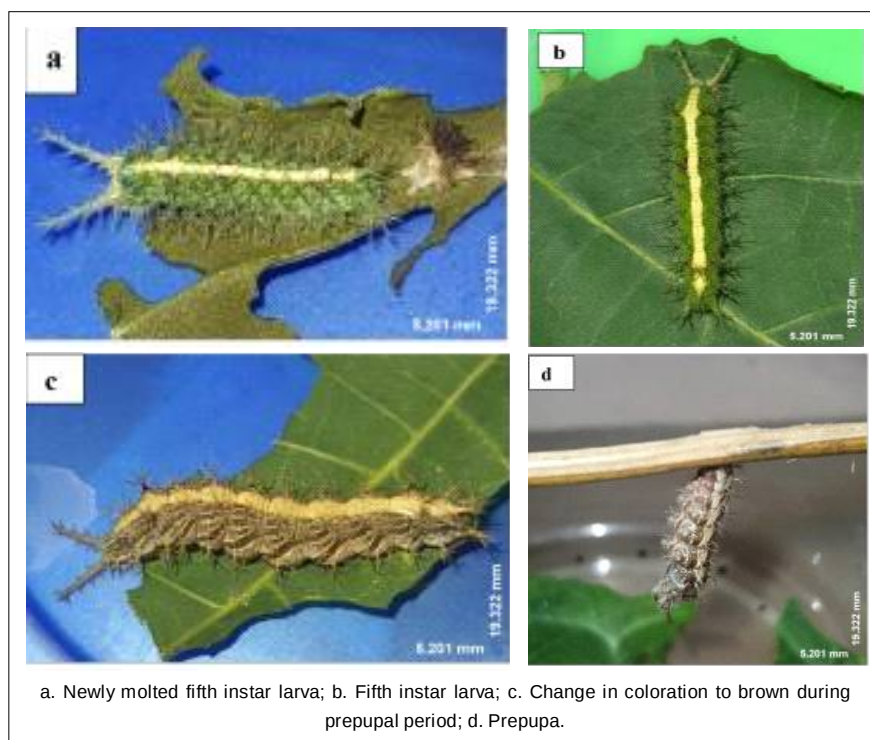


Fig 8: Fifth instar larva of *Ariadne merione* (common castor butterfly).

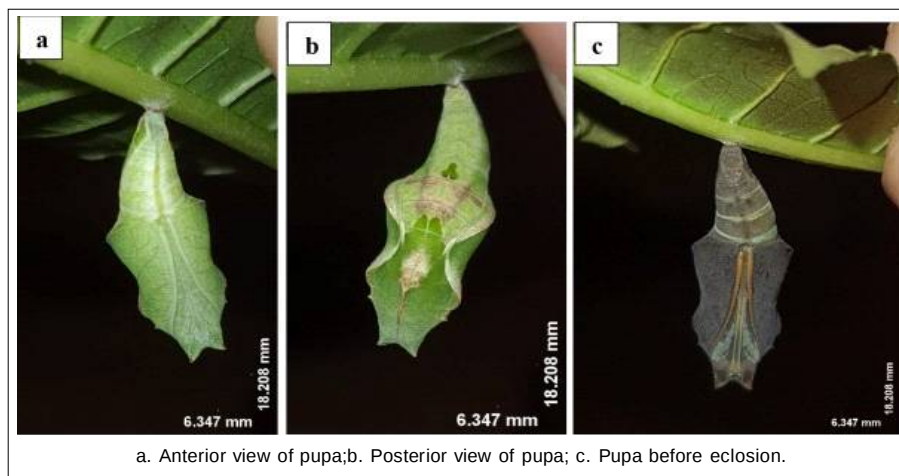


Fig 9: Pupa of *Ariadne merione* (common castor butterfly).

Table 1: Illustrates the lifecycle stages and duration (in days) of *Ariadne merione* (common castor butterfly).

Developmental stage of <i>Ariadne merione</i>	No. of days (Mean $\pm$ Standard deviation)
Egg	2.022 $\pm$ 0.839
First instar	2.422 $\pm$ 0.499
Second instar	2.156 $\pm$ 0.475
Third instar	2.444 $\pm$ 0.586
Fourth instar	2.622 $\pm$ 0.650
Fifth instar	3.867 $\pm$ 0.786
Pupa	5.5 $\pm$ 0.762

The findings reveal that larval feeding intensity increases substantially from the third instar onwards, when the caterpillars display pronounced voracity and cause visible foliar damage. Consequently, pest management actions should be initiated at or before this stage to prevent extensive defoliation and potential yield loss. Importantly, the present study provides precise data on the duration of each developmental stage of *A. merione*, which can be directly applied to the formulation of targeted control schedules. But there is a current lack of specific data on the economic threshold levels of *Ariadne merione* in castor crops, establishing precise threshold values remains an

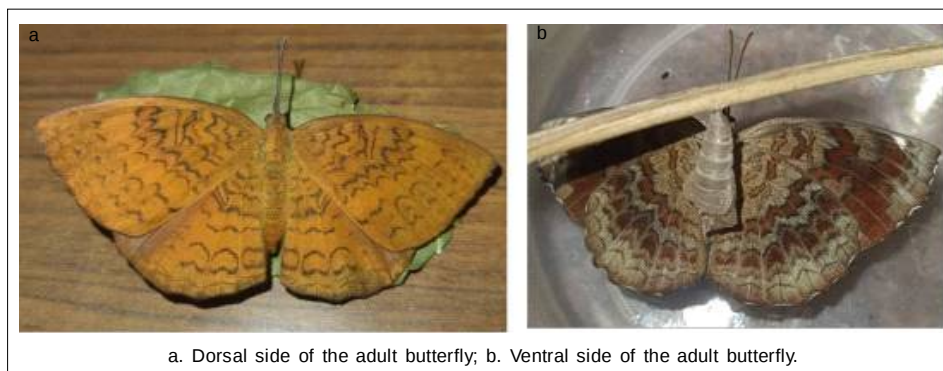
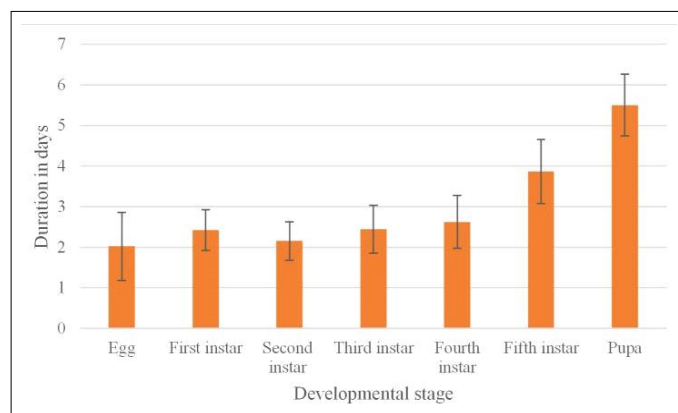
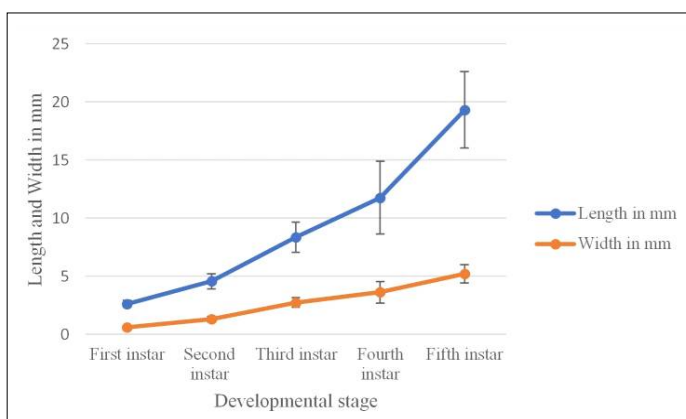
**Fig 10:** Adult butterfly of *Ariadne merione* (common castor butterfly).**Fig 11:** Mean developmental duration ($\pm$ SD) across different life stages of *Ariadne merione* (common castor butterfly).**Fig 12:** Instar-wise variation in morphometric traits ($\pm$ SD) of *Ariadne merione* Larvae.

Table 2: Morphometrics measurement of *Ariadne merione* (common castor butterfly).

Developmental stage of <i>Ariadne merione</i>	Length/ diameter* mm (Mean $\pm$ Standard deviation)	Width mm (Mean $\pm$ Standard deviation)
Egg*	1.261 $\pm$ 0.134*	
First instar	2.618 $\pm$ 0.286	0.613 $\pm$ 0.092
Second instar	4.554 $\pm$ 0.660	1.311 $\pm$ 0.228
Third instar	8.341 $\pm$ 1.294	2.736 $\pm$ 0.402
Fourth instar	11.751 $\pm$ 3.125	3.621 $\pm$ 0.922
Fifth instar	19.322 $\pm$ 3.290	5.201 $\pm$ 0.789
Pupa	18.208 $\pm$ 1.095	6.347 $\pm$ 0.320

Table 3: Pictorial key for field identification of different developmental stages of *Ariadne merione* (common castor butterfly).

Developmental stage	Image	Diagnostic features	Field notes
Egg		Spherical, white, opaque with spikes, laid singly.	Found on underside of castor leaves.
Larva-early instar (I - II)		Tubular, green, initially body covered with fine hairs later changing to spiny appearance.	Feeds on tender foliage, highly mobile.
Larva-late instar (III - V)		Darker green, spines become branched and elongated, Voracious feeder.	Feed on mature leaf, causes visible defoliation.
Pupa		Compact, immobile, attached to leaf or stem, adult structures visible upon emergence.	Camouflaged against plant surface.
Adult		Wings orange in colour with intricate brown lines, active during early daylight.	Often seen basking or feeding on nectar sources, found in unpolluted areas.

important area for future research to optimize integrated pest management strategies.

While the larval stage is destructive to castor crops, the adult butterfly performs beneficial ecological functions, particularly as a pollinator. This dual role highlights the need for a balanced pest management approach that mitigates agricultural damage without unnecessarily harming beneficial insect populations. One practical solution is the application of phytochemical-based biopesticides during the early larval instars. Such products, as noted by Walia *et al.* (2017), exert considerably less impact on non-target organisms compared with conventional synthetic pesticides. In addition, the adoption of plant-derived biopesticides reduces reliance on chemical inputs in agriculture (Jat *et al.*, 2024; Pillai *et al.*, 2020). In integrated pest management (IPM), semiochemicals offer a promising avenue for non-toxic control strategies by modulating pest insect behaviour. These compounds can serve as attractants in baited traps for effective population monitoring, or function as repellents and cues that lure natural enemies, thereby helping to suppress pest numbers below economically damaging thresholds (Smart *et al.*, 2014).

Preserving the adult butterfly population carries multiple ecological and socio-economic benefits. Beyond maintaining biodiversity, adult butterflies contribute to ecosystem stability, support food security through pollination services and hold cultural as well as aesthetic value (Potts *et al.*, 2016). By integrating early intervention with biological control measures, it is possible to limit pest damage while sustaining the positive ecological functions performed by the adult stage (Ratto *et al.*, 2022).

The implementation of such a strategy depends on rigorous field monitoring, accurate life stage identification and the timely execution of control measures. The present study's life cycle and morphometric data provide a foundation for such decisions. Continued research should focus on refining these pest management tactics, with an emphasis on enhancing efficacy, minimizing non-target effects and ensuring long-term sustainability in castor agroecosystems.

Future research can also focus on the use of artificial intelligence in morphometric analysis, as illustrated by Neupane *et al.* (2024). This marks a major leap forward in lepidopteran studies. By harnessing community-sourced photographs and applying deep learning techniques, their method enables automated identification and measurement of key morphological traits essential for determining the growth stages of monarch caterpillars. This AI-assisted approach not only accelerates the collection of extensive, high-resolution developmental data but also improves consistency and accuracy by reducing the subjective errors common in manual assessments. Moreover, integrating AI into this process expands public involvement in data gathering and opens new avenues for tracking population changes and developmental patterns in natural habitats-offering valuable contributions to ecological research and conservation efforts.

CONCLUSION

Although *Ariadne merione* occurs sporadically, it remains an economically important pest of castor (*Ricinus communis*), capable of causing considerable yield losses during severe infestations. The present investigation on its life cycle, developmental biology and morphometric traits offers valuable information for devising precise and timely pest management strategies. Findings clearly indicate that the larval stage is the most destructive phase, with intense defoliation potential, whereas the adult butterfly plays an ecologically beneficial role, particularly as a pollinator contributing to biodiversity maintenance and ecosystem stability.

Therefore, control measures should be strategically directed towards the larval stage to prevent economic damage while minimizing negative impacts on the adult population. Such an integrated approach ensures not only the protection of castor crops but also the preservation of pollination services and the broader ecological functions that adult butterflies provide. Adopting this balanced pest management strategy is essential for achieving both agricultural productivity and environmental sustainability. Future research should continue to refine and validate these targeted, eco-friendly interventions to support long-term, sustainable castor production systems.

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Ethical approval

Not applicable, as the study involved only pest species and no human subjects, cell lines or animals.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship was received and nothing influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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