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**Aspects of larval development in population
of *Platycnemis subdilatata* (Zygoptera:
Platycnemididae) in northeast Algeria."**

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Dedication

*All praise is due to Allah, by whose grace good deeds are completed.
I dedicate this work, the fruit of effort, perseverance, and sleepless nights, to:*

My beloved mother

*The heartbeat of my life and the secret behind every success.
You instilled in me the love of knowledge and gave everything for my sake.
Your prayers were my nourishment, your kindness my support. For you, I
offer a lifetime of gratitude.*

My dear father

*My role model and source of strength.
You taught me that ambition has no limits, and that true manhood is
patience and responsibility.
All my thanks and love to you — you have always been my compass in life.*

My dear grandmother Fatima

*The soul of kindness and a treasure of stories and prayers.
Your sincere supplications were a hidden pillar behind every step I took.
For that, you have my heartfelt love and gratitude.*

My beloved sisters: Hadiyat, Lina, Marwa, and Ni'mat Allah

My companions through life and its moments.

*You were my safety, my strength, and the pure laughter that lifted my
spirits.*

Every moment spent with you was a balm on the road to achievement.

To my dear uncle Omar

The gentle face and the silent supporter.

*Thank you for always being there, giving me strength and reassurance
through your presence.*

To my beloved aunt Sabrina and my dear aunts

*To my cousins: Romaisaa, Bouthaina, Sondous, Salsabeel, Nourhan, and
Khawla*

Childhood companions and the beauty of memories.

*To my dear friends: Hadeel, Donia, Noha, Chaima, Asya, Iman, Asmaa,
Hind, Bouthaina, Ikram, and Kholoud*

*Those who were light in times of exhaustion, and who filled my days with
their laughter.*

Summary:

This study aims to enhance our understanding of Odonata in the Khenchela region, a relatively unexplored area of northeastern Algeria. It addresses the dynamics and spatial distribution of the damselfly *Platycnemis subdilatata* within the wetlands of Oued El Hamma, located in the semi-arid climatic zone of Khenchela. Sampling campaigns were conducted from January to late May, comprising a total of 20 field trips distributed across five stations, with the objective of assessing seasonal activity patterns and larval development of Odonata species. Larvae were evenly distributed across stations, reflecting environmental uniformity, with a clear preference for specific depths, emphasizing the role of abiotic factors in habitat selection. Kruskal-Wallis tests revealed significant differences in larval abundance concerning several environmental factors. Larval abundance significantly increased with water depth ($p = 0.03675$), while it significantly decreased with increasing vegetation density ($p = 0.00449$). Air temperature alone did not show a significant effect when analyzed independently ($p = 0.90125$); however, its interaction with vegetation density was highly significant ($p = 0.00842$), indicating that the effect of temperature on larval abundance depends on the level of vegetation cover. The study revealed that larvae were evenly distributed across stations, indicating uniform environmental conditions, with a preference for specific water depths. Morphometric variations reflected seasonal growth and adaptation. These results highlight the ecological stability of Oued El Hamma and underscore its importance as a suitable habitat for damselfly development, contributing to Odonata research and aquatic habitat conservation in semi-arid northeastern Algeria.

Keywords: Khenchela, *Platycnemis subdilatata*, endemic, dragonflies, metamorphosis.

Résumé :

Cette étude vise à améliorer notre compréhension des odonates dans la région de Khenchela, une zone relativement inexplorée du nord-est de l'Algérie. Elle traite de la dynamique et de la distribution spatiale de la demoiselle *Platycnemis subdilatata* dans les zones humides de Oued El Hamma, situées dans la zone climatique semi-aride de Khenchela. Des campagnes d'échantillonnage ont été menées de janvier à fin mai, comprenant un total de 20 sorties sur le terrain réparties sur cinq stations, dans le but d'évaluer les schémas d'activité saisonnière et le développement larvaire des espèces d'odonates. Les larves étaient uniformément réparties entre les stations, reflétant l'uniformité environnementale, avec une nette préférence pour des profondeurs spécifiques, soulignant le rôle des facteurs abiotiques dans la sélection de l'habitat. Les tests de Kruskal-Wallis ont révélé des différences significatives dans l'abondance des larves concernant plusieurs facteurs environnementaux. L'abondance des larves a augmenté de manière significative avec la profondeur de l'eau ($p = 0,03675$), tandis qu'elle a diminué de manière significative avec l'augmentation de la densité de la végétation ($p = 0,00449$). La température de l'air seule n'a pas eu d'effet significatif lorsqu'elle a été analysée indépendamment ($p = 0,90125$) ; cependant, son interaction avec la densité de la végétation était hautement significative ($p = 0,00842$), ce qui indique que l'effet de la température sur l'abondance des larves dépend du niveau de la couverture végétale. L'étude a révélé que les larves étaient uniformément réparties entre les stations, ce qui indique des conditions environnementales uniformes, avec une préférence pour des profondeurs d'eau spécifiques. Les variations morphométriques reflètent.

Keywords: Khenchela, *Platycnemis subdilatata*, endemic, dragonflies, metamorphosis.

ملخص

تهدف هذه الدراسة إلى تعزيز فهمنا لليعاسيب في منطقة خنشلة، وهي منطقة قليلة الاستكشاف في شمال شرق الجزائر. تتناول الدراسة ديناميكية وتوزيع اليرقات لنوع ضمن الأراضي الرطبة لوادي الحامة، الذي يقع في المنطقة المناخية شبه الجافة من ولاية خنشلة. تم جمع العينات من يناير إلى نهاية مايو، وشملت 20 خرجة ميدانية موزعة على خمس محطات، بهدف تقييم أنماط النشاط الموسمي وتطور اليرقات لأنواع اليعاسيب. أظهرت النتائج أن اليرقات كانت موزعة بشكل متساوٍ عبر مختلف المحطات، مما يعكس تجانس الظروف البيئية، مع وجود تفضيل واضح لأعماق معينة من المياه، مما يبرز دور العوامل اللاأحيائية في اختيار المواطن. كشفت اختبارات كروسكال واليس عن وجود فروق معنوية في وفرة اليرقات فيما يتعلق بعدة عوامل بيئية. فقد زادت وفرة اليرقات بشكل ملحوظ مع عمق المياه ($p = 0.03675$)، في حين انخفضت بشكل ملحوظ مع زيادة كثافة الغطاء النباتي (قيمة $p = 0.00449$ لم يُظهر عامل درجة حرارة الهواء تأثيرًا معنويًا عند تحليله بشكل مستقل ($p = 0.90125$)، غير أن تفاعله مع كثافة الغطاء النباتي كان ذا دلالة إحصائية عالية ($p = 0.00842$)، مما يشير إلى أن تأثير درجة الحرارة على وفرة اليرقات يعتمد على مستوى الغطاء النباتي. كشفت الدراسة أيضًا عن وجود تباينات مورفومترية تعكس النمو الموسمي والتكيف مع الظروف البيئية. تسلط هذه النتائج الضوء على الاستقرار البيئي لوادي الحامة وتؤكد أهميته كمأوى مناسب لتطور يرقة اليعسوب، مما يساهم في أبحاث اليعاسيب وجهود الحفاظ على المواطن المائية في شمال شرق الجزائر شبه الجاف..

الكلمات المفتاحية: خنشلة، *Platycnemis subdilatata*، المستوطنة، اليعسوب، التحول.

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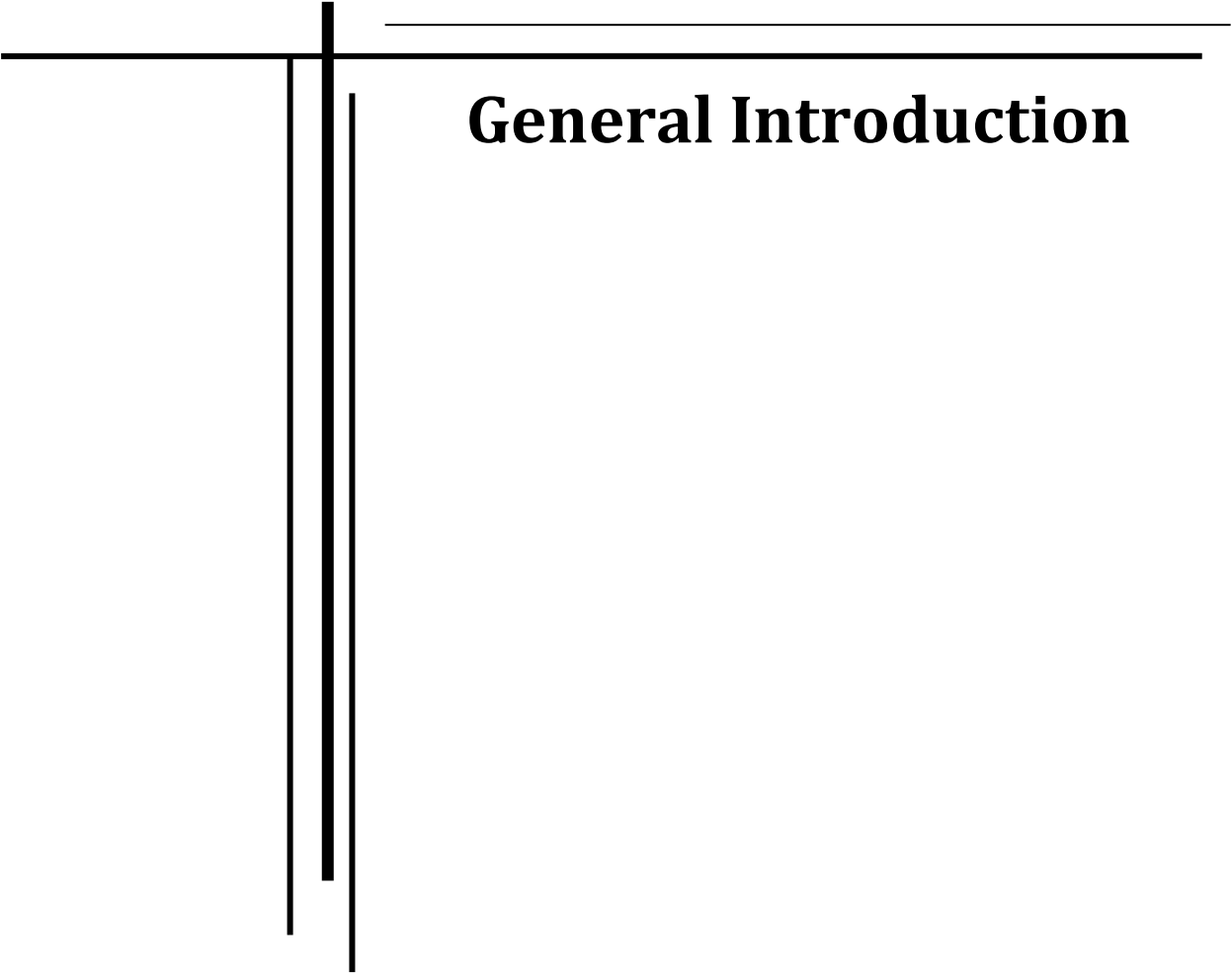
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General Introduction

Introduction

The freshwater biodiversity of the Mediterranean hotspot, recently recognized for its major importance, has been assessed as highly diverse but extremely threatened (Barrios et al., 2014). Freshwater ecosystems such as rivers, lakes, streams, and wetlands are home to a high diversity of species, many of which are endemic and play critical roles in maintaining ecological balance (Dudgeon et al., 2006).

Based on three sub-regions of this hotspot—namely the Balkans (Jahorina, Bosnia and Herzegovina), Turkey and the Levant (Azraq, Jordan), and North Africa (Algeri, Khenchela)—a total of 167 freshwater areas, covering a total surface of 302,557 km², have been identified as Key Biodiversity Areas (KBAs), meaning they significantly contribute to the global persistence of biodiversity (Barrios et al., 2014). Among these 167 KBAs, 40 have also been recognized as Alliance for Zero Extinction (AZE) sites. In Algeria, Western Numidia is recognized as an Alliance for Zero Extinction (AZE) site due to its hosting of endangered species (Darwall et al., 2014).

Odonata are important organisms in freshwater ecosystems, comprising a significant portion of the insect biomass in these environments. They play a crucial role in the food web as both predators and prey, which helps maintain ecological balance. In North Africa, 83 species of Odonata have been recorded (35 species of Zygoptera and 48 species of Anisoptera). The Zygoptera group shows a higher rate of endemism (14.3%) compared to Anisoptera (4.2%) (Samraoui et al., 2010). This highlights the significant role of Zygoptera in regional biodiversity. Furthermore, these species of Odonata are sensitive indicators of environmental quality, including water temperature and oxygen levels, making them effective tools for monitoring water quality and ecological changes (Dijkstra & Lewington, 2006).

Odonata also play a crucial role as ecological indicators in various environmental assessments, such as biodiversity evaluation, water quality monitoring, and ecosystem function studies. They serve as bioindicators to track changes in water bodies and surrounding environments, which reflects the importance of studying these species in different ecological contexts. For instance, Odonata can provide precise indications of water quality and habitat conditions, assisting in monitoring environmental changes due to climate change (Oertli, 2008).

Additionally, a decline in Odonata populations is often a sign of environmental degradation, such as water pollution or habitat destruction, thus reinforcing their role in monitoring environmental health (Wilson Osbern 2009). Despite extensive research on Odonata in other

parts of the world, many species remain understudied, especially in Africa and the Maghreb region. Research attention in these areas is limited compared to other regions, requiring more studies to better understand the species and their ecological roles (Samraoui et al., 2010). In this regard, biodiversity studies in these regions need accurate sampling and environmental data analysis to identify ecological patterns and the geographical distribution of under-researched species (Kalkman et al., 2008).

Concerning the role of Odonata in assessing habitat sustainability, studies show that threatened species such as Epiophlebia supersets and Coenagrionid exhibit high sensitivity to environmental changes caused by human activities such as intensive agriculture and urban expansion (Boudot & Kalkman, 2006)

Platycnemis subdilatata is the only species of the Platycnemididae family found in North Africa, with occurrences in Tunisia, Algeria, and Morocco. Although it is classified as a species of "Least Concern" on the IUCN Red List (Samraoui et al., 2010), its habitat is under significant anthropogenic pressure, which could threaten natural populations in the near future. This species primarily inhabits river and stream sections with relatively slow water currents. Its flight period extends from May to October (Dijkstra & Lewington, 2007). Due to the lack of previous studies, available knowledge about this species remains limited. To investigate its distribution, abundance, taxonomy, life cycle, behavior, and population dynamics, this study was conducted in one of the most significant watershed areas in the Khenchela region, *Oued El Kissan*, located in eastern Algeria. The four aspects studied in this dissertation are described above

- 1_Study the impact of environmental factors on larval development
- 2_Determine the preferred habitats of larvae.
- 3_Examine the dynamics and structure of larval populations
- 4_Explore the ecological interactions of larvae with their environment.

This dissertation will explore aspects of larval development in *Platycnemis subdilatata* populations in Khenchela through four main chapters. The first chapter will provide a detailed description of the species, focusing on its morphological characteristics, ecological aspects, and geographical distribution. The second chapter will be dedicated to describing the region of Khenchela, emphasizing environmental factors that may influence the presence of this species. The third chapter will outline the materials and methods used for data collection

GENERAL INTRODUCTION

and the study of larval development stages. Finally, the fourth chapter will present the results obtained and discuss them in relation to previous studies. The thesis will conclude with a conclusion of key findings and future recommendations.

CHAPTER I

Description of the species

1. Systematic of the species

Platycnemis subdilatata is a North African damselfly from the family Platycnemididae. It prefers calm freshwater habitats and is recognized by its pale body and broad male tibiae. It also serves as a bioindicator of water quality (Dijkstra & Kalkman, 2012).

1.1 Classification of *Platycnemis subdilatata*

- **Kingdom:** *Animalia*
- **Phylum:** *Arthropoda*
- **Class:** *Insecta*
- **Order:** *Odonata*
- **Suborder:** *Zygoptera*
- **Family:** *Platycnemididae*
- **Genus:** *Platycnemis*
- **Species:** *subdilatata*

2. Morphology

2.1. Morphology of the adult *P. subdilatata*

The adult morphology of *Platycnemis subdilatata* is characterized by a slender and elongated body, typically ranging from 30 to 35 mm in length. The thorax is pale greenish or grayish, while the eyes are large and well-developed, with a reddish-brown color. The wings are transparent, with a slight darkening at the tips and feature dark markings. The legs are slender, and the first pair of legs in males may be slightly modified, with expanded femora. These morphological traits and coloration help distinguish *P. subdilatata* from other species in the *Platycnemis* genus, which also have similarly slender bodies (Dumont & de Moor, 1993).

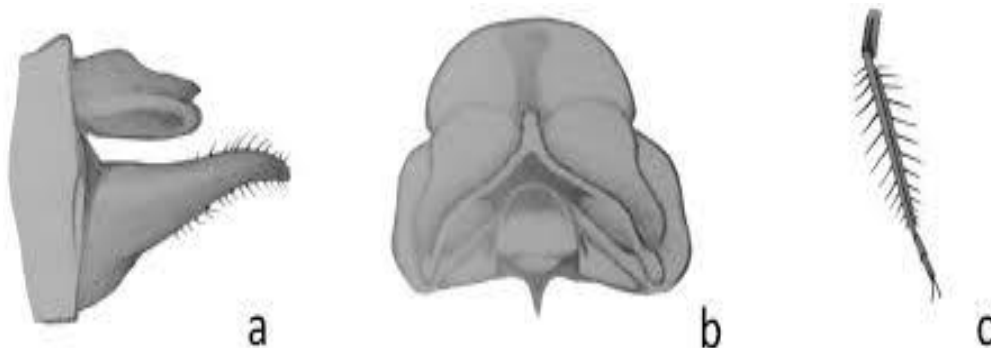


Figure 1.1: Anatomical parts of *P. subdilatata*. a – Male anal appendages (lateral view). b – Female pronotum (dorsal view). c – Male posterior tibia (Dijkstra & Lewington, 2007).

2.1.1. Size and shape

The total body length of males' ranges from approximately 35 to 40 mm, with a wingspan of up to 50 mm. Females tend to be slightly large (Khelifa et al., 2016).

2.1.2. Color

Platycnemis subdilatata exhibits pronounced sexual dimorphism in coloration. Males are characterized by a pale blue to whitish-blue hue, whereas females display a brownish coloration that changes as they age. Young females (7 to 10 days old) have a lighter shade, which gradually darkens and turns brown after 19 days. These chromatic variations play a crucial role in reproductive behavior and individual recognition (Khelifa et al., 2016)

2.1.3. Head

- The head is relatively small and equipped with large compound eyes, providing excellent visual acuity
- Eye color generally varies depending on sex and can be blue, green, or brown (Boudot & Kalkman, 2015).

2.1.4. thorax

the thorax of *Platycnemis subdilatata* is divided into three segments: a small, flexible prothorax, and larger mesothorax and metathorax that support the wings and legs. The thorax contains both direct and indirect flight muscles, which facilitate agile wing movement. Its elongated, light-colored structure, along with setae-bearing legs, contributes to efficient flight and prey capture (Corbet, 1999).

2.1.5. Abdomen

The abdomen of *Platycnemis subdilatata* is characterized by a light greenish-blue to white coloration in males and a brownish-white hue in females, with black longitudinal stripes. Its length ranges from 33 to 36 mm, aiding in species identification (Khelifa et al., 2015).

2.1.6. wings

2.1.6.1. Structure and General Characteristics

The wings of the adult *Platycnemis subdilatata* (Rambur, 1842) are membranous, transparent, and finely veined. As with all damselflies (Zygoptera), the forewings and

hindwings are similar in shape and size, providing the species with excellent maneuverability during flight (Khelifa et al., 2016).

2.1.6.2. Wing Venation and Functional Adaptation

The venation pattern of *P. subdilatata* is characterized by a moderate density of cells in the discoidal area, ensuring a balance between rigidity and flexibility. (Dumont et al.2010), the wing structure in damselflies plays a crucial role in thermoregulation and energy conservation during flight.

2.1.6.3. Sexual Dimorphism in Wings

The wings exhibit some morphological differences between males and females. Male wings tend to be longer and slenderer, facilitating greater agility during flight, which is advantageous for courtship displays and territory defense. In contrast, female wings are slightly broader and more robust, which may be linked to their reproductive role and the need for more stable flight during oviposition (Khelifa, 2016).

2.1.7. Paws

Platycnemis subdilatata has a slight widening of the tibiae, a distinctive feature of the *Platycnemididae* family, This broadening is less pronounced compared to other species within the same family, It is believed that this structure plays a role in partner recognition during mating ,The hind legs are relatively longer than the other legs, helping the species grip moist surfaces such as vegetation near water sources, The legs are usually pale in color, with dark stripes on the femur and tibia, providing effective camouflage in their natural habitat (Khelifa et al., 2016).

2.1.8. Gills

Unlike larvae that have external gills, adult dragonflies breathe in the air, their respiratory system is based on an internal network of tracheae, Oxygen is directly transported to the tissues through these tracheae, Gas exchange occurs through spiracles located on the thorax and abdomen, this system enables efficient respiration without the need for gills (Corbet,1999).

2.1.9. Mouthparts

The adults of *Platycnemis subdilatata* have mouthparts adapted for capturing prey in flight. Their mandibles are robust, and the maxillae are modified into a pincer-like shape to grasp and manipulate prey (Silsby, 2001)



Figure 1.2: Original photo of mouthparts of *Platycnemis subdilatata*

2.1.10. Adaptation to the Environnement of *Platycnemis subdilatata* Adults

2.1.10.1. Morphological Adaptations

The morphology of *P. subdilatata* is well suited to its habitat. The species possesses elongated tibiae, which facilitate perching on emergent vegetation, providing stability and an advantage in avoiding predators. Additionally, the pale coloration of adults, particularly in males, helps them blend with surrounding vegetation, offering effective camouflage (Dumont, 1972)

2.1.10.2. Behavioral Adaptations

Several behavioral traits contribute to the species adaptation. Adults engage in basking behavior, using sunlight to regulate their body temperature, which is essential for flight activity. Males establish and defend territories near water bodies, ensuring access to suitable oviposition sites and increasing their chances of reproductive success (Samraoui & Corbet, 2000)

2.1.10.3. Reproductive Adaptations

Reproductive strategies play a significant role in the survival of *P. subdilatata*. The species engages in tandem flights during mating, and females deposit eggs in submerged vegetation, reducing the risk of predation. Furthermore, an extended reproductive period allows populations to take advantage of seasonal water availability, ensuring successful larval development (Samraoui & Corbet, 2000)



Figure 1.3: Morphology of the adult *P. subdilatata* [A].

2.2. Morphology of *P. subdilatata* larva

2.2.1. Général description

The larvae of *Platynemesis subdilatata* are characterized by a slender, elongated body that blends well with their aquatic environment, with colors ranging from light brown to green for effective camouflage among submerged vegetation (Dumont & Hinnekint, 1973). Their broad head features forward-facing compound eyes, enhancing their ability to detect prey, while their specialized labial mask allows for swift and efficient predation of small aquatic insects like mosquito larvae (Askew, 2004). The thorax supports long, finely setose legs, which aid in clinging to surfaces and sensing vibrations in the water (Corbet, 2004). At the end of the segmented abdomen, three external gill-like structures known as caudal lamellae facilitate respiration and, in some cases, assist in swimming (Askew, 2004). These larvae undergo multiple molting stages before reaching their final instar, at which point they emerge from the water to metamorphose into adults. Their development is strongly influenced by environmental factors such as temperature, food availability, and water quality (Dumont & Hinnekint, 1973).

2.2.2. Size and shape

Platynemesis subdilatata larvae have slender, elongated bodies with a cylindrical shape that tapers posteriorly. They possess three caudal lamellae for respiration and stabilization (Dumont & Hinnekint, 1973). Their size varies with development, with last-instar larvae measuring 12–18 mm, plus additional length from the caudal lamellae (Jacquemin et al., 2014). Morphologically, they have a broad, slightly flattened head with large lateral compound eyes

(Dumont & Hinnekint, 1973). The prehensile labium aids in prey capture (Jacquemin et al., 2014), while the elongated thorax bears three pairs of segmented legs for clinging to vegetation (Dumont & Hinnekint, 1973). The segmented abdomen ends with three leaf-like caudal lamellae, which regenerate if lost (Jacquemin et al., 2014).

2.2.3. Color

The larvae of *Platycnemis subdilatata* exhibit a pale coloration, ranging from light brown to yellowish or greenish, with darker markings along the body. Their coloration may vary depending on environmental factors such as substrate composition and water quality, which contribute to their camouflage and protection against predators (Dumont & Heidari, 1996).

2.2.4. Head

The larva of *Platycnemis subdilatata*, commonly known as the Barbary Featherleg, possesses distinct morphological features that set it apart from other damselfly species. One key characteristic is the filamentous extension at the tip of the caudal lamellae. The head width of the larva is precisely measured using a digital caliper with an accuracy of 0.01 mm. These measurements, along with traits such as the number of segments covered by wing sheaths and the structure of the prementum, are essential for identifying different larval stages (Khelifa et al., 2015)



Figure 1.4: Original photo of head of *Platycnemis subdilatata* larva

2.2.5. Thorax

The thorax is the central part of the larval body in *Platycnemis subdilatata*, characterized by a strong structure that supports the larva's essential movements. It serves as the attachment site for both the legs and wings, making it a crucial region for locomotion. The thorax contains a well-developed set of muscles responsible for leg movement, allowing the larva to navigate its

aquatic environment efficiently. Additionally, it plays a fundamental role in wing development, as the wings begin forming within this region in preparation for the next stage of the life cycle. Thanks to its robust musculature, the larva can perform precise and rapid movements, which are essential for avoiding predators and searching for food (Corbet, 1999).



Figure 1.5 : Thorax of *Platynemis subdilatata* larva (Sahraoui & Ouendjeli 2024).

2.2.6. Abdomen

The larvae of *Platynemis subdilatata* have a long and slender abdomen composed of ten segments (S1–S10), a common adaptation among *Zygoptera* (damselfly) larvae. The posterior end of the abdomen features three caudal gills, which are thin, membranous structures functioning as respiratory organs through gas exchange with water (Dumont & Heidari, 1996). Some abdominal segments possess dorsal or lateral spines, which are believed to provide additional protection against predators. Furthermore, the abdomen is highly flexible, allowing the larva to move smoothly through lateral undulations, a typical swimming strategy among species of this family (Askew, 2004).

2.2.7. Wings

- In *Platynemis subdilatata* larvae, wings develop as wing sheaths (wing pads), which are non-functional structures located dorsally on the mesothorax and metathorax. These wing pads gradually increase in size with each developmental instar, reaching their maximum length in the final instar before metamorphosis (Dumont & Heidari, 1996).
- In the early instars, the wing sheaths appear small and rounded, but as the larva matures, they become elongated, extending posteriorly over the first few abdominal segments. This progressive elongation is a key characteristic used for instar determination in *Zygoptera* larvae (Askew, 2004).

2.2.8. Paws (legs)

- The legs of *Platycnemis subdilatata* larvae are long and slender, adapted for movement and hunting in aquatic environments. These elongated legs provide stability and aid in navigating submerged vegetation (Dumont&Heidari,1996).
- Each leg consists of five segments: coxa, trochanter, femur, tibia, and tarsus, with the tarsus ending in a single sharp claw. This structure allows the larva to grip onto surfaces and capture prey effectively (Askew, 2004).

2.2.9. Gills

Possess three caudal lamellae that function as external gills, facilitating gas exchange underwater. These delicate structures enable the larvae to absorb oxygen directly from the aquatic environment, aiding their adaptation to their habitat. Additionally, the shape and structure of the caudal lamellae can be used as a taxonomic criterion in classification and ecological studies (Khelifa, 2017)

2.2.10. Adaptation to environment of larva of *Platycnemis subdilatata*

Platycnemis subdilatata, known as the Maghreb Featherleg, is a species of damselfly endemic to North Africa, particularly in Algeria, Morocco, and Tunisia. Studies have shown that this species has several environmental adaptations that help it cope with the changing conditions of its aquatic habitats

3. Life Cycle of *Platycnemis subdilatata*

The **life cycle** of *Platycnemis subdilatata* (Zygoptera: Platycnemididae) involves several distinct stages, from egg to adult, each with specific environmental requirements.

3.1. Egg stage

Female *Platycnemis subdilatata* deposit their eggs on aquatic plants or submerged surfaces in slow-moving or stagnant waters. The eggs develop and hatch into larvae within a few days to weeks, depending on temperature and environmental conditions (Dumont, 1972).

3.2. Larval (Nymphal) stage

The larvae are aquatic predators, feeding on small invertebrates. They undergo multiple molts, gradually developing wing buds. The duration of this stage varies based on

environmental factors such as temperature, food availability, and water quality. It can last from several months to over a year (Boudot & Kalkman, 2015).

3.3. Adult stage

Fully developed larvae leave the water and undergo their final molt, emerging as winged adults. After emergence, they require a maturation period to develop full coloration and reproductive capability. Adult damselflies are aerial predators, feeding on small flying insects. Mating occurs once they reach maturity, completing the reproductive cycle (Dijkstra & Lewington, 2006).

4. Distribution of *Platycnemis subdilatata*

4.1. International distribution

Platycnemis subdilatata is primarily found in North Africa (Algeria, Morocco, Tunisia) and prefers rivers and mountain streams (Dijkstra & Lewington, 2006). It has been recorded in Spain and Portugal, though these reports are rare (GBIF, 2025). In 1978, an individual was found on Tenerife, Canary Islands, but no stable population was confirmed (Wikipedia, 2025). The IUCN Red List classifies it as "Least Concern" due to its widespread distribution (IUCN, 2010). Recent data confirm its continued presence, with significant populations in Algerian river systems (GBIF, 2025).

4.2. National distribution (In Algeria)

- ❖ **Northeast Algeria:** A study focusing on the Seybouse River basin in Northeast Algeria found that *P. subdilatata* is the most abundant lotic (stream-dwelling) species in the area, with an estimated adult population size of approximately 50,000 individuals [A]
- ❖ **Kabylia Region:** Research conducted in the Wadi Isser area of Kabylia, Algeria, recorded the presence of *P. subdilatata*, highlighting its status as a Maghreb endemic species [B]
- ❖ **Sidi Bel Abbes Province:** A comprehensive survey in Sidi Bel Abbes, Northwest Algeria, documented 29 Odonata species, including *P. subdilatata*, across 23 sites [C]

4.3. Distribution in khenchela

The Khenchela region in northeastern Algeria contains wetland areas such as rivers and lakes, providing an ideal habitat for *Platycnemis subdilatata*. Although there are indications of the presence of this species in the region, field studies on its distribution remain limited. Recent

work by Elafri et al. (2021) highlighted the importance of highland hydrosystems in northeastern Algeria as key habitats for Odonata, including endangered and localized species, using species occupancy models. This reinforces the need for focused surveys on *P. subdilatata* in these environments. It is essential to conduct such surveys to assess the impact of environmental factors and human activity on its distribution, which would help in its conservation (Bouzid et al., 2021)

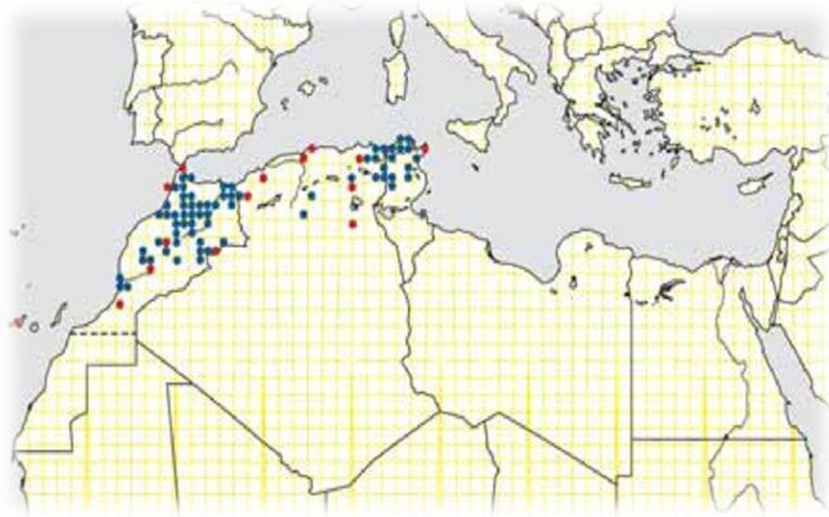


Figure 1.6: the distribution area of *P. subdilatata* (Boudot et al., 2009) observations made before 1980 are in red and those made after 1980 are in blue.

5. The Relationship Between the Distribution of *Platynemis subdilatata* and Hydrological Characteristics

The distribution of *Platynemis subdilatata* is closely linked to the hydrological characteristics of its aquatic habitat. This species prefers shallow rivers and streams with light to moderate currents. It is significantly affected by environmental factors such as water temperature and oxygen concentrations in the water, as oxygen-rich water with suitable temperatures provides an ideal environment for larval growth. Furthermore, the hydrological stability of the aquatic environment is an important factor influencing the distribution of this species, as areas with stable water levels offer favorable conditions for its reproduction (Harrison, S., & Horne, B. D. 2001).

6. Factors Affecting the Distribution of *Platynemesis subdilatata*

6.1. Biotic factors

- **Competition:** *Platynemesis subdilatata* may compete with other species of dragonflies for food and suitable habitats. Species interactions can influence the density and distribution of individuals in the ecosystem (Ehrmann, 2009).
- **Predators:** Dragonflies can be preyed upon by fish and birds. Environments that are distant from predators provide better conditions for breeding and growth (Corbet, 1999).
- **Reproduction:** The availability of suitable aquatic habitats for reproduction is a key factor in determining the distribution of this species. *Platynemesis subdilatata* prefers environments with slow-moving waters and suitable aquatic vegetation (Westfall & May, 2006)

6.2. Abiotic factors

- **Temperature:** Temperature affects the development of various life stages in *Platynemesis subdilatata*. Moderate temperatures support the growth of larvae and adults (Siva-Jothy, 1995).
- **Water:** *Platynemesis subdilatata* depends on the availability of clean, slow-moving waters. Polluted waters or those with strong currents may limit the species' presence. Stable aquatic environments are ideal for larval development (Dow, 1982).
- **Light:** Light is an important factor in determining breeding sites, as aquatic species tend to favor sunny environments where food availability is higher due to photosynthetic processes (Lutz & Schultz, 2006).
- **Water Chemistry:** The presence of *Platynemesis subdilatata* is affected by water characteristics such as PH levels and oxygen concentration. This species prefers waters with moderate and high oxygen levels (Kalkman et al., 2008).
- **Topography:** Areas with stagnant or shallow waters provide an ideal environment for *Platynemesis subdilatata*. Species like this prefer locations with minimal water flow (Boudot & Rupp, 2006)

7. Reproduction of *Platynemesis subdilatata*

7.1. Mating

In *Platynemesis subdilatata*, the mating process begins when the male grasps the female by her thorax using his abdominal claspers, forming what is known as the Tandem Position. At

this stage, the male remains attached to the female while she prepares for copulation. The female then curves her abdomen forward to connect her genital opening with the male's secondary genitalia, creating the Copulation Wheel or Heart Shape, where sperm transfer occurs. This characteristic position is common among Odonata and is crucial for successful reproduction (Corbet, 1999)



Figure 1.7: The mating wheel position in dragonflies similar to *Platynemesis subdilatata* [B]

7.2 Oviposition

The female lays eggs in or near water, often in submerged vegetation, using her ovipositor to place them in the water (Buchwald, 2000)

7.3 Development

The eggs hatch into predatory nymphs that live in the water, feeding on smaller organisms and undergoing several molts (Stoks & De Block, 2005).

7.4 Emergence and Adult Stage

The nymph emerges from the water, shedding its exoskeleton to become an adult, ready to begin the reproductive cycle again (Corbet, 1999).

CHAPTER II

Description of the study region

1. Description of the study region

Province, located in northeastern Algeria within the Aures Mountains, is known for its mountainous landscapes, agricultural significance, and rich cultural heritage. The terrain is predominantly mountainous, with elevations reaching up to 2,300 meters, creating a Mediterranean climate characterized by hot, dry summers and cold winters with snowfall in higher altitudes (Lamine, 2004). The province's economy primarily relies on agriculture, with fertile valleys supporting the cultivation of cereals, olives, and fruits, alongside livestock farming, particularly sheep and cattle (Ministry of the Interior and Local Authorities, 2020). The population is predominantly Berber-speaking, with the Chaoui dialect widely used, reflecting a deep connection to its Amazigh roots, which is evident in its traditional crafts and cultural festivals (Belhadj, 2005). Geographically, Khenchela is situated in the southeastern part of the Constantine Basin and on the foothills of the Aures Mountains, between latitudes 34°06'36" and 35°4'21" North and longitudes 06°34'12" and 07°35'56" East, covering an area of 9,715 km². It is bordered by five provinces: Oum El Bouaghi to the north, El Oued to the south, Tebessa to the east, Batna to the northwest, and Biskra to the west Khenchela serves as a crucial link between the northeast and the south of the country, strengthening economic and social ties with neighboring provinces (Ouanass et Salhi, 2021)

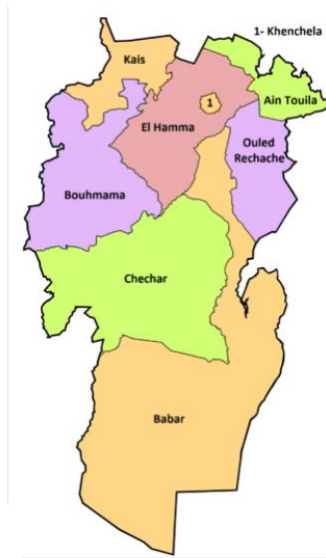


Figure 2.1 : Khenchela province Map, Algeria [C]



Figure 2.2: Location of El Hamma in the wilaya of Khenchela[D]

2. Presentation of the study area _Oued El Kissan _

The sub-basin of Oued El Kissane, located between latitudes 35° and $35^{\circ}30' N$, and longitudes 7° and $7^{\circ}6'5'' E$, covers an area of 37.5 km^2 . It is characterized by elevations ranging from 850 m to 1900 m. The basin is drained by Oued El Kissane and its tributaries, passing through the Hammam El Salhine depression and the city of El Hamma before reaching its final destination in the Remila plain (Achour & Zaouioui, 2021).

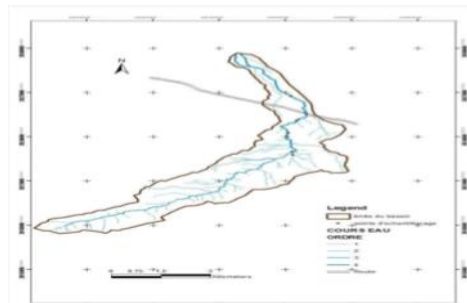


Figure 2.3 : the geographical location of Oued El Hamma (Oued El Kissane)

khenchela (Achour and Zaouioui 2021)



Figure 2.4 : Hydrographic network of Oued El Hamma (Oued El Kissan) Khenchla (google earth 2025)

3. The climate

The climate is the most influential environmental factor directly affecting animal populations (Thomas, 1976). The region of Khenchela, like much of the country, is characterized by a Mediterranean climate, which features a summer drought lasting between four and five months, along with a relatively consistent rainfall pattern, with the highest precipitation levels recorded during winter (Bouakkaz, 2015).

To analyze climatic variations and their impact on the local ecosystem, meteorological data collected over twenty-four consecutive years (2008–2017) from the El-Hamma station (ONM, 2008-2017) were examined. The Bagnouls and Gaussen method was employed to construct the pluviothermal diagram, which allows for the identification of the dry season by plotting annual average precipitation and temperature on separate axes, with the precipitation scale set at twice that of temperature. According to this approach, the dry season is identified when the precipitation curve intersects and falls below the temperature curve, reflecting a period of water stress and its ecological implications for the region (Bagnouls & Gaussen, 1957; Fists & Lefeuvre, 2000; Achour & Zaouioui, 2021).

The climate analysis reveals a dry period lasting four months, from May to September (Figure 23). The pluviothermal quotient of Emberger (Q_2) is calculated using the following formula:

$$Q2 = \frac{3.43 \times P}{M - m}$$

where:

P: represents the annual precipitation in mm,

M: is the mean maximum temperature of the hottest month

m: is the mean minimum temperature of the coldest month (°C).

Based on the obtained value ($Q2 = 62.04$), along with the mean minimum temperature of the coldest month (5.7°C) and the mean maximum temperature of the hottest month (28.1°C), it is observed that the study area falls within the semi-arid bioclimatic stage with a cool winter (Figure 13) (Achour & Zaouioui, 2021).

Table 1: Average precipitation and temperature in the Khenchela region (2008-2018)

(source: station of El Hamma: 2008-2018)

Month	Jan	Feb	mar	apr	may	Jun	Jul	aug	sep	oct	nov	dec
P	26.96	24.19	42	34.38	27.8	21.75	54.56	42.74	59	43	25	63
T average	6.4	5.7	9.6	16.7	22.6	26.9	28.1	27.7	21	28.1	16.2	15.6

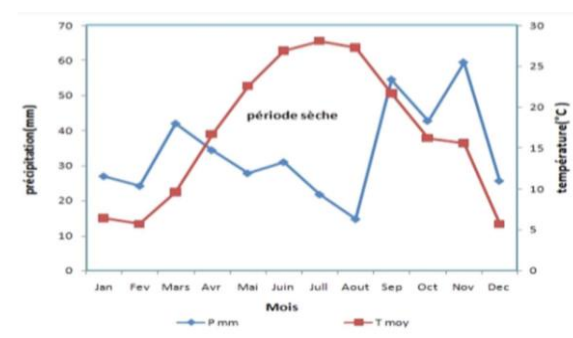


Figure 2.5 : Gaussian ombro-thermal diagram of the El Hamma region 2008-2018

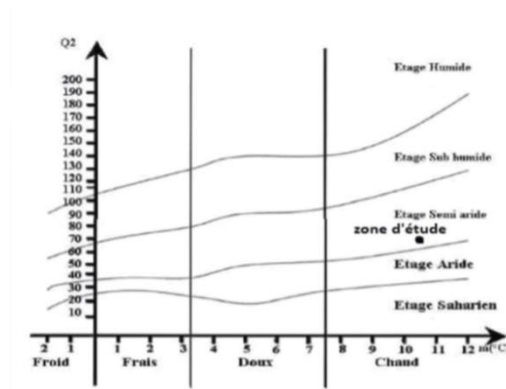


Figure 2.6 : Bioclimatic level of the wilaya of Khenchela (Achour and Zaouioui 2021).

4. Study of climatic parameters

4.1. Précipitations

The variation in rainfall across the region is largely determined by elevation and topographical features. The western part of Khenchela is classified as an arid zone, where annual precipitation ranges between 250 and 400 mm, following a north-south pattern. This classification is based on the precipitation distribution map of eastern Algeria provided by A.N.R.H (1993) (Salhi & Ounassi, 2022).

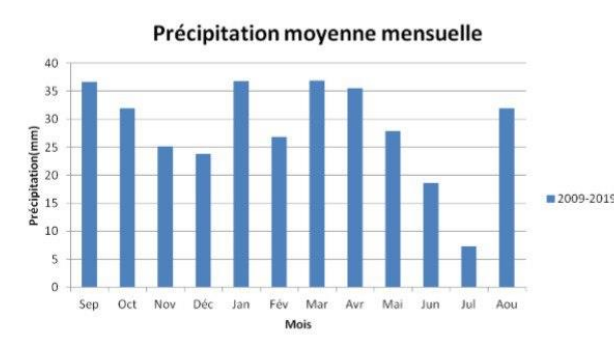


Figure 2.7 : Average monthly rainfall in Khenchela

The wettest month is March with a monthly average of 36.89 mm, while the driest month is July with a monthly average of 7.33 mm

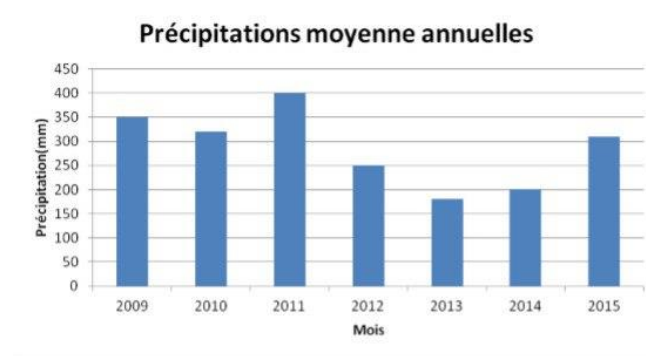


Figure 2.8 : Average annual rainfall in Khenchela

Analysis of the Figure 14 shows that the wettest year is 2011, with an annual average of 400 mm, while the driest year is with an annual average of 180 mm

4.2. Temperature

Since it regulates all metabolic phenomena and influences the distribution of all living species in the study area, temperature is a crucial limiting factor. The table below presents the average monthly temperatures over a ten-year period (2009–2019) (Salhi & Ounassi, 2022).

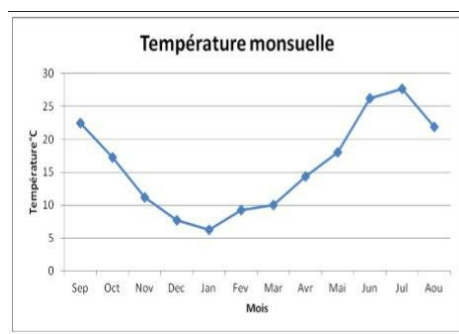


Figure 2.9: Monthly temperature variation at the El Hamma station (2009_2019)

The curve of monthly average temperature variations (figure15) shows that January is the coldest month, with an average temperature of 6.28°C, while July is the hottest month, with an average temperature of 27.62°C

CHAPTER III

Materiels and methods

1. Study Period

This study is being conducted from December 2024 to late May 2025. Three field trips are carried out each week to the designated study sites. The trips are scheduled based on weather conditions and the availability of specimens in the natural environment, usually between 11:00AM to 13:00PM.

2. Field collection equipment

During my fieldwork focused on the larval populations of *Platycnemis subdilatata*, I used various tools to ensure the proper collection, handling, and preservation of specimens, as well as to measure certain physicochemical parameters of the water. The equipment used includes:

- **Entomological net:** Used to capture larvae and adults in aquatic environments and riparian zones.
- **forceps:** For precise and gentle handling of larvae without causing damage.
- **Plastic spoon:** Useful for collecting larvae in shallow or hard-to-reach areas.
- **Plastic collection boxes:** Used for the temporary storage of specimens during fieldwork.
- **Plastic tubes (Eppendorf type):** Containing 70% alcohol for the preservation of specimens intended for laboratory analysis.
- **Field notebook:** For recording environmental conditions, habitat characteristics, location, date, and time.
- **Thermometer:** Used to measure both air and water temperature.
- **Hydrometer:** To determine the density (or possible salinity) of the water.
- **Portable pH meter:** Used to measure the pH of the water on-site.
- **Digital camera:** For visual documentation of specimens and their natural habitats.
- **Portable GPS device:** To accurately record the geographic coordinates of each sampling site.
- **Appropriate clothing and boots:** Essential for comfort and safety in wet or difficult terrain.

3. Equipment Used in the Laboratory

Once the specimens were collected in the field, various tools and equipment were used in the laboratory for their analysis and preservation. According to standard methods in

entomological research (Triplehorn & Johnson, 2005; Gullan & Cranston, 2014),. Here's what I used during this phase:

- **Optical and binocular microscope:** these microscopes allowed me to closely examine the morphological characteristics of the larvae.
- **Slides and cover slips:** I used these materials to prepare specimens for observation under the microscope.
- **Test tubes:** these were useful for performing chemical tests on small quantities of samples.
- **Falcon tubes:** for larger samples, I used these tubes for their preservation and analysis.
- **70% alcohol:** I used this solution to preserve the specimens for later analysis.
- **Preservation containers:** to store specimens in good conditions, I used containers with preservative solutions.
- **Computer with statistical software:** to analyze the data collected in the field, I used software like R or SPSS (Quinn & Keough, 2002)
- **Image processing software:** for analyzing the images of specimens and their structures, I used dedicated software.
- **Observation sheets:** these sheets helped me record all the important observations and parameters during the laboratory analysis.



Figure 3.1 : Original photo of the equipment used in the laboratory

4. Method of Study

4.1. Field Data Collection

Platycnemis subdilatata larvae develop continuously from January to May with a shift from marked asynchrony in winter to greater synchrony in spring. Khelifa et al. (2015). The study was carried out in Oued El Kissan, located in Khenchela Province, northeastern Algeria. Five distinct sampling points were selected along the stream. These points were chosen based on variations in environmental features such as water flow, vegetation density, and stream depth. Regular field visits were made throughout the study period to collect larvae and observe their developmental stages.



Figure 3.2: Personal photograph of Oued El Kissan and sampling method 2025

4.2. Identification of larval stages

To identify the various larval instars, we employed the standard method developed by Dyar, which remains a widely accepted approach for analyzing insect growth stages (Dyar, 1890; Peterson, 1962). This method is based on the measurement of head capsule width and its frequency distribution (Olamelas-López et al., 2017). We constructed a histogram of head width measurements, where the discontinuous nature of insect growth typically results in gaps between successive instars (Gaino et al., 2003). These gaps appear as areas of low frequency between distinct peaks on the histogram, each peak representing a concentration of individuals at a particular developmental stage. Such patterns provide clear indicators of transitions between larval instars (Parra & Zucchi, 2004).



Figure 3.3: Personal photo taken in the laboratory

5. Physicochemical Characteristics of the study sites

The physicochemical parameters of the natural habitat, such as water pH, turbidity, water and air temperature, and vegetation, were measured during the study to assess their influence on the development of *Platycnemis subdilatata* larvae. These measurements were carried out using specific instruments such as PH meter, thermometer and a hand net used for collecting aquatic insect samples from the study sites .

6. Analysis of Morphological traits of *Platycnemis subdilatata* in the Laboratory

In the study of larval morphological characteristics, proper sample preparation is essential to ensure the accuracy of observations. For this purpose, larvae must first be euthanized using ethanol or alcohol, which helps fix the tissues and prevents any deformation or alteration during microscopic examination (Gullan & Cranston, 2014; Triplehorn & Johnson, 2005).

After fixation, the larvae are placed on a glass slide, with a millimeter scale paper positioned beneath the slide to allow precise measurements (McAlpine, 1981). Initially, a low magnification ($\times 10$) is used to locate the larva and properly position it on the slide. This step facilitates focusing and identifying the specific part to be analyzed.

Subsequently, a higher magnification ($\times 40$) is applied with appropriate lighting to observe fine details of the larva, such as the head, antennae, abdomen, and caudal region. This level of magnification allows for accurate measurements and detailed identification of morphological features (Borror et al., 1989; Merritt & Cummins, 1996).

Finally, images were taken of the observations under the microscope to document the findings and enable further detailed analysis.



Figure 3.4: Personal photo showing how to handle *Platynemesis subdilatata* larvae in the laboratory

7. Data Processing and Analysis

- **Data Collection:** The data were grouped, classified, and entered using Microsoft Excel 2016 software.
- **Descriptive Statistics:** Descriptive statistics were used to summarize the measured parameters (means, minimums, maximums, standard deviations).
- **Statistical tests:** were applied to explore the relationships between the physico-chemical factors of the water and the larval development of *Platynemesis subdilatata*.

8. Environmental and Temporal Constraints Affecting Data Collection

- **Unstable environmental conditions:** Sudden weather changes such as rain and high temperatures affected the presence of larvae in their natural habitat.
- **Limited time:** The short sampling period limited the ability to collect and analyze a sufficient number of samples

9. Statistics

Kruskal-walis test was applied to test the difference between larval number and the sampling stations.

To identify some relationship between larval abundance and the measured environmental variable a generalized linear mixed models (GLMMs) from the glmmTMB package in R assuming a Poisson distribution for the dependent variable and station as random factor was performed (Harrison et al. 2018).

The relation between morphological trait and the selected environmental variables have been investigated using Multivariate generalised linear models (ManyGLMs) (Jupke and Schäfer 2020). Results were visualized using RDA ordination plots with the significant environmental variables influenced clustered assemblages (Oksanen et al. 2016).

CHAPTER IV

Results And Discussion

Results

1. Spatio-temporal evolution of larval Abundance

Temporally, the curve (Figure 4.1) represents the progression of the number of individuals over the course of 18 field sampling. In January, no individuals were recorded. The first appearance occurred during the mid-February with a small number of individuals. The number gradually increased during the late February and early March. It reached its first peak in the mid-April, then decreased in the late April. The number rose again in the mid-May, with two distinct peaks observed in the mid- and late-May.

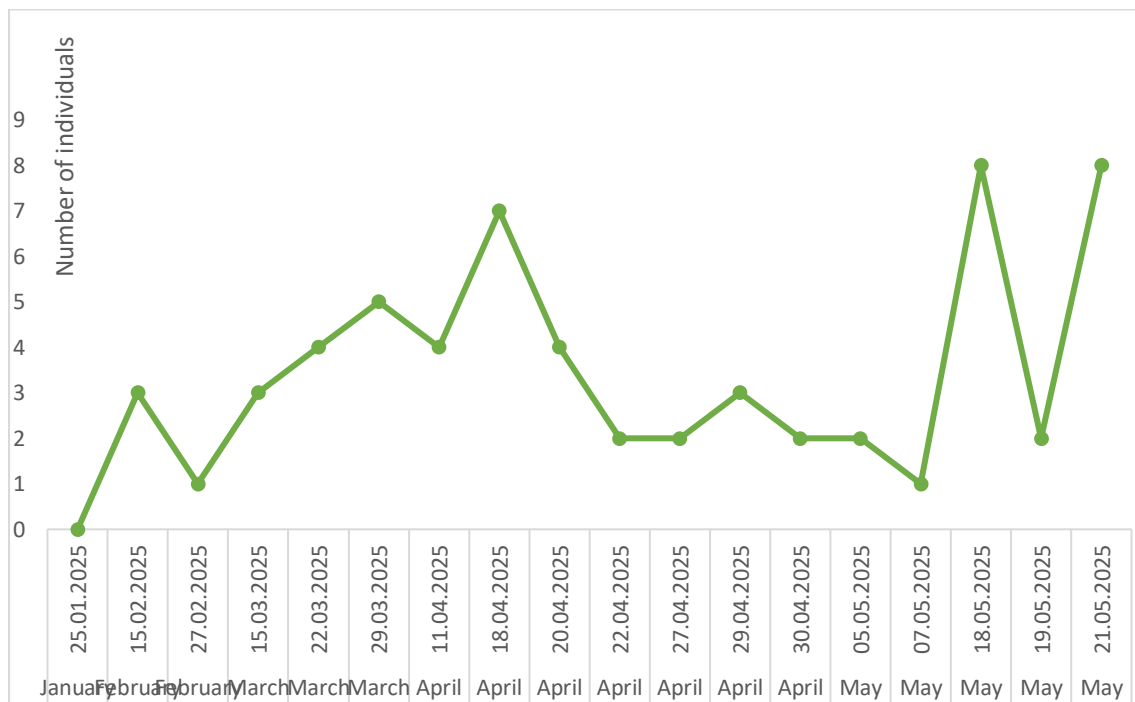


Figure 4.1: Temporal dynamics of *P. subdilatata* larval abundance in the Oued El HAMMA from January 2025 to May 2025

Spatially, There is no statistically significant difference in larval abundance among the stations ($p = 0.3248$). This means that, based on the rank distributions, the median abundance does not differ significantly between stations. Larval abundance of *Platynemesis subdilatata* does not vary significantly across the four sampling stations (Figure 4.1).

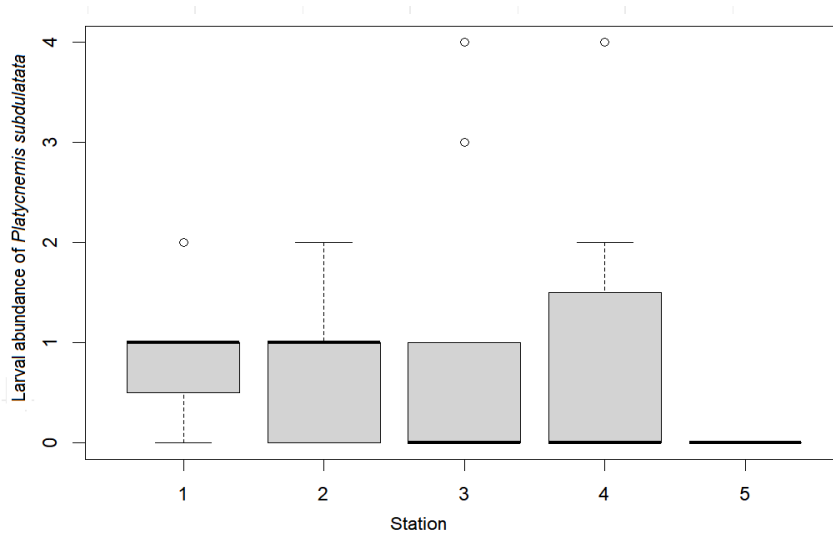


Figure 4.2: Spatial dynamics of *P. subdilatata* larval abundance in the Oued El HAMMA from January 2025 to May 2025

2. Morphological description of *P. subdilatata* larvae

Analyzing the minimum (Min), maximum (Max), and average (Moy) values of the three major parts—the head, abdomen, and caudal—across the months is essential. The following table shows the growth of *P. subdilatata* larvae. These numbers are unmistakable markers of the larvae's growth phases and the slow shifts in size over time.

Table 4.1: Morphometric data of *P. subdilatata* larvae collected from February to May 2025

		FAB	March	April	May
Head	Min	2.0	2.0	2.0	2.0
	Max	2.3	3.8	4.0	4.1
	Moy	2.13	2.79	2.79	2.92
Abdomen	Min	5.7	5.8	5.7	4.2
	Max	6.1	6.9	9.0	11.0
	Moye	5.88	5.97	6.05	7.40
Caudal	Min	2.9	3.5	3.4	3.2
	Max	3.2	5.3	7.1	10.0
	Moy	3.02	4.57	4.22	5.10

Interpretation

Head

minimum dimensions: Stay at 2.0 mm, suggesting that people at the lower size limit are growing slowly but steadily.

Maximum dimensions: Increase dramatically from 2.3 mm in February to 4.1 mm in May, indicating significant individual growth variability that may be influenced by dietary or environmental factors

A general trend of consistent and continuous growth in head size over the months is indicated by the average dimensions, which show a constant advancement from 2.13 mm in February to 2.92 mm in May

Abdomen

Minimum dimensions: Variations are noticeable, especially in May when the value falls to 4.2 mm. This decline could be the result of individual variations or a change in a specimen's developmental stage.

Maximum measurements: increase dramatically from 6.1 mm in February to 11.0 mm in May, suggesting times of fast development that may have been brought on by environmental or seasonal changes.

Average measurements: exhibit a steady increase from 5,88 mm to 7,40 mm, indicating ongoing and vigorous abdominal growth, most likely associated with enhanced energy storage or metamorphosis preparation.

Caudal

Minimum measurements: From 2.9 mm in February to 3.2 mm in May, with a discernible rise in March (3.5 mm) and a subsequent minor decline. This suggests that even the tiniest individuals are growing modestly.

Maximum dimensions: Show a noticeable rise from 3.2 mm in February to 10.0 mm in May, indicating that some individuals have grown significantly, perhaps as a result of environmental factors or developmental variance

The average dimensions show a steady but slightly erratic increase in tail length throughout time, rising from 3.02 mm in February to 5.10 mm in May, with a peak in March (4,57 mm) and a minor decline in April (4,22 mm).

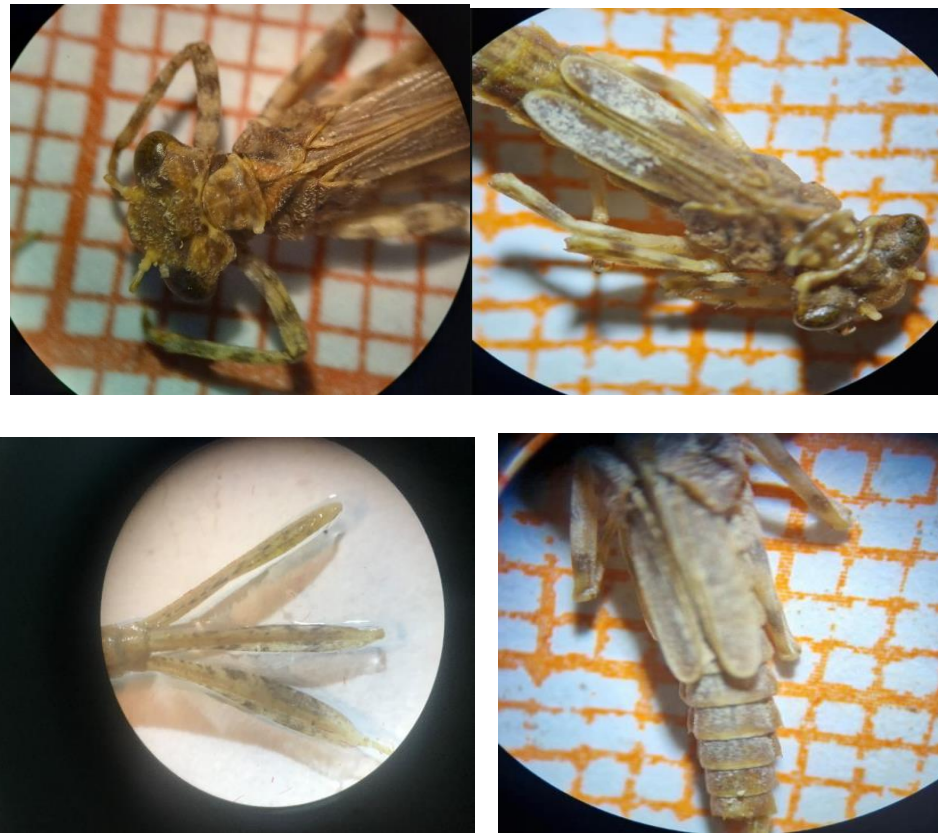


Figure 4.3: Original photos of larval characteristics observed under the magnifying lens. 2025

3. Environmental variables effect larval abundance of *P. subdilatata*

The Poisson GLMM results (Table2) indicate that larval abundance of *Platycnemis subdilatata* is significantly influenced by depth (Figure 4.4), vegetation cover, and the interaction between air temperature and vegetation (Figure 4.5). Specifically, abundance increases with depth ($p = 0.03675$) and decreases with increasing vegetation cover ($p = 0.00449$). While air temperature alone does not have a significant effect ($p = 0.90125$), its interaction with vegetation is highly significant ($p = 0.00842$), suggesting that the influence of temperature on larval abundance depends on the level of vegetation cover. The near-zero ($4.325e-10$) random effect variance for station implies that spatial differences among stations have minimal influence on abundance after accounting for the fixed effects (Table 4.2).

Table 4.2: Summary of the Poisson GLMM (abundance~Abundance ~ scale(depth) + scale(Airt) * scale(veget) + (1 |station))

Fixed effect	Estimate	Std error	P-value
Intercept	-0.14	0.13	0.31
Depth	0.29	0.14	0.03
Air temperature	0.02	0.17	0.9
Air temperature* Vegetation cover	-0.46	0.17	0.008
Random effect	Variance = 4.325e-10		

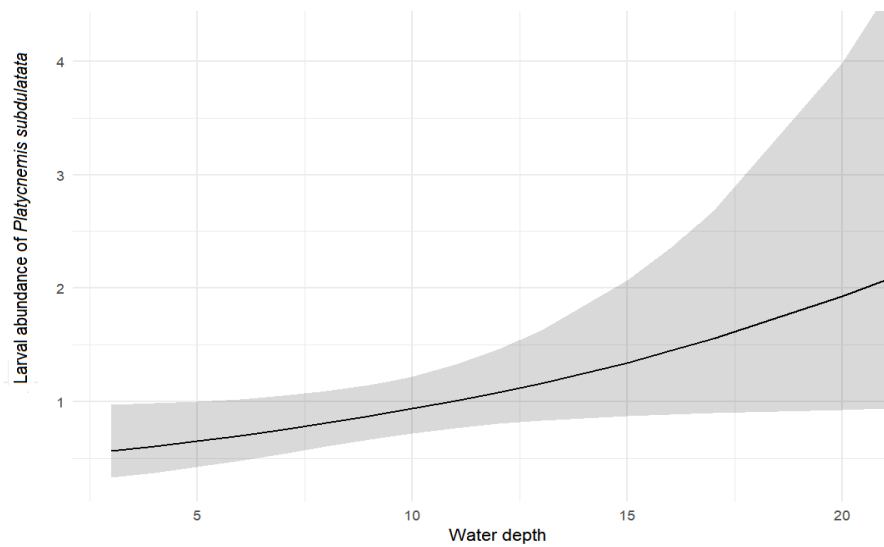


Figure 4.4: Positive signifecat relation between wter depth and larval abundance (Depth (cm))

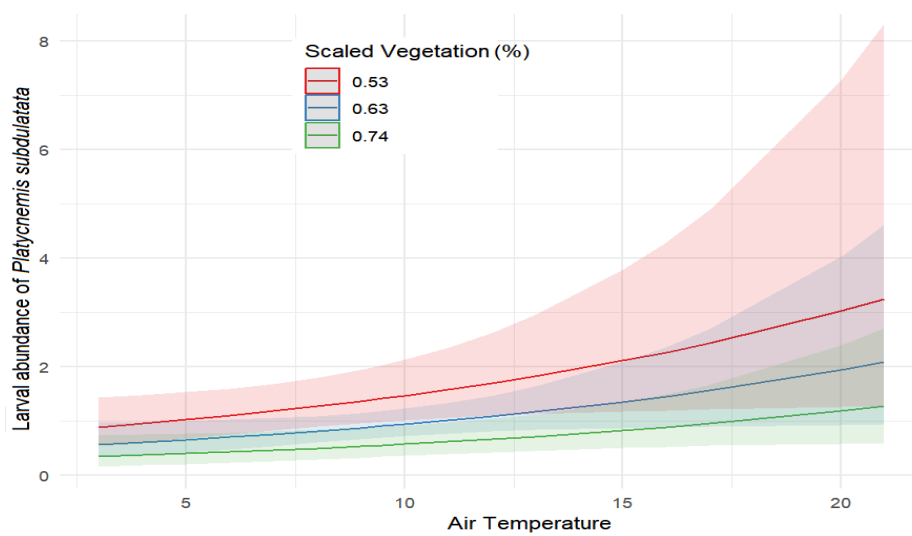


Figure 4.5: interactin effect of vegetation cover and air temperature (°C) on larval abundance of *Platynemmis subdilata*

4. Larval development of *Platynemís subdilata*

4.1. Evolutionary Aspects of Larval Stage

The histograms of head width measurements for *Platynemís subdilata* larvae from February to May 2025 illustrate a temporal shift in larval size distribution, indicating changes in developmental stages over time. May culminates the maximal number of larval instar (9 stages). Early instars were observed during February suggesting recent hatching. Multiple instars co-occurring during March reflects ongoing development. Late instars occurring in April and May pointing to accelerated growth and developmental progression. The dominance of larvae across all size classes in May suggests *P. subdilata* may exhibit asynchronous or overlapping development, possibly linked to extended breeding periods or multi-generational (multivoltine) life cycles.

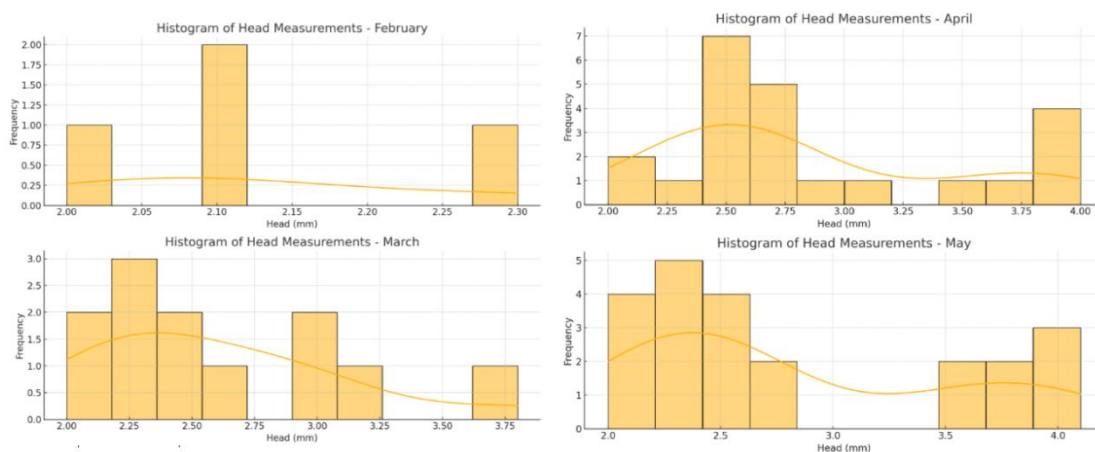


Figure 4.6: temporal frequency of larval stage of *Platynemís subdilata* from February to May 2025 based on head width measurements

4.2. Environment and larval development

The results of the multivariate linear model indicate that depth has a statistically significant effect ($F = 17.08$, $p = 0.018$) on larval morphology traits of *Platynemís subdilata*, specifically head width, antenna length, caudal filament length, and abdomen length (figure 4.7). In contrast, water temperature, vegetation cover, and pH were not significant predictors in this analysis, implying they may not strongly influence larval morphology within the studied range.

The model explains approximately 10.2% of the total variation (Hooper's $R^2 = 0.1021$), which is moderate for ecological data and highlights depth as an important environmental gradient affecting larval development. These findings suggest that larvae may

adapt morphologically to depth-related environmental conditions, possibly influencing survival or fitness as they progress through different instars.

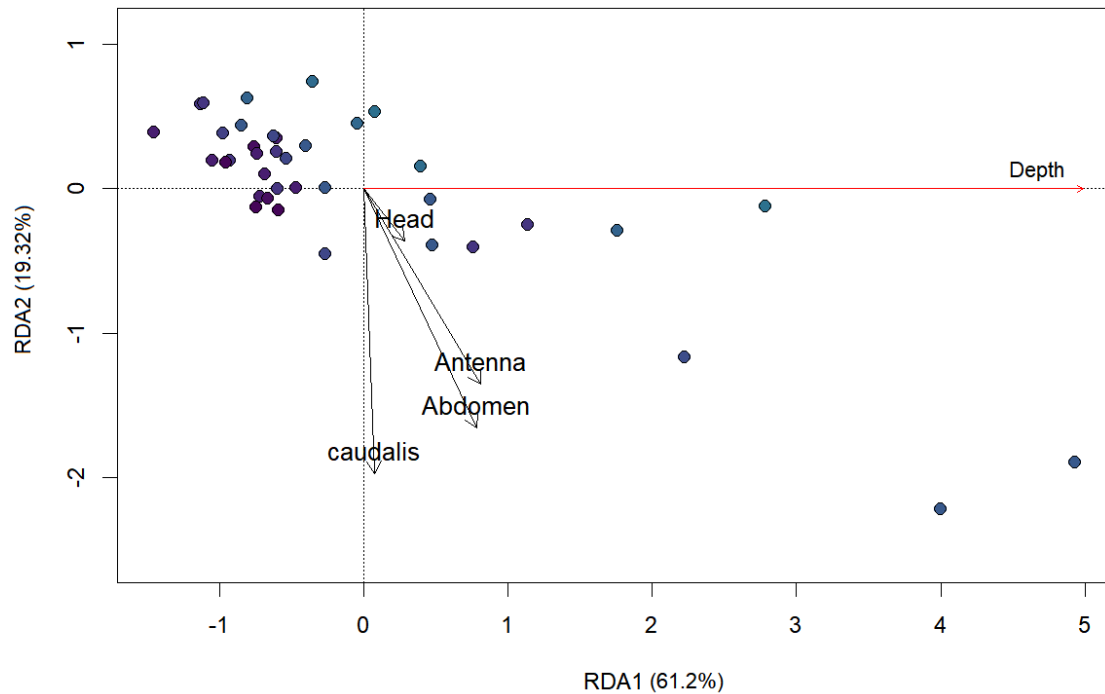


Figure 4.7: Relation between depth and morphological traits of *Platycnemis subdilatata* at Oued Elhamma, Khenchela.

Discussion

Platycnemis subdilatata – Maghreb Featherleg (*Pennipatte maghrébin*) (Selys, 1849), Endemic to north Africa (Morocco, Algeria, and Tunisia), this species is locally threatened by the overexploitation of water resources, particularly in the more arid regions (Dijkstra 2007, 2023), this is the only pale-colored damselfly (*Zygoptera*) in the Maghreb region, characterized by a broad head, a rectangular discoidal cell, and feathered legs. It closely resembles the European species *Platycnemis pennipes* in the distribution of black markings on the abdomen and legs. However, the mature male is distinguished by a whitish to pale bluish-green coloration, unlike the vivid blue seen in *P. pennipes*. Females turn white upon maturity, and the tibiae are noticeably narrower than those of the European species (Dijkstra 2007, 2023). This species shows remarkable abundance and a wide distribution across Tunisia, Algeria, and Morocco (Samraoui, 2010).

In our study, it was observed that the larvae did not appear continuously throughout the year, as they were absent during the winter months. The larvae began to emerge with the onset of rising temperatures in spring, gradually increasing in activity until reaching a peak in April and May. This contrasts with some previous studies that reported continuous larval growth even during winter (Olamelas et al., 2017), likely due to the influence of local climatic conditions, where the low winter temperatures in our region limit larval activity or cause temporary dormancy or disappearance. During the winter season, specifically in January, larvae are absent from the natural environment due to the cold weather, which creates unsuitable conditions for growth and activity. The severe cold slows down their bodily movements and temporarily halts their vital processes, as if they are taking a rest in preparation for better times. This natural pause in growth is part of the insect life cycle, which depends on warmth to resume activity (Corbet, 1999) , with the arrival of spring and rising temperatures, the larvae awaken from this dormant stage, finding themselves in a more vibrant environment rich in food, which helps them grow rapidly and increases their numbers significantly. By May, their population stabilizes as most larvae reach advanced developmental stages, and the environmental conditions balance between available resources and larval density, allowing continued growth under favorable conditions (Dommanget, 1987).

Our research on the head, abdomen, and caudal dimensions of *Platynemís subdilata* larvae revealed a slow growth and individual variation, which is unmistakably consistent with Khalifa et al. (2015)'s findings. Khalifa and colleagues found that during the study period, the minimum values of head dimensions remained stable while the maximum values increased. This suggests that the larvae grew asynchronously as a result of the influence of environmental and dietary factors. My results supported this, showing that the maximum head size rose from 2.3 mm to 4.1 mm while the minimum stayed constant at 2.0 mm. Similar to this, Khalifa et al. reported a progressive increase in abdominal dimensions with variations in the minimum and maximum values, suggesting that several developmental phases exist and that some people have progressed into more advanced stages. This is consistent with May's decrease in the minimum abdominal length and my study's noticeable increase in the maximum values. My findings, which demonstrated a notable increase in the maximum caudal length accompanied by oscillations in the mean values, are consistent with Khalifa et al.'s observation of significant variability in caudal dimensions, which reflects individual variances in growth rates. Because various sampling intervals and environmental conditions

have a direct impact on the growth rate and synchronization of developmental phases in these larvae, there are some minor discrepancies between Khalifa's work and mine.

Our results are also concordant with Corbet (1962) regarding the cessation of larval activity during the winter season due to low temperatures. During this period, larvae enter a state of biological dormancy known as diapause, characterized by a temporary halt in growth and physiological activity. Both sources indicate that this state is not a form of death but rather an adaptive environmental response that enables larvae to survive under unfavorable growth conditions. With the onset of spring and the rise in temperature, larvae rapidly resume physiological activity, taking advantage of the increased availability of food resources to promote growth and development.

In addition to the clear seasonal variation in the occurrence of *Platycnemis subdilatata* larvae, our best generalized Poisson model highlights depth as a significant predictor of larval abundance. The model results show that as depth increases, larval abundance also tends to increase, suggesting that deeper water conditions may provide more favorable habitats, possibly due to factors like stable temperatures, reduced predation, or increased food availability. While other variables such as air temperature and vegetation cover showed complex interactions, depth alone emerged as a consistently important factor influencing larval distribution. Our results indicate that depth plays a crucial environmental role in determining the distribution and growth of larvae, with a higher concentration of individuals observed at certain depths, suggesting the existence of an optimal depth for their development (Dekshenieks et al., 1997). This is attributed to the direct influence of depth on the availability of food resources, as some water layers tend to be richer in plankton, which serves as the primary food source for larvae (Fiksen & Jørgensen, 2011). Furthermore, depth provides protection against predation, as larvae tend to stay at greater depths during the day to avoid visual predators and ascend to the surface at night to feed, a behavior known as diel vertical migration (Hunter & Sanchez, 1976). This vertical distribution is not random but reflects an environmental preference for depths that balance feeding opportunities with predator avoidance, thereby enhancing survival and growth (Nature Communications, 2020). Therefore, depth is a key environmental factor influencing the spatial structure of larvae and the success of their life cycle in aquatic environments (Dekshenieks et al., 1997).

The survey of larval development and the presence of early instars in May suggest that *Platynemesis subdilatata* may exhibit bivoltinism, producing two generations per year. This life-history trait is consistent with patterns observed in other odonate species, where voltinism is influenced by latitude—with higher latitudes often favoring greater plasticity in generation number due to shorter growing seasons (Mahdjoub et al., 2015). Another key factor influencing growth rate and voltinism is habitat type. Odonates that inhabit temporary or seasonal water bodies often exhibit faster growth to complete development before desiccation (Corbet et al., 2005). This aligns with the ecology of *P. subdilatata*, which appears adapted to such habitats by maintaining a rapid life cycle and producing multiple generations annually, ensuring successful reproduction despite environmental constraints.

Concerning larval morphology, our analysis revealed a significant positive effect of water depth on four key larval traits: antenna length, head width, abdomen length, and caudal gill length. These morphological features tended to increase with greater depth, suggesting that deeper habitats may promote more developed or larger larval forms in *Platynemesis subdilatata*. This pattern may reflect ecological adaptation, where deeper environments offer more stable or resource-rich conditions that support enhanced growth. Alternatively, it may indicate depth-related differences in developmental stage or instar distribution, with more mature larvae occupying deeper zones. These findings highlight the influence of abiotic factors like depth on larval development and morphology (Corbet, 1999).

Conclusion

This study on *Platycnemis subdilatata* provided valuable insights into the environmental factors influencing its larval development within freshwater systems of northeastern Algeria. The results demonstrated that water depth and temperature are key parameters determining the presence and distribution of this species, highlighting the importance of physico-chemical characteristics in shaping aquatic communities.

Despite some field constraints, including weather conditions and limited sampling resources, the research was successfully carried out and met its main objectives. It represents an original and valuable contribution to the study of Odonata in Algeria.

Among the recommendations, it would be beneficial to diversify research approaches by exploring other species and aquatic habitats, while encouraging the use of advanced methods such as molecular analyses and long-term monitoring. Improved collaboration between ecologists, water managers, and policymakers would also strengthen the conservation and sustainable management of this still underexplored biodiversity.

Looking ahead, this study paves the way for more in-depth work, particularly within a doctoral project focused on adaptation mechanisms and ecological responses of this species to environmental pressures.

In summary, this research enriches our understanding of local aquatic biodiversity and promotes a better comprehension of freshwater ecology—both essential for the sustainable and integrated management of our natural heritage.

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