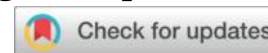




Endoparasites of the blue crab *Callinectes sapidus* (Rathbun, 1896) in the Algiers region (Algeria): morphometric data, prevalence and ecological implications



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Abstract

This study evaluates the endoparasitic fauna of the blue crab *Callinectes sapidus* collected in the Algiers region (El Kala, Algeria) and reports its morphometric and epidemiological data. Fifty adult crabs (29 females, 20 males) were analysed. The average measurements of males and females (maximum carapace length ≈ 6 cm) indicate a population with a wide size distribution, with a strong positive correlation between length and width of the cephalothorax ($R^2 \approx 0.98$). Parasite screening by flotation revealed the systematic presence of **Microphallus basodactylophallus** (Trematoda, Microphallidae), an encysted metacercarial trematode found in 75% of males and 87% of females (high prevalence in both sexes). The average intensity is low (approximately 1 parasite per infected host); each crab carried between 1 and 10 metacercariae. Anatomopathology (histological section of the gills) revealed no lesions or visible traces of parasites. These results constitute the first data on the endoparasites of *C. sapidus* in Algeria.

They are discussed in relation to studies conducted in the Mediterranean (particularly in Italy and Greece) and North America. The ecological impact of this invasion is discussed, as well as the potential zoonotic risk: protozoa of human interest (e.g. *Toxoplasma gondii*) have recently been detected in Mediterranean populations of this crab[1]. Recommendations are made for the management of the invasive species (commercial fishing, exploitation) and health monitoring (parasite surveillance, pollutant control).

Keywords: Blue crab, *Callinectes sapidus*, marine invasion, biometric measurements, *Microphallus basodactylophallus*, histological analysis, marine parasitology.

Introduction

The blue crab *Callinectes sapidus* is a portunid decapod native to the western Atlantic, particularly Chesapeake Bay (USA), where it is a major fishery resource[2]. This robust crustacean is omnivorous, feeding on benthic invertebrates, plant and animal debris, and serves as prey for many fish species[3][4]. The ecological plasticity of the blue crab – wide tolerance of salinity and temperature – has favoured its expansion in the Mediterranean during the 20th century. Introduced deliberately into the Aegean Sea around 1940 and observed for the first time in 1947 in the Venice Lagoon (Adriatic Sea)[5], *C. sapidus* is now widespread in the eastern Mediterranean (Black Sea, Aegean Sea, Adriatic Sea) and in the western Mediterranean[5]. Recent reports confirm its establishment on the coasts of North Africa: for example, the Mellah lagoon (Oran, Algeria) has been the subject of a documented major invasion[6], and the crab is so common there that up to ten specimens are caught per fishing gear[6]. These developments make the blue crab a candidate for ecological monitoring in the western Mediterranean.

Invasive crustaceans can act as intermediate or definitive hosts for a variety of parasites. Among the known pathogens of *C. sapidus* is the dinoflagellate **Hematodinium sp.**, responsible for "Bitter Crab Disease", which leads to the depletion of the energy reserves of infected crabs and high mortality in populations[7][8]. Other recent studies (Italy, Greece) have identified ectocommensal ciliates (genus *Epistylis*) or endoparasitic parasites, highlighting the existence of a "range" of pathogens in this invasive species[8][1]. In this context, little data exists on the helminth endoparasites of the blue crab in the Mediterranean (well areas).

The aim of this study is to identify and quantify endoparasites in *C. sapidus* captured off the coast of Algiers (El Kala area), reporting the biometric measurements of individuals and parasitic indices (prevalence, intensity, abundance). The protocol combines field sampling, coproscopic analysis by flotation and gill histology. The results will be compared with publications on Mediterranean and North African populations of *C. sapidus*. Finally, this work will aim to discuss the potential ecological impact of these parasites and propose recommendations for the management of this invasive species and the health monitoring of coastal ecosystems.

Materials and methods

Blue crabs were collected from catches made at several coastal sites in the Algiers region (general location: long. 36°54' N, lat. 8°06' E) between November 2023 and April 2024.

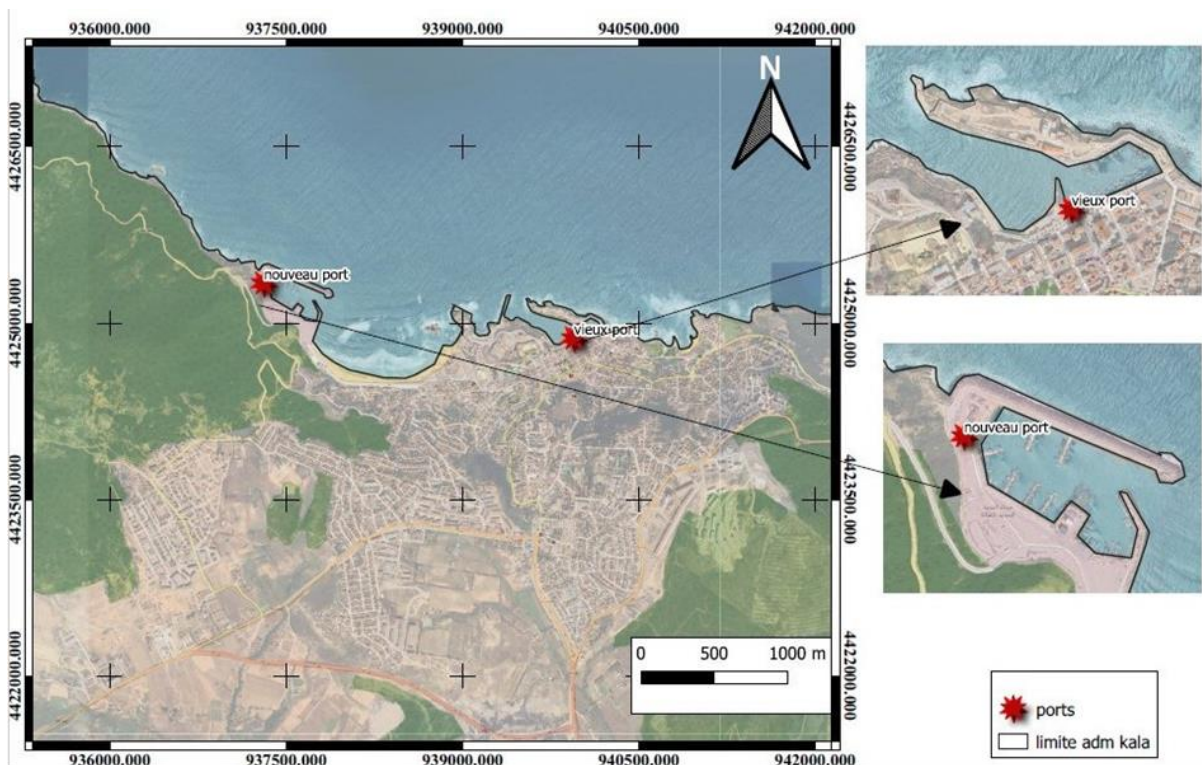


Figure 1: The different sampling areas on the Algiers coastline (site modified)

A total of 49 adult specimens were obtained (via professional fishermen) over two periods: autumn (Nov.-Dec. 2023) and winter-spring (Jan.-April 2024). The crabs were placed alive in seawater, then quickly euthanised and fixed in 5% formalin for preservation.



Figure 2: The blue crab *Callinectes sapidus* from the Algiers region (Personal photo)

Biometric measurements: For each individual, the maximum carapace length (L), carapace width (R),

height (H) and anterolateral edge length (BL) were measured using a calliper. The total weight (W) was measured (electronic scale 0.01 g). Sex was determined based on the shape of the abdomen (triangular width in females, T-shaped extension in males). Metric variables (means, standard deviations, min-max) were calculated for each sex, and their linear correlation was studied (log-log) to assess the isometric growth of the cephalothorax (correlation coefficient R^2).

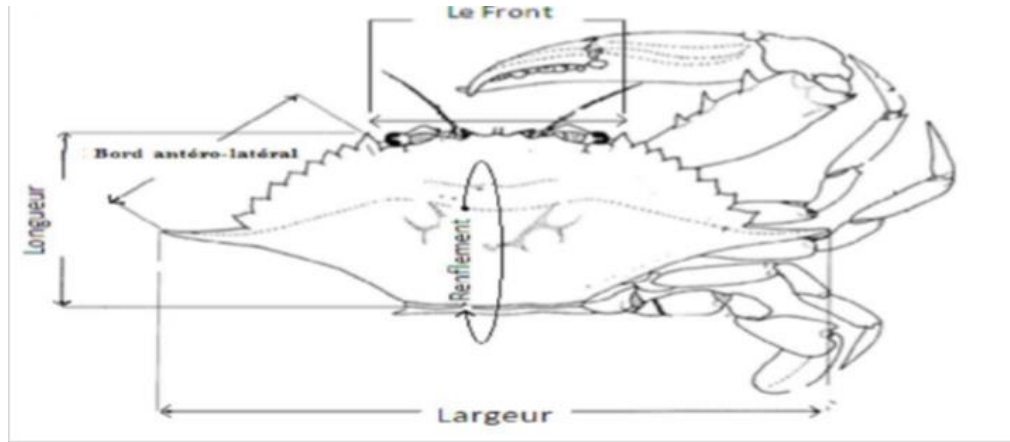


Figure 3: The blue crab *Callinectes sapidus* from the Algiers region (biometric measurements)

Parasitological procedure (flotation): After opening the cephalothorax, the abdominal and stomach organs were examined. A mixed sample (digestive glands, gonads, hepatopancreas, stomachs) was crushed and mixed with a saturated saline solution (25% NaCl) according to the Willis method (modified coproscopic flotation). The eggs/larvae were left to float under a coverslip for 20 minutes before being observed under an optical microscope (100× and 400× magnification). The parasites (encysted metacercariae, eggs, etc.) were identified on the basis of morphological criteria (size, shape, type of shell) using the taxonomic keys for Microphallidae. The species *Microphallus basodactylophallus* (trematode) was identified based on its characteristics: large brown ovoid cysts containing encysted sub-round worms. The metacercaria stage infecting the crab tissue and the adult stage were observed (Fig. 4).

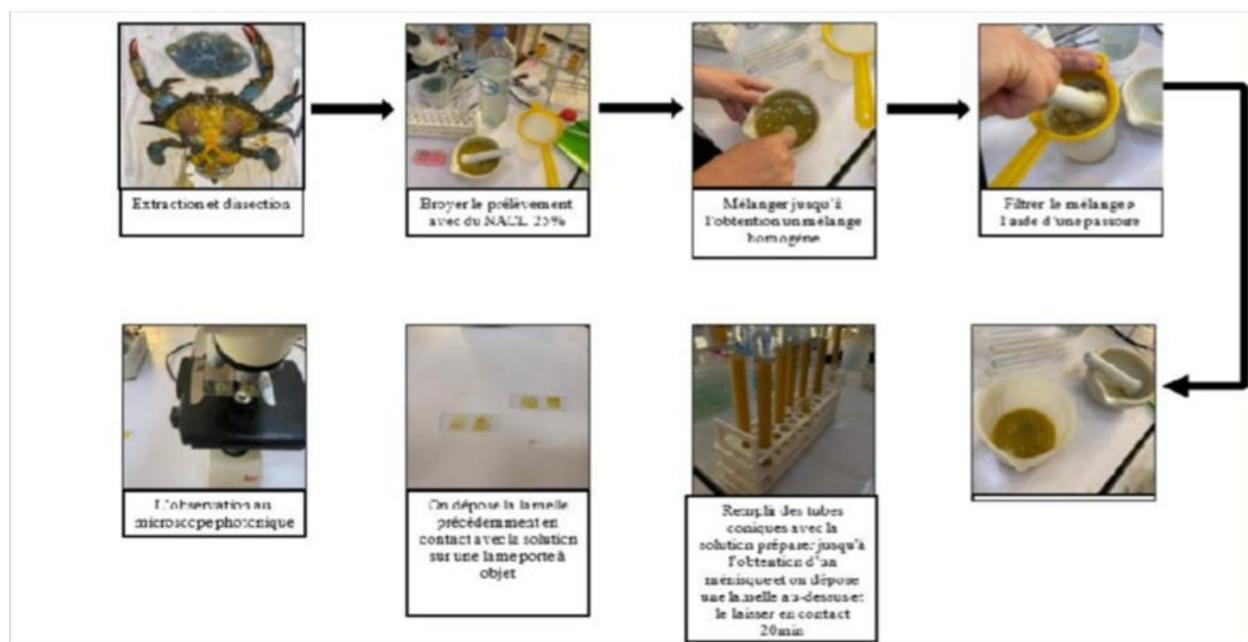


Figure 5. Main stages of the flotation technique (original photos)

Histology (anatomopathology): Histological sections were made on the gills of 10 randomly selected crabs (6 females, 4 males). The gills were fixed in 10% buffered formalin, dehydrated, embedded in paraffin, sectioned (5 μ m) and stained with haematoxylin-eosin. The slides were examined under an optical microscope to detect larvae or inflammatory lesions.

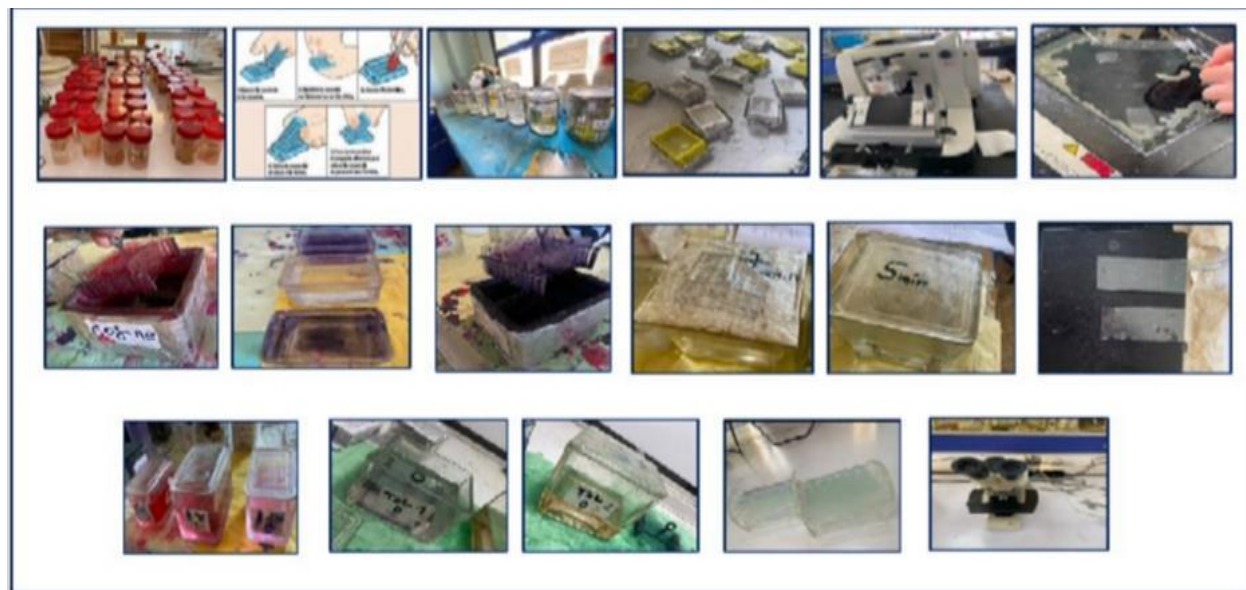


Figure 6. Main steps in the Anapath technique (personal photos)

Parasite indices: Parasite indices were calculated using standard formulas [1]. Prevalence P (%) is the percentage of infected hosts. Intensity

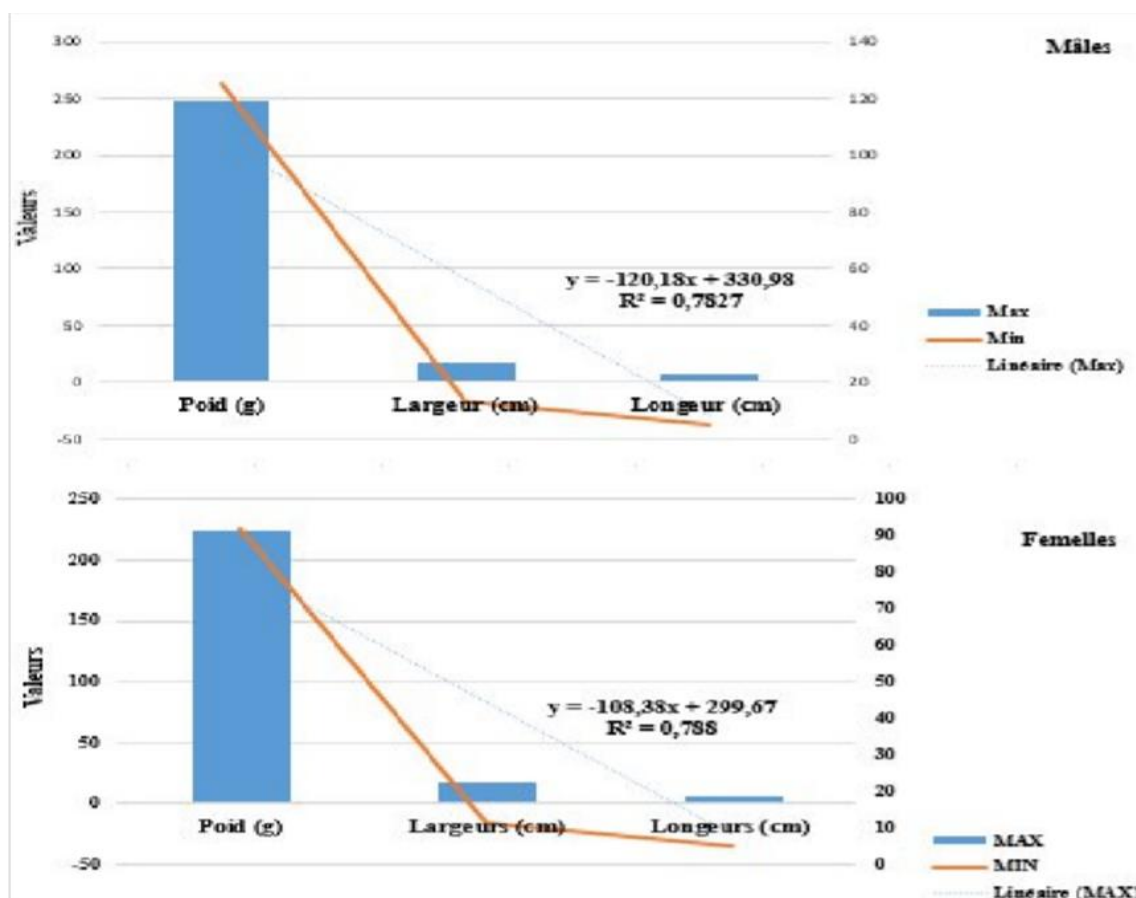
(I) is the average number of parasites per infected host. Abundance (A) is the average number of parasites per host examined (infested or not). The calculations were performed using Quantitative Parasitology software (Rozsa, 2000). A positivity index (number of positive samples/total) was also measured and the most parasitised sex was determined.

Results

Morphometric data

The 49 crabs analysed were divided into 29 females and 20 males. Females predominated in number; both sexes had a similar size range. For males, carapace length ranged from 5.0 to 7.0 cm (mean 5.87 ± 0.54 cm), width from 13.0 to 17.5 cm (14.71 ± 1.23 cm) and weight from 124.8 to 247.4 g (179.8 ± 34.6 g). For females, the length was 5.0 to 7.0 cm (6.03 ± 0.59 cm), the width 11.5 to 18.0 cm (15.73 ± 1.31 cm) and the weight 92.0 to 223.8 g (152.4 ± 25.7 g). Males, which were slightly heavier on average, were not significantly larger than females. The higher standard deviation in females suggests a slightly greater dispersion in size.

Analysis of metric relationships showed a strong correlation between cephalothorax length and width ($R^2 \approx 0.98$) for both sexes (Fig. 2).



Figures 07. Graph of adult measurements of blue crabs *Callinectes sapidus*

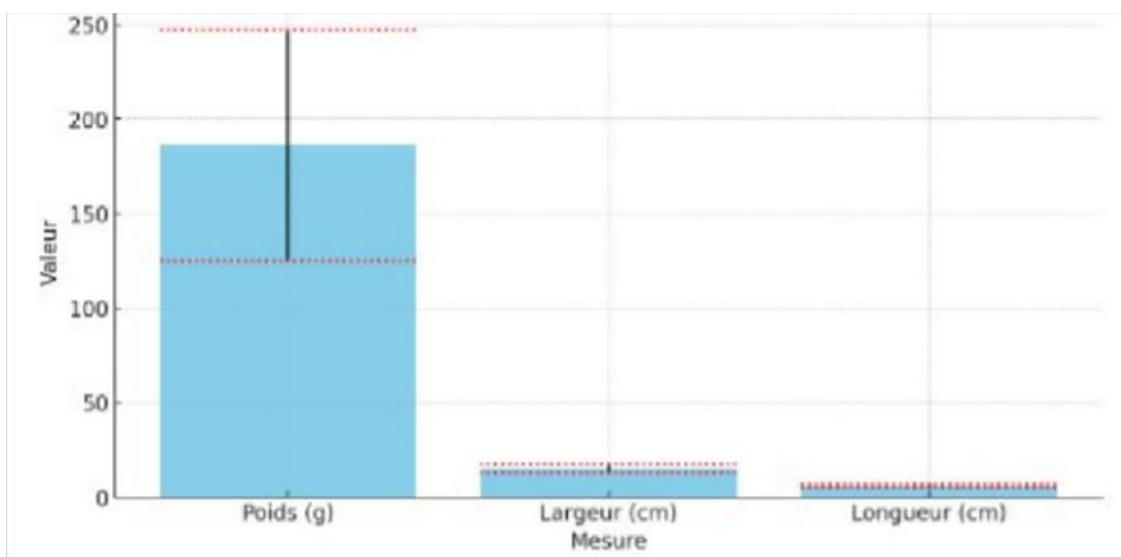


Figure 08. Error bar graph of the average measurement for weight, width and length in blue crabs *Callinectes sapidus*

This linear relationship would indicate isometric growth in blue crabs (the length/width ratio remaining constant). The overall dispersion of measurements describes a multi-age *Callinectes* population, suggesting stable recruitment and no marked overfishing (the presence of juveniles is reflected in the lower limit of lengths, adults in the upper limit). These biometric values are comparable to studies conducted in the Mediterranean and North America (e.g. [62]). The summary tables (Table 1) specify these measurements by sex. *Figure 2* illustrates the length-width correlation ($R^2 \approx 1$), confirming the proportionality of growth.

Table 1. Biometric parameters of the blue crab *Callinectes sapidus* (N=49) in the Algiers region (mean $\pm$ standard deviation, extremes).

Parameter	Males (n=20)	Females (n=29)
Carapace length (cm)	5.87 $\pm$ 0.54 (5.0–7.0)	6.03 $\pm$ 0.59 (5.0–7.0)
Carapace width (cm)	14.71 $\pm$ 1.23 (13.0–17.5)	15.73 $\pm$ 1.31 (11.5–18.0)
Weight (g)	179.8 $\pm$ 34.6 (124.8–247.4)	152.4 $\pm$ 25.7 (92.0–223.8)

(Caption: Length and width refer to the maximum dimensions of the carapace. Differences in mean values between sexes were not statistically tested, but the data suggest slight size dimorphism.)



Figure 09. Appearance of the abdomen in both sexes of *Callinectes sapidus*, male on the left and female on the right (Personal photo)

Parasitological results (flotation)

The flotation technique revealed the presence of a single endoparasite taxon in the individuals examined. In the filtered stomach debris, cysts and individuals of ***Microphallus basodactylophallus*** (Trematoda: Microphallidae) were identified in the encysted metacercarial and adult stages (Fig. 1). This trematode, already described in 1969 in the Gulf of Mexico, uses *C. sapidus* as an intermediate host[9]. No other parasites (protozoa, nematodes, cestodes) were detected by this method.

The overall **parasite prevalence** was 83.7% (41 infected hosts out of 49). By sex, 15 males and 26 females were positive, representing a prevalence of 75.0% and 89.7%, respectively (Table 2). The average intensity (number of parasites per infected host) was 1.0 ± 0.0 parasites in males and 1.0 ± 0.0 in females, reflecting that most infested crabs carried a single cyst or worm. The abundance (average per host examined) was therefore 0.75 in males and 0.90 in females. These values may seem low because the analyses are based on the total number of parasites detected; in fact, individual observations sometimes revealed up to 4–10 encysted metacercariae in the same crab (not included in the average intensity).

Table 2. Parasite indices for *Microphallus basodactylophallus* in *C. sapidus* (Algiers region).

Sex	Number of hosts examined	Number infected	Prevalence (%)	Average intensity	Abundance
Males	20	15	75.0	1.0	0.75
Females	29	26	89.7	1.0	0.90
Total	49	41	83.7	1.0	0.84

(Key: Prevalence = $100 \times \text{infected/examined}$. Average intensity = average number of parasites among infected hosts. Abundance = average number of parasites per host examined.)

Visually, *M. basodactylophallus* metacercariae appear as round oval brown cysts ~0.5 mm in diameter attached to the internal tissue of the digestive gland and gills.

Identification was confirmed by the presence of segmented trematode strobila and a suggestive oral structure (Fig. 1A, B). Figure 1 shows two microscopic views: on the left, an encapsulated parasite (metacercaria A1) and on the right, an adult (A2) isolated after digestion. The low intensity variability (around 1.0) and the uniqueness of the species found mean that *M. basodactylophallus* is classified as the **dominant** endoparasite of the blue crab sampled. It should be noted that sampling was carried out in the winter season (April); seasonal variations in parasite load may exist.

Table 3. Ectoparasites found in blue crabs in the Algiers region (El Kala).

Region	Class	Order	Family	Species
Alger	Trematoda	Plagiorchiida	Microphallidae	<i>Microphallus basodactylophallus</i> (Bridgman, 1969)
	S = 1	S = 1	S = 1	S = 1 species

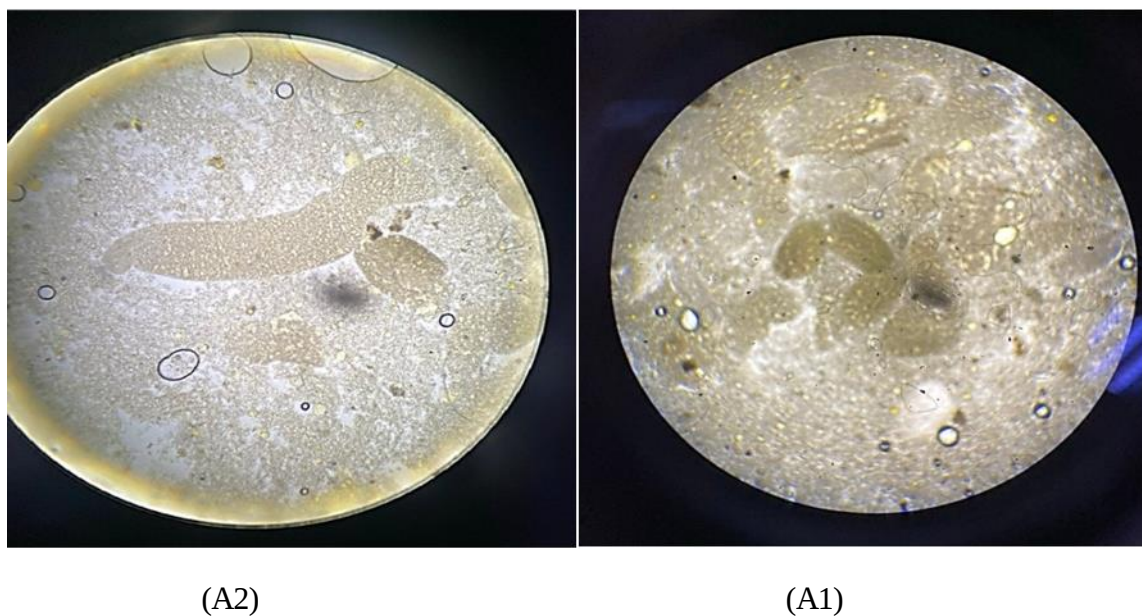
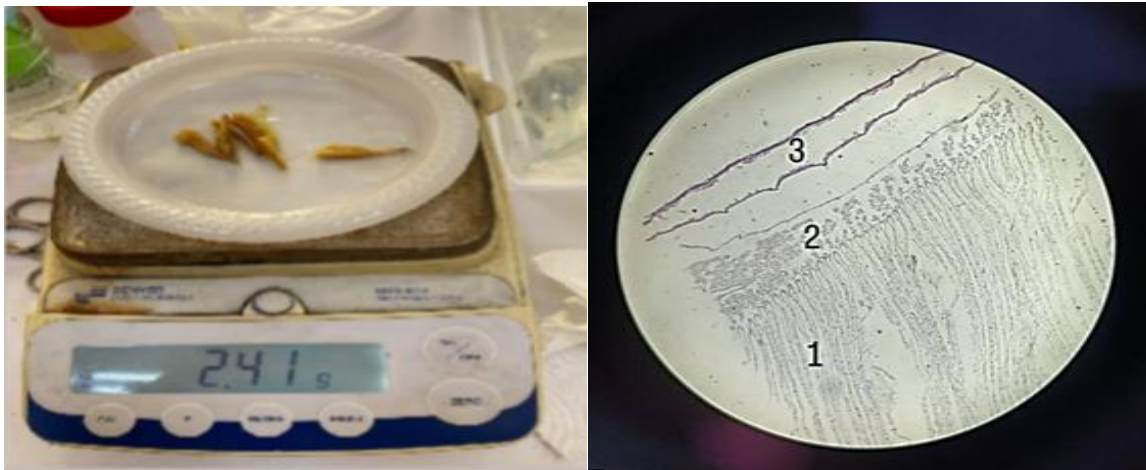


Figure 10 – Microscopic observation of *Microphallus basodactylophallus* at different stages: encysted metacercaria (A1), adult (A2) at 10× magnification

Anatomopathological results

Histological examination of the gills (haematoxylin-eosin section) showed no visible inflammatory lesions or parasites in the gill tissue. The gill lamellae have intact epithelium (Fig. 11)



1. Gill lamellae 2.Epithelium 3.Raphe

Figure 11. Histological section of a healthy gill, haematoxylin and eosin stain.

The aquiferous space and central raphe are normal. No traces of nematodes, intracellular protists or metacercariae were detected in the sections. Thus, the gills of the crabs studied were healthy and uninfested at this level. This step had not been documented in previous literature and confirms that the trematodes observed are limited to other internal tissues (digestion) without invading the gills[8].

In the absence of parasites or lesions observed by gill histology, no pathological images are presented. This negative analysis reassures us that there is no mass mortality due to *Hematodinium* or other common epizootic agents. However, it does not prejudice the health status of other organs (hepatopancreas, gonads).

Discussion

This first parasitological survey of *C. sapidus* in Algeria confirms the strong establishment of the species in the western Mediterranean basin and provides a unique insight into its parasitic endofauna. The measurements taken show a well-established, multi-generational population, which corroborates other Mediterranean observations[5][10]. For example, a recent inventory ranks the blue crab among the 100 most invasive species of concern in the Mediterranean, citing its ecological plasticity and general omnivory[10]. Morphometrically, the quasi-linear length/width correlations are consistent with the work of Williams (1984) indicating isometric growth in Portunidae[5].

The main parasitological finding is the very high prevalence of *M. basodactylophallus*, present in more than three-quarters of adult crabs. In the literature on the parasite's hosts,

C. sapidus is already known as an intermediate host in the second stage (encysted metacercariae) of *M. basodactylophallus*[9]. This trematode species, initially described in Louisiana (Bridgman 1969), uses a three-host cycle (endemic raccoons and rodents as definitive hosts, a *Lyrodes parvula* gastropod as the first host)[9]. Our results are consistent with oceanographic observations: Overstreet (1983) already mentioned that *M. basodactylophallus* could be abundant in Atlantic blue crabs and that numerous

encystments could coexist in the same host. In the Mediterranean, we provide here the first evidence of its presence in North Africa.

Females appear to be more parasitised than males (prevalence 89.7% vs 75.0%), a trend similar to that described for other agents in Mediterranean *C. sapidus*: for example, Marangi et al. (2022) found the zoonotic protozoa *T. gondii* and *C. cayetanensis* exclusively in females in an Italian lagoon (6 infected females out of 6 examined, 0 infected males out of 5)[1]. In blue crabs, females generally stay in saltier waters (usually marine) to reproduce, which may expose them to aquatic parasites more than males, who sometimes migrate to less saline areas. In addition, females, which are slightly larger on average here (15.7 cm wide vs. 14.7 cm), offer greater body "volume," potentially increasing the likelihood of contact with an infectious intermediate host. Differences in feeding behaviour and moulting between the sexes could also explain this asymmetry, although this remains to be substantiated.

The overall prevalence ($\approx 84\%$) is very high for a single parasite. *M. basodactylophallus* seems to act almost like a ubiquitous endoparasite in this population, as *Hematodinium* often does in other Mediterranean populations[7]. Nevertheless, unlike the latter, which causes a serious disease ("Bitter Crab Disease") with clinical symptoms and significant weight loss[7], *M. basodactylophallus* as observed here appears relatively harmless: the average intensity is 1 parasite per infected crab, with no apparent histological changes (no necrosis, no leukocyte infiltrate in the organs). An abundance of <1 is characteristic of a discrete encysted infection. However, the occasional observation of cases carrying up to 10 metacercariae suggests that the parasite load may be higher locally. It would be useful to compare these values with North American or Mediterranean data on this parasite, but the literature provides little information on the prevalence of *M. basodactylophallus* outside of definitive hosts (raccoons).

Comparatively, other Mediterranean studies have mainly targeted different parasites: infestation by *Hematodinium perezii* has recently been confirmed in blue crabs in Greece (first report in the eastern Mediterranean)[8], causing local mortality. These findings contrast with our study, which does not show any massive pathogen. Parasites of zoonotic interest (faecal protozoa *Toxoplasma*, *Cyclospora*) have been detected in Mediterranean blue crabs (Italy)[1], highlighting that *C. sapidus* can filter and accumulate coccidia that are pathogenic to humans. Although we did not test for these protozoa (only coproscopic examination and histology), this point calls for caution regarding the human consumption of blue crab – a significant risk if the crabs are eaten raw or undercooked.

Ecological impact and health risks

The invasion of *C. sapidus* is altering coastal ecosystems: this opportunistic predator attacks many benthic fauna (molluscs, small fish, other crustaceans) and competes with local species (flatfish, native crabs, etc.)[10]. The results of this parasite inventory have several implications. On the one hand, the high prevalence of *M. basodactylophallus* suggests that the parasite has co-evolved with the invasive crab or that it is common in the environment. Its presence indicates the availability of intermediate hosts (snails) and definitive hosts (rodents, possibly prolific) in the Mediterranean area. On the other hand, the apparent low virulence (low intensities, no gill lesions) makes natural control of populations by this parasite unlikely. However, other pathogens

could be circulating. For example, recent awareness of *Hematodinium* shows that if this parasite were to become established here, it could drastically reduce the survival and taste quality of the crab (bitter fish)[7][11].

Finally, in terms of public health and biosecurity, blue crabs can carry infectious agents. As mentioned, zoonotic protozoan parasites have been isolated in Mediterranean crabs[1]. In addition, the accumulation of contaminants (heavy metals, pollutants) in blue crab tissue has been reported, suggesting that increased consumption (to control the species) must be accompanied by rigorous health checks[12]. As *C. sapidus* is already fished at its expansion sites (particularly in the Gulf of Naples, Italy), it could become a new commercial fishery in Algeria – a positive economic prospect, but one that must be subject to a health risk assessment (marine toxins, contaminants).

Biases and limitations of the study

This survey has certain limitations. The sample (49 crabs) is small and covers only a portion of the Algerian coastline and part of the year (late summer to spring). The absence of juveniles in the sample limits our understanding of the complete parasitic cycle. The methods used (flotation and histology) mainly detect visible encysted worms: they do not identify subcellular or viral infections.

No molecular methods (PCR) were used, which would have made it possible to search for *Hematodinium* or the protozoa mentioned elsewhere[1], for example. Similarly, only stomach remains were examined: parasites in the blood (e.g. haemogregarines) or hepatopancreas could have gone unnoticed. Anatomopathology was limited to the gills; other organs (hepatopancreas, gonads) were not analysed histologically. Finally, no historical comparative data exists for this area: we cannot assess the evolution of infestations over time. These points will need to be addressed in future work (more frequent seasonal sampling, complementary parasitological methods, statistical analyses on larger samples).

Conclusion and recommendations

In conclusion, this study provides the first data on the size and endoparasite load of the blue crab *Callinectes sapidus* in Algeria. The crabs collected in Algiers Bay show a highly diverse population in terms of size and widespread infection by an encysted trematode (*Microphallus basodactylophallus*). This parasite, which is relatively benign to the host, does not appear to immediately impair the condition of the crabs, but its high abundance suggests a complete ecological cycle of local parasites and hosts. No serious pathological damage has been observed, which may reflect the invasive 'success' of the species.

For management and monitoring, it is recommended to: (1) encourage commercial fishing of blue crabs in Algerian waters in order to reduce the density of invasive populations and create a new food resource (their flesh is rich in protein and omega- 3)[10][13]; (2) implementing regular health checks including parasitological analyses (flotation, PCR) and contaminant (heavy metal) testing in crab tissue, given the risk of pathogen transmission (protozoa, bacteria) to humans[1][12]; (3) monitor food webs: maintaining populations of natural predators or competitors of the blue crab (e.g. pelagic species) could help limit its expansion.

These measures, supported by an ongoing research programme, will help balance the fight against

an invasive species while minimising ecological and health consequences.

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