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Health Condition of *Sparus aurata* (Linnaeus, 1758) Fish in Ain El-Ghazala Lagoon, eastern Libya

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Abstract:
The first thorough baseline for the health status of *Sparus aurata* in the ecologically crucial Ain El-Ghazala lagoon in eastern Libya is established by this study. Hematological markers and morphometric indicators (Fulton's condition factor, hepatosomatic index) were examined periodically during a one-year period. The findings showed a distinct yearly physiological cycle, with springtime marking the pinnacle of bodily condition and energy stores. Hematological stress markers, such as leukocytosis and decreased erythrocyte indices, were seen in conjunction with a marked deterioration in somatic and hepatic conditions during the summer. These results show a vulnerable time throughout the summer, which is probably caused by reproductive cycles and environmental stressors. In order to manage this crucial fish supply sustainably, this study emphasizes the need for focused conservation efforts and the need for additional research to link these physiological changes to certain environmental factors.

Keywords: Sparus aurata, Fish Health Condition, Ain El-Ghazala Lagoon, Seasonal Variation, Hematological Stress, Condition Indices.

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الحالة الصحية لسمك الجاجوج (*Sparus aurata*, Linnaeus 1758) في خليج عين الغزالة، شرق ليبيا

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الملخص:

هذه الدراسة هي المرجع الأساسي الأول لتقييم الحالة الصحية لسمك الجاجوج (*Sparus aurata*) في خليج عين الغزالة ذات الأهمية البيئية في شرق ليبيا. تم على مدار عام تحليل المؤشرات المورفومترية (مثل معامل فولتون للحالة ومؤشر حالة الكبد) والمعايير الدموية بشكل موسمي. كشفت النتائج عن وجود دورة فسيولوجية سنوية واضحة، حيث سُجلت ذروة الحالة الجسدية ومخزون الطاقة خلال فصل الربيع. بينما لوحظ تراجع ملحوظ في الحالة الجسدية والكبدية خلال فصل الصيف، رافقه مؤشرات دموية على الإجهاد الفسيولوجي، تتمثل في ارتفاع عدد كريات الدم البيضاء وانخفاض مؤشرات كريات الدم الحمراء. تُظهر هذه النتائج وجود فترة ضعف خلال الصيف، يُرجح أن تكون ناتجة عن الضغوط البيئية والدورات التناسلية. تؤكد هذه الدراسة على ضرورة وضع استراتيجيات مستهدفة، وتسلط الضوء على الحاجة لأبحاث مستقبلية لربط هذه التغيرات الفسيولوجية بمتغيرات بيئية محددة من أجل الإدارة المستدامة لهذا المخزون السمكي الهام.

الكلمات المفتاحية: سمكة الجاجوج، الحالة الصحية للسمكة، خليج عين الغزالة، التغيرات الموسمية، الإجهاد الدموي، مؤشرات الحالة.

Introduction:

In our Mediterranean waters, the Gilthead Sea bream, scientifically known as *Sparus aurata*, is more than simply a typical fish. Actually, it's one of the most profitable species for fish farms around the Libyan coast as well as local fisherman. Because of its exceptional flavor, it is widely valued by people and is therefore an important species for the fishing industry. However, we've begun to see some concerning indicators in recent years. Human activity and environmental changes are putting increasing strain on the habitats

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of these fish. Actually, according to some research, their populations are in danger in some places (FAO, 2020). For unique habitats like the Ain El-Ghazala lagoon here in eastern Libya, this is especially worrisome. For many marine species, including our prized Gilthead Sea bream, this lagoon serves as an essential nursery and feeding ground. These lagoon habitats are very productive, but they are also very sensitive. They are particularly susceptible to issues like habitat degradation and pollution. This implies that we may learn a lot about the general health of the lagoon ecosystem from the condition of the fish that call it home (El-Barasi *et al.*, 2013). Examining fish health involves more than just looking for visible illnesses. We must investigate their physiological state in greater detail. Their blood parameters, stress hormone levels, and other bodily condition indices are among the items we are discussing. These precautions serve as early warning systems, alerting us long before any outward symptoms of illness appear to indicate that the fish are under stress from their surroundings (Barton, 2002). The primary problem we are now facing is that, in spite of the Gilthead Sea bream's significance to our local economy and the Ain El-Ghazala lagoon's ecological value, we have very little hard data regarding the true health status of these fish in this particular area. Addressing this substantial knowledge gap is essential, particularly if we wish to effectively manage our marine resources (Shakman *et al.*, 2019). We carried out this investigation for just that reason. We set out to conduct a thorough health evaluation of the Gilthead Sea bream population in the Ain El-Ghazala lagoon, something that has never been thoroughly examined before. Our primary objectives were simple: In order to establish baseline health standards for this specific population, we wanted to measure important health indicators in these fish, such as their blood work and physical condition. More importantly, we wanted to know how the fish are adjusting to their current environmental circumstances (Martinez-Alvarez *et al.*, 2005). The knowledge gained from this study should be useful in directing conservation initiatives in the future and ensuring the sustainability of this significant fishing resource in our area.

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Materials and Methods:

1- Study Area and Sampling

About 60 kilometers east of Benghazi, along Libya's northeastern Mediterranean coast, lies the Ain El-Ghazala Lagoon (32°55'N, 22°10'E), which covers an area of about 50 km² of shallow coastal habitat (Figure 1). One of the biggest lagoons in North Africa, it has a distinct brackish water habitat due to the combination of freshwater and saltwater supplies. Three preset stations that represented different levels of human impact and habitat types inside the lagoon-for example, close to a suspected source of influence, a central open water area, and a more remote zone-were used for sampling.

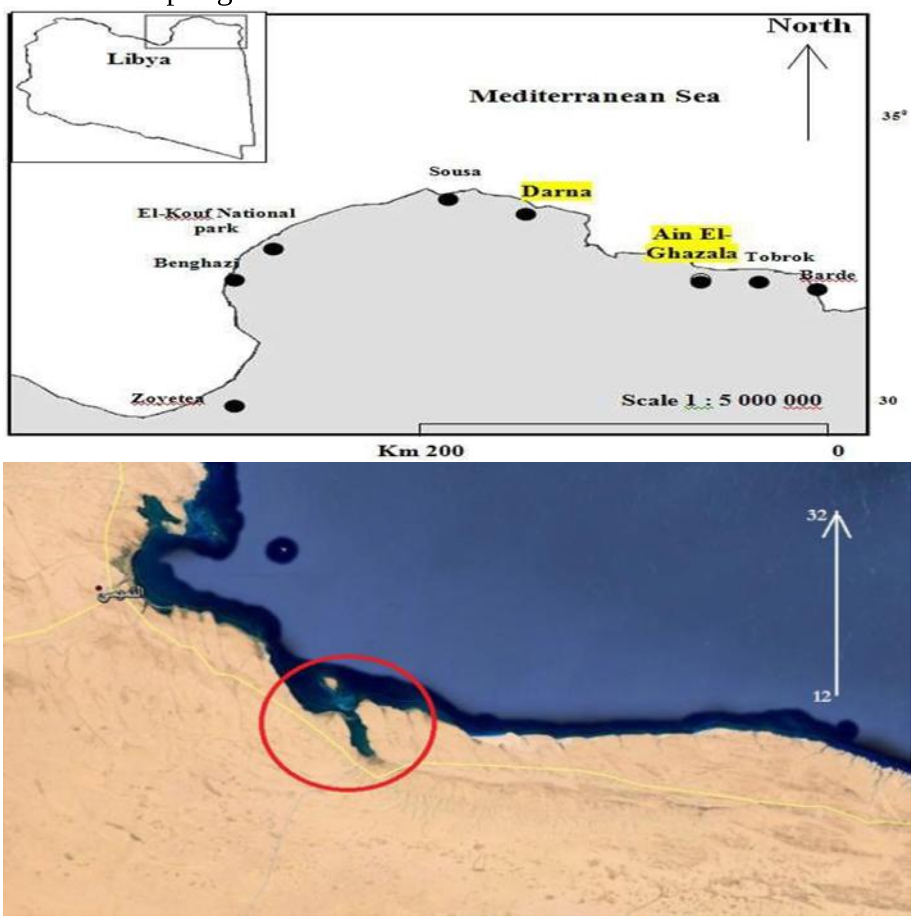

Figure 1: Illustrated Ain El-Ghazala Lagoon in eastern of Libyan coast.

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2- Sample Collection

120 mature *Sparus aurata* individuals, weighing between 180 and 300 g and with a total length of 20 to 30 cm, were gathered periodically over the course of a year (January to December 2023) and appeared to be in good health. Using gill nets, fish were gathered in cooperation with regional artisanal fishermen. Within two hours of their catch, live fish were taken to the marine biology lab at Omar Al-Mukhtar University's Faculty of Science in aerated, insulated tanks filled with lagoon water for processing.

3- Laboratory Analyses

All laboratory work was carried out at Omar Al-Mukhtar University's Faculty of Science, namely in the Departments of Marine Biology and Chemistry.

3. 1. Morphometric Analysis and Condition Indices

For each specimen, the following were measured:

Using a measuring ruler, the Standard Length (SL) and Total Length (TL) of each specimen were recorded to the nearest 0.1 cm.

Total Body Weight (TW) and Gutted Weight (GW) to the nearest 0.1 g using a digital balance.

The following condition indices were calculated:

Fulton's Condition Factor (K): $K = (TW / TL^3) \times 100$ (Froese, 2006).

Hepatosomatic Index (HSI): $HSI = (\text{Liver Weight} / TW) \times 100$ (Lambert and Dutil, 1997).

3. 2. Hematological Analysis (Hrubec and Smith, 2019).

Blood was drawn from the caudal vein of each fish using a sterile 3 mL syringe rinsed with an anticoagulant (EDTA).

Hemoglobin (Hb): Concentration was determined using the cyanmethemoglobin method at a wavelength of 540 nm using a spectrophotometer (Shimadzu UV-1800).

Hematocrit (Hct): Microhematocrit capillary tubes were filled with blood and centrifuged at 12,000 rpm for 5 minutes. The packed cell volume was expressed as a percentage.

Blood Smears: Smears were prepared, air-dried, fixed with methanol, and stained with Giemsa stain for differential leukocyte (white blood cell) count under a light microscope (Olympus CX23).

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4. Data Analysis

SPSS software (Version 26) was used to statistically analyze all of the data. For every parameter, descriptive statistics (mean ± standard deviation) were computed. To check for significant seasonal fluctuations in the observed parameters, a one way analysis of variance (ANOVA) was employed. If necessary, a post-hoc test (Tukey's HSD) was then performed. To investigate the connections between various physiological markers, a Pearson correlation analysis was conducted. A significant threshold of $p < 0.05$ was established.

Results:

The seasonal fluctuation in *Sparus aurata* morphometric characteristics and condition indices is shown in table 1. The specimens' total weights varied from 220±25 g to 255±30 g, while their total lengths varied from 24.5±1.2 cm in the winter to 25.8±1.5 cm in the spring. There were minor seasonal variations in both metrics, with springtime exhibiting the greatest mean values. Seasonal variations were evident in Fulton's Condition Factor (K), which ranged from 1.48±0.09 in summer time to 1.61±0.07 in the spring. Summertime had the lowest K value, which was substantially different ($p<0.05$) from the other seasons. This suggests that somatic condition was lower during the warmer months. On the other hand, the spring's greatest K value indicates better feeding conditions and energy storage, which may be connected to pre-spawning activity.

Similar to the condition factor, the Hepatosomatic Index (HSI) fluctuated between 1.35±0.14 in the summer and 1.68±0.12 in the spring. A decrease in hepatic energy stores is suggested by the significant ($p<0.05$) drop in HSI during the summer, which is probably caused by higher metabolic demands or a shortage of food. Increased liver activity and nutrient buildup before the reproductive season are reflected in elevated HSI readings in the spring. Fulton's condition factor (K) and total length have a quadratic relationship, as shown in figure 2, suggesting that smaller and medium-sized people often have slightly higher condition values than bigger people. The hepatosomatic index (HSI) and total length exhibit a similar polynomial relationship in figure 3, suggesting that liver development and energy storage are somewhat size-dependent.

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Additionally, figure 4 shows that both K and HSI show distinct seasonal cycles, peaking in the spring and sharply dropping in the summer before partially rebounding in the fall. All things considered, these findings imply that Sparus aurata undergoes significant seasonal physiological changes that are impacted by environmental factors and reproductive cycles, with spring serving as the time of peak health and energy storage.

Table 1: Seasonal Variation in Morphometric Parameters and Condition Indices of Sparus aurata (Mean ± SD)

Season	No.	Total Length (cm)	Total Weight (g)	Fulton's Condition Factor (K)	Hepatosomatic Index (HSI)
Winter	**30**	24.5 ± 1.2	220 ± 25	1.52 ± 0.08	1.45 ± 0.15
Spring	**30**	25.8 ± 1.5	255 ± 30	1.61 ± 0.07	1.68 ± 0.12
Summer	**30**	24.9 ± 1.3	230 ± 28	1.48 ± 0.09*	1.35 ± 0.14*
Autumn	**30**	25.2 ± 1.4	245 ± 32	1.58 ± 0.06	1.60 ± 0.11

*Significantly different from other seasons ($p < 0.05$).

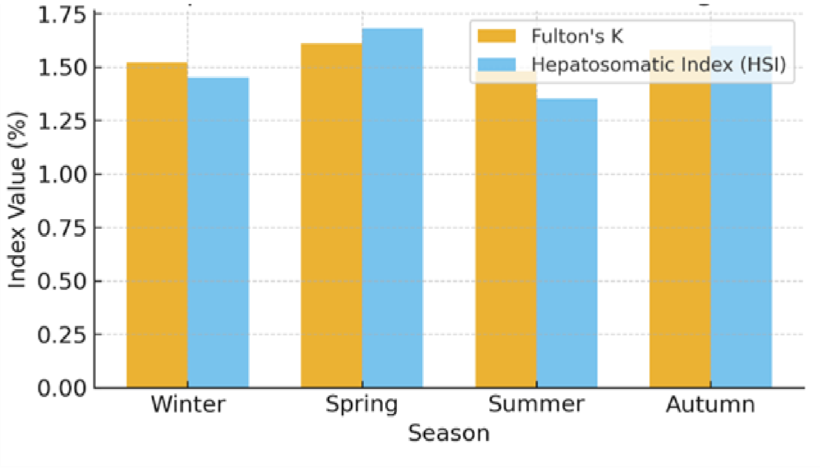

Figure 2: Polynomial curve showing the relationship between Total Length and Fulton's Condition Factor (K) of *Sparus aurata*

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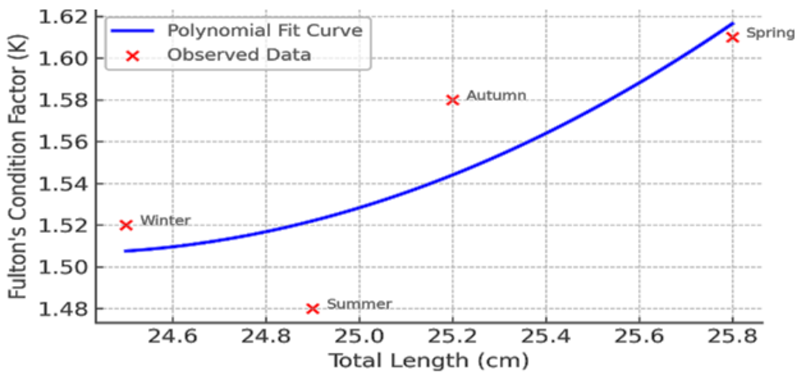

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Figure 3: Polynomial curve showing the relationship between Total Length and Hepatosomatic Index (HSI) of Sparus aurata.

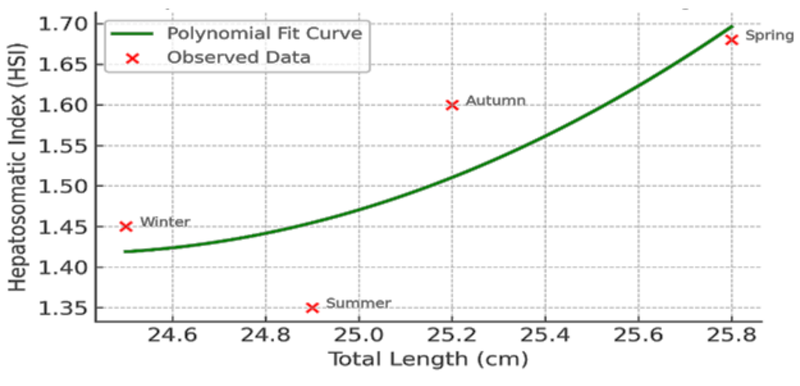

Figure 4: Seasonal variation in Fulton's Condition Factor (K) and Hepatosomatic Index (HSI) of Sparus aurata.

Significant seasonal variations in *Sparus aurata's* hematological parameters were observed throughout the year, reflecting physiological adaptations to environmental changes (Table 2). Springtime saw the highest levels of hemoglobin (Hb) and hematocrit (Hct) (9.2±0.5 g/dL and 35.8±2.5 %, respectively), suggesting increased erythropoietic activity and oxygen-carrying capacity, which may be related to ideal temperature, elevated metabolic rate, and better feeding conditions (Figures 5 and 6). On the other hand, summertime Hb and Hct values were the lowest (7.8±0.7 g/dL and 29.3±3.1 %), indicating a substantial decrease ($p<0.05$). This could be because of thermal stress, decreased

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dissolved oxygen levels, or hemodilution from hotter water. The total leukocyte count (TLC), which peaked in the summer ($96.8\pm7.2\times10^3/\mu L$) with a significant difference ($p<0.05$), demonstrated the opposite pattern, indicating an immunological response to high temperatures brought on by stress and potential exposure to pathogens (Figure 7). Stable physiological circumstances and lower levels of stress are indicated by the lower TLC values in the spring and fall (78.4 ± 5.8 and $82.1\pm6.1\times10^3/\mu L$, respectively). The species' ability to adjust to environmental variability is generally demonstrated by these seasonal hematological changes, with blood parameters acting as sensitive markers of physiological state and environmental stress in *Sparus aurata*.

Table 2: Seasonal Hematological Parameters of *Sparus aurata* (Mean ± SD)

Season	No.	Hemoglobin (g/dL)	Hematocrit (%)	Total Leukocyte Count ($\times10^3/\mu L$)
Winter	**30**	8.5 ± 0.6	32.5 ± 2.8	85.2 ± 6.5
Spring	**30**	9.2 ± 0.5	35.8 ± 2.5	78.4 ± 5.8
Summer	**30**	7.8 ± 0.7*	29.3 ± 3.1*	96.8 ± 7.2*
Autumn	**30**	8.9 ± 0.6	33.6 ± 2.7	82.1 ± 6.1

*Significantly different from other seasons ($p < 0.05$)

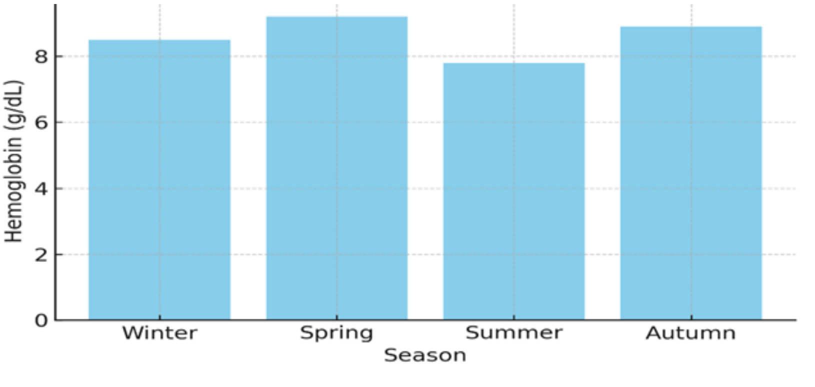

Figure 5: Seasonal variation in Hemoglobin (g/dL) of *Sparus aurata*.

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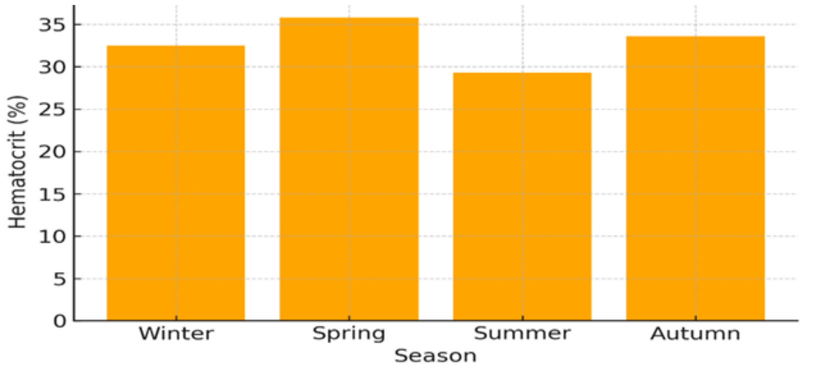

Figure 6: Seasonal variation in Hematocrit (%) of *Sparus aurata*.

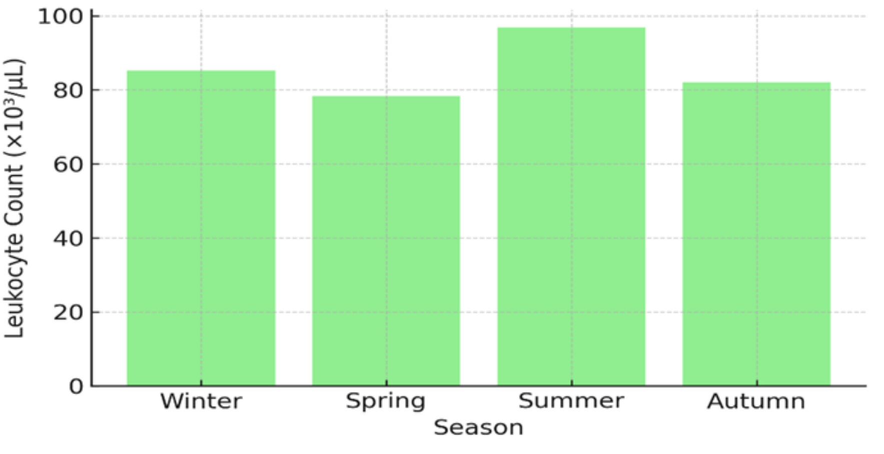

Figure 7: Seasonal variation in Total Leukocyte Count (×10³/µL) of *Sparus aurata*.

Discussion:

This study offers the first thorough evaluation of the health of a natural population of *Sparus aurata* in eastern Libya's Ain El-Ghazala lagoon. The findings unequivocally show that this economically important species' physiological state and hematological profile are significantly influenced by the seasons, most likely as a result of a mix of environmental stressors and reproductive cycles. Our results complement existing knowledge of gilthead sea bream physiology while also providing a novel viewpoint. The Hepatosomatic Index (HSI) and Fulton's Condition Factor (K) show seasonal trends that align with *S. aurata's* known life history. The species' natural pre-spawning period in the

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Mediterranean, which normally lasts from late winter to spring, aligns with the springtime high values (K=1.61, HSI=1.68; Basaglia, 2007). In order to support gametogenesis and spawning migrations, fish aggressively build up energy stores in the form of hepatic lipids and proteins during this time (Suarez *et al.*, 2015). According to our research, the Ain El-Ghazala lagoon supports this time of high energetic demand by acting as a vital feeding and nursery ground. There are several reasons for the notable drop in K and HSI throughout the summer (K=1.48, HSI=1.35). First, somatic and hepatic reserves are depleted due to the energetic cost of spawning itself. Second, the shallow lagoon habitat's high summer water temperatures raise metabolic rates, which speeds up the use of energy reserves (Martinez-Alvarez *et al.*, 2005). Teleost fishes have a well-documented condition deterioration after spawning (Lambert and Dutil, 1997). Nonetheless, the drop's extent in our study is quite noticeable. Although other Mediterranean populations have shown comparable patterns (Arends *et al.*, 1999), the particular values from Ain El-Ghazala might be the result of local stresses like greater temperature swings or variations in food availability in the brackish ecosystem of the lagoon as opposed to open-sea settings. A very sensitive biomarker of the fish's physiological condition is the hematological data. An optimal physiological state is indicated by the spring peak in hematocrit (Hct: 35.8 %) and hemoglobin (Hb: 9.2 g/dL). Under ideal spring conditions, elevated hemoglobin concentration and erythrocyte counts promote the increased metabolic and locomotor activities linked to spawning and feeding by improving the blood's ability to deliver oxygen (Barton, 2002). On the other hand, the notable drop in these indices throughout the summer (Hb: 7.8 g/dL; Hct: 29.3 %) definitely points to physiological stress. While higher metabolic rates in warmer, perhaps hypoxic environments might raise oxygen demand, which strangely corresponds with a decreased oxygen-carrying capacity, thermal stress can cause hemodilution. The work of Martínez-Alvarez *et al.* (2005), who observed that abiotic stresses such high temperatures might interfere with fish osmoregulatory and hematological functioning, directly supports this finding. The Total Leukocyte Count (TLC) significantly increased in the summer ($96.8\times10^3/\mu L$), which is the strongest indication of stress in our study. When fish are exposed to a range of stressors, such as heat

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shock, pollution, and bacterial or parasite diseases, their major nonspecific immunological response is leukocytosis (Hrubec and Smith, 2019). A strong, multi-parameter indication that the summer months are a time of major physiological strain for S. aurata in the Ain El-Ghazala lagoon is provided by the co-occurrence of poor condition indices, depressed erythrocyte indices, and elevated TLC.

Conclusion:

In Ain El-Ghazala Lagoon, this study offers the first baseline evaluation of important health markers for *Sparus aurata*. The findings show a distinct seasonal physiological cycle, with springtime marking the top of body condition and energy reserves, followed by summertime hematological stress and a decline in somatic and hepatic conditions. These patterns are consistent with previous research on the physiology of stress in fish. A time of ecological fragility is indicated by the observed summer stress response, which is characterized by leukocytosis and decreased erythrocyte indices. This cyclical stress phase should therefore be taken into account for the lagoon's effective management and conservation. In order to pinpoint the primary stresses and promote sustainable management of the lagoon ecosystem, future studies should relate these physiological reactions to environmental elements including temperature, oxygen, and pollution.

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