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First record of *Ferosagitta galerita* (Dallot, 1971) [Chaetognatha] in the Mediterranean Sea

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The first record of Ferosagitta galerita in the Mediterranean Chaetognatha fauna is reported. The morphological and ecological features of this species, which was hitherto only known to live near Madagascar in the Indian Ocean, are given in detail. With this new finding, the number of chaetognath species to be known in the Mediterranean Sea is increased.

INTRODUCTION

Although these are members of a small phylum consisting of slightly more than a hundred species, chaetognaths are among important components of all marine ecosystems. They are abundant in various marine habitats, from open seas to benthic zones of the oceans, from polar to tropical regions and at all depths (Casanova, 1999).

In spite of their small sizes, ranging between 2 and 120 mm, these carnivorous animals play an important role in the food chain. They are secondary consumers in zooplankton communities. In addition, chaetognaths were proved to be good "indicators" for specific water masses (Kehayias, 2004).

Furnestin (Furnestin, 1979) and Kehayias *et al.* (Kehayias *et al.*, 1999) recorded 20 species from the Mediterranean, mentioning *Aidanosagitta neglecta* as a Lessepsian migrant from the Red Sea. In the previous studies (Besiktepe and Unsal, 2000; Ismen, 2000; Yilmaz, 2002; Mutlu, 2005; Ustun, 2005), a total of seven chaetognath species were identified in Turkish seas, and all of these were observed to be in Iskenderun Bay. In this study, *Ferosagitta galerita*, which has an original distribution near Madagascar, is reported for the first time in the Eastern Mediterranean Sea. With this new finding, the number of chaetognath species to be known in the Mediterranean Sea is increased.

METHOD

Iskenderun Bay (Fig. 1) is located in the north-eastern corner of the Levantine Sea. It has a length of ~65 km and a width of ~35 km giving surface area of ~2275 km^2. Maximum depth is 100 m. Iskenderun Bay is influenced by the winds associated with the passage of storm system over Mediterranean, as well as local and regional winds. Ceyhan is the major river discharging into Iskenderun Bay (Iyiduvar, 1986), but eutrophication does not occur. The sea surface temperature varies from nearly 16°C in February–March to 29°C in August. The salinity reaches a maximum of 39–39.4. The general circulation characteristics of the bay are affected by the prevailing currents in the open sea (Yılmaz *et al.*, 1992).

The specimens of the study were previously obtained during a survey of zooplankton diversity conducted off the coast Iskenderun Bay (Fig. 1) near the Iskenderun Iron and Steel Factory Cooling Water Drainage Canal (36°11.2′N, 36°43.1′E) from January to November 2003. A UNESCO WP2 model standard zooplankton net with a mesh size of 200 μm and a diameter of 57 cm was used in this study. The samples were collected vertically and horizontally from the sampling stations shown in Fig. 1, seasonally. In Station 1 (N 36°47′25″, E 36°21′17″), the samples were collected with only horizontal tows. Depths of vertical sampling

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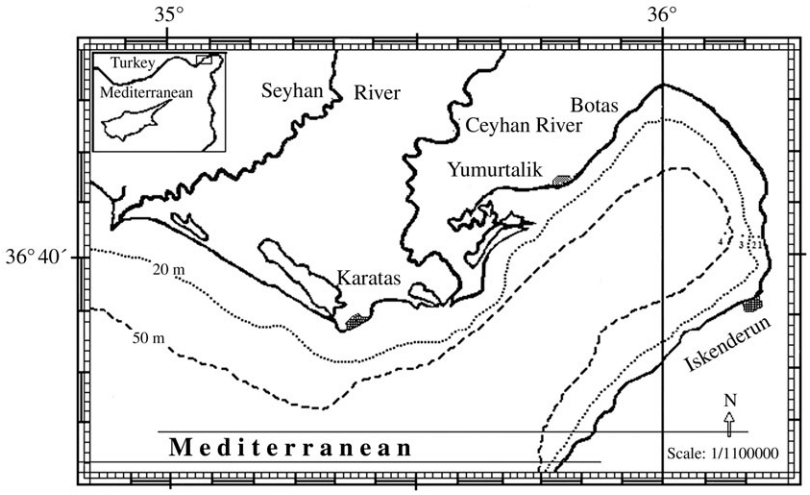


Fig. 1. Iskenderun Bay.

were 5 m (Station 2, N 36°43′36″, E 36°12′52″), 10 m (Station 3, N 36°47′09″, E 36°11′59″) and 50 m (Station 4, N 36°49′53″, E 36°18′39″). A total of 24 samples were taken. Sea surface temperature, salinity and Secchi depth measurements were taken during the sampling. Samples were fixed in 4% formaldehyde for further investigations.

The subsequent laboratory examination of the samples and detailed morphological analysis showed conclusively that specimens of *F. galerita* were present in the region. Classification of identified species was examined according to Bieri (Bieri, 1991). Specimens have been deposited in the Department of Marine Biology (Cukurova University) and are still available for examination.

RESULTS

Eight chaetognath species were identified in the region: *Flaccisagitta enflata, Mesosagitta minima, Parasagitta friderici, Parasagitta tenuis, Sagitta bipunctata, Pseudosagitta lyra, Serratosagitta serratodentata* and *F. galerita. Ferosagitta galerita* was not known to be in any other waters except Madagascar before this study. Abundance (n m^{-3}) of all these eight species is shown in Table I.

Order: Chaetognatha
Family: Sagittidae (Claus and Groben, 1905)
Genus: Ferosagitta (Kassatkina, 1971)
Ferosagitta galerita (Dallot, 1971)

It has two pairs of lateral fins without a fin bridge (Fig. 2). Anterior fins are of medium length and begin at the posterior edge of the ventral ganglion. Posterior fins were situated on both the trunk and caudal part with approximately two-third of their length on the caudal part. The body is semi-opaque and rigid.

Large eyes show a T-shaped pigment spot (Figs 3 and 4). A gut diverticulum (Fig. 5) and a short collarette are present (Fig. 6). The ovaries are long, reaching up to the neck and, the ova are relatively big and situated in one row (Fig. 7). The seminal vesicle consists of a trunk, a knob (Figs 8 and 9), and touches both the lateral

Table I: Seasonal abundance (n m^{-3}) of chaetognath species in studied area

	Winter		Spring		Summer		Autumn	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
F. enflata	0.005	3.294	0.008	28.235	0	1.1	0.09	4.418
M. minima	0	0.366	0	0	0	0	0.096	2.51
P. tenuis	0.002	0	0.028	0.392	0.003	0.314	0.003	0
P. friderici	0.005	0	0.117	0.392	0.003	1.1	0.005	0.523
S. bipunctata	0.002	0	0.004	0	0	0	0	0
S. serratodentata	0	0.654	0	0	0	0	0	0.261
P. lyra	0	0	0	0	0	0	0	0.002
F. galerita	0	0	0.002	0	0.002	0	0.696	13.595
Immature	0.03	2.2	0.09	2.94	0.008	2.2	0.229	7.634

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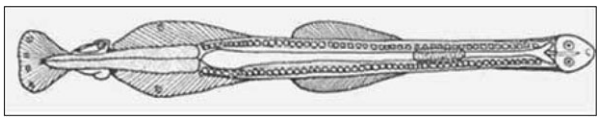


Fig. 2. *Ferosagitta galerita*, whole animal, dorsal view (Dallot, 1971).

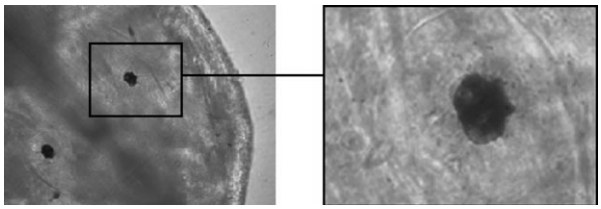


Fig. 3. Appearance of T-shaped pigment spot of *F. galerita* (original).



Fig. 4. T-shaped pigment spot of eye (Dallot, 1971).

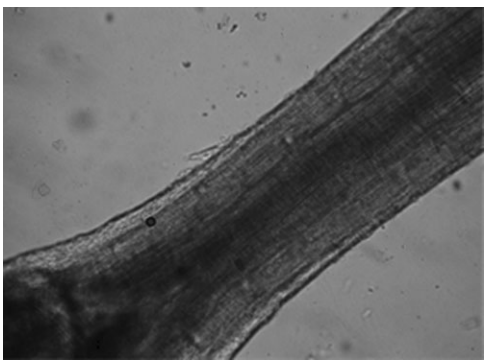


Fig. 5. *Ferosagitta galerita*, presence of gut diverticula (original).

posterior fins and the caudal fin (Fig. 10). Also little triangular epidermal protuberance at the level II are observed (Figs 11 and 12). The number of hooks extends from 6 (Fig. 13) to 7 (Fig. 14) with smooth edges (Fig. 15). The number of anterior teeth is 5–10, and the number of posterior teeth is 6–18. Mature body length is 9.7–12 mm. The length of the caudal part/length of body vary between 26 and 30%. The length of anterior fins/length of posterior fins is between 74 and 96%. The length of the part of posterior fins in trunk/length of the part of posterior fins in caudal is between 42 and 55%.

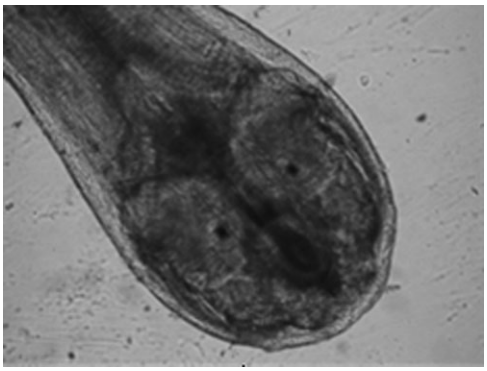


Fig. 6. *Ferosagitta galerita*, presence of collarette (Original)

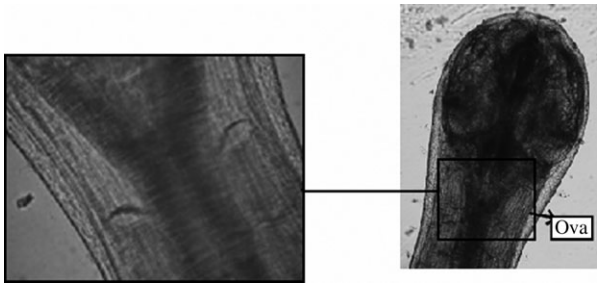


Fig. 7. *Ferosagitta galerita*, appearance of ovarium reaching to neck part (original).

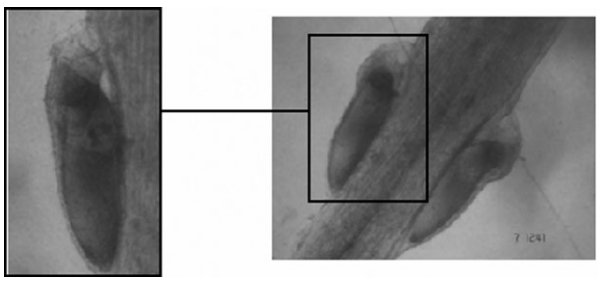


Fig. 8. Shape of seminal vesicles of *F. galerita* (original).



Fig. 9. Seminal vesicle of *F. galerita* (Dallot, 1974).

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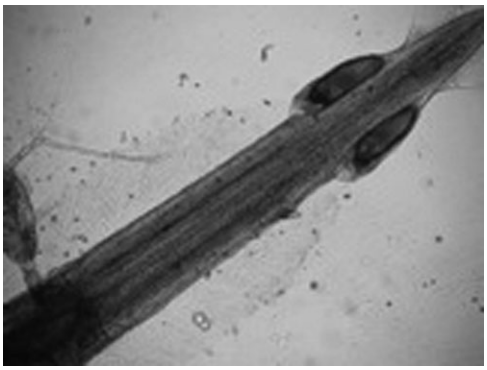


Fig. 10. Seminal vesicles touching both the posterior fins and caudal fin (original).

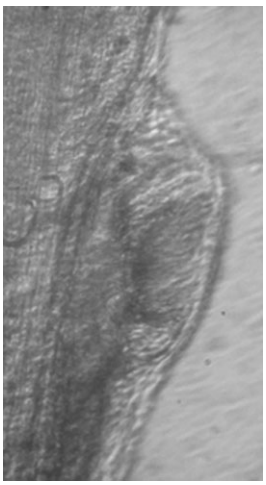


Fig. 11. Triangular epidermal protuberance at the level II (original).



Fig. 12. Triangular epidermal protuberance at the level II (Dallot, 1971).

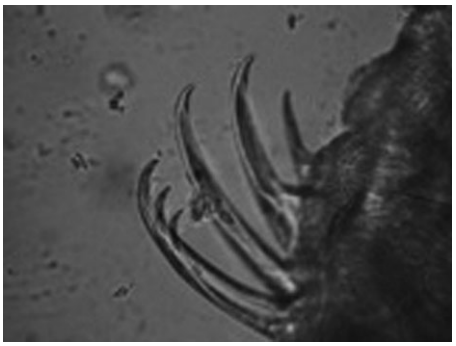


Fig. 13. Number of hooks is 6 (original).

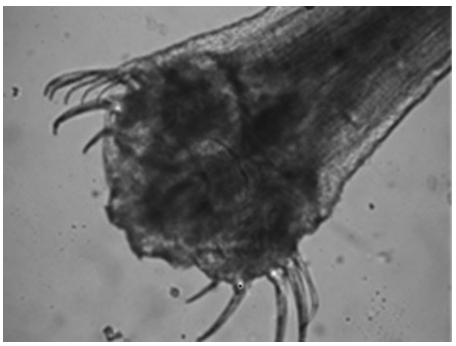


Fig. 14. Number of hooks is 7 (original).

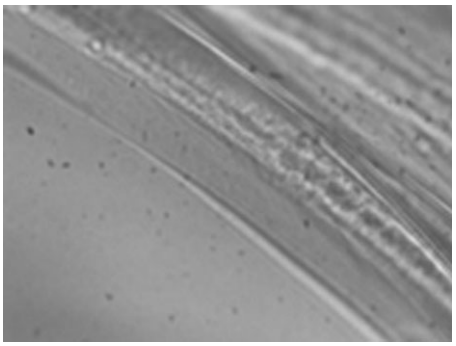


Fig. 15. Smooth edges of inner part of hooks (original).

Found in seasons: Spring (Station 4), summer (Station 4) and November (Stations 3 and 4).

Ecological values of the stations where *F. galerita* found: Temperature, 21, 2−32, 5°C; salinity, 34.4−36.1.

The specimens obtained from horizontal tows, with the exception of Station 3. In this station, these were obtained from vertical tows and horizontal tows. Different maturity stages of this species were seen simultaneously in November, when the abundance of this species was at the highest, which is a good indication to show that it reproduces in Bay (Table II).

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Table II: Relative density (%) of maturity stages of F. galerita

	Stage			
Season	Juvenile	Stage 1	Stage 2	Stage 3
Winter	—	—	—	—
Spring	—	100	—	—
Summer	—	100	—	—
Autumn	5	45	19	31

DISCUSSION

F. galerita has some common morphological characteristics with *A. neglecta*, another chaetognath species found in Mediterranean Sea and known to migrate from Indian Ocean. But with some other morphological characteristics, both species are clearly seen to be two different ones: both species have two pair of lateral fins without rayless zone. Anterior fins start at the posterior edge of ventral ganglion. Posterior fins are mostly located on the caudal, nearly two-thirds of their total length, and the rest on the trunk. Both species have relatively large eyes. *Ferosagitta galerita* possesses T-shaped pigment spot, whereas *A. neglecta* possesses star-shaped pigment spot. Both the species have a gut diverticula and a collarette. The collarettes show difference in both species: the collarette of *A. neglecta* at the neck point is well developed while it gets thinner by the ventral ganglion and stretches till the caudal region. As to *F. galerita*, it is only located in the neck part. The ovaries are long and aligned in a single row. Mature ovaries of *F. galerita* reach up to the neck part. The ovaries of *A. neglecta* are between ventral ganglion and neck part.

Seminal vesicles of the mature individuals of these species are different from each other in position and shape. Seminal vesicles of *F. galerita* touch both caudal fin and posterior fins and are cylindrical in shape. Seminal vesicles of *A. neglecta* touch the back end of the posterior fins and are separated from the tail fin by a distance almost equal to the length of the seminal vesicle. They are roundish, egg shaped, and their anterior part is more voluminous than the posterior part and has a wide and short prominence at the anterior part. The length of the *F. galerita* can reach up to 12 mm; whereas *A. neglecta* can reach maximum of 8 mm. Description of *A. neglecta* is given according to Alvariño (Alvariño, 1967).

The previous studies carried out for the region (Lakkis, 1977; Ismen, 2000) give different numbers related to the percentage of chaetognath species. The found species and their percentages are shown in Table III. Compared with the data of Ismen (2000), the species detected in the present study, excluding *F. galerita*, have lower percentages. The juveniles of *P. tenuis*, *P. friderici* and *S. bipunctata* were not classified in order not to make a mistake in the classification, and they were given as an immature specimen, but they were shown together with mature of these species on Table III.

The natural ecological and hydrographical conditions of the Eastern Mediterranean appear to be favourable for the establishment of alien, and Erythraean species gradually enter the Mediterranean Sea via the Suez Canal. One of the most affected areas in Levantine Sea, after Israel coasts, is the south-eastern Turkish coast including Iskenderun Bay (north-eastern Levantine Sea) (Cevik *et al.*, 2005) in which many Lessepsian species especially mollusks, fish and crustaceans are reported for the first time (Furnestin, 1979). Zooplankton studies along Turkish coasts are not very numerous, and this can explain the scarce records of alien species.

During the sampling in the spring and summer time, abundance of *F. galerita* was at low values. In the autumn when the temperature and salinity of the water were close to the values in the Red Sea, the abundance of *F. galerita* was at its highest. Also the abundance of this species was the highest among other chaetognath species in autumn (Table I). All Lessepsian species of Indo-Pacific origin are recorded in the Eastern Mediterranean during the autumn, when the seawater temperature and salinity are similar to those of the Red Sea (S. Lakkis, Lebanese University, Lebanon, personal communication).

There is no trace or records along the route showing this species came from Madagascar waters to the Mediterranean Sea. This reminds another possibility that *F. galerita* may have brought to the Eastern Mediterranean

Table III: Relative density (%) of chaetognath species in previous studies and present study

	Present study	Ismen (2000)	Lakkis (1977)
Species	Iskenderun Bay (vertical)	Iskenderun Bay (vertical)	Libanese coasts (vertical)
S. bipunctata	22.874	5.8	1.6
P. friderici		—	85
P. tenuis		17.2	—
F. enflata	45.19	60.6	10
S. serratodentata	1.499	2.5	3
M. minima	4.311	8.8	0.3
F. hexaptera	—	—	0.15
P. lyra	0.002	—	
S. bierii	—	—	
P. megalopthalma	—	1	
K. subtilis	—	—	
P. setosa	—	3.5	—
F. galerita	22.232	—	—

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by ballast waters. To decide whether the introduction is by Lessepsian migration or ballast water introduction, it is necessary to carry out further detailed studies such as the population structure and the dispersal of this species in the Eastern Mediterranean as well as in the western Indian Ocean and on the likely migration routes.

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