

**FISHERY LIGHTS RESULT IN ELEVATED PREDATION OF THE ENDANGERED FISH
ECONOMIDICHTHYS TRICHONIS BY *ATHERINA BOYERI* IN LAKE TRICHONIS
(GREECE)**

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Abstract

Atherina boyeri is the dominant fish species in Lake Trichonis (Greece) and the target species in the professional purse seine fishery, conducted mainly during the night by the use of lamp rafts. A recent study on its diet when fed close to the fishery lights showed that it is capable of preying large numbers of larvae of the native and endangered fish *Economidichthys trichonis*. This study reports the first results of a conservation program aiming to the reduction of this predation by *A. boyeri*. Stomach content analysis, applied on specimens of *A. boyeri* caught around lamp rafts of the purse seine fishing conducted between May and December 2017, revealed that among seventeen prey categories, the *E. trichonis* larvae were second in frequency of occurrence after the larvae of the mollusk *Dreissena blanci*. Each of the larger *A. boyeri* specimens was able to consume up to 14.5 (± 7.98) *E. trichonis* larvae in certain periods, with a maximum number of 51 larvae being consumed by a single individual. The predation pressure exercised on these larvae by the *A. boyeri* school aggregated around the lights of a single purse seine fishing boat, reached a maximum of about 260,000 (SE = 43,000) specimens per night in June with a second peak in November (220,000 \pm 42,000). This study verifies the previous findings about the predation pressure that *A. boyeri* can exercise on other fish species of the lake due to the specific fishing practice and points out the need of alteration in the fishery legislation, along with estimates of the current population size of *E. trichonis* in Lake Trichonis. Considering that fishing with light is exercised in various forms all over the world, this investigation may be considered instigation for more studies worldwide in order to evaluate the actual ecological consequences.

Keywords: *Atherina boyeri*, purse seine, LED light, *Economidichthys trichonis*, diet, predation

1. INTRODUCTION

Artificial light has been used for the attraction and capture of fish since the ancient eras and today a great part of the fishery worldwide relies on the use of light to obtain large quantities of various epipelagic species, both in marine and freshwater ecosystems [1]. The attraction of a fish to light is an indirect response, since it is actually attracted to the increased density of other prey organisms which have primarily approached close to the light source. Indeed, shortly after the switch on of a light into the water or close to the surface, a trophic chain reaction starts to develop with initially the approaching of zooplanktivorous fish or fish larvae, which later are followed by larger species and even top predators [1, 2, 3]. A great effort has been given to the improvement of the fishing techniques that utilize light for the fish attraction during past decades, and consequently, there is a large bibliography dealing mainly with the phototactic reaction of different fish species to various light intensities and wavelengths [1, 2, 4, 5, 6], and the adaptation of fishing gears [7, 8]. However, there is lack of studies on the effect of the fishing lights to the creation of this trophic chain reaction previously mentioned, as well as on the possible ecological consequences of this fishing practice [1].

In a recent study, Kehayias et al. (2018) [3] investigated the effects of the purse seine fishery lights on the diet of *Atherina boyeri* (Risso, 1810) in Lake Trichonis (Greece). This lake is inhabited by a landlocked population of *A. boyeri* that has been naturally introduced into this basin from the sea via river channels in past centuries and is the dominant species in the ichthyofauna [9, 10]. Due to its abundance, *A. boyeri* is the target species of the local commercial fishing being exercised with the purse seine method allowed to be conducted only by three boats, according to the Greek fishing

legislation for this area. These three fishing boats are using three lamp rafts each to attract *A. boyeri* schools when conducting purse seine at night. According to the local fishing practice, from May/June until December/January the fishermen exercise the purse seining mainly at night using lamp rafts. For the rest of the year they fish only in daylight hours tracking *A. boyeri* schools with sonars, while there is a fishing prohibition in March-April and between the 15th of June and the 20th of July.

Kehayias et al. (2018) [3] found that light used in the lamp rafts for the attraction of *A. boyeri* may alter the dietary preferences of this zooplanktivorous fish towards other positively phototactic organisms approaching the light source. It was especially interesting that *A. boyeri* showed increased predation on the larvae of *Economidichthys trichonis* (Economidis and Miller, 1990) that also approach the fishing lights to take advantage of the great zooplankton concentrations. This fish species is native in Lake Trichonis and is listed among the endangered species in the Red List of IUCN [11]. Further, in their study Kehayias et al. (2018) [3] estimated the predation impact of a school of *A. boyeri* formed around a single lamp raft to reach up to 100,321 (SE = 18,610) *E. trichonis* larvae per night in certain periods of the year.

These findings forced the above research team to apply for a conservation project to investigate further the effects of the particular fishing practice, with the final goal to be the reduction of *E. trichonis*'s predation by *A. boyeri*. Thus, the present study reports the first results of this program that came from an eight-month investigation (May to December 2017) on the predation of this fish to the larvae of *E. trichonis* using stomach content analysis. Moreover, utilizing data on the size frequency distribution and the weight of the *A. boyeri* catch, there was an effort to estimate the predation impact as the number of the *E. trichonis* larvae being consumed per night in Lake Trichonis. Finally, considering the results of this study as well as of the recent previous investigation [3], there is an attempt to establish certain conservation actions that the authorities in combination with the local fishermen should adopt, in order to minimize the ecological consequences of this fishery practice.

2. MATERIALS AND METHODS

2.1. Study area

The present study was conducted in the largest natural lake of Greece, Lake Trichonis (Figure 1). The lake is situated in the western part of the country (38°30'–38°36' N, 21°26'–21°39' E) and has a surface area of 98.6 km². It is a deep, warm monomictic lake with oligo- to mesotrophic characteristics [12]. From the biodiversity point of view, Lake Trichonis has great ecological importance and is included in the Natura 2000 protection network. In the western part there is a sluice gate canal with which the excess of the lake's water is discharged to the nearby Lake Lysimachia in order to avoid potential flooding, since Lake Trichonis has positive water balance equilibrium.

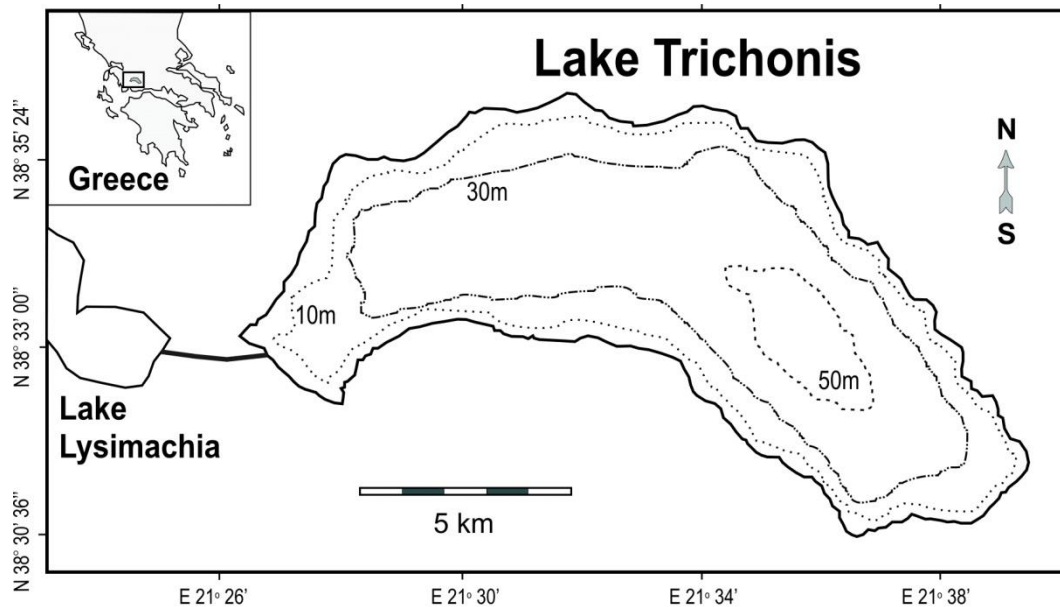


Figure 1. The geographic location and the bathymetric map of Lake Trichonis.

2.2. Field operations

The investigation of *A. boyeri*'s diet was based on stomach content analysis of fish samples obtained from night purse seine fishing trials in Lake Trichonis. Each of these trials was conducted once a month from May to December 2017 in a moonless night with the assistance of local fishermen and the use of lamp rafts. Each of these lamp rafts is an improvised metal frame construction built and operated by the local fishermen. This raft design floats by the use of empty plastic barrels hung underneath it. A 12V/60A lead car battery provides the energy to light a 30 Watt cylindrical LED lamp producing green light (2400 lumens) that is attached onto a frame projected a few centimeters above the water's surface on the one side of the raft.

Purse seine fishing practice in Lake Trichonis involves a "mother vessel", a large rowing boat, and lamp rafts for the attraction of *A. boyeri*. According to the Greek legislation only three lamp rafts for each purse seine fishing boat are allowed in this lake. On each sampling occasion, the three lamp rafts were anchored at a distance of about 50 m from each other in certain sites on the eastern part of the lake. Just before dark, their lamps were turned on and remained lit for several hours (6-8 hours depending on the date). Before dawn, the rowing boat slowly approaches the one of the three lamp rafts, tides it to the boat and drag it to the next lamp raft. This process results to the transfer of the fish school that has been previously aggregated around each lamp raft. Finally, all three rafts are tied together and, after that, the "mother vessel" approaches to encircle the fish up to the point of the large rowing boat. Then, it winches in the purse line, closing the bottom of the seine and forming a bag-shaped net that encloses the fish and bring it on board of the vessel. Fishing was conducted using a purse seine net (length: 150 m, height: 20 m, mesh size: 6 mm). After retrieving the net, all the *A. boyeri* specimens of the catch were placed into wooden crates each of which contains approximately 10 kg. The number of these full crates was used to roughly estimate the total weight of the catch. Immediately after net retrieval a number of randomly selected *A. boyeri* specimens were placed into a 3 L plastic jar containing 10 % formalin solution to minimize post-capture digestion of prey, and transferred to the laboratory.

2.3. Laboratory analyses

In the laboratory, all the *A. boyeri* specimens in the samples taken as previously described were counted and their total body length (TL) and total body weight (TW) were measured. The specimens were separated into four size classes: L_1 : TL < 50 mm, L_2 : 50.1 < TL < 70 mm, L_3 : 70.1 < TL < 85 mm and L_4 : TL > 85.1 mm, corresponding to the total length of the 0⁺ to 3⁺ age groups of *A. boyeri* in Lake

Trichonis [9]. Stomach content analysis was conducted under a Leica MZ 7.5 stereoscope in a number of 120 randomly selected specimens from each sample. All fish larvae being in fairly good condition (not showing pronounced digestion) were identified according to Daoulas et al. (1993) [13] and counted. Fish bones, fins and other fish parts found in the diet formed a separate category called “identified fish larvae remains”. All the other prey items in each specimen containing food were identified to the lowest taxonomic level possible, but not counted. Along with the number of the *Economidichthys trichonis* larvae (Num) found in the stomach contents of each *A. boyeri* specimen containing food, their frequency of occurrence (F) was calculated as the percentage of stomachs (s) containing this prey category over the total of non-empty stomachs (S) as follows:

$$F = \frac{s}{S} \times 100$$

To estimate the total number of *E. trichonis* larvae preyed upon each night by one *A. boyeri*'s school aggregated around the three lamp rafts, data of the catch weight as well as the length and weight measurements of all the specimens in each *A. boyeri* sample were used. Assuming that the size distribution in the random sample taken from the catch corresponds to the entire catch, the percentage contribution of the four size classes ($L_1 - L_4$) in the catch was found. The total number of *A. boyeri*'s specimens caught in the purse seine catch (N) was estimated as:

$$N = \frac{W \times n}{w}$$

where (W) is the total weight of the catch, (n) is the total number of *A. boyeri*'s specimens in the sample, and (w) is the total weight of the sample or monthly catches.

Based on the percentage contribution of L_j ($j=1, 2, 3, 4$) the numbers of *A. boyeri*'s specimens in each size class (N_j) were found. The *E. trichonis* larvae preyed by the *A. boyeri* specimens of each of the four size classes were calculated as follows:

$$Pl_j = N_j \times (p_j \pm SEp_j)$$

where Pl is the *E. trichonis* larvae preyed by the j size class *A. boyeri* specimens of the catch, p is the average number of *E. trichonis* larvae preyed by one j size class *A. boyeri*'s specimen and SEp is the standard error in the estimation of p . Finally, the total number of *E. trichonis* larvae preyed upon each night by one fish school aggregated around a single lamp was:

$$Pl = \sum_{j=1}^{j=4} (Pl_j)$$

3. RESULTS

During the period from May to December 2017 purse seine fishing was conducted in Lake Trichonis and the weight of the *Atherina boyeri* catch taken in each fishing occasion is shown in Figure 2. The catch weight showed an increase from 120 kg in May to 300 kg in August, which was the highest value. Between September and November an increase was also noticed from 120 to 290 kg, while the lowest catch weight was recorded in December (85 kg).

From these catches, a total number of 1889 *A. boyeri* specimens have been randomly selected and their total length and weight was measured. Their length frequency distribution is presented in Figure 3. There was an increase in the average length of *A. boyeri* in the samples from 5.6 cm (Standard deviation = 1.54 cm) in May to 7.12 cm (± 1.39 cm) in September. From this month to November there was a decrease of length (6.66 ± 2.04 cm) and then an increase in December (7.19 ± 1.51 cm).

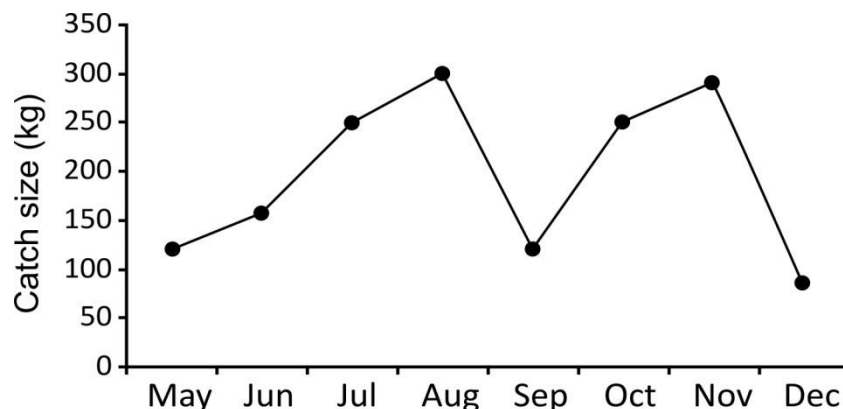


Figure 2. Variation of the *A. boyeri* catch (kg) taken with the purse seine fishing between May and December 2017 in Lake Trichonis.

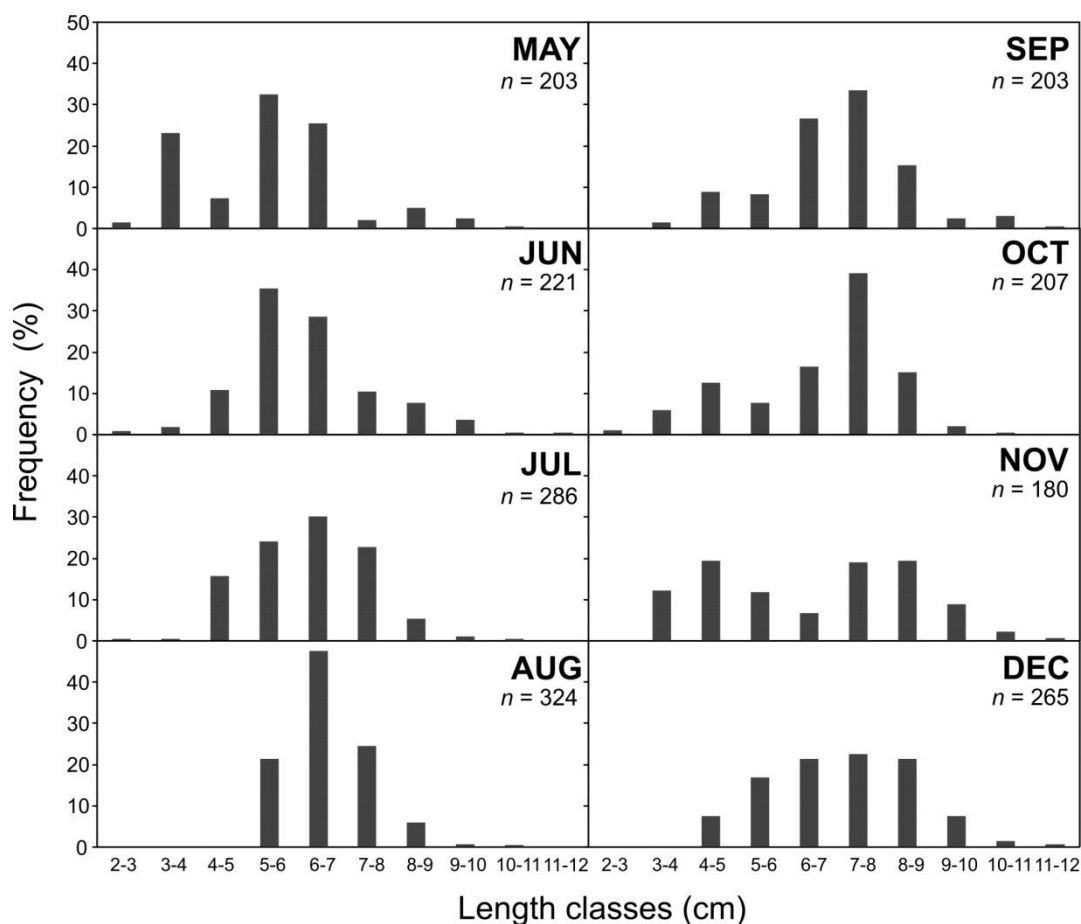


Figure 3. Length frequency distribution of *A. boyeri* specimens from the samples taken between May and December 2017 in Lake Trichonis.

From the stomach content analyses of 960 *A. boyeri* specimens, a total number of 1681 larvae of *Economidichthys trichonis* have been identified. Along with this type of prey, sixteen other prey categories were found (Table 1). The *E. trichonis* larvae were second in the frequency of occurrence (*F*) after the larvae of the mollusk *Dreissena blanci* (Westerlund, 1890). The cladoceran *Diaphanosoma orghidani* (Negrea, 1982) presented high *F* values especially in the warmer period of the year, followed by the calanoid copepod *Eudiaptomus drieschi* (Poppe & Mrazek, 1895) presenting

the highest *F* value in May, along with the harpacticoid copepods. The amphipods were present in the diet from May to September and *Bosmina longirostris* (Müller, 1785) was found in the stomach contents in most of the year, except in September and October. Higher frequency of occurrence for the cyclopoid copepods was recorded in the period from May to July, and *Daphnia cucullata* (Sars, 1862) and *Ceriodaphnia pulchella* (Sars, 1862) presented their highest *F* values in May. Among the other prey categories, unidentified fish larvae were present for most of the year, while terrestrial insects were found only from May to September. Finally, the remaining prey categories such as copepod nauplii, shrimps, chironomid larvae and the cladocerans *Leptodora kindtii* ((Focke, 1844)) and *Alona* sp. (Baird, 1843) were occasionally present in the diet.

Table 1. The frequency of occurrence (F) of the prey categories as calculated from the stomach analyses of the *A. boyeri* specimens caught around the lamp raft between May to December 2017 in Lake Trichonis.

Prey type	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harpacticoid copepods	66.1	0.0	24.0	6.5	0.0	0.0	14.6	0.0
<i>Eudiaptomus drieschi</i>	69.6	29.2	67.8	26.2	2.8	6.0	27.2	1.3
Cyclopoid copepods	39.3	11.7	24.8	0.0	0.0	0.0	2.9	2.5
Copepod nauplii	0.0	10.8	0.0	0.0	0.0	0.0	0.0	21.5
<i>Dreissena blanci</i> larvae	37.5	76.7	33.1	41.1	26.4	3.6	18.4	84.8
<i>Alona</i> sp.	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Bosmina longirostris</i>	28.6	38.3	2.5	0.9	0.0	0.0	9.7	15.2
<i>Ceriodaphnia pulchella</i>	62.5	1.7	4.1	0.9	0.0	0.0	1.0	0.0
<i>Daphnia cucullata</i>	74.1	0.0	3.3	0.0	0.0	0.0	1.9	0.0
<i>Diaphanosoma orghidani</i>	25.9	14.2	70.2	59.8	26.4	21.4	34.0	0.0
<i>Leptodora kindtii</i>	2.7	0.0	0.8	0.0	0.0	0.0	7.8	0.0
Amphipods	53.6	8.3	5.0	17.8	15.3	0.0	0.0	0.0
Shrimps	8.9	0.0	1.7	0.0	0.0	0.0	0.0	0.0
Chironomid larvae	4.5	0.0	0.0	0.0	2.8	0.0	0.0	0.0
Insects (terrestrial)	17.0	2.5	3.3	2.8	8.3	0.0	0.0	0.0
<i>Economidichthys trichonis</i> larvae	23.2	55.0	27.3	40.2	47.2	56.0	57.3	5.1
Fish larvae (unidentified)	8.0	0.0	8.3	8.4	9.7	21.4	9.7	5.1

Considering the *E. trichonis* larvae, their frequency of occurrence as well as their numbers in the stomach contents of the four size classes ($L_1 - L_4$) of *A. boyeri* during the entire sampling period, are presented in Table 2. The analysis showed that only in a few cases the smaller specimens of L_1 have consumed *E. trichonis* larvae. Instead, the larger stages of *A. boyeri* presented the higher *F* values for this type of prey which was part of their diet in the entire sampling period. The average number of *E. trichonis* larvae that have been consumed by an individual from each of the four size classes of *A. boyeri* during May to December is presented in Figure 4. Among the size classes, the average number of *E. trichonis* larvae that a L_4 specimen was able to consume reached 14.5 (SE = 7.98) in July, while there was a great variation starting from 0.4 (\pm 0.20) in August and 0.41 (\pm 0.27) in December. The respective values for the L_3 specimens of *A. boyeri* varied from 0.07 (\pm 0.07) in December, to 4.39 (\pm 0.86) in June and for the L_2 specimens from 0.06 (\pm 0.06) in October, to 3.05 (\pm 0.41) in June.

Table 2. The number (Num) of *E. trichonis* larvae found in the stomach contents and their frequency of occurrence (*F*) in the four size classes (L_1 - L_4) of the *A. boyeri* specimens caught around the lamp raft between May to December 2017 in Lake Trichonis.

	L_1		L_2		L_3		L_4		Total Num
	Num	<i>F</i>	Num	<i>F</i>	Num	<i>F</i>	Num	<i>F</i>	
May	1	10.0	31	15.2	40	60.0	94	53.8	166
June	0	0.0	125	51.2	158	52.8	350	89.7	633
July	10	4.8	17	19.4	97	34.5	87	83.3	211
August	0	0.0	30	52.8	26	31.8	4	10.0	60
September	0	0.0	7	23.8	39	74.1	17	81.8	63
October	0	0.0	1	31.3	127	65.2	57	85.7	185
November	0	0.0	2	6.3	149	77.3	198	80.0	349
December	0	0.0	0	0.0	2	3.7	12	10.3	14

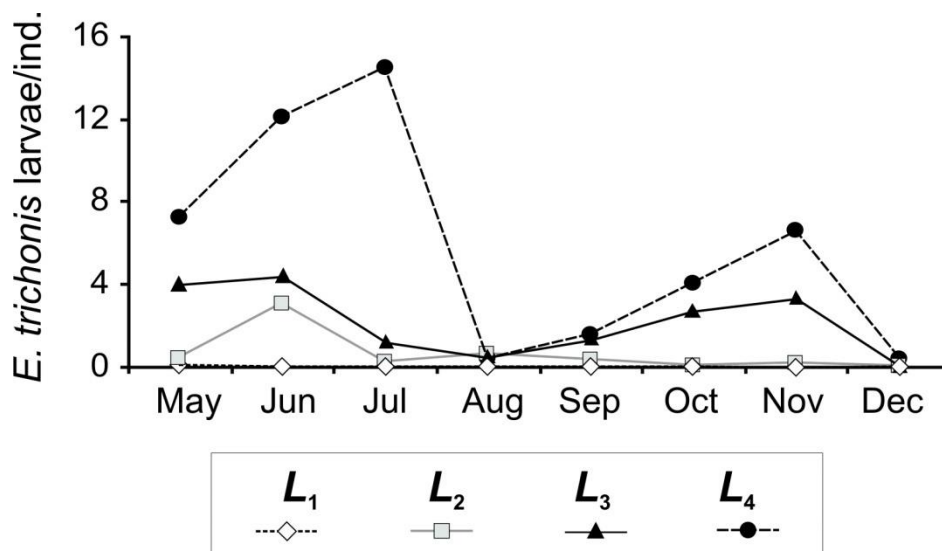


Figure 4. The average number of *E. trichonis* larvae consumed per individual of *A. boyeri* containing food in each of the four size classes (L_1 to L_4) from May to December 2014 in Lake Trichonis. Standard error is shown as vertical bar.

The estimations of the total number of *E. trichonis* larvae preyed upon each sampling night by one *A. boyeri* fish school aggregated around the three lamp rafts were based on the weight of the *A. boyeri* catch taken around them in all fishing occasions (Figure 5). According to these estimations, the overall predation of one school of *A. boyeri* on *E. trichonis* larvae reached the highest number of 264,880 (SE = 43,995) individuals in June, while the lowest number was recorded in December (1957 ± 1828 individuals). The variation of this predation impact presented a second peak in November when the number of *E. trichonis* larvae consumed in a single night was 222,402 ± 42,114 (Figure 5A). An estimation of the *A. boyeri*'s predation impact on all the fish larvae found in the stomach content (including both the *E. trichonis* larvae and the unidentified fish larvae) showed the highest predation in June, when only *E. trichonis* larvae were present in the stomach contents. Generally, there were no intense differences, since the *E. trichonis* larvae were by far the most abundant among the fish larvae. It must be pointed however, that we cannot exclude the probability the unidentified fish larvae (mostly

fish remains) could have been larvae of *E. trichonis* in a state of pronounced digestion that did not permit their identification.

Considering the predation impact exercised by each of the four size classes of *A. boyeri*, the highest number per night was achieved by the L_2 specimens in June ($140,471 \pm 18,829$ individuals), while the highest respective value for the L_4 specimens was $124,156 \pm 21,688$ individuals per night in November and for L_3 specimens was $99,253 \pm 19,453$ individuals per night in October (Figure 5B).

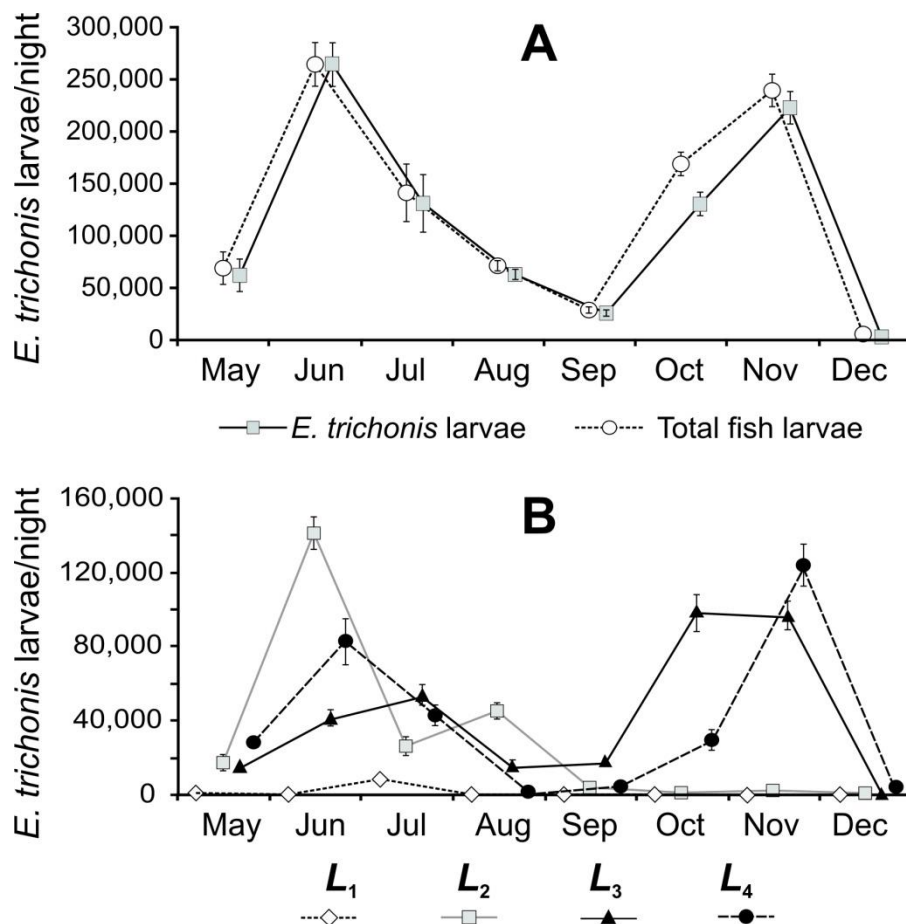


Figure 5. (A) The number of *E. trichonis* larvae and the total fish larvae (both *E. trichonis* and unidentified fish larvae) estimated to have been consumed by a single *A. boyeri* school around the three lamp rafts during each sampling session between May and December 2017 in Lake Trichonis. (B) The number of *E. trichonis* larvae estimated to have been consumed by the four size classes of a single *A. boyeri* school around the three lamp rafts. Standard error is shown as vertical bar.

4. DISCUSSION

There are two previous studies on the feeding of *A. boyeri* in Lake Trichonis reporting the presence of unidentified finfish fry in its diet [14], while Doulka et al. (2013) [10] were the first to report the presence of fish larvae of *E. trichonis* in the stomach contents. However, direct comparisons of the contribution of *E. trichonis* larvae in the diet of *A. boyeri* cannot be made, since in these two studies the fish samples had been taken by daylight purse seining. In contrast, the results of the present study can be directly compared with those of the recent article of Kehayias et al. (2018) [3] who have investigated the *A. boyeri*'s feeding close to purse seine lights for a period of seven months in 2014. In fact, the same general methodology was applied in the sample collection and the stomach content analysis. One of the differences is that the fishermen in this investigation used three lamp rafts that were pooled together in the manner described in the methodology, instead of only one lamp raft in the

previous study [3]. Another difference lies to the sampling period that was increased by one month (May) in the present study and also to the elevated number of *A. boyeri* specimens examined (120 instead of 100). Moreover, the analysis of the other prey types found in the stomach of *A. boyeri* specimens was qualitative instead of quantitative in the previous investigation, since the present study is focusing on the presence of the *Economidichthys trichonis* larvae in the diet.

The present results are in accordance to the previous study of Kehayias et al. (2018) [3] and both showed that great numbers of *E. trichonis* larvae are attracted to the lamp rafts' light, and suffer of predation especially by the larger specimens of *A. boyeri*. Also, in accordance to the previous report [3], the larvae found in the stomach contents of these large *A. boyeri* specimens were often of the same size and in similar digestive condition with each other, which indicates a quick attack and ingestion probably when a swarm of these coeval larvae approached the light. Daoulas et al. (1993) [13] reported that in certain periods the larvae of *E. trichonis* form dense swarms and distributed in the pelagic area of the lake. In this sense, it is expected that such swarms may had approached to light from the lamp rafts and underwent the attack of these large *A. boyeri* specimens which were able to consume more than one *E. trichonis* larvae. It must has been certainly a matter of size (e.g. larger mouth gap or/and stomach capacity of the larger specimens) that the smaller individuals of *A. boyeri* were not found to have ingested multiple of this prey, similarly to the reports of Kehayias et al. (2018) [3]. Taking into account the constantly greater frequency of occurrence (F) of *E. trichonis* larvae in the diet of the largest size class (L_4) of *A. boyeri*, along with the small participation of this size class to the overall sample, we could suggest that these larger specimens may have, or exercise, some kind of priority over the other size classes on the exploitation of this type of prey. This cannot be verified by the present investigation however, if it stands, it could mean that the *E. trichonis* larvae are among the most preferable prey categories for this zooplanktivorous fish, possibly because of their greater nutritional value in comparison to the zooplankton taxa.

Indeed, the *E. trichonis* larvae were having high frequency of occurrence in the diet of *A. boyeri* in comparison to the other prey types, and in some occasions the highest values, such as in autumn (September to November). According to Doulka & Kehayias (2008) [15], this is the period of the decreasing of the zooplankton density in the lake, posing extra pressure in the energy pursuit from this dominant zooplanktivorous fish. This is in accordance with the report of Doulka et al. (2013) [10] who also found great numbers of *E. trichonis* larvae in the diet of *A. boyeri* in autumn, although the fish samples had been obtain from daylight fishing, as previously stated.

In respect to the dietary composition of *A. boyeri* as for the other prey categories, the results were in a great part similar to the reports of Kehayias et al. (2018) [3]. However, in the present study several other different prey types existed, such as the harpacticoid copepods, being very abundant in May, as well as others occasionally found such as the cladocerans *Alona* sp. and *Leptodora kindtii*, shrimps and chironomid larvae. In the study of Kehayias et al. (2018) [3], the larvae of the mollusk *Dreissena blanci* were always having the highest frequency of occurrence among the prey categories, with F values ranging from 71.6 to 97.4. In the present study however, the *D. blanci* larvae had considerably lower F values, which sometimes were lower than of other taxa.

The average number of *E. trichonis* larvae ingested by a single *A. boyeri* specimen of the four length classes was similar to the previous study of Kehayias et al. (2018) [3]. On the other hand, there were some similarities as well as differences in the seasonal variation of the predation impact of *A. boyeri* upon the *E. trichonis* larvae. The estimates of the predation impact of one school of *A. boyeri* gathered around the three lamp rafts showed the consuming of several thousand larvae per night. These values are comparable to those reported by Kehayias et al. (2018) [3] considering a 1 to 3 analogy, since the latter made analogous estimations for a single lamp raft. Thus, they reported a maximum predation of nearly 100,000 *E. trichonis* larvae per night using one lamp raft in June [3], in comparison to 265,000 larvae per night with the use of three lamp rafts in the present study. The values are also comparable in July, August, and December, but not in September, October and November. In these latter months the numbers of larvae preyed each night by *A. boyeri* were much higher than the expected taking into account the 1 to 3 analogy. Indeed, the respective values for September, October and November are 74, 13 and 24 times greater than in those of the previous study.

The greatest values of the predation impact of *A. boyeri* upon *E. trichonis* larvae in June as came from both studies, are probably attributed to the great density of the larvae in this particular season, due to the preceding reproduction of this species which starts in late February and lasts up to June [13]. According to Daoulas et al. (1993) [13], during this period the larvae tend to form large swarms and distributed in the pelagic part of the lake away from the shores. As their maturation proceeds, the larvae gradually turn to benthic distribution close to the reeds of the banks [13]. This must have been the reason of their lower predation that suffered after June. However, in the present study there was a second increase of the predation impact in the autumn months October and November, with the latter accounting for a peak close to the maximum value of June. Daoulas et al. (1993) [13] reported the presence of *E. trichonis* larvae year-round in Lake Trichonis, which indicates possibly the existence of more than one reproductive period for this species. In October and November the number of *E. trichonis* larvae ingested per individual of *A. boyeri* showed an increase, which may indicate the elevated density of them that came probably from previous reproductive incidents. However, there are no data on the seasonal abundance variation of the *E. trichonis* larvae to verify this hypothesis.

According to Kehayias et al. (2018) [3], the investigation of the stomach content of the *A. boyeri* specimens caught around a lamp raft which operates for several hours, poses serious limitations on the investigation of the actual time, duration and general conditions under which their prey has been consumed. The operating duration of the lamps seems to affect the predation incidents involving the *A. boyeri* specimens and the larvae of *E. trichonis* approaching close to the light source. It is expected then, that during all this time the predation of *A. boyeri* upon the *E. trichonis* larvae is favored. Considering that the lamp rafts operate for 6-8 hours before fishing, it is expected that predation could occur around the light for most of this time, in a manner that fed *A. boyeri* specimens may withdraw from the area, while others not fed yet approach to exploit the elevated abundance of prey. Therefore, stomach analysis of *A. boyeri* specimens caught at the end of this period could underestimate the magnitude of their predation impact on *E. trichonis* larvae, as well as on other types of prey.

Taking into consideration that *E. trichonis* is a critically endangered native fish species which is suffering from predation from another fish due to the particular fishing practices, certain conservation actions should be taken to ensure its existence. As an action against this risk would be the reduction of the operation time of the lamp rafts to 2-3 hours, which is the usual time of the lamp rafts' operation in the purse seining of pelagic species in sea areas of the Mediterranean [16, 17]. Kehayias et al. (2018) [3], utilizing surface and underwater observations close to a lamp raft, reported that shortly after switching on the light, an aggregation of zooplankton starts to develop and during the first hour fish fry approach foraging for prey. Although some *A. boyeri* specimens approach during this first hour, it takes more than 2 and even 3 hours for a large school to be formed (personal observations). Even though the fishermen in Lake Trichonis are aware of the fact that a smaller operation time of the lamp rafts may be adequate to concentrate the fish around the light, they don't follow this practice for logistic reasons. In particular, they choose to anchored and activate the lamp rafts late in the afternoon, go resting for the evening and perform the purse seine fishing after 6-8 hours getting on their boats shortly before fishing, since the distance of the anchored lamp rafts from the shore is small. In order to assist in overcoming these logistic issues, Kehayias et al. (2016) [8] design, constructed and operated an autonomous photovoltaic-battery-LED lamp raft having the advantages of no operational cost and having a timer to switch on and off the light of the raft. However, the withdrawal from these long-lasting customs by the local fishermen is difficult, and still they prefer to construct simple designs of improvised lamp rafts, like those in the present study. On the other hand, a legislative directive towards the reduction of the operation time of the lamp rafts in this area is doubtful to be followed by the fishermen due to the above reasons, while it is also impracticable by the authorities. Furthermore, along with the legal commercial fishery of *A. boyeri* by the three boats in Lake Trichonis, there is also extensive illegal fishing with the use of light, the consequences of which cannot be estimated.

The fishery legislation for Lake Trichonis prohibits the purse seine fishing between the 15th of June and the 20th of July. Kehayias et al. (2018) [3] propose the extension of this prohibition for two full months (June-July) taking into account the increased predation of *E. trichonis* larvae in this period, but also the socio-economic consequences from a greater gear prohibition to the local economy. Though, the present results are in agreement with this, they also reveal that in other periods such as the autumn

(October and November) the predation of this endangered species may also be dangerously high. On the other hand, it must be kept in mind that the predation impact estimates came from the results of a single night fishing each month, thus, more accurate estimations would be derived from analogous measurements for several fishing trials each month.

Consequently, the present study confirms the estimations of previous studies on the heavy predation of the larvae of a native and endangered fish by another fish species that takes place close to lamp rafts used for the purse seine fishery in the greatest lake of Greece. There is urgent need for the estimation of the current population size of *E. trichonis* in Lake Trichonis, along with extensive investigations of the ecological processes that take place around a light source, in order to provide the necessary scientific evidence to convince the authorities to modify the current fishery legislation for this area. Finally, taking in mind that fishing with light is practiced in various forms in marine and freshwater ecosystems all over the world the present investigation anticipates to assist understanding the ecological outcomes of this practice by stimulating analogous investigations worldwide.

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