in the roots of plants of economic importance as symbionts, arousing the interest of many a worker and subsequent discovery of new species[19–21]. In the dispersed state, as has already been stated, it is difficult to delimit them into generic level because the auxiliary cells, vesicles and chlamydospores are monotonously uniform. The Glomales is associated with plants since its transmigration on land more than four hundred million years ago; still the morphology of the vesicles has not changed indicating its utmost stability against mutation and other evolutionary processes. Perhaps the urge and initiative for further development were lost due to the availability of readymade food from the hosts and external protection.

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Occurrence and intensity of some parasites in five sturgeon species (Chondrostei: Acipenseridae) southwest of Caspian Sea

Sturgeons (Chondrostei: Acipenseridae) are evolutionary relicts with a wide distribution in the northern hemisphere. Their status as basal actinopterygian fishes, their unique benthic specializations, and variation in their basic diadromous life history make sturgeons interesting biological and biogeographical subjects. Extensive studies on *Eurasian* sturgeons indicate that they are also unique among fishes, in possessing a markedly diverse assemblage of host-specific parasites.

The parasites of sturgeons have been studied by several authors[1–5]. However, there are only a few reports about such parasites in the southern part of the Caspian Sea. Mokhayer[6] studied parasites of three sturgeon species, including *Acipenser stellatus* ($n = 72$), *A. gueldenstaedti* ($n = 95$) and *Huso huso* ($n = 4$) and reported 17 parasite species from all of them. Gorogi[7] studied parasites of *A. persicus* ($n = 604$) and reported three parasite species. In another study, Gorogi[8] reported six parasite species from *H. huso*. Hence an attempt was made to determine the parasite fauna of all sturgeon species southwest of the Caspian Sea and also the status of the parasite communities.

A total of 542 samples of five sturgeon species (including *A. stellatus*, *A. persicus*, *A. gueldenstaedti*, *A. nudiventris* and *H. huso*) were collected from April 1999 to February 2001. The samples included sturgeons which were caught in fisheries sections 1 (location 1) and 2 (location 2) along with a shore area of more than 200 km and also the broodstocks of a hatchery adjacent to the Sefid-Rud River (location 3; Figure 1).

As the sampling in this study was restricted by the governmental fishing programme (including the induced spawning of broodstocks and then exporting their flesh), age determination of the sturgeons (by removing pectoral fin ray) was not possible. After recording biometric characteristics (Table 1), standard necropsy and parasitology methods[9] were used. After removal, all viscera were examined for parasites; sections of the spleen and liver were squashed and major ducts in the liver were dissected and examined. Mucus from the first part of the intestine was removed and examined between glass plates for protozoans. Live trematodes and acanthocephalans were relaxed in distilled water at 4°C for 1 h and fixed in 10% hot buffered formalin. Live nematodes were fixed in hot 70% ethanol and cleared in hot lactophenol. Frozen specimens were thawed in water, fixed with 10% formalin (trematodes and acanthocephalans) or 70% ethanol (nematodes). All specimens fixed in 10% formalin were stained with aqueous acetocarmine, dehydrated and

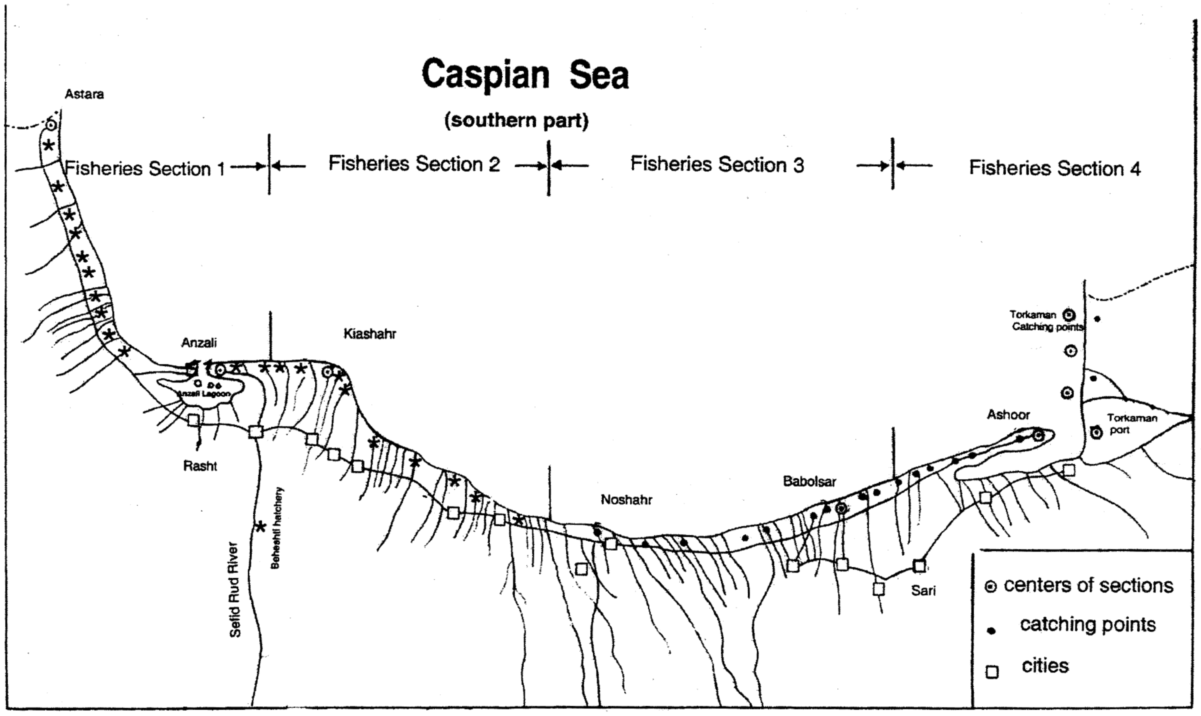

Figure 1. Fisheries sections and catching points in southern part of Caspian Sea (sampling points indicated by asterisks).

Table 1. Biometric characteristics (weight, forked length, total length, weight of caviar) of some sturgeons caught southwest of Caspian Sea

Fish characteristics	Weight (kg) range Mean ± SD	Forked length (cm) range Mean ± SD	Total length (cm) range Mean ± SD	Weight of caviar (kg) range Mean ± SD
A. stellatus	4–16	83–155	101–175	0.500–3.520
$N = 234$	9.089 ± 2.751	124.9 ± 12.3	142.80 ± 13.43	1.699 ± 0.697
A. persicus	6–49	106–185	125–210	0.500–8.200
$N = 206$	22.900 ± 8.126	148.22 ± 15.04	165.32 ± 16.16	4.102 ± 1.520
A. gueldenstaedti	7–38	105–165	120–179	0.600–7.600
$N = 78$	18.510 ± 6.860	130.36 ± 13.35	147.98 ± 14.30	3.413 ± 1.565
A. nudiventris	13.5–46	123–180	137–191	3.600–7.700
$N = 18$	29.812 ± 11.635	154.18 ± 18.45	168.87 ± 17.80	4.950 ± 1.870
H. huso	33–126	155–233	174–275	4.170–8.250
$N = 6$	61.670 ± 34.550	179.33 ± 30.32	201.66 ± 30.38	6.240 ± 2.041

mounted in permount. The worms were identified by parasite identification keys[10,11].

Standard statistical computations (mean intensity, standard deviation, prevalence, abundance and dominance) were carried out using Microsoft Excel (Office 2000) for the overall sample and for the sample grouped by season, geographical location, sex, length and weight. The differences between groups were determined by Z test and ANOVA test ($P < 0.05$). The dominance of a parasite species was calculated as N/N-sum (where N is the abundance of a parasite species and N-sum is the sum of the abundance of all parasite species found) and expressed as a percentage. Mean intensity was determined by dividing the total number of recovered parasites with the number of infected fish samples, while abundance was calculated by dividing the total number of recovered parasites with the number of (infected and uninfected) fish samples. Prevalence was also calculated by dividing the number of infected fish samples with the total number of examined ones and expressed as a percentage.

In this study, 7304 worms of 12 species, including three nematodes [*Cucullanus sphaerocephalus* Rudolphi, 1809, *Eustrongylides excisus* (L) Jagerskiold, 1909 and *Anisakis* sp. (L) Mozgovoi, 1951], three cestodes (*Eubothrium acipenserinum* Kholodkovski, 1918, *Bothrimonus fallax* Luhe, 1900 and *Amphilina foliacea* Rudolphi, 1819), two acanthocephalans (*Leptorhynchoides plagicephalus* Westrumb, 1821 and *Corynosoma strumosum* Rudolphi, 1802), one digenean trematode (*Skrjabinopsolus semiarmatus* Molin, 1858), two monogenean trematodes (*Diclybothrium armatum* Leuckart, 1835 and *Nitzschia storionis* Abildgaard, 1794) and one crustacean [*Pseudotracheliastes stellatus* (Mayor, 1824)] were found in the five sturgeon species. The prevalence, mean intensity, range, abundance and dominance of the parasites are presented in Table 2.

As shown in 234 samples of *A. stellatus*, 2672 worms of nine species were found

Table 2. Prevalence, mean intensity ± standard deviation (SD), range (minimum and maximum number), abundance and dominance of some parasites

Parasite	Prevalence (%)	Mean intensity ± SD	Range	Abundance ± SD	Dominance (%)
A. stellatus					
S. semiarmatus $N = 2146$	43.15	24.99 ± 62.32	1–426	10.78 ± 42.64	80.43
L. plagicephalus $N = 360$	20.81	8.41 ± 11.49	1–51	1.71 ± 6.09	13.28
C. sphaerocephalus $N = 61$	17.26	1.66 ± 1.11	1–5	0.29 ± 0.79	2.28
E. acipenserinum $N = 35$	9.14	1.94 ± 1.47	1–6	0.18 ± 0.71	1.31
B. fallax $N = 51$	4.75	1.91 ± 2.91	1–20	0.13 ± 0.83	0.13
E. excisus (L) $N = 12$	4.06	1.5 ± 1.41	1–5	0.06 ± 0.40	0.45
A. foliacea $N = 2$	0.43	2	2	0.02	0.075
Anisakis sp. (L) $N = 4$	1.3	1	1	0.01	0.15
C. strumosum $N = 1$	0.43	1	1	0.01	0.038
A. persicus					
C. sphaerocephalus $N = 1755$	84.85	11.31 ± 14.64	1–109	9.65 ± 14.07	56.74
S. semiarmatus $N = 1270$	51.25	15.25 ± 21.28	1–109	7.81 ± 17.01	41.06
L. plagicephalus $N = 6$	1.85	1 ± 0.0	1	0.02 ± 0.14	0.193
E. excisus (L)* $N = 3$	1	3 ± 1.4	2–4	0.04 ± 0.35	0.097
Anisakis sp. (L)* $N = 3$	2	1 ± 0.0	1	0.01 ± 0.11	0.097
*A. foliacea** $N = 2$	1	1.5 ± 0.5	1–2	0.02 ± 0.18	0.065
*D. armatum** $N = 50$	0.5%>	50	50	0.02 ± 0.17	1.62
*N. storionis** $N = 2$	0.5%>	2	2	0.006 ± 0.08	0.065
*P. stellatus** $N = 2$	0.5%>	2	2	0.006 ± 0.08	0.065
A. gueldenstaedti					
C. sphaerocephalus $N = 274$	68.11	5.98 ± 6.84	1–32	3.65 ± 6.08	59.18
E. excisus (L) $N = 47$	15.28	2.91 ± 2.51	1–8	0.44 ± 1.41	10.15
S. semiarmatus $N = 36$	15.28	2.82 ± 2.56	1–9	0.43 ± 1.40	7.78
L. plagicephalus $N = 23$	6.94	4.4 ± 6.5	1–16	0.31 ± 1.91	4.97
Anisakis sp. (L) $N = 6$	5.56	1.5 ± 0.58	1–2	0.08 ± 0.37	1.30
C. strumosum $N = 72$	9.72	9.57 ± 16.02	1–45	0.93 ± 5.46	15.55
A. nudiventris					
C. sphaerocephalus $N = 105$	75	8.75 ± 7.09	1–32	6.56 ± 7.22	14.81
S. semiarmatus $N = 527$	68.75	47.91 ± 56.49	1–177	32.93 ± 51.51	74.33
E. excisus $N = 59$	31.25	9.6 ± 10.43	1–21	3.00 ± 7.08	8.32
E. acipenserinum $N = 15$	31.25	2.8 ± 2.49	1–6	0.88 ± 1.86	2.12
L. plagicephalus $N = 3$	6.25	3	3	0.19 ± 0.75	0.42
H. huso					
C. sphaerocephalus $N = 25$	66.67	6.25 ± 6.65	2–16	4.17 ± 6.08	6.72
E. excisus (L) $N = 328$	50	109.33 ± 153.86	20–287	54.67 ± 114.26	88.17
C. strumosum $N = 11$	33.33	5.5 ± 0.71	5–6	1.83 ± 2.86	2.96
E. acipenserinum $N = 2$	33.33	1	1	0.33 ± 0.52	0.54
Anisakis sp. (L) $N = 5$	16.67	5	5	0.83 ± 2.04	1.34
S. semiarmatus $N = 1$	16.67	1	1	0.17 ± 0.41	0.27

*New host records.

(Table 2). All the nine species were gut helminthes. About 33% of the fish had no worm, 37.76% was infected with one parasite species, 24.72% with two species and 4.64% with three species. About 38.14% of the fish harboured less than 10 worms, 24.74% had between 10 and 30 worms and 6.70% harboured more than 30 worms. *S. semiarmatus* had the highest prevalence (43.15%), mean intensity (24.99), abundance (10.78) and dominance (80.43%) in *A. stellatus* (Table 2). The prevalence, mean intensity and dominance of *L. plagicephalus* (20.81%, 8.41 and 13.28% respectively) were also more than the others. *S. semiarmatus* and *L. plagicephalus* constituted more than 93% of parasite communities in *A. stellatus*.

In 206 samples of *A. persicus*, 3093 worms of nine species were recovered (Table 2). Among these, six species are new host records (indicated by asterisks in Table 2). About 11.95% of the fish had no parasite; 37.74% was infected with one parasite species; 47.17% with two species and 3.14% with three species. Nearly 42.77% of the fish harboured less than ten worms; 28.93% had between 10 and 30 worms and 16.35% harboured more than 30 worms. As shown in Table 2, *C. sphaerocephalus* had the highest prevalence (84.85%) in *A. persicus* and *S. semiarmatus* had the second highest (51.25%). The mean intensity of these two parasites was 11.31 and 15.25 respectively. Other parasites had low prevalence and also low mean intensity. The dominance of *C. sphaerocephalus* and *S. semiarmatus* was also more than the other parasites and these two worms constituted more than 97.5% of parasite communities of the fish.

In 78 samples of *A. gueldenstaedti* (Table 2), 458 worms of six species were found. About 23.61% of the fish had no parasite; 47.22% was infected with one parasite species; 22.22% with two species and 6.94% with three species. Nearly, 58.33% of fish harboured less than ten worms and 18.06% had between 10 and 30 worms. As shown in Table 2, *C. sphaerocephalus* had the highest prevalence (68.11%) and dominance (59.18%) in the fish. The prevalence of *E. excisus* (L) (15.28%) and *S. semiarmatus* (15.28%) was also high. In addition, mean intensities of *C. strumosum* (9.57) and *C. sphaerocephalus* (5.98) were higher than the other parasites.

As shown in Table 2, 709 worms of five species were found in 18 samples of *A. nudiventris*. All the fish had parasites; Among these, 25% was infected with one parasite species, 43.75% with two species, 12.5% with three species and 18.75% with four species. About 31.25% of the fish harboured less than ten worms; 31.25% had between 10 and 30 worms and 37.5% harboured more than 30 worms. As shown in Table 2, *C. sphaerocephalus* had the highest prevalence (75%). Prevalence of *S. semiarmatus* was also high. In addition, mean intensity and dominance of *S. semiarmatus* (47.91 and 74.33% respectively) were higher than the others.

In this study, six samples of *H. huso* were examined and 372 worms of six species were found in the fish (Table 2). *E. excisus* (L) had the highest mean intensity (109.33) in *H. huso*. The mean intensities of *C. sphaerocephalus* (6.25) and *C. strumosum* (5.5) followed second and third. Interestingly, up to 278 specimens of *E. excisus* (L) were found in the stomach of one large *H. huso*. They were embedded in the muscles of the stomach as granulomatous cysts.

In this study, 542 samples of five sturgeon species were examined in the time period of two years and more than 7300 worms of 12 species, including three nematodes, three cestodes, two acanthocephalans, three trematodes and one crustacean were found. There are few reports about parasites of sturgeons in Iran. Mokhayer[6] studied parasites of only three sturgeon species, including *A. stellatus* ($n = 72$), *A. gueldenstaedti* ($n = 95$) and *H. huso* ($n = 4$) and reported 17 parasite species. Gorogi[7,8] also studied parasites of two sturgeons, including *A. persicus* ($n = 604$) and *H. huso* ($n = 99$) and reported six and three parasite species from the fishes respectively. In the present investigation, attempts were made to carry out a comprehensive study on parasites of all of the sturgeons which inhabit the southern part of the Caspian Sea (except *A. ruthenus* which is found in the northern part). Notably, *A. foliacea*, *E. excisus* (L), *Anisakis* sp. (L), *D. armatum, N. storionis* and *P. stellatus* are reported for the first time from *A. persicus* (new host records).

C. sphaerocephalus and *S. semiarmatus* were the most prevalent worms of the sturgeons. Also the mean intensity, abundance and dominance of these two parasites were more than the others. However, some differences were found among the sturgeons: The diversity of parasites in *A. stellatus* was more than in the others (probably because of wide variety of food items, including crustaceans, molluscs and also fishes in its diet). Prevalence, mean intensity, abundance and dominance of *C. sphaerocephalus* in *A. stellatus* were less than in the other sturgeons (probably due to smaller amounts of nereids in its diet, since these organisms are known to be intermediate hosts of *C. sphaerocephalus*). *L. plagicephalus* had higher prevalence, mean intensity and dominance in *A. stellatus* than the others (perhaps due to high amounts of gammarids, the intermediate hosts of the parasite, in its diet). *B. fallax* was only found in *A. stellatus.* No Eucestoda was found in *A. persicus* and *A. gueldenstaedti. E. excisus* (L), *Anisakis* sp. (L) and *C. strumosum* were mostly found in more carnivorous sturgeons such as *H. huso*, *A. gueldenstaedti* and *A. nudiventris*. This is probably because *E. excisus* (L) needs some benthophagous fishes (e.g. *Rutilus rutilus caspius* and *Neogobius* spp.) as obligatory second intermediate hosts and also *C. strumosum* needs some fishes (e.g. *Clupeonella* spp. and some gobiids) as reservoir hosts. It is also true about *Anisakis* sp. (L) where the sturgeons are unusual hosts of the parasite and harbour it by feeding on some carnivorous cyprinids.

The prevalence, mean intensity and dominance of *A. foliacea* (a freshwater parasite) in all the sturgeons were low. This is probably because the spawning migrations of sturgeons into the freshwater have decreased, which may be due to unfavourable conditions of freshwater ecosystems caused by pollutions, etc.

It was also found that the diversity of parasites in *A. persicus* was less than the other sturgeons. *C. sphaerocephalus* and *S. semiarmatus* constituted more than 97.5% of parasite communities of the fish. This is because the fish has selective feeding habits and mostly feeds on Polychaeta and Oligochaeta, which are known to be the intermediate hosts of the parasites respectively.

According to the results of this study and also those of Mokhayer[6] and Gorogi[7,8], the diversity of parasites of sturgeons in the southern part of the Caspian Sea is less than that in the northern part. It should be noted that the maximum depth of the Caspian Sea in the northern part is about 12 m, while in the southern part it is about 980 m. The salinity of water in the north is about 5 ppt (parts per thousand), while in the south it is about 13 ppt and may reach to 20 ppt in the southeast. In addition, productivity and carbonate ions in the two regions also differ. All these factors may have some impact on the parasite communities of sturgeons.

It also seems that the diversity of parasites (including freshwater parasites) in the southern part of the Caspian Sea has decreased during the time period from the first study[6] till now. It may relate to unfavourable conditions of freshwater ecosystems, such as pollution, dam construction, etc. Under such conditions, it will be impossible for the sturgeons to ascend into the rivers for spawning.

In this study, the prevalence and mean intensity of some parasites (including *C. sphaerocephalus* and *S. semiarmatus*) in sturgeons varied in different locations. A direct relation was found between some parasites (particularly *C. sphaerocephalus* and *S. semiarmatus*) and size of the fish. The prevalence and mean intensity of parasites in females were more than in males. It was found that there is a correlation between some parasites (particularly *C. sphaerocephalus* and *S. semiarmatus*) and season. There was also correlation between fish food and diversity of parasites.

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MEETINGS/SYMPOSIA/SEMINARS

Workshop on Molecular Biology – A Laboratory Training Course

Date: 22–26 August 2005
Place: Ahmedabad

The workshop will focus on theoretical aspects of molecular biology as well as hands-on training in various molecular biology techniques like genomic DNA extraction, plasmid isolation, restriction digestion, ligation, transformation, DNA amplification by PCR, protein gel separation and analysis by blotting, etc.

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Conference on Natural Resource Management for Eco-development and livelihood security in southern India

Date: 24–25 November 2005
Place: Udhagamandalam

Themes include: Resource appraisal, resource management and socio-economic aspects.

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