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NOTE

An unidentified haplosporidian parasite of bay scallop *Argopecten irradians* cultured in the Shandong and Liaoning provinces of China

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ABSTRACT: Since 1988 growers of bay scallop *Argopecten irradians* in China have been experiencing mortality in their cultured stocks. Although poorly documented, mortality apparently began near Qingdao and has since spread to other areas of Shandong and Liaoning provinces. Samples of cultured scallops were collected from several growing areas and analyzed by histological methods for pathogens. An unidentified haplosporidian parasite was observed in a high proportion of scallops from two of the stocks examined. Most infections were of low intensity, but one heavy infection was also observed. Only plasmodia stages were observed; they occurred intercellularly in connective tissues throughout the scallops. Plasmodia were spherical to oval, varied from 4.0 to 17.0 μm in diameter and contained from 2 to 18 nuclei. Absence of spores prevented generic assignment of the parasite. The source and pathogenicity of the haplosporidian could not be assessed without additional research. No other microbial parasites (i.e. rickettsia-like, chlamydia-like or kidney coccidia) were observed in any of the scallops examined.

KEY WORDS: *Argopecten irradians* · China · Culture · Haplosporidia · Histopathology · Parasite

The bay scallop *Argopecten irradians* was first introduced to China from the east coast of the United States in December 1982. Presently, bay scallop cultivation is one of the major aquaculture activities in China, particularly along the coasts of the Bohai and Yellow Seas in Shandong and Liaoning provinces (Fig. 1). Significant production was first achieved in 1987 and was recorded as 20–25 000 t live weight; production has increased steadily and was estimated at 220 000 and near 300 000 t live weight for 1993 and 1994 respectively. Bay scallop growers in recent years have experienced problems with increasing mortality in their cultured scallops. Scallop mortality was first noticed in the Yang Ma DaO hatchery in 1988. Subsequently, scallop mortalities spread into other areas of the Shandong peninsula. In 1989 mortalities occurred in Jiaozhou Bay, in 1990 in Laoshan and Haiyang, in 1991 in the Jiaonan region, and in 1992 in Jimo, Penglai and Laizhou Bay (Shandong province) and in Dalian (Liaoning province). Currently, there is no adequate documentation of the mortality rate, but scallops usually die in the spring of each year, somewhat after spawning. Although little research has been conducted on the cause of mortality, it has been attributed to energetic stress resulting from spawning, and to diseases, because large numbers of juvenile scallops often died at the same time. Moribund scallops were characterized by mantle recession, with the mantle detached from the edge of the shell.

This paper reports the results of a histopathological study of adult bay scallops collected from several of the bay scallop growing areas of Shandong and Liaoning provinces while two of the authors, Fu-Lin E. Chu and Kenneth K. Chew, visited China under the Marine and Fishery Science and Technology Protocol between the US and China. The morphology of an unidentified haplosporidian parasite is described and its source and potential pathogenicity are discussed.

Materials and methods. Most samples were collected in March 1993, but some were collected in October 1993 (Table 1). At the Jiaonan scallop hatchery samples were taken from conditioned stocks of the following growing areas: Dazhusan, Zhaiili counties, the shrimp pond of Hongshuya county and Laizhou Bay. At the Penglai hatchery, samples were taken from...
The digestive gland and gonad was dehydrated and embedded in paraffin using standard histological techniques. In large scallops, the tissue section was cut into 2 pieces to facilitate embedding, sectioning and mounting on glass slides. Sections were cut at 5 μm, stained with Harris' hematoxylin and eosin and examined at 100× for the presence of parasites. A total of 40 haplosporidian parasites were measured with a calibrated ocular micrometer.

Results. Plasmodia of what appeared to be a haplosporidian parasite were observed in a high proportion of scallops from Fushan stock at the Penglai hatchery and from Zhaili stock at the Jiaonan hatchery (Table 1). The intensity of most infections was low (<1 plasmodium per 100× field), but one scallop at Penglai hatchery had a heavy infection (≥1 plasmodium per 400× field). Plasmodia were usually located intercellularly in the connective tissue adjacent to the stomach epithelium, but other sites included the connective tissue of the gonad and labial palps and hemal spaces of the adductor muscle.

Plasmodia were typically spherical to oval and contained 2 to 18 nuclei. The size of the spherical plasmodia varied from 4.0 to 17.0 μm in diameter; oval plasmodia ranged from 4.0 × 6.0 to 15.5 × 17.0 μm (Figs. 2 to 5). Nuclear morphology varied from uniform distribution of chromatin (Figs. 2 & 3) to peripheral chromatin with a more or less central nucleolus (Fig. 4). In the scallop with the heaviest infection from Penglai hatchery, small, mostly spherical plasmodia averaging 6.0 μm in diameter were present throughout the connective tissue, but were concentrated in the labial palps (Fig. 5). From 2 to 6 nuclei were observed in these small plasmodia, but in many the internal morphology could not be discerned because of dark staining or lack of detail.

<table>
<thead>
<tr>
<th>Location</th>
<th>Date collected</th>
<th>Mean shell height (mm) and range</th>
<th>No. of scallops infected/examined (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jiaonan Hatchery:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dazhushan stock</td>
<td>18 Mar 1993</td>
<td>57.2 (49–63)</td>
<td>0/6 (0%)</td>
</tr>
<tr>
<td>Zhaili stock</td>
<td>18 Mar 1993</td>
<td>59.9 (54.5–66)</td>
<td>5/6 (83%)</td>
</tr>
<tr>
<td>Hongshiya shrimp pond stock</td>
<td>18 Mar 1993</td>
<td>58.6 (52–65)</td>
<td>0/6 (0%)</td>
</tr>
<tr>
<td>Laizhou Bay stock</td>
<td>18 Mar 1993</td>
<td>51.0 (42.5–61)</td>
<td>0/6 (0%)</td>
</tr>
<tr>
<td>Jiaonan</td>
<td>4 Oct 1993</td>
<td>47.7 (41–52)</td>
<td>0/6 (0%)</td>
</tr>
<tr>
<td>Laizhou Bay, Bohai Sea</td>
<td>19 Mar 1993</td>
<td>59.0 (55–67)</td>
<td>0/12 (0%)</td>
</tr>
<tr>
<td></td>
<td>4 Oct 1993</td>
<td>49.0 (42–57)</td>
<td>0/12 (0%)</td>
</tr>
<tr>
<td>penglai Hatchery:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fushan stocks</td>
<td>20 Mar 1993</td>
<td>55.7 (52–59)</td>
<td>6/6 (100%)</td>
</tr>
<tr>
<td>Dalian Fisheries College</td>
<td>23 Mar 1993</td>
<td>51.7 (45–57)</td>
<td>0/6 (0%)</td>
</tr>
</tbody>
</table>
The haplosporidian parasite did not stimulate widespread hemocyte infiltration in lightly infected scallops, although in some cases there was localized hemocyte infiltration adjacent to the stomach epithelium. However, there was moderate hemocyte infiltration in the scallop with a heavy infection from Penglai hatchery.

No prokaryotes or other eukaryote parasites were observed in histological sections of scallops. Noticeably absent were rickettsia-like organisms in the gills, chlamydia-like organisms in the digestive diverticula and kidney coccidia. No parasites or infectious disease agents were observed in any of the *Crassostrea gigas* examined.

**Discussion.** Haplosporidians were previously included along with the paramyxea in the phylum Ascetospora, but recently both of these groups have been elevated to phylum rank and the Ascetospora has been abandoned (Perkins 1991). The protistan parasite observed during this study was determined to be a member of the phylum Haplospordia on the basis of typical multinucleate plasmodia. The genus of the parasite cannot be determined because the spore stage was not observed. Haplosporidian parasites have not previously been reported from *Argopecten irradians* (Leibovitz et al. 1984, Karlsson 1990, Getchell 1991, Bower et al. 1994). Potential disease agents of *A. irradians* that are reported most often are chlamydia-like organisms in the digestive diverticula (Getchell 1991), rickettsia-like organisms in the gills (Getchell 1991) and coccidia in the kidney epithelium (Whyte et al. 1994), but the lesions caused by these organisms are not well studied. None of these latter organisms was observed in *A. irradians* from China. *Perkinsus karlssoni* has been implicated in mortality of juvenile *A. irradians* in Nova Scotia, Canada (McGladdery et al. 1991), but this parasite was not observed during the present study.
It is impossible to determine at this time if the haplo-
sporidian parasite is endemic to China or was intro-
duced with the importation of Argopecten irradians
from the east coast of the United States. No haplo-
sporidian parasite has been observed in A. irradians
from the United States so it seems unlikely that the
parasite was introduced. However, an undescribed
species of Marteilia, a genus previously grouped with
the haplosporidia in the phylum Ascocephora but
now placed in the phylum Paramyxidea, has recently
been implicated in mass mortalities of calico scallops
Argopecten gibbus in Florida, USA (Moyer et al.
1993). Cells of Marteilia spp. are usually restricted to
the epithelium of the gut (Villalba et al. 1993) and
sporulation stages are commonly observed, usually
in large numbers, in the epithelium of digestive diver-
ticula. Multinucleate plasmodia are not known from
Marteilia spp. The presence of plasmodia in the con-
nective tissues strongly suggests that the unidentified
haplosporidian in A. irradians is not related to
Marteilia.

An undescribed haplosporidian is known from Cras-
sostrea gigas in Korea (Kern 1976) and has also been
observed in C. gigas seed oysters imported from Japan
(Friedman et al. 1991). Plasmodia are distributed
throughout the connective tissues. The plasmodia
reported in C. gigas are similar to those observed in
Argopecten irradians from China and it is possible that
the parasites are the same species. No similar parasites
were observed in the few C. gigas sampled from the
scallop growing areas of China, but the parasite in C.
gigas is known to be uncommon and, in the present
study, C. gigas was not collected from areas where the
parasite was present in scallops.

The haplosporidian in Argopecten irradians is not
similar to the 2 unidentified protistan parasites re-
ported by Bower et al. (1992) from Japanese scallops
Patinopecten yessoensis cultured in British Columbia,
Canada. None of the observed stages of these para-
sites, designated SPX and SPG, was a multinucleated
plasmodium. The pathogenicity of the haplosporidian
parasite cannot be determined without further study.
Most observed infections were light, suggesting mini-
mal mortality at least at that sampling point. However,
the presence of at least one heavy infection at Penglai
hatchery suggests that the parasite is capable of de-
veloping in A. irradians and has the potential to cause
mortality. Seasonal sampling of live scallops from all
growing areas would permit documentation of the
prevalence, intensity, and distribution of the infections,
and, in conjunction with documented scallop mortality,
would provide data for assessing pathogenicity. Sam-
ping of dying or dead scallops that still contain
tissue would provide additional data on the relation-
ship between the presence of the parasite and scallop
mortality.

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