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Introduction in Europe, from 1972 to 1980, of the Japanese Manila clam (*Tapes philippinarum*) and the effects on aquaculture production and natural settlement

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La palourde du Pacifique (*Tapes philippinarum*) a été introduite en France entre 1972 et 1975 par la Société SATMAR et en Angleterre en 1980 par le laboratoire de Conwy. Les introductions ont porté en premier lieu sur du naissain et par la suite sur des adultes, dans chaque cas en provenance de la côte ouest des Etats-Unis. La production aquacole a été lancée à partir d'adultes. Les organismes scientifiques ont développé les recherches de base à partir du naissain produit par la SATMAR à l'échelle semi-industrielle, recherches qui aboutirent à la mise en oeuvre de programmes de transfert. L'aquaculture de la palourde commença en premier lieu sur la côte atlantique, dans la frange intertidale et en claires ostréicoles. Les caractéristiques de cette nouvelle culture sont données. Les maladies rencontrées sont citées. Il est observé des développements naturels dans les bassins de production.

The Pacific Manila clam (*Tapes philippinarum*) was introduced in France between 1972 and 1975 by the SATMAR Corporation, and in England through the Conwy Laboratory in 1980. Initially, spat were introduced and later adults, both from the west coast of North America (Puget Sound area). Aquaculture production in France started from adults. Until 1975, experiments with the spat were conducted at half-industrial scale, and research activities and plans to transfer the knowledge were set up. The breeding began at first on the French Atlantic coast in intertidal areas and at the same time in oyster ponds. Characteristics of the new culture are presented in this paper. The diseases met with in larval production and growout are also discussed. Natural developments of the species are observed.

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Introduction

Following the work of Loosanoff and Davis (1963) in the United States, Walne (1966) in England and Lucas (1970) and Flassch *et al.* (1975) in France, techniques concerned with controlled production of molluscs developed rapidly. Several hatcheries (the Madec hatchery in Brest Harbour, 1966, then the SATMAR hatchery on the Cotentin Peninsula in 1972) were set up using American techniques to produce flat oysters (*Ostrea edulis*) (phytoplankton production and larval production in large tanks of several cubic metres). Following the outbreak of epizootic disease in 1965 in Portuguese oysters (*Crassostrea angulata*), a large demand for seed oysters arose. For this, SATMAR, the only remaining hatchery at the time, actively developed the techniques of controlled production of the species.

Since 1972, knowledge of hatchery techniques has increased, and in an effort to diversify the controlled production of bivalves, steps have been taken concerning imports of Manila clam (*Tapes philippinarum*) from the Pacific coast of North America. This species was accidentally introduced into North America in 1936 (Quayle, 1964). It was imported with Pacific oysters (*Crassostrea gigas*) from Japan, which were placed overboard in Ladysmith Harbour. Since 1941, Manila clams have colonized the coastal zone from Vancouver southward, spreading as far as California. The natural distribution of the Manila clam extends between the latitudes of 25° and 45° North. Prior to the introduction into France of the Pacific oyster (Gruet *et al.*, 1976; Grizel and Héral, 1990), the hard clam (*Mercenaria mercenaria*) was repeatedly imported (Ruckebusch, 1949) in 1861 (Arcachon Basin), in 1910 (Seudre Basin), and

Table 1. Schedule of Manila clam introductions into France.

Date of request	Date of receipt	Origin	Number	Weight kg	Size
08.11.1972	15.05.1973	Puget Sound (Southwestern Canada)	500 000	1.6	Spat (3–4 mm)
03.01.1974	21.06.1974	Puget Sound	300	15.4	Adult (60 mm)
04.02.1974	08.08.1974	Puget Sound	300		Adult
		Puget Sound	400	25	Adult (64 mm)

from 1936 to 1939 in Southern Brittany. Natural beds, whose size has varied over the years, have developed in the Seudre Basin and in the Gulf of Morbihan.

he development of new techniques, on the one hand, and examples of the successful introduction of other non-native species (hard clams and Pacific oysters) on the other, have thus paved the way for importing the Manila clam. Several stages in the process occurred: the elaboration of introduction procedures, the development of hatchery techniques, the improvement of breeding through research, the refinement of transfer and development operations, the establishment of a profession and, unfortunately, the occurrence of problems such as epizootic diseases and commercial competition.

Formation of the European stock

Introduction of the Manila clam into France was carried out under the supervision of the Institut Scientifique des Pêches Maritimes (Scientific Institute of Marine Fishing). Details of these operations are listed in Table 1. As regards importation into England, it was not until 1980 that 50 clams from Puget Sound were received by the Conwy Laboratory (B. Spencer, pers. comm.) of the MAFF (Ministry of Agriculture, Fisheries, and Food). Manila clams which were subsequently introduced into Spain and Italy (Breber, 1985) came from this introduced stock. All the imports mentioned above were carried out in accordance with the health controls in force in the United States, France, and England (histological examinations, quarantine periods, etc.). This import was made in accordance with 1972 ICES Code of Practice for the introduction of non-indigenous species.

Biological data

Initial research focused on the biological reaction of the species to the temperate ecosystem of the Atlantic coast, and production control techniques for spat were improved in hatcheries.

The potential of first season growth (Fig. 1; Lucas, 1977; IFREMER, 1988), of subsequent growth (a general reference growth curve was described for the use of

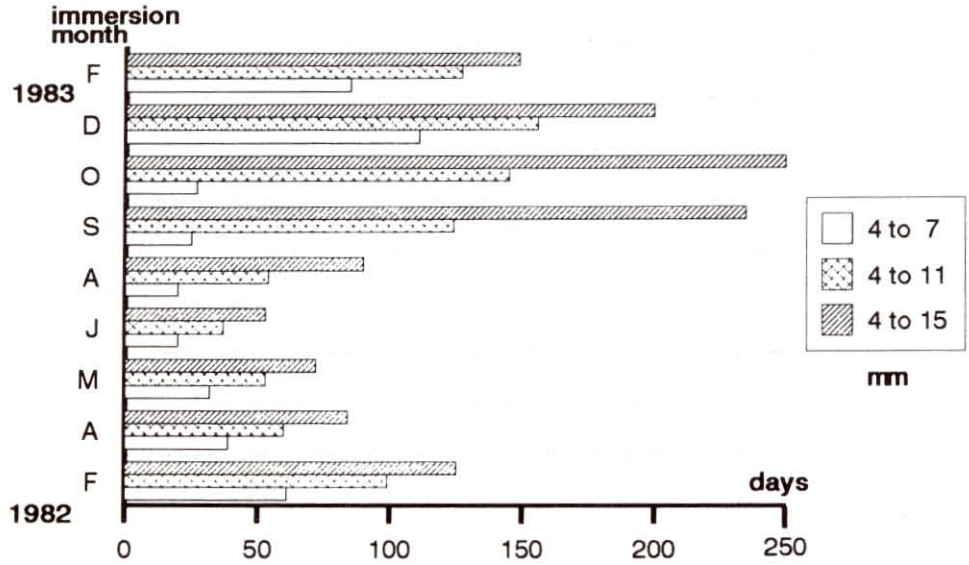

Figure 1. First-season growth of *Tapes philippinarum*, Ile-Tudy, Brittany, 1982/1983. Number of days required to develop seed spat bred in plastic mesh bags (10 000 spat m^2).

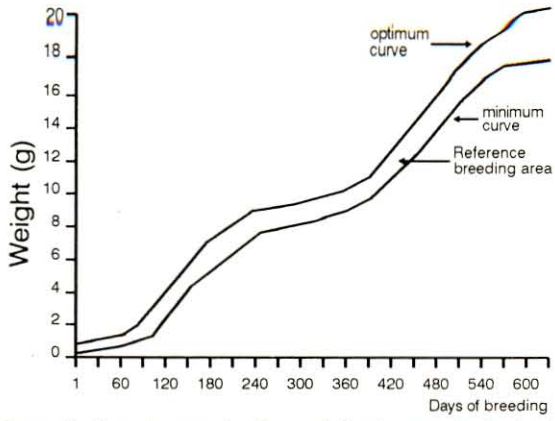

Figure 2. Growth curve for *Tapes philippinarum*, beginning in mid-March.

farmers, based on five years' data; Fig. 2; Flassch, 1978, 1987; de Kergariou *et al.*, 1982; Menesguen *et al.*, 1984; IFREMER, 1988), and the natural reproductive cycle (Goulletquer, 1983; Beninger and Lucas, 1984) were studied. Problems to be resolved quickly were identified as optimum immersion size and impact of predators. Breeding strategy was directed according to the behaviour patterns of the principal predator, the green crab (*Carcinus maenas*) (IFREMER, 1988).

Production development

In France, growers concerned with molluscs have been established for decades, i.e. oyster and mussel farmers. Since the introduction of production trials with Manila clams, few shellfish breeders have become involved, and so new experts from agriculture, universities, and institutes of technology have appeared. This new type of breeding was introduced with the aim of diversifying mollusc breeding (oysters, mussels, cockles). Once the scientific basis was established, national and regional programmes were developed – programmes aimed at testing the proposed techniques and the different sites in which the production experiments were carried out (IFREMER, 1988; Flassch, 1989).

Problems encountered

Epizootic diseases

The Manila clam, which is generally fairly resistant, has been subject to two outbreaks of bacterial disease which have altered the rate of production growth (Table 2). This has affected production procedures during the period in which all of the necessary ingredients for the long-term establishment of production were being set up (hatcheries, creation of new firms, mechanization).

The first outbreak, developed in a hatchery (Anon., 1987), was caused by a *Vibrio* strain not previously described, and was given the name of VRP (*Vibrio* of *Tapes philippinarum*). This strain has new distinguishing characteristics, in particular:

- it attacks larvae and spat
- it is specific to the Manila clam (Pacific oyster larvae (*Crassostrea gigas*) and the scallop (*Pecten maximus*) are not affected)
- larvae begin to die on the fifth day
- a very small dose is enough to trigger the disease
- it cannot be detected by direct inoculation of water samples on a Petri dish
- it does not develop in an environment which is specific to *Vibrio* (TCBS)
- a strain of the pathogen isolated at Brest from contaminated stocks is resistant to chloramphenicol, but is sensitive to streptomycin and very sensitive to furan.

Sanitary measures and the use of appropriate antibiotics have reduced the effect of this disease on hatchery production.

The second disease occurred in the natural environment for the first time in spat, at the end of 1986. Then, in 1987, it occurred in both spat and juvenile clams. It was first recognized, on the breeding grounds in the region of Landeda and in the Aber Benoît River (Finistère, France), by a brownish deposit on the inside of the shell. The infected spat died quickly. The juveniles rose partly from bottom sediments before dying. Infected clams grew very slowly. The pathogenic origin of this "Brown Ring Syndrome" was discovered in late 1988 (Paillard *et al.*, 1989). The cause of the disease is an unidentified bacterium very similar to the *Vibrio* type called "P_1" (not dangerous to human health). The formation of the brown matter correlates with the proliferation of this organism in the cellular zone which forms the periostracum of the shell.

Research findings about the pathogen (Paillard and Maes, 1990) help to explain some of the epidemiological characteristics observed:

Table 2. Evolution of French production in tonnes of the Manila clam (*Tapes philippinarum*).

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Aquaculture production	2	4	10	100	200	400	460	550	550	450*

*Effect of the brown ring disease.

- the organism is sensitive to temperatures above 27°C
- the disease can only be reproduced with high doses of the pathogen ($10^5 - 10^6$ ml^{-1})
- the higher the number of Manila clams in the breeding ground, the higher the risk of infection
- the brown ring appears at the earliest on spat of between 8 and 10 mm
- growth of spat of this size which appear healthy will proceed normally if carried out under the correct technological conditions (IFREMER, 1988)
- *Vibrio* P_1 is sensitive to Furazolidone; standard protocol for the use of this product has been suggested to breeders in order to provide 2 mm spat with the best chance of survival.

e spread of the P_1 disease has hindered the development of Manila clam culture, but the field strategy adopted in close cooperation with the breeders has enabled the process of infection to be controlled (Table 2).

Natural production and markets

French producers are facing commercial problems which are directly linked to the ability of the species to reproduce naturally in controlled breeding grounds. French production is almost entirely exported to Spain. The ex-producer price rose from 50 to 55 FF/KG (8.3 to 9 US $) between 1984 and 1988 and fell in 1989 to between 35 and 45 FF/KG. Over the past two years, there has been severe competition from Italian producers exporting *Tapes philippinarum* to Spain. It was only in 1983 that the first Manila clams were imported into Italy from Great Britain (Breber, 1985). In 1983, 200 000 spat were sown in the Venice Lagoon (Chioggia Basin); in 1984, 1 250 000 spat were sown in the Venice goon (Pessestrina), and the same amount at Rosalina. In the space of six years, stocks have increased naturally to such an extent that Italian production in 1989 amounted to more than 6000 t.

So the French breeders face increased competition from other areas with natural production. The latter is becoming particularly widespread in southern Brittany. In that area, natural production is considerably larger than that of the breeders. In 1990, natural production reached 1500 t as compared with 500 t from aquaculture production.

Discussion

Apart from the initial import of Manila clams (500 000 spat) (Table 1), the batches that have been introduced into France and later into England were small and therefore easy to control, at least as regards epibionts. The imports of Pacific oysters (*Crassostrea gigas*) (Grizel and Héral, 1990), which included as much as 562 t of adults and 10 000 t of seed on collectors, were not so easily controlled. Batches of tens or hundreds of adults can be processed individually, but it will always be very difficult to assess in advance the influence of a species on the marine environment and, conversely, the effect of the receiving ecosystem on the species introduced. Therefore, ICES and EIFAC developed a Code of Practice for introductions – designed to prevent disasters.

As regards the Manila clam, the number imported into Europe is very small, especially if one considers the fact that the 500 000 spat imported by SATMAR in 1972 disappeared very quickly, falling victim to predators. In all, 1050 adults generated a combined European breeding and natural stock of over 20 000 t in 1989. A genetic survey carried out on the French stocks (Moraga, 1986) shows that the species is still highly heterozygotic, which aided its adaptation and enabled a large stock to be formed from only a few individuals.

Natural production of *Tapes philippinarum* is very high compared with that from controlled breeding. The quality of the aquaculture product has been improved and in most cases the taste is much better. Research to produce clams of a different quality emphasizes genetics – for example, the development of batches of polyploids. These products will be easily distinguished from the natural product, since their energy, which will no longer be used for gametogenesis, should be more evenly distributed and thus should improve the quality of the product, as in the case with oysters.

Conclusions

The European population of Pacific Manila clams (*Tapes philippinarum*) has grown from four batches of between 50 and 400 clams to form a stock which yielded 20 000 t in 1990 – the amount of natural stock being much larger than the amount from controlled breeding. The two production methods (natural production and aquaculture) have to cohabit. But controlled breeding will only continue if it is able to produce clams of a different quality, such as *Tapes philippinarum*/*Tapes decussatus* polyploids, or to produce clams that are disease-resistant, or that have a colour more acceptable to consumers – to maximize the value of the crop.

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