

**19th International Conference on Diseases of Fish and Shellfish
PORTO 10th September 2019**



ParaFishControl

**Economic Impact of Parasitic
Diseases in Mediterranean
Mariculture**

Dr. A. Le breton – VET'EAU France.

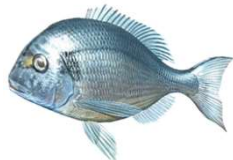
**ParaFishControl Industry Forum “Mediterranean
Fish Parasite Management Strategies”**

Introduction

In intensive production systems, economic evaluations based on financial and data analyses are very useful in animal health management, including adopting control and prevention measures

- treatment costs
- Prevention
- technical assistance
- lowered performance and/or quality of feedstock.
- Over costs induced

It is important to determine how much resources should be allocated to the detection, control and prevention of parasitic diseases in Mediterranean Mariculture systems.



Introduction

① What are the problematics?

External parasites

Protozoa

Monogenea & Isopodia

Internal parasites

Colozoic

Histozoic

② Factors influencing economic impact of parasitic diseases

③ Induced costs

④ Practical cases

Future trends

Introduction

2 types of events
= 2 different economical impacts

① Unpredictable sporadic infections	② Predictable regular infections
<p>Losses Post harvest down grading Growth impact and FCR Destruction of dead fish Control of infection</p>	<p>Losses Post harvest down grading Growth impact and FCR Destruction of dead fish Control of infection Prophylactic treatments Health management & management practices</p>

Introduction

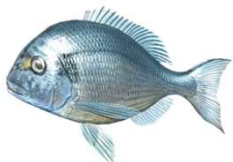
- ① What are the problematics?
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① What are the problematics?

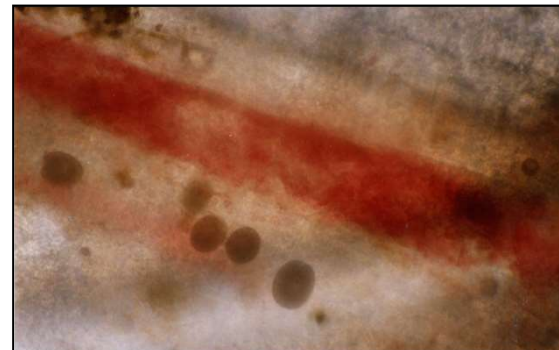
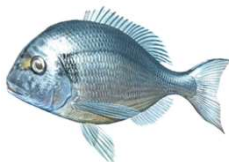
① External parasites

	Land Based Operation		Sea cages	
Type	RAS ¹	Open System ²	Pre growing	Ongrowing
Protozoa	-	✓✓✓	✓	-
Metazoa				
Monogenean	(✓) ³	✓	✓	✓✓✓
Isopodia	-	-	✓✓	✓

¹ Hatchery – Pre growing

² Flow through system in land based farm or ponds

³ Only on spawners



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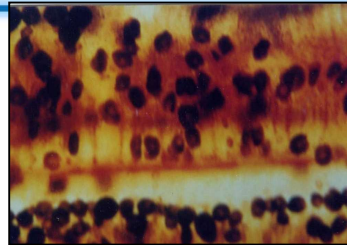
② Factors influencing economic impact of parasitic diseases

③ Induced costs

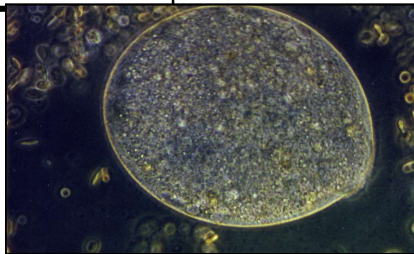
④ Practical cases

Future trends

External parasites in Mediterranean Mariculture: Protozoa



Ciliates	Host species
<i>Trichodina</i> sp.	All species
<i>Trichodinella</i>	Sparidae, Turbot
<i>Cryptocaryon irritans</i>	Sea bass, Sea bream
<i>Cryptocaryon</i> like	Sea bass, Sea bream
<i>Philasteroïdes dicentrarchi</i>	Sea bass, Turbot



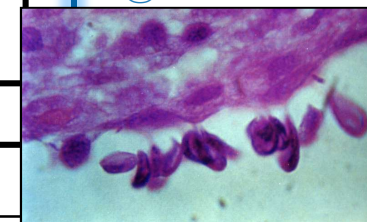
Dinoflagellates	Host species
<i>Amyloodinium ocellatum</i>	Sea bass, Sparidae, Mulet, Sole
<i>Oodinium</i> sp.	Sea bass, Sea bream
Kinetoplastidae	Host species
<i>Cryptobia</i>	Sea bass, Sea bream, Solea
<i>Ichtyobodo</i> (Costia)	Sea bass, Sea bream, Turbot

Rhizopoda	Host species
<i>Paramoebae</i>	Sea bream, Turbot, Solea



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 - Protozoa
 - Monogenea & Isopodia
 - Internal parasites
 - Colozoic
 - Histozoic
- ② Factors influencing economic impact of parasitic diseases
- ③ Induced costs
- ④ Practical cases



External parasites in Mediterranean Mariculture: Monogenea & Isopodia

Monogenea	Host species
<i>Diplectanum aequans</i>	Sea bass
<i>Sparicotyle chrysophrii</i>	Sea bream
<i>Sciaenocotyle panceri</i>	Meagre



Isopodia	Host species
<i>Caligus minimus</i>	Sea bass
<i>Ceratothoa oestroïdes</i>	Sea bass, Sea bream
<i>Lernanthropus kroyeri</i>	Sea bass
<i>Lernea</i>	Sea bass, Sea bream



Introduction

- ① What are the problematics?
External parasites
Protozoa
Monogenea & Isopodia
Internal parasites
Colozoïc
Histozoïc

- ② Factors influencing economic impact of parasitic diseases

- ③ Induced costs

- ④ Practical cases

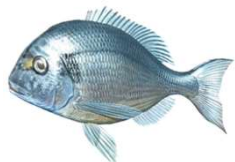
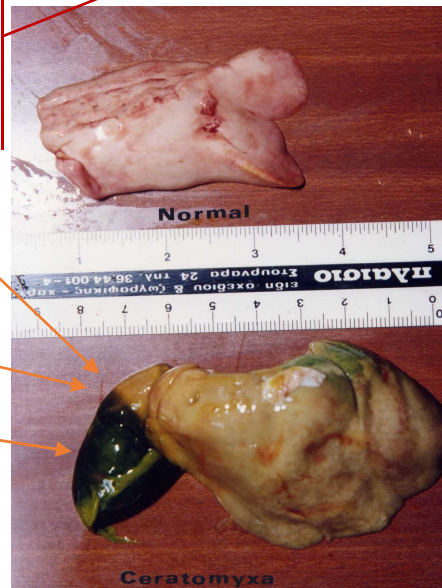
Future trends

① What are the problematics?

② Internal parasites

	Land Based Operation		Sea cages	
Type	RAS ¹	Open System ²	Pre growing	Ongrowing
Coelozoïc	-	✓	✓	✓
Histozoïc				
			- ✓ ✓	- ✓ ✓ ✓

Diplodus sargus
 Enteromyxum infection Greece 1996
 Up to 40% mortality
 =
STOP PRODUCTION



Introduction

- ① What are the problematics?
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 - Coelozoïc
 - Histozoïc

- ② Factors influencing economic impact of parasitic diseases

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Future trends

① What are the problematics?

② Internal parasites

300.000 fish sold @ 400g aw = 120T production

FCR expected: **1.8** ▶ Economic FCR: **2.0**
 No mortality, no morbidity

Minimum losses
24.000€

Introduction

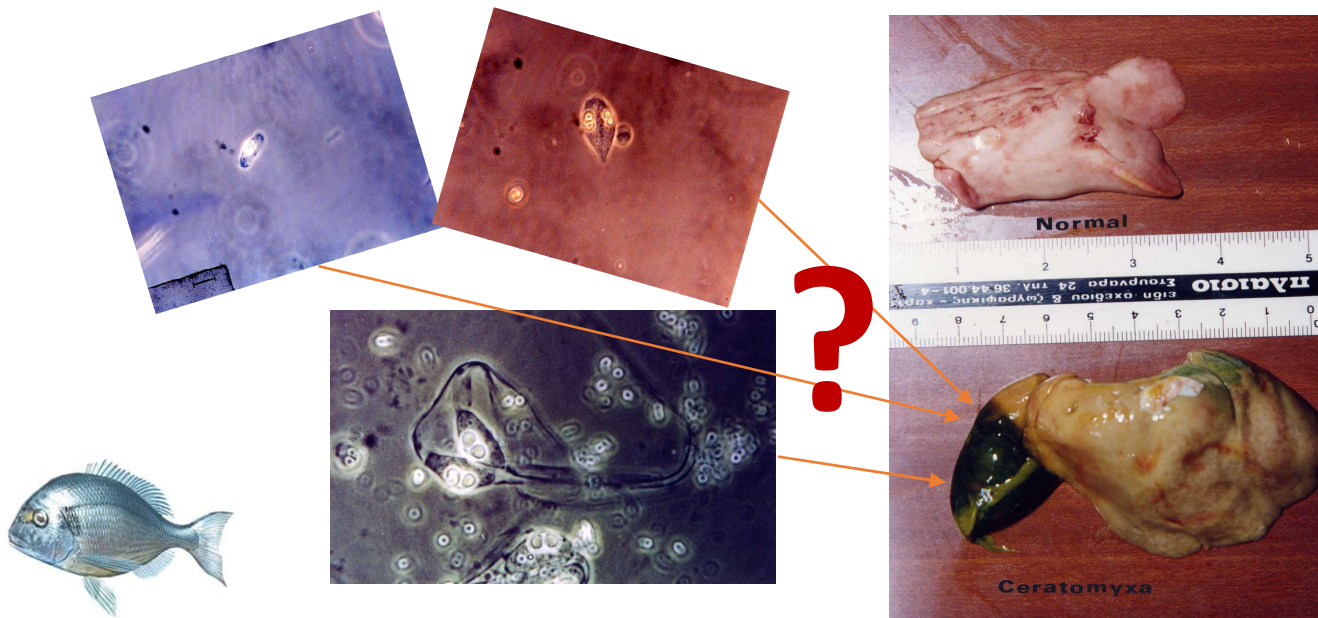
- ① What are the problematics?
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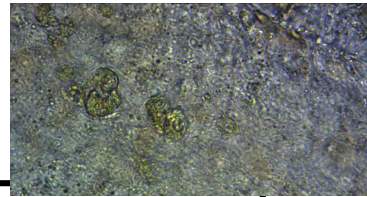
- ③ Induced costs

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Future trends



Internal parasites in Mediterranean Mariculture: coelozoic



Apicomplexa	Host species
<i>Eimeria</i>	Sea bass, Sea bream,
<i>Cryptosporidium molnari</i>	Sea bass, Sea bream

Myxosporidia	Host species
<i>Ceratomyxa sparuaurati</i> , <i>diplodae</i> , <i>labracis</i>	All species



Ciliate	Host species
<i>Philasterides dicentrarchi</i>	Sea bass, Turbot
<i>Cryptocarium like</i>	Sea bream



Introduction

- 1) What are the problematics?
- External parasites
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 - Monogenea & Isopodia
 - Internal parasites
 - Coelozoic
 - Histozoic

2) Factors influencing economic impact of parasitic diseases

3) Induced costs

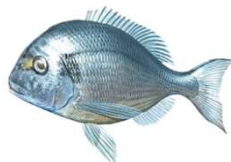
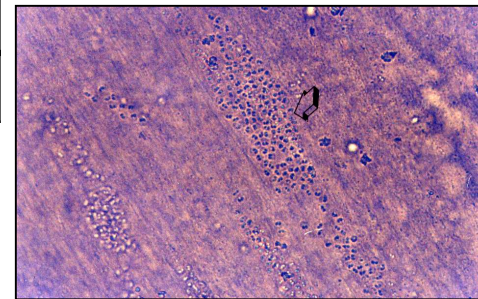
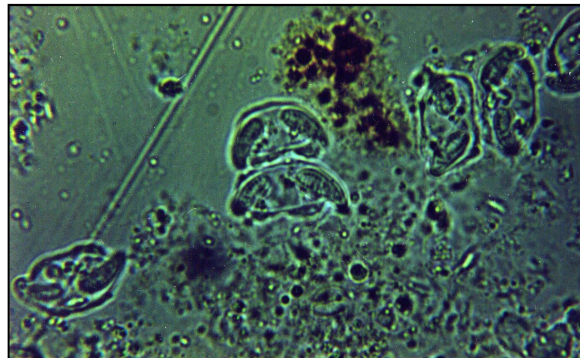
4) Practical cases

Future trends



Internal parasites in Mediterranean Mariculture: histozoic

Myxosporidia	Host species
<i>Enteromyxum leei</i>	Sea bream
<i>Enteromyxum scopthalmi</i>	Turbot
<i>Sphaerospora dicentrarchi</i> <i>Sphaerospora testicularis</i>	Sea bass
<i>Polyporoplasma</i>	Sea bream



Microsporidia	Host species
<i>Glugea</i> sp.	Sea bream

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Future trends

① What are the problematics?

EAFP 2015: Fish health in Mediterranean Aquaculture, past mistakes and future challenges

Ranking	Western med.	Eastern Med.	Central Med.	South med.
①	Gill flukes	Gill flukes	Isopods	Gill flukes
②	Gill flukes Seabream	Vibriosis	Gill fukes	Gill flukes
③	Vibriosis	Gill flukes	<i>P. d. piscicida</i>	<i>Enteromyxum</i>
④	Tenacibaculum	<i>P. d. piscicida</i>	Isopods	<i>P. d. piscicida</i>
⑤	<i>Enteromyxum</i>	Tenacibaculum	Gill flukes	Mycobacteria

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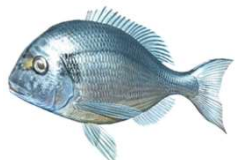
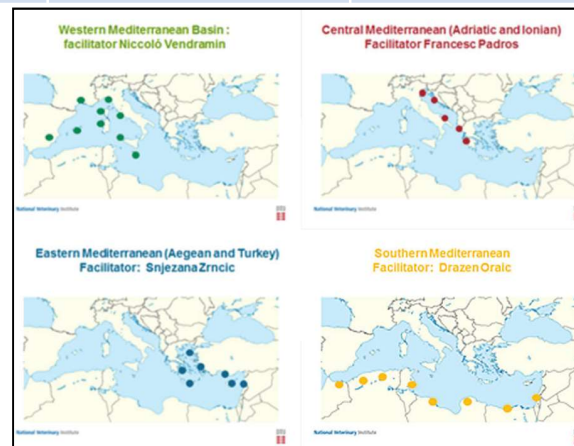
- ③ Induced costs

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Future trends

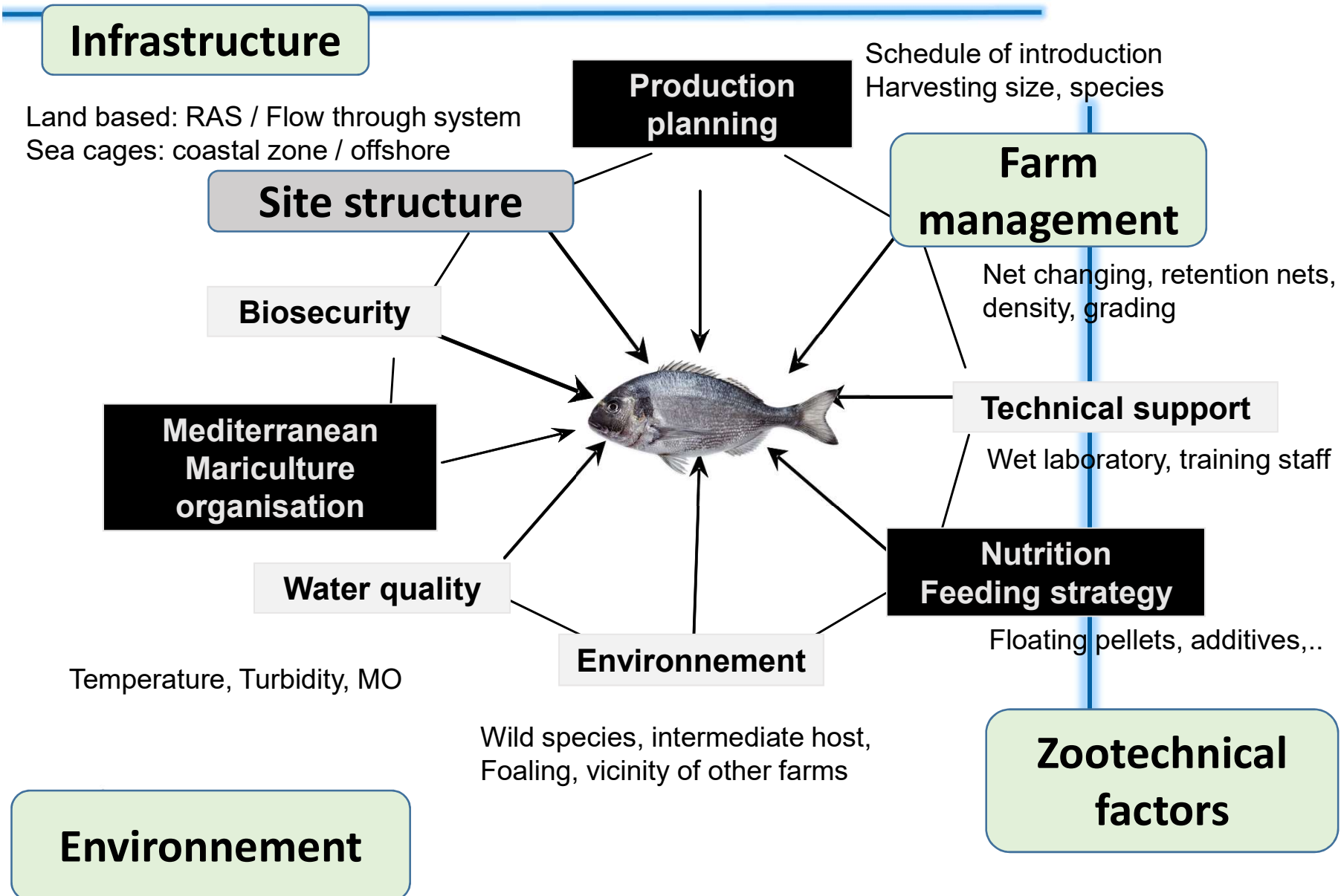
Parafish pannel of expert 2016:

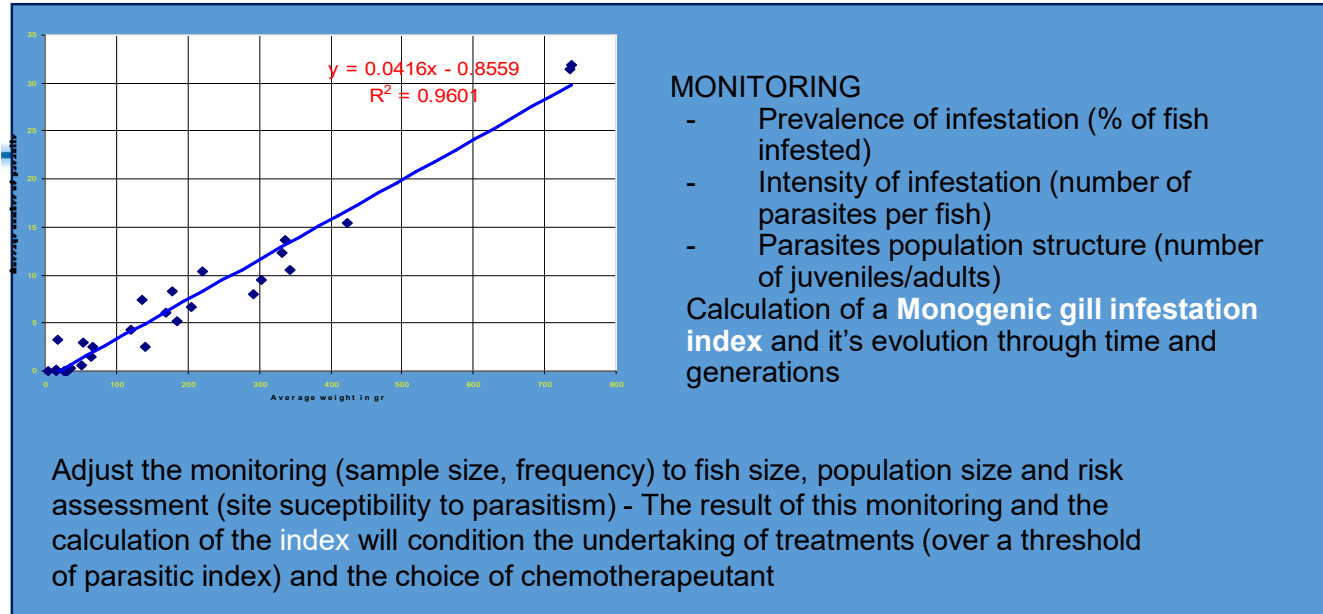
- *Sparicotyle chrysophrii*
- *Enteromyxum leei*
- *Ceratomyxa oestroides*
- *Amylodium ocellatum*



Why those differences ?

② Factors influencing the economic impact of parasitic diseases





Parasitic diseases

of introduction
size, species

**Farm
management**

net changing, retention nets,
density, grading

**Mediterranean
Mariculture
organisation**

Technical support

Wet laboratory, training staff

Water quality

**Nutrition
Feeding strategy**

Floating pellets, additives,...

Temperature, Turbidity, MO

Environnement

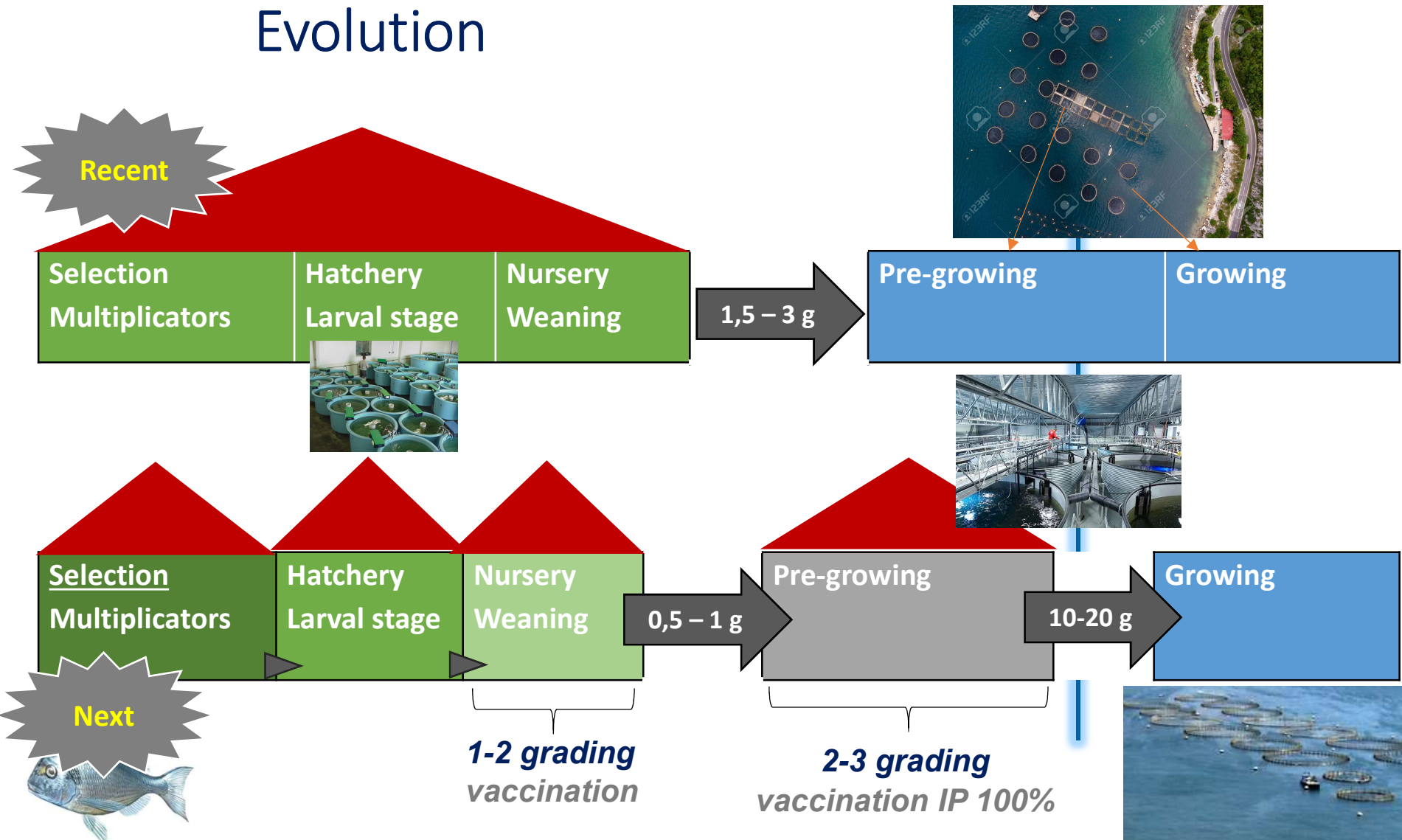
Wild species, intermediate host,
Foaling, vicinity of other farms

**Zootechnical
factors**

Environnement

Mediterranean Mariculture structure

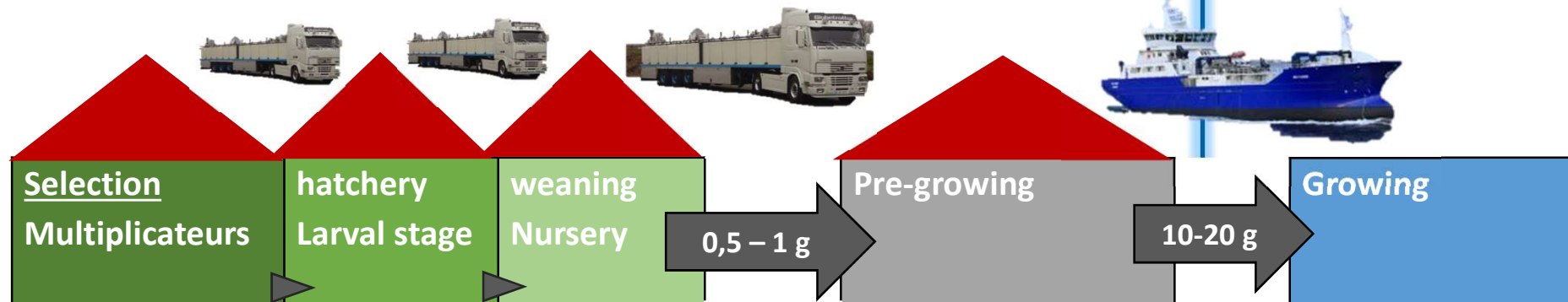
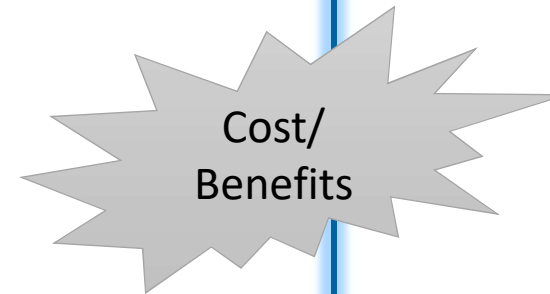
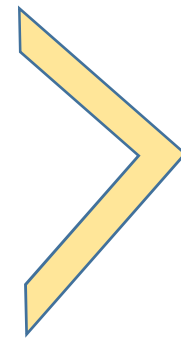
Evolution



Mediterranean Mariculture structure

Logistic

- ❑ Simplification of sea site operation (no small mesh nets,...)
- ❑ Shorter cycles of production
- ❑ Larger size juveniles at sea – graded, vaccinated, more resistant
- ❑ Separation of generations



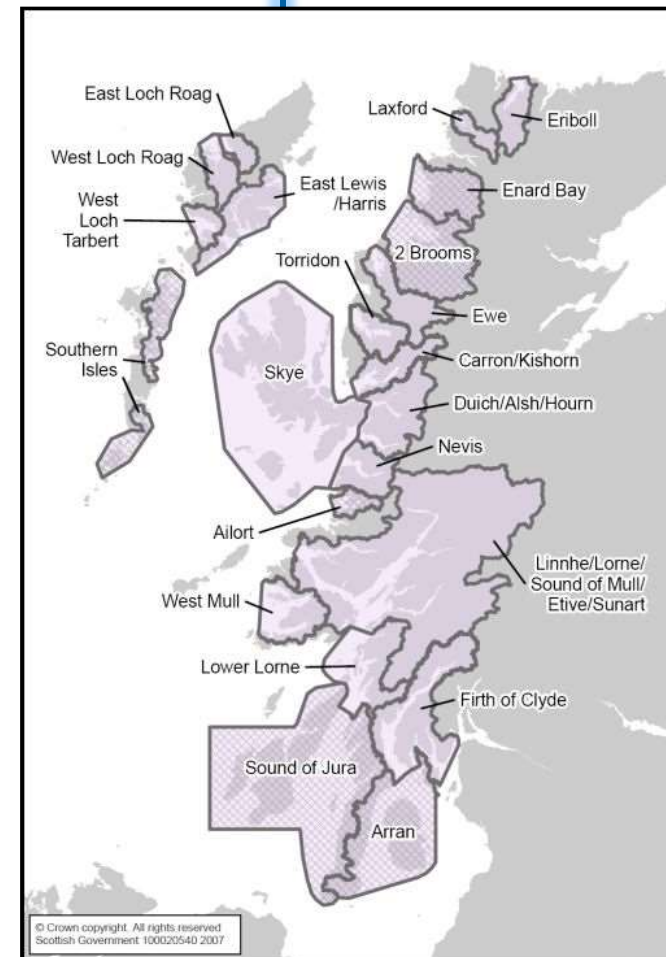
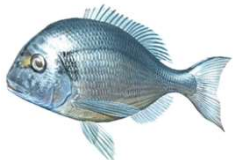
Zone management: i.e. Sealice management in Salmon

👉 Prevention

- Single generation sites – All in / All out
- Fallowing periods (4-6 weeks min.)
- Area management agreement
- Cooperation and communication amongst farmers
- Synchronized treatments in a determined area
- Eggs collection (importance of knowing the parasite cycle and spawning times)
- Net washing facilities

Lessons to learn:

**Sea lice (*Lepeophthirus salmonis*)
management in Norway or UK.**



③ Induced costs

Direct costs

- Mortality
- Morbidity
- Treatment cost (chemical + man work)
- Declassified fish
- Destruction of dead fish
- Health management cost (vet, analysis)

• Juveniles

Cost of juvenile or market size cost/kg? What about fix costs?

• Medium size

Biomass lost or market size? And feed?

• Large fish market size

Indirect costs

- Quality chart & labels
- Public image

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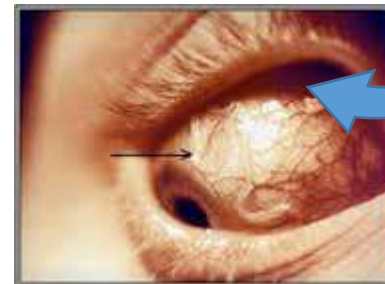
- ④ Practical cases

Future trends

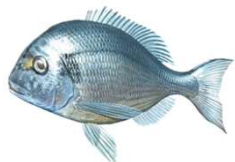
Public image: Zoonotic aspects & unmarketable fish

- **Fashion for raw fish consumption increase the risk**

Mainly *Anisakis* (human cases reported in Italy, Turkey)



- **Unmarketable fish (*Glugea* sp.)**



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► Corsica summer 2006 – Meagre *Sciaenocotyle panceri*

9 cages Meagre

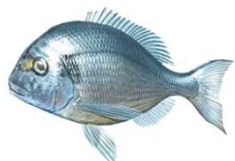
- Generation 2005-2006 (x3 cages) juveniles under 60g aw
42.22% mortality
- Generations 02-03-04 (x 6 cages) aw from 900gr to 2kg
16.5% mortality

2006 Prices: 0.70€ juvenile – 8.72€ exfarm /kg average

- Ternengo & al, 2008 / Cost estimation in Shinn & al 2014

Estimated losses	59.500€
------------------	----------------
- Farm estimation (personnel data)

Unmarket fish	411.362€
Over costs	129.000€
	540.362€



Almost stop production of the species

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Case : *Enteromyxum leei* / Seabream / Land based farm

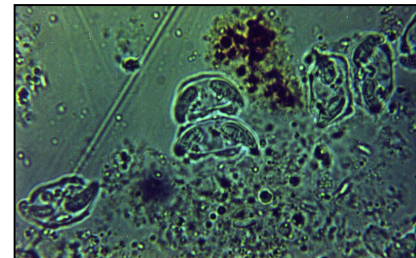
★ May 2001

- Large size sea bream (a.w. 700gr) melanic & cachectic fish detected.
- In this batch, 8-10% of fish downgraded during packing

 1st identification of the parasite on this site

★ July / Decembre 2001

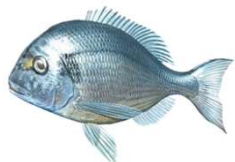
- 55 tons mortality
- On 500 tons harvested, 15 tons destroyed et 17 tons downgraded
- Conversion rate up to 7 instead of 2.0 on large size seabream
- 10% growth rate losses on the global stock of sea bream = 70 tons
- Cumulative mortality in affected tanks up to 15%



End 2001



Research program initiated



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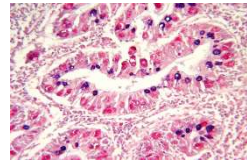
Future trends

FACTOR SUSTAINING THE HYPOTHESIS OF AN AMPLIFICATION OF THE PARASITIC INFESTATION, RESPONSIBLE OF THE PATHOGENICITY OF THE MYXOSPORIDIAN *ENTEROMYXUM LEEI* IN AQUACULTURE.

MARQUES A., TOUBIANA M., SAUVEGRAIN C., WYERS M. & LEBRETON A.

MARQUES A., TOUBIANA M.:
Dept. BEE, UM2, Université Montpellier II, F34095 Montpellier cedex 5

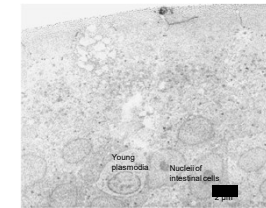
LEBRETON A.:
Fish health consultant F31330 Grenade sur Garonne,



Presence of a lot of pansporoblasts (coloured in red) in the intestinal mucosa.
The blue elements are mucus secretory cells.
PAS-Bleu Alcian, objectif x40

SAUVEGRAIN C.:
Aquanord Terre des Marins, F59820 Gravelines

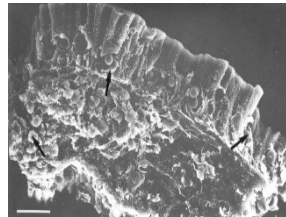
WYERS M.:
Laboratoire d'Histologie et de Pathologie animale, E. N. V. N., BP 40706, F 44307 Nantes



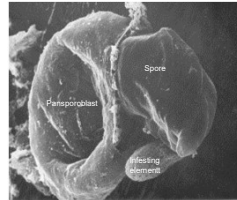
Young unicellular plasmodia, which has migrated into a healthy area of the intestinal mucosa. Its size is small and the morphology similar to the surrounding cells. Only its ultra structure is different.



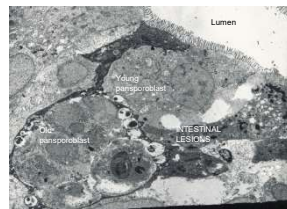
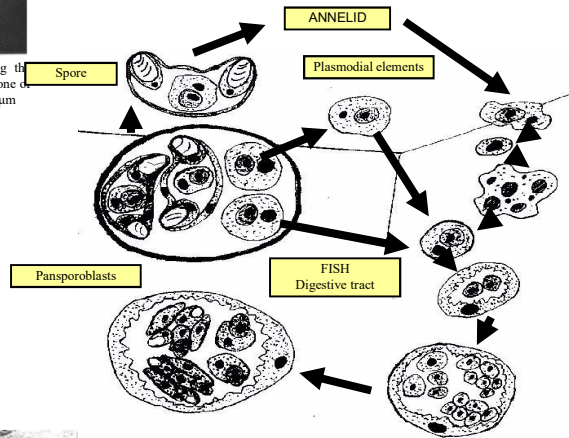
Young multicellular plasmodia in the intestinal mucosa.



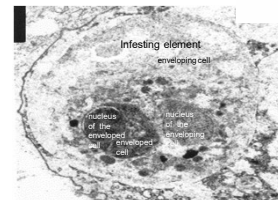
Portion of intestine under Scanning Electron Microscopy (SEM), showing a high number of large size pansporocysts appearing as nodules set at different levels between the intestinal cells (arrows). Scale: 20 µm



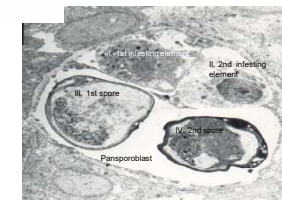
Mature pansporoblast (SEM) showing the exit of a spore and beneath the exit of one of the infesting element. Scale: 15 mm=2 µm



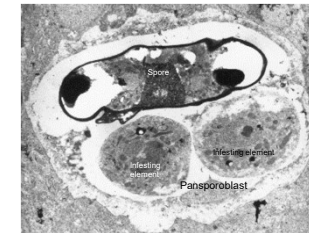
Advanced stage of infestation: extensive healing lesions resulting from the evacuation of the pansporoblast (TEM).



Detail of an infesting element, showing the complex enveloping cell-enveloped cell. The difference in density of the cytoplasm and the nuclei of the two cells can be noticed (soma role/germinal role). Scale: 15 mm=2 µm



Transverse section of a pansporoblast (TEM) showing four visible elements: 2 spores in maturation and 2 infesting elements similar to plasmodia. Scale: 15 mm=2 µm



Transverse section of a pansporoblast (TEM) showing a spore in longitudinal section and clearly two differentiated infesting elements
Scale: 15 mm=2 µm

The Myxosporidian *Enteromyxum leei* observed by Diamant (1992) and described as *Myxidium leei* by Diamant et al. in 1994 develop in the intestine of the fish. It threatened the rearing of Sparidae species inducing severe pathology and losses (Le Breton et Marques 1995, Tarer et al. 1996, Sakiti et al. 1996). The parasite shows an important capacity to expand and can be recovered from fish put in the vicinity of infected fish by introduction in rearing structure (Diamant 1998) or in aquariums (Padros et al. 2001). The progressive invasion of the intestinal mucosa is not a common characteristic of the Myxosporidian. These usually are coelozoic and colonised internal cavities of the fish hosts (gall-bladder, urine-bladder, kidney tubules ...). The characteristic and progressive invasion of the intestinal track brought Palenzuela et al. (2002) to create a new genus *Enteromyxum* for a Myxosporidian threatening the production of the flounder *Scolophthalmus maximus*. They renamed the previously described *Myxidium leei*, which has similar but not identical characteristic, as *Enteromyxum leei*. However referring to other documented Myxosporidian, no satisfactory explanation can be given to the progressive invasion of the intestinal track.

In this study, fish used belong to the species *Sparus aurata* and were sampled in different French farms in which the study of this pathogen is undertaken.

References

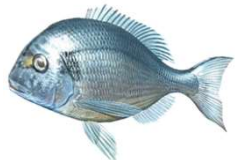
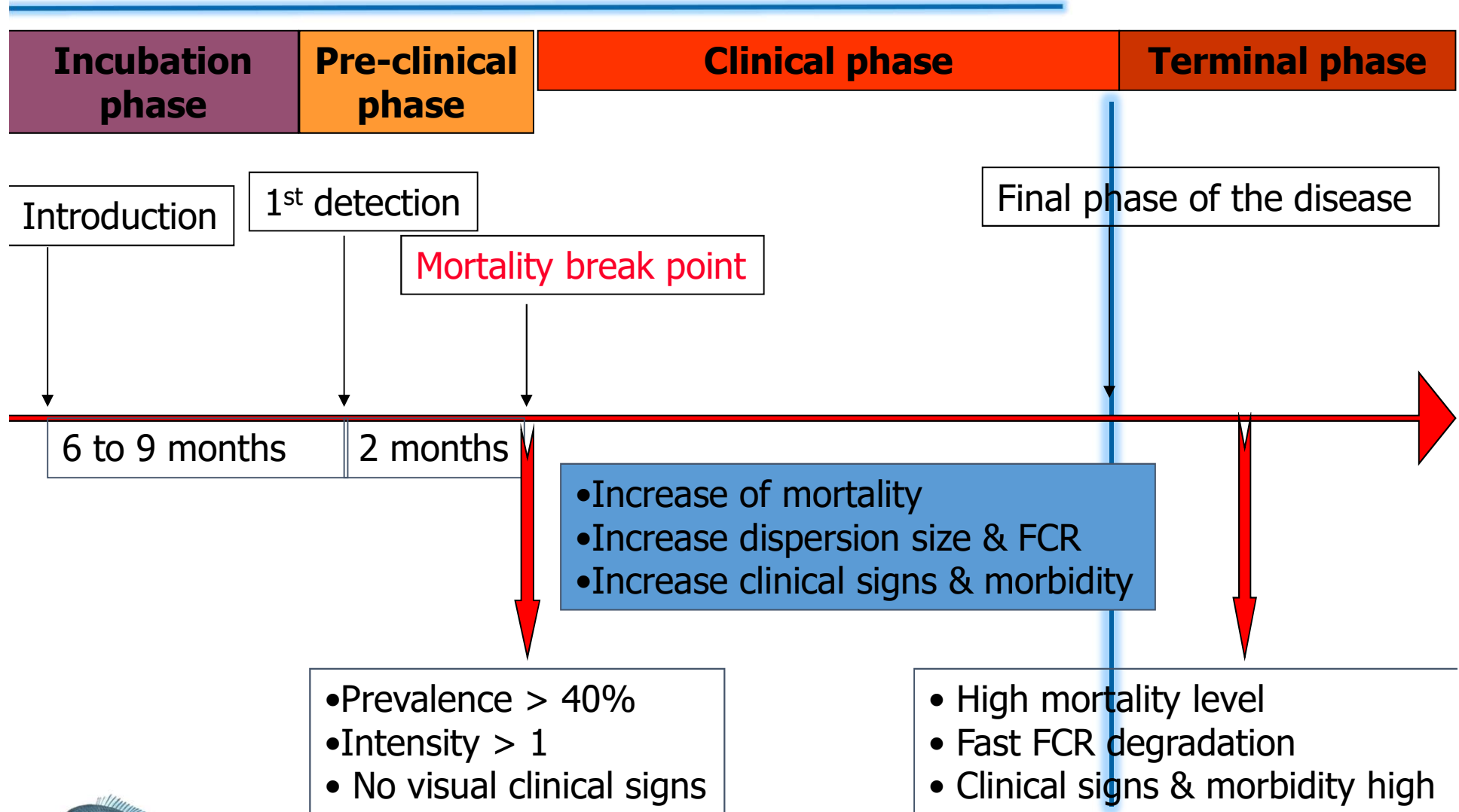
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The presence of the Myxosporidian *E. leei* is searched on diseased fish, observing fresh smears from scrapping of the mucosa of fragments of the intestine, in light microscopy with phase contrast. For Transmission Electron Microscopy (TEM), observations are done with a JEOL-EX II transmission electron microscope. For Scanning Electron Microscopy (SEM), samples are observed with a JEOL JSM-35 scanning electron microscope

Histology sections observations in light and electronic microscopy reveal the formation of four distinct elements and not two, inside the pansporoblasts: 2 spores and 2 bi-nucleated cellular mass, which contain a cell within a cell. These bi-cellular elements are similar to the sporoplasm present in each spore and range $7.5 \pm 1.5 \mu\text{m}$ in size. The enveloping cell has a clear cytoplasm with sparse cytoplasmic inclusions. Its 1.5 to $2.5 \mu\text{m}$ in size nucleus has a low density and a very clear nucleolus. The enveloped cell has a smaller size of 2.5 to $3.5 \mu\text{m}$ in size; its cytoplasm and its nucleus show a high density. These cells might represent internal infesting elements able to explain the exponential development of this pathology in infested batches and the horizontal transmission from fish to fish under rearing conditions.



Enteromyxum leei : development scheme of the pathology



Case : *Enteromyxum leei* / Seabream / Land based farm

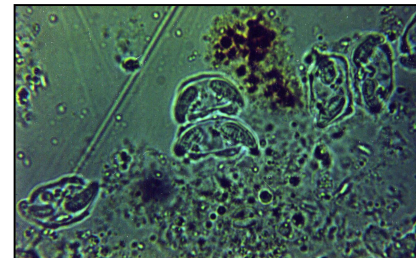
★ May 2001 5 (Sea bream production 1000 tons)

- Large size sea bream (a.w. 700gr) melanic & cachectic fish detected.
- In this batch, 8-10% of fish downgraded during packing

 1st identification of the parasite on this site

★ July / Decembre 2001

- 55 tons mortality **275.000€**
- On 500 tons harvested, 15 tons destroyed et 17 tons downgraded **192.500€**
- Conversion rate up to 7 instead of 2.0 on large size seabream **250.000€**
- 10% growth rate losses on the global stock of sea bream = 70 tons **385.500€**
- Cumulative mortality in affected tanks up to 15%

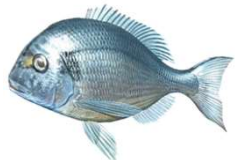


End 2001



Research program initiated

+ Destruction of dead fish **42.000€**



Initial economic impact of the infection
(Production costs without over cost)

1.145.000€

Introduction

- ① What are the problematics?
External parasites
Protozoa
Monogenea & Isopodia
Internal parasites
Colozoic
Histoic

- ② Factors influencing economic impact of parasitic diseases

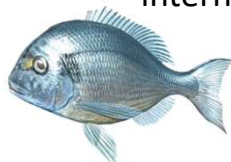
- ③ Induced costs

- ④ Practical cases

Future trends

Future trends

- Mediterranean Mariculture might be driven by the economic impact of parasitic infestation in the future
- To determine how much resources should be allocated to the detection, control and prevention of parasitic diseases, real economic impact need to be evaluated but
 - Difficulty in getting real production data
 - Difficulty to evaluate incur costs associated
 - No economic model defined for such impact study & diversity of production models, production conditions – **Define tools to assess these economic impact**
- Technical support at farm level
 - Availability of indicators and training of staff
 - Wet laboratory
 - **Lack of targeted surveillance for predictable infection and early diagnosis of unpredictable /sporadic cases**
- Mediterranean basin diversity
 - Difference in legislation, in technical support availability, in training of staff
 - Difference in medicine availability (well, not much available anyway ☹)
 - Lack of coordination & cooperation @ regional – national levels – international level.



Introduction

① What are the problematics?

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Protozoa

Monogenea & Isopodia

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Histozoic

② Factors influencing economic impact of parasitic diseases

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Future trends