Economic Impact of Parasitic Diseases in Mediterranean Mariculture

Dr. A. Le breton – VET’EAU France.
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

## 2 types of events

= 2 different economical impacts

<table>
<thead>
<tr>
<th>① Unpredictable sporadic infections</th>
<th>② Predictable regular infections</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Losses</strong></td>
<td><strong>Losses</strong></td>
</tr>
<tr>
<td>Post harvest down grading</td>
<td>Post harvest down grading</td>
</tr>
<tr>
<td>Growth impact and FCR</td>
<td>Growth impact and FCR</td>
</tr>
<tr>
<td>Destruction of dead fish</td>
<td>Destruction of dead fish</td>
</tr>
<tr>
<td>Control of infection</td>
<td>Control of infection</td>
</tr>
<tr>
<td></td>
<td>Prophylactic treatments</td>
</tr>
<tr>
<td></td>
<td>Health management &amp; management practices</td>
</tr>
</tbody>
</table>

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① What are the problematics?
- External parasites
  - Protozoa
  - Monogenea & Isopodia
- Internal parasites
  - Coloizoic
  - Histozoic

② Factors influencing economic impact of parasitic diseases

③ Induced costs

④ Practical cases

Future trends
## What are the problematics?

### External parasites

<table>
<thead>
<tr>
<th>Type</th>
<th>Land Based Operation</th>
<th>Sea cages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RAS(^1)</td>
<td>Open System(^2)</td>
</tr>
<tr>
<td>Protozoa</td>
<td>-</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Metazoa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monogenean</td>
<td>(✓)(^3)</td>
<td>✓</td>
</tr>
<tr>
<td>Isopodia</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1. Hatchery – Pre growing
2. Flow through system in land based farm or ponds
3. Only on spawners

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**Introduction**

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

2. Factors influencing economic impact of parasitic diseases

3. Induced costs

4. Practical cases

Future trends
External parasites in Mediterranean Mariculture: Protozoa

<table>
<thead>
<tr>
<th>Ciliates</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Trichodina</em> sp.</td>
<td>All species</td>
</tr>
<tr>
<td><em>Trichodinella</em></td>
<td>Sparidae, Turbot</td>
</tr>
<tr>
<td><em>Cryptocaryon irritans</em></td>
<td>Sea bass, Sea bream</td>
</tr>
<tr>
<td><em>Cryptocaryon like</em></td>
<td>Sea bass, Sea bream</td>
</tr>
<tr>
<td><em>Philasteroides dicentrarchi</em></td>
<td>Sea bass, Turbot</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dinoflagellates</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Amyloinum ocellatum</em></td>
<td>Sea bass, Sparidae, Mulet, Sole</td>
</tr>
<tr>
<td><em>Oodinium</em> sp.</td>
<td>Sea bass, Sea bream</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kinetoplastidae</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cryptobia</em></td>
<td>Sea bass, Sea bream, Solea</td>
</tr>
<tr>
<td><em>Ichthyobodo</em> (Costia)</td>
<td>Sea bass, Sea bream, Turbot</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rhizopodae</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Paramoebae</em></td>
<td>Sea bream, Turbot, Solea</td>
</tr>
</tbody>
</table>
# External parasites in Mediterranean Mariculture: Monogenea & Isopodia

## 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**

5. **Future trends**

### Monogenea

<table>
<thead>
<tr>
<th>Monogenea</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Diplectanum aequans</em></td>
<td>Sea bass</td>
</tr>
<tr>
<td><em>Sparicotyle chrysophrii</em></td>
<td>Sea bream</td>
</tr>
<tr>
<td><em>Sciaenocotyle panceri</em></td>
<td>Meagre</td>
</tr>
</tbody>
</table>

### Isopodia

<table>
<thead>
<tr>
<th>Isopodia</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Caligus minimus</em></td>
<td>Sea bass</td>
</tr>
<tr>
<td><em>Ceratothoa oestroïdes</em></td>
<td>Sea bass, Sea bream</td>
</tr>
<tr>
<td><em>Lernanthropus kroyeri</em></td>
<td>Sea bass</td>
</tr>
<tr>
<td><em>Lemea</em></td>
<td>Sea bass, Sea bream</td>
</tr>
</tbody>
</table>
## What are the problematics?

### Internal parasites

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<tbody>
<tr>
<td></td>
<td>RAS&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Open System&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coelozoïc</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Histozoïc</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Diplodus sargus*

Enteromyxum infection Greece 1996

Up to 40% mortality

= STOP PRODUCTION
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€
### Internal parasites in Mediterranean Mariculture: coelozoïc

#### Introduction

- **What are the problematics?**
  - External parasites
    - Protozoa
    - Monogenea & Isopodia
  - Internal parasites
    - Colezoïc
    - Histozoïc

#### Factors influencing economic impact of parasitic diseases

#### Induced costs

#### Practical cases

#### Future trends

#### Apicomplexa

<table>
<thead>
<tr>
<th>Host species</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Eimeria</em></td>
<td>Sea bass, Sea bream,</td>
</tr>
<tr>
<td><em>Cryptosporidium molnari</em></td>
<td>Sea bass, Sea bream</td>
</tr>
</tbody>
</table>

#### Ciliate

<table>
<thead>
<tr>
<th>Host species</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Philasterides dicentrarchi</em></td>
<td>Sea bass, Turbot</td>
</tr>
</tbody>
</table>

#### Myxosporidia

<table>
<thead>
<tr>
<th>Host species</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceratomyxa sparuaurati, diplodae, labracis….</td>
<td>All species</td>
</tr>
<tr>
<td>Cryptocarion like</td>
<td>Sea bream</td>
</tr>
</tbody>
</table>

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*Image of fish and microscope images*
Introduction

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

② Factors influencing economic impact of parasitic diseases

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Future trends

### Myxosporidia

<table>
<thead>
<tr>
<th>Myxosporidia</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteromyxum leei</td>
<td>Sea bream</td>
</tr>
<tr>
<td>Enteromyxum scopthalmi</td>
<td>Turbot</td>
</tr>
<tr>
<td>Sphaerospora dicentrarchi</td>
<td>Sea bass</td>
</tr>
<tr>
<td>Sphaerospora testicularis</td>
<td>Sea bass</td>
</tr>
<tr>
<td>Polyporoplasma</td>
<td>Sea bream</td>
</tr>
</tbody>
</table>

### Microsporidia

<table>
<thead>
<tr>
<th>Microsporidia</th>
<th>Host species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glugea sp.</td>
<td>Sea bream</td>
</tr>
</tbody>
</table>
### Introduction

#### What are the problematics?

**External parasites**
- Protozoa
- Monogenea & Isopodia

**Internal parasites**
- Colozoic
- Histozoic

#### Factors influencing economic impact of parasitic diseases

#### Induced costs

#### Practical cases

#### Future trends

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

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gill flukes</td>
<td>Gill flukes</td>
<td>Isopods</td>
<td>Gill flukes</td>
</tr>
<tr>
<td>2</td>
<td>Gill flukes</td>
<td>Vibriosis</td>
<td>Gill flukes</td>
<td>Gill flukes</td>
</tr>
<tr>
<td></td>
<td><em>Seabream</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Vibriosis</td>
<td>Gill flukes</td>
<td><em>P. d. piscicida</em></td>
<td><em>Enteromyxum</em></td>
</tr>
<tr>
<td>4</td>
<td>Tenacibaculum</td>
<td><em>P. d. piscicida</em></td>
<td>Isopods</td>
<td><em>P. d. piscicida</em></td>
</tr>
<tr>
<td>5</td>
<td><em>Enteromyxum</em></td>
<td>Tenacibaculum</td>
<td>Gill flukes</td>
<td>Mycobacteria</td>
</tr>
</tbody>
</table>

### Parafish pannel of expert 2016:

- **Sparicotyle chrysophrii**
- **Enteromyxum leei**
- **Ceratothoa oestroïdes**
- **Amylodinium ocellatum**

### Why those differences?
Factors influencing the economic impact of parasitic diseases

Infrastructure
- Land based: RAS / Flow through system
- Sea cages: coastal zone / offshore

Production planning
- Schedule of introduction
- Harvesting size, species

Site structure
- Net changing, retention nets, density, grading

Biosecurity

Environnement
- Temperature, Turbidity, MO
- Wild species, intermediate host, Foaling, vicinity of other farms

Mediterranean Mariculture organisation

Water quality

Technical support
- Wet laboratory, training staff

Farm management

Nutrition Feeding strategy
- Floating pellets, additives,..

Zootechnical factors

Environnement
Factors influencing the economic impact of parasitic diseases

- Pathology in aquaculture
- Zootechnical factors

**Monogenic gill infestation index**

MONITORING
- Prevalence of infestation (% of fish infested)
- Intensity of infestation (number of parasites per fish)
- Parasites population structure (number of juveniles/adults)

Calculation of a Monogenic gill infestation index and its evolution through time and generations

Adjust the monitoring (sample size, frequency) to fish size, population size and risk assessment (site susceptibility to parasitism) - The result of this monitoring and the calculation of the index will condition the undertaking of treatments (over a threshold of parasitic index) and the choice of chemotherapeutant.

**Graph:**

\[ y = 0.0416x - 0.8559 \]

\[ R^2 = 0.9601 \]

**Axes:**
- X: Average weight in g
- Y: ?

**Data points:**
- Points plotted on the graph

**Legend:**
- Blue line: Trend line
- Red line: Confidence interval

**Nodes:**
- Mediterranean Mariculture organisation
- Water quality
- Environnement
- Nutrition Feeding strategy
- Zootechnical factors
- Technical support
- Farm management

**Diagram elements:**
- Fish
- Graph
- Monitoring nodes
- Factors influencing the economic impact of parasitic diseases
- Pathology in aquaculture
- Zootechnical factors
- Monogenic gill infestation index
- Calculation of index
- Monitoring adjustment
- Treatment conditions
- Chemotherapeutant choice
- Fish size
- Population size
- Risk assessment

**Additional notes:**
- Temperature, Turbidity, MO
- Wild species, intermediate host, Foaling, vicinity of other farms
- Floating pellets, additives...
- Wet laboratory, training staff
Evolution

**Recent**
- Selection Multiplicators
- Hatchery Larval stage
- Nursery Weaning

**1,5 – 3 g**

**Growing**

**Next**
- Selection Multiplicators
- Hatchery Larval stage
- Nursery Weaning

**0.5 – 1 g**

**1-2 grading vaccination**

**2-3 grading vaccination IP 100%**

**Pre-growing**

**Growing**

**0-1 g**

**10-20 g**

Mediterranean Mariculture structure
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

### Cost/Benefits

- 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 (Lepeophtirus salmonis) management in Norway or UK.
Introduction

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- Internal parasites
  - Colozaïc
  - Histozoïc

② Factors influencing economic impact of parasitic diseases

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

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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4. Practical cases

Future trends
4 Practical cases

- **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

  Estimated losses 59,500€

- Farm estimation (personnel data)
  Unmarket fish 411,362€
  Over costs 129,000€
  **540,362€**

→ Almost stop production of the species
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

1️⃣ identification of the parasite on this site

**July / Decembre 2001**

- 55 tons mortality
- On 500 tons harvested, 15 tons destroyed and 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
**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.**

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 threatens the rearing of Sparidae species inducing severe pathology and losses (Le Breton et Marques 1995, Tarer et al. 1996). The parasite shows an important capacity to expand and can be recovered from fish put in the vicinity of infected fish. It threatened the rearing of Sparidae species inducing severe pathology and losses (Le Breton et Marques 1995, Tarer et al. 1996). The parasite shows an important capacity to expand and can be recovered from fish put in the vicinity of infected fish. It threatened the rearing of Sparidae species inducing severe pathology and losses (Le Breton et Marques 1995, Tarer et al. 1996).

The progressive invasion of the intestinal mucosa is not limited to a healthy area of the intestinal mucosa. Its size is small and the morphology similar to the surrounding cells. Poly to ultra structure is different.

**References**


Enteromyxum leei: development scheme of the pathology

**Incubation phase**
- Introduction
- Prevalence > 40%
- Intensity > 1
- No visual clinical signs
- 6 to 9 months

**Pre-clinical phase**
- 1st detection
- 2 months

**Clinical phase**
- Mortality break point
- Increase of mortality
- Increase dispersion size & FCR
- Increase clinical signs & morbidity
- High mortality level
- Fast FCR degradation
- Clinical signs & morbidity high

**Terminal phase**
- Final phase of the disease
- 2 months
- Prevalence > 40%
- Intensity > 1
- No visual clinical signs
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

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End 2001

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+ Destruction of dead fish

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

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Future trends

23

\[ \text{Initial economic impact of the infection} \]
\[ \text{Production costs without over cost} \]

\[ \text{250.000€} \]
\[ \text{385.500€} \]

\[ \text{42.000€} \]

\[ \text{1.145.000€} \]
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.