CLIMATE CHANGE AND HOST-PARASITE INTERACTIONS

Ariadna Sitjà-Bobadilla

Instituto de Acuicultura de Torre de la Sal (CSIC) Castellón, Spain

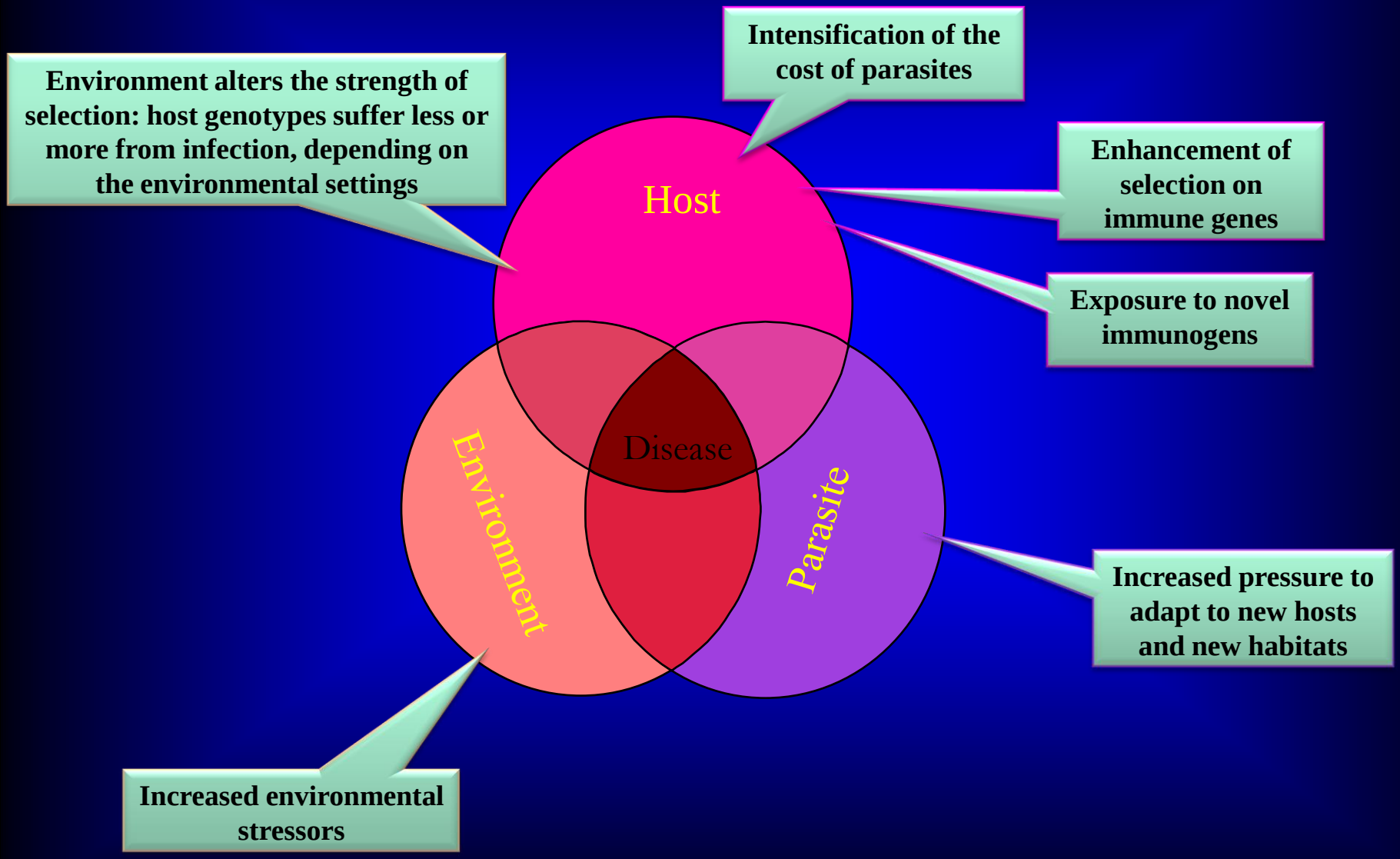
MINISTERIO DE CIENCIA E INNOVACIÓN

CSIC
Consejo Superior de Investigaciones Científicas

14th EAFP INTERNATIONAL CONFERENCE
Prague, September 14–19 2009

Source : www.linfield.edu

Effects on fish individuals



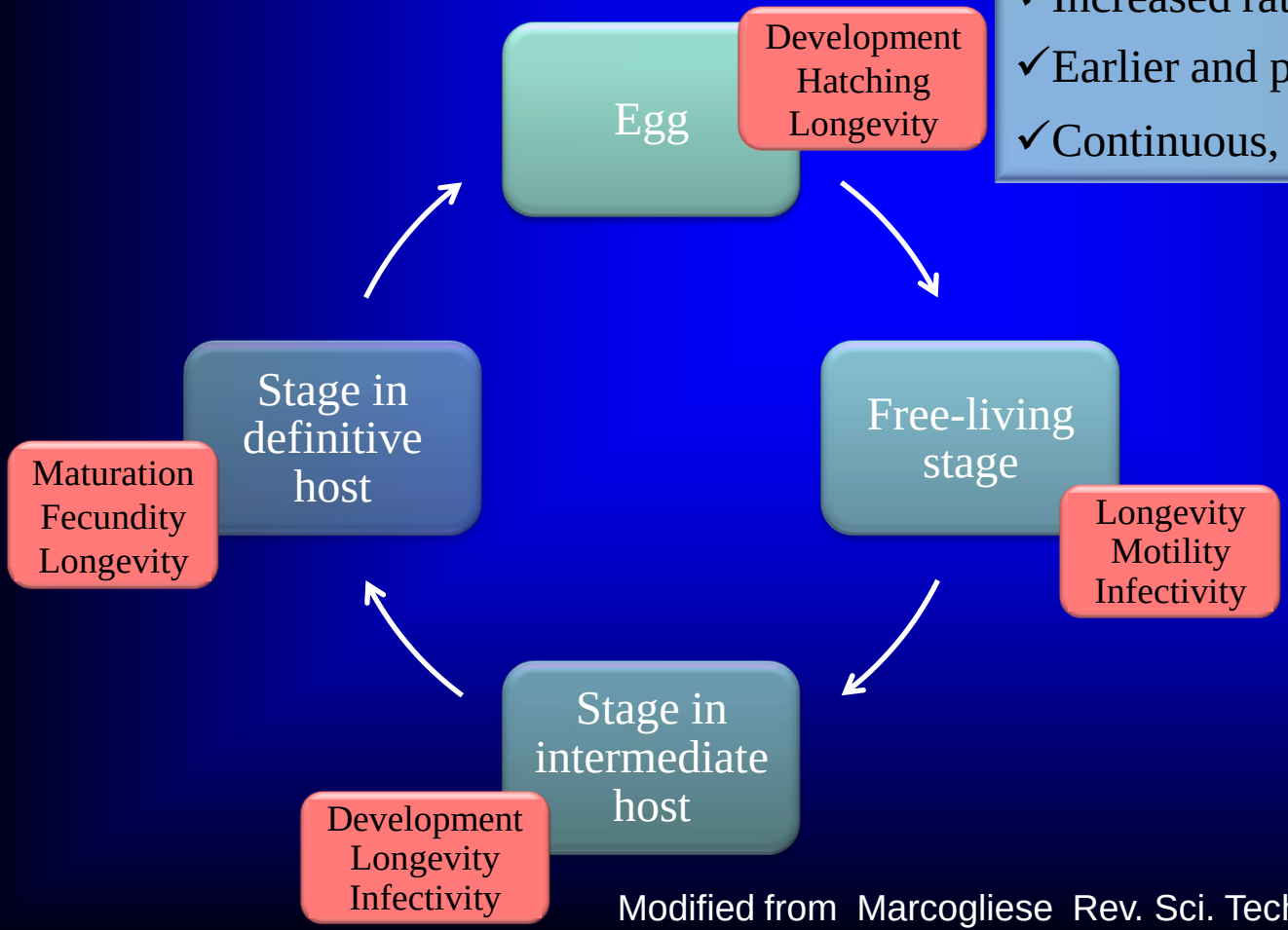
Effects on parasites

Depend on:

- ✓The life cycle complexity
- ✓The host specificity
- ✓The adaptation to the habitat

INCREASED TEMPERATURES:

- ✓Rapid growth and maturation
- ✓Earlier onset of spring maturation
- ✓Increased numbers of generations/year
- ✓Increased rates of parasitism and disease
- ✓Earlier and prolonged transmission
- ✓Continuous, year-round transmission



Modified from Marcogliese Rev. Sci. Tech. Off. Int. Epiz, 2008, 27:467-484

Effects of global change on parasites and hosts

Global change

Modification of environmental variables

Alteration of:
- Host range
- Parasite range
- Host immunocompetence
- Parasite virulence
- Parasite transmission rates

Alteration of:
- Disease occurrence
- Parasite infections

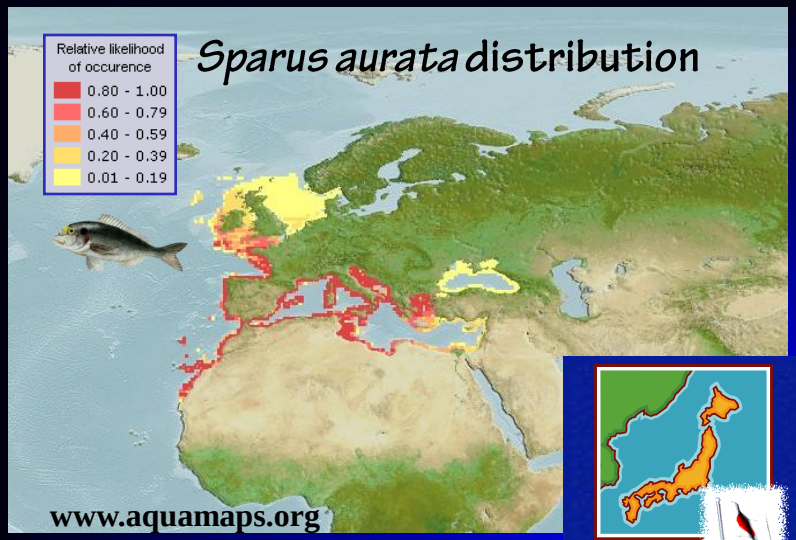
Impact on host populations

Socioeconomic consequences

Impact on communities and ecosystems

Modified from Marcogliese Rev. Sci. Tech. Off. Int. Epiz, 2008, 27:467-484

A myxosporean example



HYPOTHETICAL INCREASED TEMPERATURES :

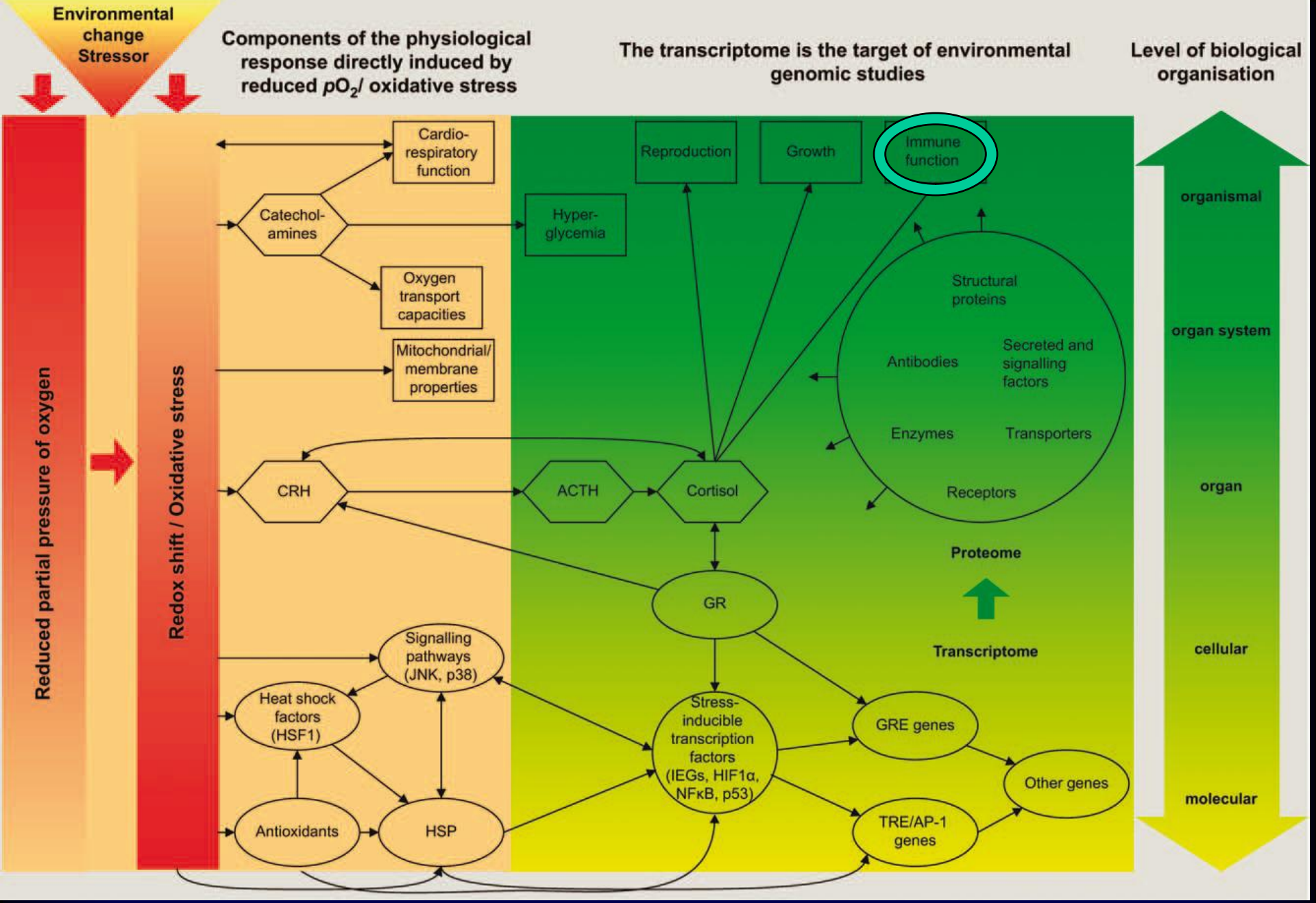
- ✓The host range shifts to the north
- ✓The parasite has low host specificity
- ✓The parasite infects new hosts
- ✓New host are immunologically naïve
- ✓Parasite transmission is accelerated with higher temperatures
- ✓The parasite persists better during winter

COULD RESULT IN:

- ✓Higher prevalence and disease outbreaks in extended areas and hosts

Basic concepts in fish immunology and thermoregulation

- ✓Bony fish are poikilothermic: body temperature is constantly equilibrated
- ✓Optimal immune response is obtained at its normal summer temperature
- ✓Permissive: The range where an optimal response can occur
- ✓Temperatures below or above are immunosuppressive: “non-permisive”
- ✓Fish conduct behavioural thermoregulation
- ✓Optimal growth temperature can be not coincident with some optimal immune factors
- ✓Acquired immune system is more temperature sensitive than innate system, with some exceptions.
- ✓There is a minimum temperature below what antibody production is inhibited



Conceptual model of capacity limitations and the subsequent stress response linking organismal, cellular and molecular responses. The stimulus may be heat, cold, hypoxia, hyposmotic exposure, or other environmental change including exposure to pollutants and toxins. Reduced partial pressures of oxygen and oxidative stress are common to many stress conditions and elicit parallel responses at all levels of biological organization. (Kassahn et al., Biol. Rev. 2009, 84: 277–292.)

Factors affecting immune response

Immune Factors	Environmental stressors					
	Temperature ▲	Oxygen ▼	Particulates ▲	Salinity ▲	UV radiation ▲	pH ▼
Complement	Chronic ▲ Acute ▼	Sea bream = Cat fish ▼		▲		
Lysozyme	Chronic ▲ Acute ▼		▲	Plasma ▲ Mucus ▼	▲	≠
Leucocyte functions, numbers, percentages, etc.	*Chronic*: Phagocitosis ▼ RB ▲ Lymphocytes ▲ *Acute*: ▼	Bact. Acti. ▼ RB ▼	Haematocrit ▲ Leucocrit ▼	Phagocytosis RB	Citotoxicity ▼ RB ▲ Granulocites ▲ Lymphocytes ▼ Phagocytosis Prolif. Lymph. ▼ NCC ▼ Haematocrit ▼	Phagocytosis
IgM	[IgM], Ig^+ cells Specific Ab ▲	Sea bream ▼ Sea bass =	[IgM] ▲	[IgM] ▲	[IgM] =	[IgM] acute ▼ Chronic ≠
Cytokines	expression ▲					
MHC-I MHC-II	expression = ▲ expression ▼					
Mx	▲					

Data partially obtained from Bowden, Fish & Shellfish Immunol. 2008, 25:4373-383

Temperature

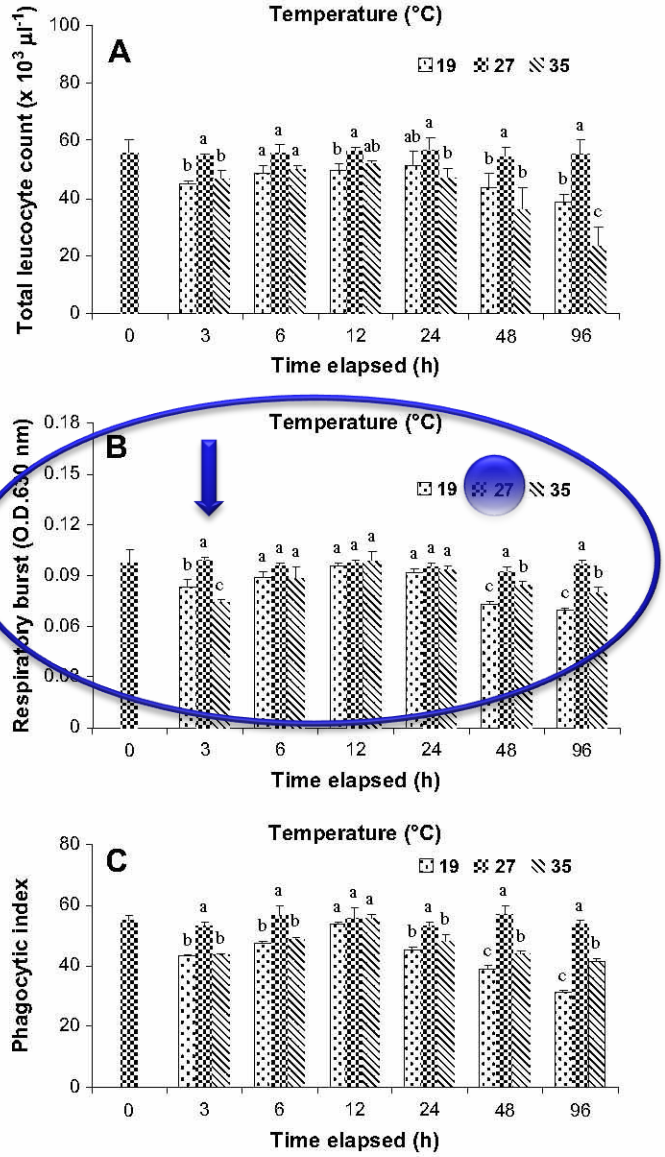


Fig. 2. Mean (±SE) total leucocyte count (A), respiratory bursts (B), and phagocytic activity (C) of orange-spotted grouper *Epinephelus coioides* kept at 27 °C at the beginning, and then 3, 6, 12, 24, 48, and 96 h after being transferred to 19, 27, and 35 °C. See Fig. 1 for statistical information.

Cheng et al. Fish & Shellfish Immunology 26 (2009) 768–772

Salinity

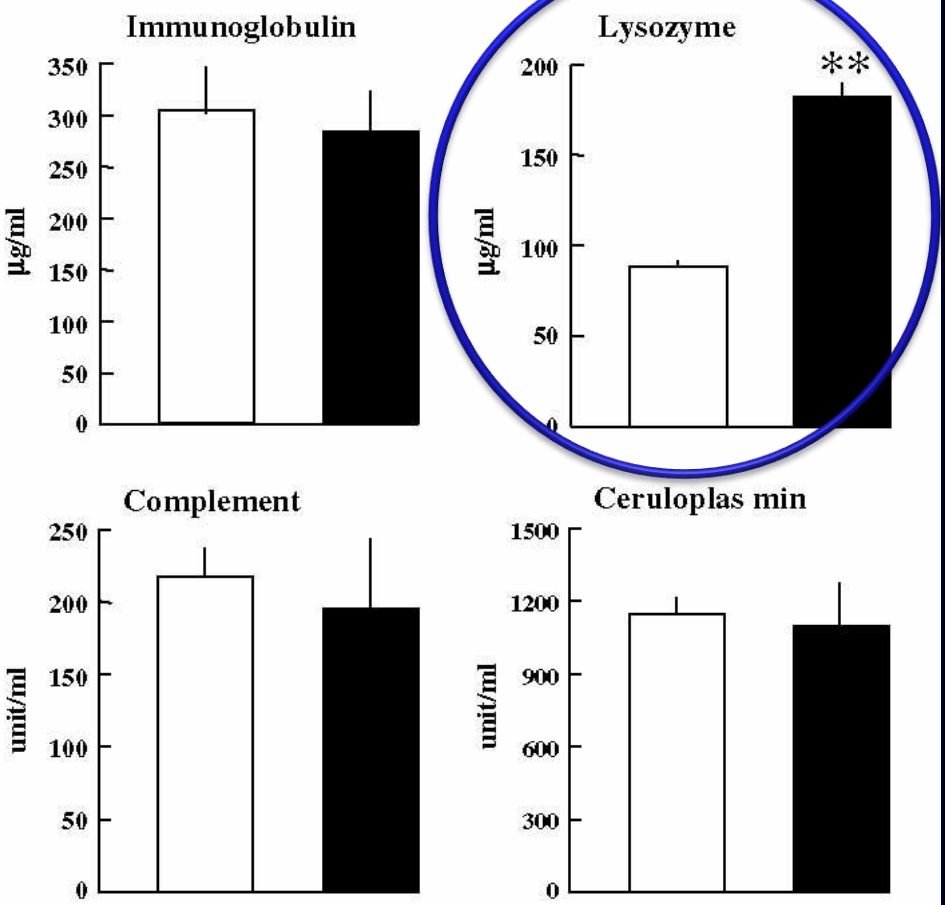
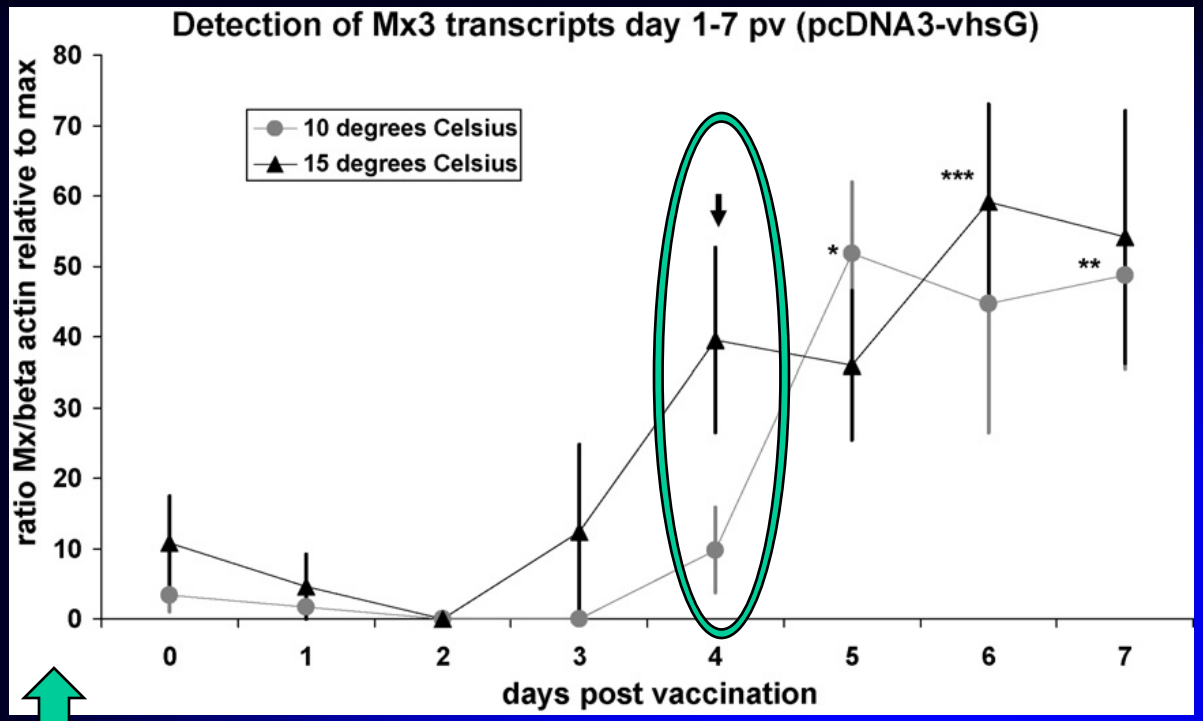


Fig. 2. Plasma immunoglobulin, lysozyme, complement, and ceruloplasmin levels in fresh water- (open column) or seawater- (closed column) acclimated trout. Data are expressed as means ± SEM ($n = 12$). **Significantly different from the initial level at $P < 0.01$.

T. Yada et al. / General and Comparative Endocrinology 156 (2008) 622–627



Salinity

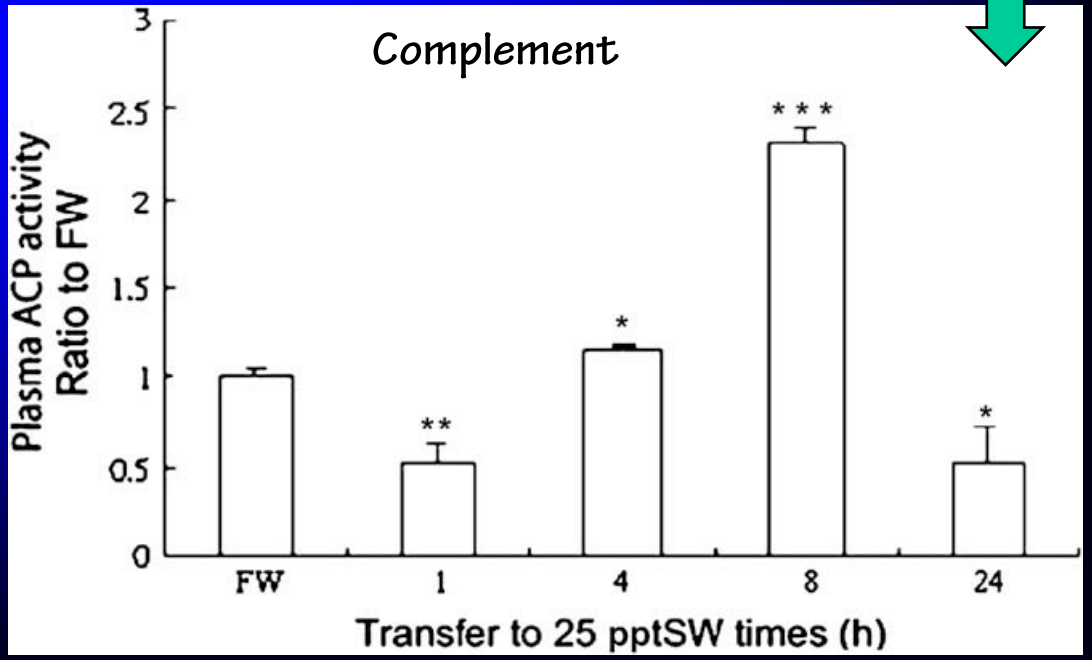
In vivo plasma ACP activity after tilapia were exposed to 25 ppt SW for 1, 4, 8, and 24 h. Data are expressed as mean SD (n ¼ 5). *P < 0.05, **P < 0.01, ***P < 0.005 are significantly different from FW.

Jiang et al., 2008, Fish & Shellfish Immunol. 25: 841–846

Temperature

Detection of Mx3-transcripts days 1–7 pv. Semi-quantitative RT-PCR with -actin as internal reference. The results are scaled, i.e. they are related to the percentage of the maximum expression for each temperature. Vaccinated rainbow trout (pcDNA3-vhsG) acclimated to 15 ◦C showed elevated levels of Mx3-transcripts at day 4 pv, although not significant compared to day 0 (arrow, *p = 0.09), but significant compared to vaccinated fish acclimated to 10 ◦C (p < 0.05). At days 5 and 7 pv vaccinated fish acclimated to 10 ◦C* showed significantly elevated levels of Mx3 expression, whereas vaccinated fish acclimated to 15 ◦C had highly significantly elevated levels day 6 pv. Statistical significance of the Mx3 levels relative to day 0 are given as follows: **p < 0.05; **p < 0.01; ***p < 0.001. Data represent average ± SE (N= 5).*

Lorenzen et al. 2009, Vaccine 27: 3870–3880.



UV-B radiation

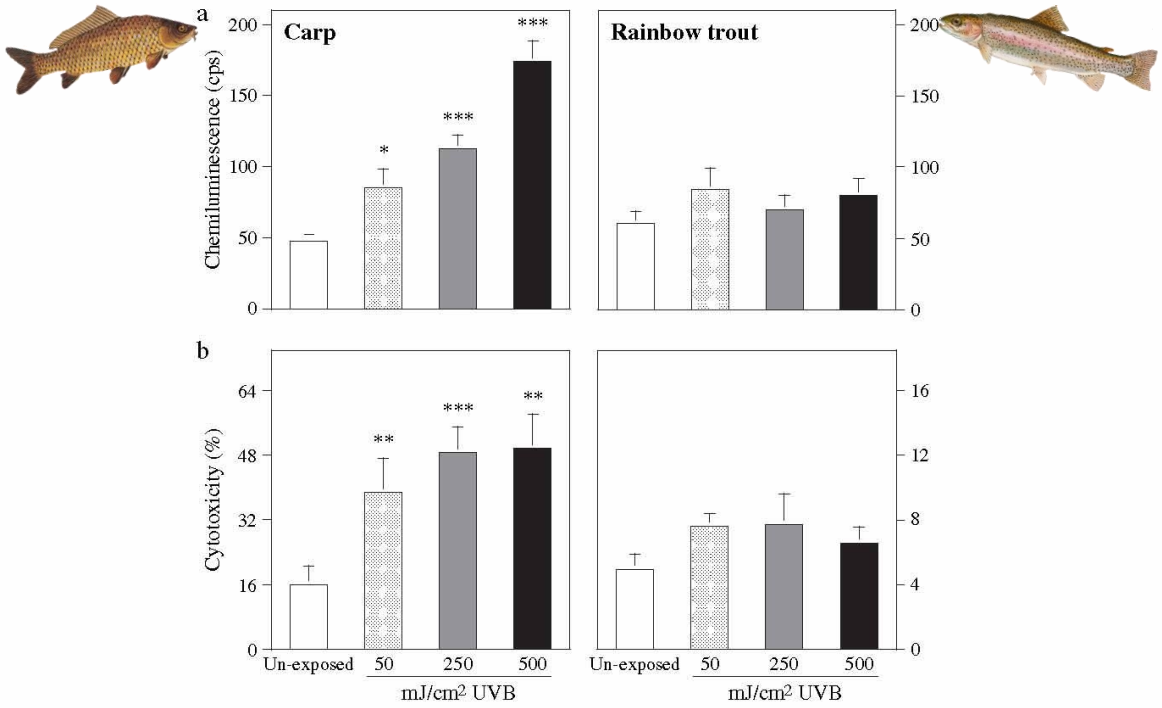


Fig. 2. Blood (a) respiratory burst, and (b) NCC activity of carp ($n = 12–14$ in each group) and rainbow trout ($n = 8–10$ in each group). Carp NCC activity was assayed with isolated blood leucocytes, whole blood was used for other tests. The results are expressed as PMA-stimulated peak chemiluminescence (cps, mean + SE), and percent cytotoxicity (mean + SE) determined by the ^{51}Cr-release method. Statistical significance is referred as $^{*}P \leq 0.05$, $^{**}P \leq 0.01$ or $^{***}P \leq 0.001$.

S.E. Markkula et al. Fish & Shellfish Immunol. 2006, 21: 70-79

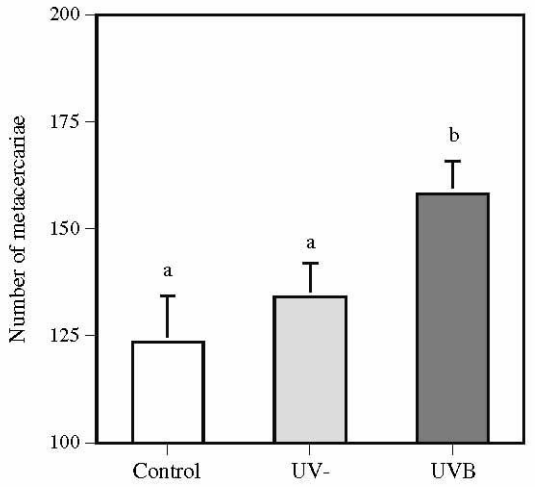
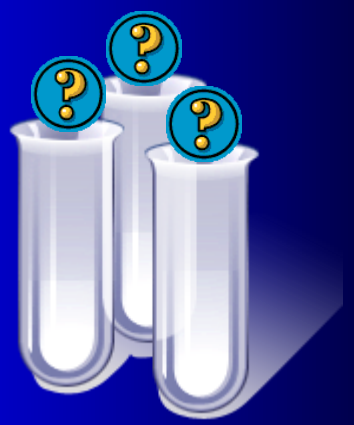


Figure 2. Number of *Diplostomum spathaceum* metacercariae established in the rainbow trout eye lenses. Results are expressed as the number of metacercariae (mean + SE) microscopically detected in the lenses of the fish eyes. n = 30, 45 and 45 for the controls, fish exposed to UV-depleted irradiation and fish exposed to UVB treatment, respectively. Identical letters over the bars indicate no statistically significant difference ($P > 0.05$) between the treatment groups.

Markkula et al., Photochem. & Photobiol., 2007, 83: 1263–1269

Problems for the identification of immune changes produceb by environmental stressors

- ✓Unknown baseline for some immune factors
- ✓Interspecific variability
- ✓Intraspecific variability
- ✓Multiple concurrent factors: synergisms
- ✓Acute/chronic factors
- ✓Thermal limits are not known for all species
- ✓How thermal limits are affected by parasitoses?



Future research directions

- ✓New tools: genomics (microarrays), bioinformatics, proteomics, metabolomics
- ✓Wide range of immune factors can be screened at once
- ✓Integration of proteomic, transcriptomic and metabolomic information to give a more complete picture of living organisms.
- ✓Precise identification of candidate markers for environmental stressors

Thank you for your attention !!

Join us at **www.myxozoa.org**

ariadna@iats.csic.es