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Future prospects for prophylactic immune stimulation in crustacean aquaculture – the need for improved metadata to address immune system complexity

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ABSTRACT

Future expansion of the crustacean aquaculture industry will be required to ensure global food security. However, this expansion must ensure: (a) that natural resources (including habitat use and fish meal) are sustainably exploited, (b) that the socio-economic development of producing nations is safeguarded, and (c) that the challenge presented by crustacean diseases is adequately met. Conventionally, the problem of disease in crustacean aquaculture has been addressed through prophylactic administration of stimulants, additives or probiotics. However, these approaches have been questioned both experimentally and philosophically. In this review, we argue that real progress in the field of crustacean immune stimulants has now slowed, with only incremental advances now being made. We further contend that an overt focus on the immune effector response has been misguided. In light of the wealth of new data reporting immune system complexity, a more refined approach is necessary – one that must consider the important role played by pattern recognition proteins. In support of this more refined approach, there is now a much greater requirement for the reporting of essential metadata. We propose a broad series of recommendations regarding the 'Minimum Information required to support a Stimulant Assessment experiment' (MISA guidelines) to foster new progression within the field.

The fundamental contribution that finfish and shellfish aquaculture will have in safeguarding food security for an estimated global population of 9 billion people by 2050 is well established (Stentiford et al., 2012). The UN Food and Agriculture Organisation (FAO) define food security in terms of (a) Availability, (b) Access, (c) Utilization and (d) Stability (FAO, 2006). Without question, however, the incidence of disease in aquaculture and particularly shellfish aquaculture, represents a key threat to the availability and stability of this commodity for global consumption (Subasinghe and Phillips, 1999; Stentiford et al., 2012). It seems clear now that no single strategy will meet the challenge of infectious outbreaks in farmed stocks. As such, efforts to limit the incidence of disease will need to rely on a holistic approach, based on the principle of the disease triad first proposed by Snieszko (1974). Under Sineszko's model, a pathogen, host and the environment interact to produce a situation in which an infectious disease can first break out and then spread. Under this model, the administration of treatments or additives by prophylaxis that significantly improve host health or immune performance, even on a short-term basis, does have merit. Consequently there has been considerable long standing interest, both scientific and commercial, in the identification of novel components or extracts to use as additives in the feed or culture system to promote the health, growth and survival of the crop to harvest (e.g. Karunasagar and Karunasagar, 1999; Meena et al., 2013).

In the vast majority of published cases the success of potential stimulants has been assessed using measures of immune effector activation, either in terms of gene transcription or protein titre (Fig. 1). Often, such treatments have provided evidence for a sustained period, of hours to days, of heightened immune reactivity in certain immune indices measured in a proportion of the treated crop (Smith et al., 2003). Such data have used to support the development of prophylactic treatments in aquaculture on a global scale. The published literature continues to report enhanced immune effector responses following treatment with extracts of natural products, subsequently advocating their application at a farm scale as a solution to disease. However, over the last decade progress in this field has slowed to only incremental advances

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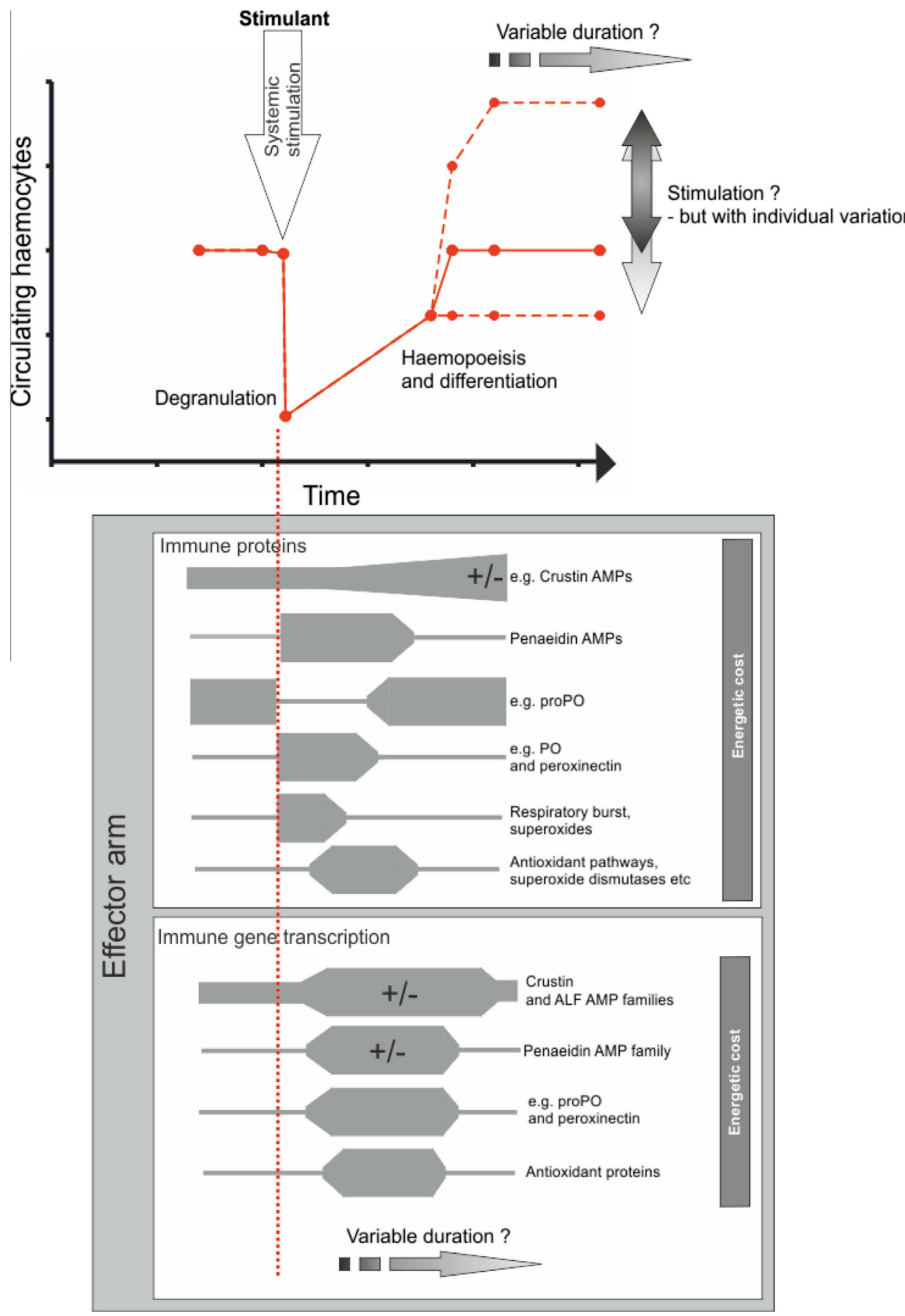

Fig. 1. Summary of conventional approaches to immune stimulation applied to crustaceans highlighting the application of stimulants to induce systemic degranulation of circulating granulocytes and the release of potent non-specific antimicrobial effector molecules (+/− indicates that some proteins and gene isoforms have been reported that are not regulated after infection, depending on the pathogen used). Stimulation of effector pathways and proteins is conventionally followed by an interval of increased gene transcription during haemopoesis to regenerate the immune system for the next challenge. The duration of stimulated protein expression, gene transcription and haemopoesis is variable, as is the density of the new population of haemocytes. Timings of changes in protein and gene expression are only indicative.

which have not made significant inroads into the continuing problem of bacterial, viral and protozoan diseases.

1. Limitations of existing prophylactic approaches to disease control

The concept of stimulating or priming an immune response as a protective solution in crustacean aquaculture has been questioned previously on both experimental and philosophical grounds (for example: Smith et al., 2003; Kounatidis and Ligoxygakis, 2012; Rowley and Pope, 2012). These challenges remain a significant impediment to the successful contribution of crustacean aquaculture to global food security.

Experimental challenges to this field often stem from the insufficient detail being included within the published literature. Implicit in the publication of scientific research is the presumption that results can be independently corroborated or validated by other research groups with the aim that the field of research can collectively advance. A fundamental impediment to this, however, starts