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ARTICLE

Biological complexity behind plankton system functioning: Synthesis and perspectives from a marine Long Term Ecological Research

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ABSTRACT

The functioning of natural communities is the cumulative outcome of multifaceted and intersecting ecological and evolutionary processes occurring at species level. Species are not stable entities but evolve in consequence of contingent factors including the relationships they establish with the environment and other co-occurring species. Studying ecosystems with an eco-evo approach, *i.e*., by explicitly considering species evolution and interactions, is thus an essential step to envisioning community adaptation to environmental changes. Such an approach would be particularly suitable for studying plankton, a community of both rapidly evolving and strongly interconnected species. In this context, Long Term Ecological Research studies (LTER) allow investigating nature at different levels of complexity, from species to ecosystems. Herein, I examine the most recent results coming from the three-decades plankton LTER 'MareChiara' (LTER-MC) in the Gulf of Naples (Mediterranean Sea, Italy) and discuss their suitability in deepening knowledge on: i) evolutionary bases to plankton diversity (*i.e*., the founding property of both species and community adaptive potential); ii) ecological and evolutionary determinants of population and community dynamics; and iii) biological complexity behind plankton system functioning.

Key words: Plankton; ecology; evolution; coastal ecosystems; biocomplexity.

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INTRODUCTION

Multiple and intersecting evolutionary processes are at the base of assembly and functioning of ecological communities (Hendry, 2016). The latter are complex entities including populations of species whose ecological roles stem from several overlapping natural history processes, in which casualties and environmental constraints play simultaneously (Gould, 2002; Koonin, 2011). Understanding the evolutionary history of species, the possible drivers of species life-histories, the ecological benefit of inter-specific interactions and, ultimately, evolutionary processes behind biodiversity are of pivotal importance for ecosystem studies (Levin, 2007; Hendry, 2016).

Conceptual and methodological approaches intersecting ecology and evolution are frequently applied to study plankton, a community of rapidly evolving and strongly interconnected species including both unicellular and multicellular organisms (Lima-Mendez *et al.*, 2015; D'Alelio *et al.*, 2016a). The huge genetic diversity of plankton provides a molecular basis to an overwhelming phenotypic variability (de Vargas *et al.*, 2015; Sunagawa *et al.*, 2015). For instance: plankton individual-sizes span three orders of magnitude (Boyce *et al.*, 2015); morphological characteristics, like surface-to-volume ratio, are extremely variable even within a single aquatic system (Morabito *et al.*, 2007); coloniality is wide-spread among distantly related phyla (*e.g.*, from diatoms to pelagic tunicates; Bone and others, 1998; Seckbach and Kociolek, 2011); mixotrophy, or the contemporary presence of heterotrophic and autotrophic metabolism within the same organism, is common in planktonic protists (Stoecker *et al.*, 2017); several intersecting trophic interactions may establish among plankters (D'Alelio *et al.*, 2016b); and, ultimately, the overall diversity hardly fits into few functional groups (Hofmann, 2010; Flynn *et al.*, 2012; Roselli *et al.*, 2017).

Plankton play a key role in aquatic ecosystems, being at the base of food-webs and driving biogeochemical cycles, and are experimenting strong perturbations apparently connected to anthropogenic factors, but the fine-scale ecological mechanisms at the base of such phenomena are not fully understood (Behrenfeld and Boss, 2013; Hutchins and Fu, 2017; Steinberg and Landry, 2017). In this context, 'eco-evo' approaches, being mainly focused on time (the main dimension of evolution), would be suitable to investigate cause-effect relationships within the wide array of potentially inter-dependent ecological phenomena. Long Term Ecological Research (LTER), consisting in sampling and analysing physical, chemical and biological variables at fixed sampling sites, with high time-frequency (*e.g.*, weekly), and in the long term (decades), can represent profiting case studies to this re-