Heteromorphic and isomorphic alternations of generations in macroalgae as adaptations to a seasonal environment

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ABSTRACT

**Background:** Some macroalgae (seaweeds) have haploid and diploid life forms that differ greatly in size and morphology (heteromorphic life cycle). Others have very similar haploid and diploid life forms (isomorphic life cycle).

**Questions:** What are the optimal reproductive cycles for a heteromorphic species and for an isomorphic species? Under what circumstances will a heteromorphic life cycle be more advantageous than an isomorphic life cycle.

**Mathematical model:** We develop mathematical models for an optimal life cycle in one environment where productivity changes seasonally. The beginning and the end of generations are chosen to maximize the population growth rate.

**Key assumption:** The variety of life cycles observed among macroalgae reflects adaptations to seasonally changing environments.

**Conclusions:** (1) In heteromorphic species, the generation with a large body size should appear in the productive season and the generation with a small body size in the unproductive season. (2) In isomorphic species, algae of different generations should mature when body size reaches a certain common value, regardless of the environment of the generation. However, the length of a generation may vary greatly between seasons. (3) In a strongly seasonal environment, a heteromorphic life cycle is more profitable than an isomorphic life cycle.

**Keywords:** alternation of generations, heteromorphic life cycle, isomorphic life cycle, life-history diversity, macroalgae, seasonal environment.

INTRODUCTION

Seaweeds, or macroalgae, have very diverse life cycles (Wynne and Loiseaux, 1976; Umezaki, 1977; Nakahara, 1986; Verges et al., 2008). Especially notable is the difference between a heteromorphic life cycle and an isomorphic life cycle. In both life cycles, haploid and diploid generations alternate. However, in heteromorphic species, the size of the multicellular body is very
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