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Review

Fish transposons and their potential use in aquaculture

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Abstract

A large part of repetitive DNA of vertebrate genomes have been identified as transposon elements (TEs) or mobile sequences. Although TEs detected to date in most vertebrates are inactivated, active TEs have been found in fish and a salmonid TE has been successfully reactivated by molecular genetic manipulation from inactive genomic copies (*Sleeping Beauty*, SB). Progress in the understanding of the dynamics, control and evolution of fish TEs will allow the insertion of selected sequences into the fish genomes of germ cells to obtain transgenics or to identify genes important for growth and/or of somatic cells to improve DNA vaccination. Expectations are high for new possible applications to fish of this well developed technology for mammals. Here, we review the present state of knowledge of inactive and active fish TEs and briefly discuss how their possible future applications might be used to improve fish production in aquaculture.

Keywords: Fish transposons; Aquaculture; Repetitive DNA; Sleeping beauty; DNA vaccination

Contents

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1. Introduction

At least 40% of the vertebrate genomes contain highly and moderately repeated (Britten and Kohne, 1968) transposon elements (TE) or mobile sequences (Sherratt, 1995). TEs occur in families, copies of which are dispersed throughout the genome. The number of copies per genome can vary from 10 to several thousands, depending on the family of TEs and the species concerned.

On the basis of their structure and presumed mechanism of transposition, TEs fall into two major classes: (i) RNA-based, which transpose DNA sequences after reverse transcription of an RNA intermediate to DNA and (ii) DNA-based, which transpose directly from DNA to DNA.

There are three types of RNA-based TEs, short interdispersed elements (SINEs), long interdispersed elements (LINEs) and retroviruses. The SINEs follow an intermediate RNA to transpose from one locus to another in genomic DNA and are dependent on the presence of a reverse transcriptase provided by separate partner LINEs. The identified fish SINEs (retroposons) are of low size (200–300 bp) and high number of copies (10,000–100,000 copies per haploid genome) and have no terminal repeats (TR). The retroviruses have ~600 bp long terminal repeats (LTRs) and encode reverse transcriptase and other polypeptides. A few retroviruses have been detected in fish (Poulet et al., 1994) belonging to both endogenous (Hronek et al., 2004) and exogenous (Shen and Steiner, 2004) virus. They will not be considered further in this review.

Most DNA-based TEs are 1000–5000 bp and contain 5′ and 3′ inverted terminal repeats (ITR) of 10–200 bp long. The DNA-based TEs depend on the presence of an active transposase to cut and paste the sequences flanked by the two ITR, to transpose from one locus to another in genomic DNA. The complete sequence of the transposase can be included (autonomous elements) or not (nonautonomous elements) into the TE sequence. The majority of the known DNA-based fish TEs are either Tc1-like of intermediate size (1200–2500 bp) and a moderate number of copies (1000–10,000 copies per haploid genome) or Tol2 of higher size (4700 bp) and lower number of copies (10–30 per haploid genome). Smaller, miniature inverted-repeat TEs (MITEs) have been also isolated from zebrafish (1000–10000 copies per haploid genome) (Izsvak et al., 1999).

In contrast to mammals, a few transpositions and complete transposase sequences have been detected in the TEs of some fish genomes. Here, we review the actual state of knowledge of active and inactive fish TEs and the possible future use of that knowledge to improve different aspects of aquaculture. Fish TEs could be used in commercial fish to generate a large number of transgenics (Davidson et al., 2003) to increase the probabilities to find among those the ones to improve production, resistance to diseases or to obtain biopharmaceuticals (Rocha et al., 2003), to identify commercially relevant genes by TE tagging to apply traditional genetic selection methods and/or to improve fish DNA vaccination vectors which would decrease the required dosages or increase the duration of immunisation (Coll, 2001; Fernandez-Alonso et al., 2001; Lorenzen and LaPatra, 2005; Lorenzen et al., 1998; Purcell et al., 2004; Takano et al., 2004; Traxler et al., 1999).

2. RNA-based fish retroposons SINEs/LINEs

RNA-based fish retroposons or mobile short interdispersed elements (SINEs) are highly repetitive (10,000–100,000 copies per haploid genome),