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Potential impact of genetically improved carp strains in Asia

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ABSTRACT

During the past one decade, the WorldFish Center and its research partners have made a systematic attempt to improve the productivity of carps through selective breeding in the major carp-producing countries in Asia. This paper analyses the potential impact of culturing the improved carp strain in five Asian countries (Bangladesh, China, India, Thailand and Vietnam), using a three-step procedure. These steps are: (i) development of a fish sector model for each country, (ii) construction of *ex ante* impact indicators of improved carp strains, and (iii) analysis of the overall potential impact of culturing the genetically improved carp strains by incorporating the technology scenarios into the fish sector model. The results show that the genetic improvement programs of carp strains are highly beneficial to fish farmers, fish consumers and national economies in Asia.

Introduction

Rapid rural development is vital for national economic prosperity and political stability of Asia's most populous countries. In these countries, fish farming, based on largely carp production, is evolving as a major industry. The rural and native consumers prefer carps because of their low price and good taste; in many areas of Asia, carps are the only source of affordable animal protein for the poor (Dey et al., 2005a). Increases in carp production can be achieved through development and adoption of new technologies and improvement in the economic efficiency of carp farming operations. If fish farmers were reasonably efficient, then achieving increases in productivity would require more inputs and adoption of new technologies. Given the relatively high technical efficiency of carp farmers in Asia (Dey et al., 2005b) and the evidence of genetic deterioration (including inbreeding depression) of cultured stocks (Eknath and Doyle, 1990), genetic improvement can play a key role in increasing fish production in Asia.

The role of genetic improvement in increasing productivity levels has been well established in crops and livestock (Evenson and Gollin, 2003; Greeff, 1997; Mitchell et al., 1982; Wickham et al., 1977). Selective breeding has resulted in higher genetic gains and productivity in terrestrial animals (Morris, 1980). But, it is only in recent years that efforts have been made to harness the benefits of genetic enhancement in aquaculture (e.g., salmon and Nile tilapia) (Eknath et al., 2007; Gjedrem, 2000; Ponzoni et al., 2007a; Quinton et al., 2005). Limited research efforts are under way to improve the productivity of carps through selective breeding and gene manipulation.

The WorldFish Center and its research partners have made a systematic attempt to improve the productivity of carps through selective breeding in the major carp-producing countries in Asia during the past one decade or so. Selective breeding programs have been implemented for silver barb (*Puntius gonionotus*) in Bangladesh and Thailand, for rohu (*Labeo rohia*) in India, and for common carp (*Cyprinus carpio*) in China and Vietnam. Initially, mass selection[2] for high body weight was carried for most countries. As the genetic gain declined after several generations of mass selection, all these countries are currently applying a combined within and between family selection[3] (referred to as 'combined selection'

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[2] The term mass selection refers to selection solely based on the individual's phenotype (Ponzoni et al., 2007b).
[3] Combined within and between family selection (usually termed as 'combined selection') means that selection is based on individual information as well as information coming from relatives (e.g., full and half sibs, progeny) (Ponzoni et al., 2007b).

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thereafter) using best linear unbiased prediction (BLUP) method. Results of the on-station experiments show that genetic gains in terms of body weight at harvest[4], across species, have ranged 8–20% per generation (Nguyen and Ponzoni, 2008).

Bangladesh, India, Thailand and Vietnam are in the process of disseminating improved carp strains through their research facilities either directly or indirectly to farmers for commercial production. These improved stains have been transferred to hatcheries of the local government network, which in turn multiplies and distributes brood fish to the next hatchery level as well as produces fingerlings to supply directly to farmers. In China, improved common carp strain developed though mass selection (locally known as *Jian* carp) has been disseminated among farmers, and efforts are underway to further improve the strain through combined selection. At this stage of carp strain development and dissemination in Asia, it is important to conduct an impact assessment to identify areas where further research and policy intervention are likely to have maximum impact in a short time.

During 2004 to 2007, the WorldFish Center and its research partners (Bangladesh Agricultural University, Mymensingh, Bangladesh; Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh; Freshwater Fisheries Research Center, China; Center for Chinese Agricultural Policy, China; Central Inland Fisheries Research Institute, India; Central Institute of Freshwater Aquaculture; Agency for Marine and Fisheries Research of Indonesia, Indonesia; Department of Fisheries, Thailand; Prince of Songkhla University, Thailand; and Research Institute for Aquaculture No. 1, Vietnam) implemented a the project entitled 'Achieving Greater Food Security and Eliminating Poverty by Dissemination of Improved Carp Strains to Fish Farmers', which constitutes the second phase of the genetic improvement of carp species in six participating countries, viz. Bangladesh, China, India, Indonesia, Thailand and Vietnam. The detailed methodology and the results of the project are given in WorldFish Center (2007). This paper reports the methodology and results of the impact assessment exercise carried out under the above-mentioned project. Specifically, the paper analyzes the potential impact of culturing the improved carp strains in five Asian counties (Bangladesh, China, India, Thailand and Vietnam) on fish production, profitability of fish farming, fish prices and fish consumption, as well as on overall economic welfare. Impacts have been measured at both the household and national levels, taking into account the interactions among various groups of fish that are related in production and/or consumption.

Studies on impact assessment[5] of agricultural research can be grouped into three broad categories: (1) *ex ante* assessment and priority setting during the research planning process, (2) monitoring and evaluation during the early stage of technology adoption, and (3) *ex post* impact assessment. Beginning with Schultz (1953) and Griliches (1964), numerous studies have examined the impact of agricultural research on productivity and output growth for a wide range of commodities and countries (reviewed by Alston et al., 1995; Maredia and Raitzer, 2006; Norton and Davis, 1981; Peterson and Hayami, 1977; Raitzer and Kelley, 2008). Most of these studies are on *ex post* impact assessment. Only a few in-depth impact assessment studies have been conducted during the early stages of technology adoption in the fields of livestock, poultry, and crops (Bantilan and Joshi, 1998; Kumar et al., 1977; Peterson, 1967). In aquaculture, Dey (2000) was the first to evaluate the potential economic impact of genetically improved tilapia in five Asian countries.

As progress from the planning and priority setting stage to full adoption of the results of agricultural research could require a very long (20 year) period, *ex post* impact assessments are not very useful in redesigning or readjusting ongoing research programs. More important to research managers is short-term feedback, which identifies new options and shapes technological solutions to users' circumstances (Collinson and Tolleus, 1994). This paper has analyzed the potential impact of culturing the improved carp strain in five Asian countries. This formative impact assessment at the early adoption phase is expected to provide feedback to further improve carp genetic improvement and dissemination program.

Methodology and data

The three-step procedure used to assess the potential impact of research on genetic improvement of carps in Asia included: (1) development of a fish sector model for each country using data from the baseline surveys of producers and from the secondary sources, viz. farmers' consumption and national production, prices, and consumption, (2) construction of a technology index using data collected during on-farm production trials (for Bangladesh, Thailand, and Vietnam) and farm survey data (for China and India), and (3) analysis of the overall potential impact of culturing the genetically improved carp strains by incorporating technology scenarios (step 2) into the fish sector model (step 1). The analysis in this research is based on data collected by the WorldFish Center and its collaborating research institutes under the "Achieving Greater Food Security and Eliminating Poverty by Dissemination of Improved Carp Strains to Fish Farmers" project during 2004–2007 (WorldFish Center, 2007). The project dealt with both genetic and socioeconomic evaluation of improved carp strains in five counties. The principle author of this article led the socioeconomic component of the project, and all the authors were directly involved in the implementation of the on-farm trials and farm surveys.

The carp (silver barb for Bangladesh and Thailand, rohu for India, and common carp for China and Vietnam) sub-sector was treated as the major sub-sector[6] for the respective countries. The remaining freshwater aquaculture species were grouped into other carps and other freshwater fish. The brackishwater and marine aquaculture species were considered as a separate group. The inland capture and marine capture were classified into high-value and low-value groups. Thus, to keep the model simple, it had six groups of species for all the countries.

Fish sector model

The conceptual framework and welfare formulation

This paper used modified balance-of-trade function (or distorted trade expenditure function) approach, suggested by Martin and Alston (1994), for evaluating the impact of improved strain of carp on the economic welfare of different types of households. The basic form of the modified balance-of-trade function used in the study was defined for a single representative household as:

$$H^i = \mathrm{e}(\mathbf{P}, u^i) - \mathrm{g}(\mathbf{P}, \mathbf{V}, \lambda) - f \quad (1)$$

where H^i is the economic welfare of ith type of household; e is the expenditure function of a representative household for a given vector of domestic prices $\mathbf{P}$ and the level of utility exogenously specified at level u^i in order to define the Hicksian money-metric

[4] Though the selection program was for harvest weight only, correlated increases in body length, height and width were also observed.

[5] Ex-post assessment is a summative form of evaluation and is conducted after program completion often for benefit of external audience. Other two types of impact assessments are formative evaluation, primarily concerned with providing information during the implementation phase on how to improve the program (MacKay and Horton, 2003).

[6] The main emphasis of this paper is to assess potential impact of using improved stains of these carp species.