Common carp (*Cyprinus carpio*) – Current status of selective breeding in Europe

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Summary

This report provides information on the current status of breeding of common carp (*Cyprinus carpio*) in European aquaculture. A survey among companies that reproduce carp provided insight to their main characteristics. Selective breeding is not commonly applied in carp breeding and genetic improvement is largely based on crossbreeding. Some carp strains have been reproduced for over 20 generations but with only limited selection. Basic selection with subjective criteria on the scaling pattern, health status, sexual maturity and general appearance is carried out to exclude fish that deviate from the desired standard of a line. Most of the production is realised from crossbreds which generally outperform the purebred lines. Crossbreeding may result in up to 35% improvement on growth performance and survival.

1. Introduction

Common carp (*Cyprinus carpio*) is one of the main aquaculture species in the EU: its production is close to 60 million tonnes with a value exceeding 130 million Euro (table 1). The Czech Republic and Poland are by far the largest producers, producing more than half of the total European production.

Table 1. Common carp production in Europe in 2012

Country	Production volume [a] (tonnes)	Production volume [b] (tonnes)	Production value [b] (1000 €)
Croatia	2484	2484	4659
Czech Republic	17972	17972	35046
France	3500	4000	4803
Germany	5521	5521	12430
Hungary	9985	9985	21078
Lithuania	-	3257	6543
Poland	17700	17700	38987
Romania	-	3400	6662
Total	57 162	64 319	130 208

Countries with a production <2000 tonnes are not presented
[a] (FEAP, 2014)
[b] (FAO, 2014)

The production and breeding of common carp has been reviewed by Flajšhans and Hulata (2007). Carp culture started in China around 2000 B.C. and has a long history of domestication. Culture practices at the time relied largely on wild supplies of small fish which were ongrown in ponds (Komen, 1990). In Europe the first articles on carp reproduction appeared in the 13th century, although the culture of carp may have already occurred in Roman times and was certainly practised in monasteries from the early middle-ages onwards (Komen, 1990 ; Balon, 1995). Carp culture became more sophisticated during the 19th century, when controlled spawning techniques in separate ponds were developed. This resulted in the development of many different strains in Germany and the Czech Republic (Komen, 1990). These strains differ both in qualitative traits such as scaling pattern and morphology as in quantitative traits such as survival, growth rate, feed conversion ratio and fat content (Gorda et al., 1995). A study of Moav and Wohlfarth (1976) in which no improvement in growth performance was achieved in five generations of selection, has often been recalled as proof that selective breeding is not effective in carp (Vandeputte, 2009). However, when care is taken of compensating for the highly skewed contributions of parents in combination

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with the use of a base population with sufficient genetic variation, selective breeding for growth performance can result in a genetic gain of 12-25% per generation (Vandeputte et al., 2004 ; Ninh et al., 2013 ; Vandeputte et al., 2008 ; Wang et al., 2006 ; Spasić et al., 2010 ; Nielsen et al., 2010 ; Yousefian et al., 2011). Nevertheless the value of improved growth performance is questionable as carp is commonly cultured in ponds with limited exogenous feed input. Therefore improvements in growth performance do not necessarily result in productivity gains. Considering the limitations of the culture system, traits of importance are rather related to survival, disease resistance, fillet yield and product quality (Vandeputte, 2009). Despite the potential of selective breeding for carp aquaculture, genetic improvement is still largely based on crossbreeding of different lines (Vandeputte, 2003); there are no specialized selective breeding programs. Therefore this report aims to:

1. Describe the main characteristics of genetic improvement in carp aquaculture
2. Assess the impact of genetic improvement on European carp production.

2. Materials and Methods

In a survey conducted in collaboration with AQUATRACE[1], questionnaires were distributed among companies that reproduce carp in Europe. This first extensive questionnaire included questions related to the number of lines used, number of selected generations, selected traits, the application of genetic markers and the quantity of eggs produced. The response rate was low, and it was concluded that there were probably no selective breeding programs for carp. We therefore decided to focus on companies that reproduce carp. Part of the questionnaire was translated to Czech and distributed among Czech companies. This second questionnaire included questions related to the annual egg production, the number of lines used and whether crossbreeding was applied.

3. Results

Two Polish, one Hungarian and 16 Czech companies participated in the surveys. Of these companies all except one performed crossbreeding, suggesting that the majority of the production is realised from crossbred animals. Criteria for the selection of broodstock generally include the scaling pattern, health status, sexual maturity and general appearance. Most companies indicated to select their broodstock based on a subjective judgement considering these traits, which is mainly aimed to exclude fish that deviate from the desired standard appearance of a line (Prchal, 2015). One company indicated that in the creation of a line, during the first few generations selection was directed at improving growth rate, disease resistance and body shape and after several generations of inbreeding selection was restricted to morphology and scaling pattern. This company used experimental ponds for performance testing rather than subjective selection criteria. None of the companies indicated to perform selective breeding in a way that genetic improvement is cumulative over a large number of generations.

[1] AQUATRACE - https://aquatrace.eu/ - 7th Framework Programme for research (FP7)

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Two companies indicated to apply marker assisted selection, which one of them applied to improve disease resistance. The number of lines varied between 2 and 19 and the oldest reported line existed for over a century, thus considering an average 4.5 year generation interval (Vandeputte et al., 2008), it has been bred for more than 20 generations.

In the Czech Republic the egg production per company ranged from 1 to 180 million per year (figure 1) and virtually all of the egg production was realized by the companies that participated in the survey (Prchal, 2015). Together the Czech companies produced 697 million eggs per year. No European egg production statistics were available. Based on an average egg to fish production ratio of 39 eggs/kg in the Czech Republic, the total European egg production can be estimated around 2.5 billion. What part of these eggs were crossbreds, cannot be judged from the results.

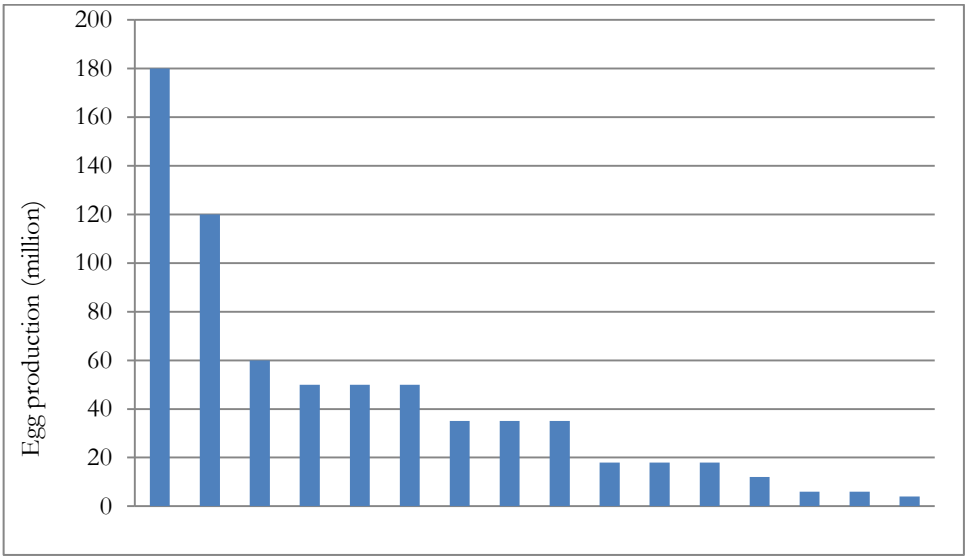

Figure 1. The annual egg production of 16 companies that reproduce common carp in the Czech Republic.

4. Discussion

The results demonstrate that, at least in the Czech Republic, genetic improvement in carp breeding is largely based on crossbreeding. This also applies to Poland (Pilarczyk, 2015), Croatia (Drasner, 2014) and probably the rest of Europe (Vandeputte, 2003). The basic selection that is carried out by most of the companies is aimed to maintain the specific characteristics of the pure lines, rather than to achieve cumulative genetic improvement (Prchal, 2015). Although one company indicated to perform selection based on performance tests with experimental ponds, this is only applied in the first few generations. Therefore it can be concluded that selective breeding plays a minor role in carp production and genetic improvement is largely based on crossbreeding.

The impact of crossbreeding in carp production can be judged from estimates of heterosis. Nielsen et al. (2010) studied heterosis in crosses of various different lines. They found a 14-29% increase in growth and a 8-37% increase in survival due to heterosis, corresponding well to a study of Bakos and Gorda (1995) who reported heterosis effects of 0-35% and 2-31% on growth and survival respectively. Nevertheless heterosis should not be regarded as the main genetic determinant of performance, as large differences among pure lines exist (Vandeputte, 2003 ; Gorda et al., 1995).

5. Conclusion

1. With some lines being reproduced for over 20 generations, carp has the longest history of domestication of all aquaculture species.
2. Selective breeding plays a minor role in carp breeding and genetic improvement is largely based on crossbreeding.
3. Important traits include the scaling pattern, health status, sexual maturity and general appearance.
4. The majority of the production is realized from crossbred animals.
5. Crossbreeding may result in improvements on growth and survival up to 35%.

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