Topical issues in genetic diversity and breeding

Genes and Fish

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The dilemmas of strain selection

In this issue I discuss some of the factors behind one of the most basic and cost effective methods of improving the performance of our cultured stocks, namely the selection of the best existing strain for a particular environment. Most of us are aware of the importance of production factors such as nutrition, water quality and general husbandry methods and the advances that have been made in the understanding and management of these factors in recent decades. Very often investments are made in aquaculture technologies and in facilities, which are then applied to whatever fish may be available at the time. Without using the best available stock it clearly will not be possible to optimize yields, whatever technology is applied within aquaculture systems.

For most aquaculture species, there are a large number of domesticated and improved strains in production and the gains achieved by the choice of the best existing strain can be equivalent to the genetic gains that could be achieved from many generations of selective breeding using inferior strains. When selecting strains it is most effective to conduct direct comparisons within the farm environment, measuring all commercially important parameters. Ideally strain selection should include an evaluation of existing local strains by way of a control. Such an approach would then account for what should be positive aspects of any local adaptation affecting the relative performance of the local stock that might have been bred in the "home" environment for several generations.

If the selected (i.e. chosen) strain(s) is intended as a base for a selective breeding program, it is useful also to make some assessment of the levels of genetic variation within the strain(s). This variation, apart from commonly being correlated with general "fitness" parameters, is necessary in order for selection to succeed.

By way of illustration of the potential gains that could come from appropriate strain selection, typically comparisons of growth rate in several different available strains can easily yield differences between the fastest and slowest growing strains of 50% or more. Such differences have been demonstrated in both tilapias and carps for example.

Methods of comparison

There are basically two methods for conducting comparisons of different strains, by stocking strains communally within a common environment or by stocking strains separately in replicated culture units. Test environment should ideally closely resemble the actual production environment to minimize the risk that significant genotype x environment interactions will result in incorrect assumptions being made about the relative superiority of selected strains when extrapolating results from one environment to another.

Communal stocking

Under communal stocking, fish from the different strains are produced and reared separately up to an age and size at which they can be marked. Following marking they are then mixed and reared through the production cycle, being sampled periodically to determine relative growth. In this type of study each individual fish within an environment is considered as a replicate. The main advantages of communal stocking are that it requires relatively few facilities, removes any effect of environmental variance on the growth of the individual fish (as the strains are all in the same environment) and usually enables identification of statistically significant differences.

The main disadvantages are that differences between strains in genetic potential for growth can be modified (usually magnified) by competitive interaction between strains. For example a strain may grow faster because it is more successful at accessing feed ahead of other strains rather than having a better genetic growth potential. Also in communal stocking, differences in initial size at stocking might be exaggerated by competitive interactions during grow-out (although research investigating the predictability of final weight based on initial

weight has produced ambiguous results). Competitive interactions are likely to be less significant in fertilization only systems where there is essentially less competition for food resources. There is nevertheless a risk that incorrect assumptions can be drawn from communal stocking experiments due to these interaction factors. This competitive interaction effect can be countered to some extent by utilizing internal reference strains and assessing parameters relative to the reference strain. Also correction factors for differences in initial size can be estimated by deliberately inducing differences in initial size, within strains by multiple pre-nursing of batches under different stocking densities.

Another disadvantage is that certain parameters cannot be measured under communal stocking such as relative food conversion efficiencies or the effects of different sex ratios on the overall growth of populations.

It should be possible to integrate communally stocked trials into the regular production system on the farm with tagged fish followed through to harvest and even processing. This is an ideal situation as we can be confident that our interpretation of the relative performance of strains really does apply to the culture environment of interest.

Separate stocking with replication

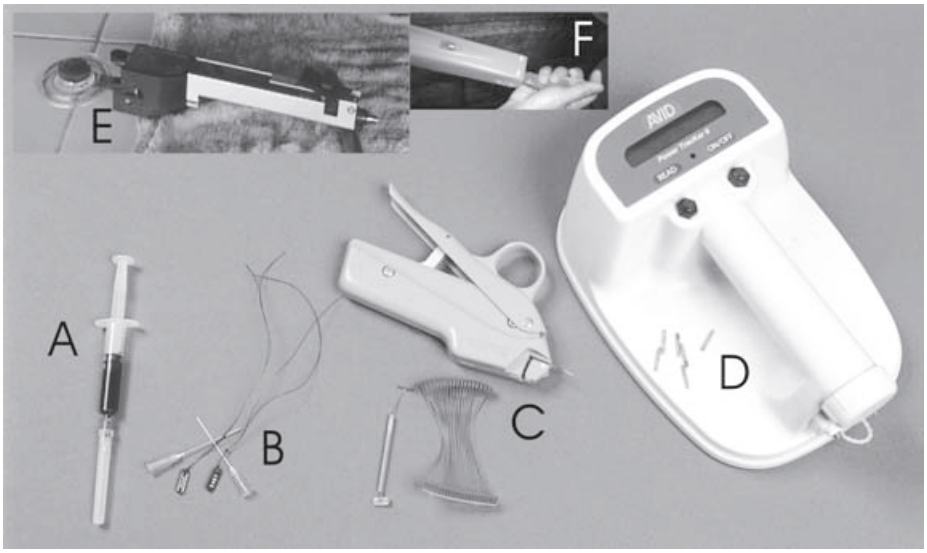
In separate stocking, the strains are stocked separately in discrete units (tanks, cages or ponds). In order to take account of inevitable differences between the individual units (e.g. in water quality, post mortality stocking densities etc.) each unit must be replicated for each strain. The number of replications required depends on the degree of variation between environments. In fairly uniform culture environments (such as cages within the same water body) a minimum of three replications can suffice but in more variable environments, especially ponds in which growth performance can vary widely, five or more replicates may be required. The major disadvantage of separately stocked comparisons is that they require heavy use of facilities and, even with good replication, high variation between culture units can disguise real differences between strains so that they appear statistically insignificant. Due to the requirement for replication, culture units used for separate stocking are often smaller or of a different type than normally used for production and thus representing a different environment increasing risks of incorrect interpretations due to genotype x environment interactions.

The major advantages are that, if environmental differences are effectively minimized, results from successful experiments are more reliable and more parameters can be measured when stocks are reared separately.

Summary

Having myself been involved in many strain evaluations with both communal and separate stocking approaches I perceive significant risk of arriving at incorrect interpretations of data coming from these trials, particularly if the data are not analyzed correctly. Often replicated trials yield differences in mean growth rates and harvest size of strains of considerable magnitude and yet between replicate variance results in differences being statistically non-significant. Also heterogeneity of variance that cannot be corrected by data transformation often invalidates assumptions of ANOVAs. Communal stocking more commonly yields statistically valid and significantly different growth rates between strains. Provided there are not large differences in stocking size, I usually have confidence in the ranking of the strains but how confident can we be that the magnitude of the differences has not been affected by competitive interactions?

Logistical constraints often dictate that communal stocking is the most practical method for strain evaluation and this is likely to be the case for most farm-based evaluations, provided marking options are accessible. Such trials can produce very useful results but attention must be given to the possible effects of competitive interactions between strains. Intelligent use of internal reference strains or multiple pre-nursing to generate different stocking sizes can be used to partially correct/mitigate for interaction effects and thus making for more reliable data.



(Modified from photo by K. Rana.)

Communal stocking of strains requires that fish from different strains be distinguished. Usually this is not possible based on appearance alone and it is necessary to mark the fish. There are many options for marking and tagging fish, some of which are shown in the accompanying photo including dye marking (A), numbered fingerling tags (B), "T-bar" floy tags (C), electronic PIT tags (D – tags and reader) and coded wire tags or CWT (E – applicator; F – detector). For communal stocking individual identification is usually not required so batch marking methods are usually more cost effective. My current preferred marking method is with CWT, which can mark four or five genotypes using different tagging positions. This can be combined with fin clipping for more options.