What are "Farmed Types" in Aquaculture and why do they Matter?

FAO launched the first-ever Report on *The State of the World's Aquatic Genetic Resources for Food and Agriculture* (the Report) in August 2019. One of the principal findings of this report is that very little information is available on aquatic genetic resources (AqGR) used in aquaculture (or their wild relatives), below the level of the species. In this regard, the Report recommended to "establish and strengthen national and global characterization, monitoring and information systems for AqGR". The Report further concluded that there was a lack of standardization of terminology and nomenclature used to describe AqGR, which generates confusion and uncertainty. While identifying a clear need to standardize and harmonize this terminology, FAO presented and used standardized terminology throughout the Report. Subsequently, FAO, in August 2019, held an expert workshop on the development of a registry of farmed types of AqGR (see article on pages 18-19 of this issue). This registry will be the core component of a broader information system for AqGR to be developed in the near future.

The objective of this article is to present and explain the definitions of farmed types and identify the importance of using standardized definitions through a proposed information system for AqGR.

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Common carp (*Cyprinus carpio*) is one of the longest domesticated aquaculture species with a wide distribution and has a number of distinct strains. These examples are held at the live gene bank maintained at the Research Institute for Fisheries, Aquaculture and Irrigation (HAKI), Szarvas, Hungary

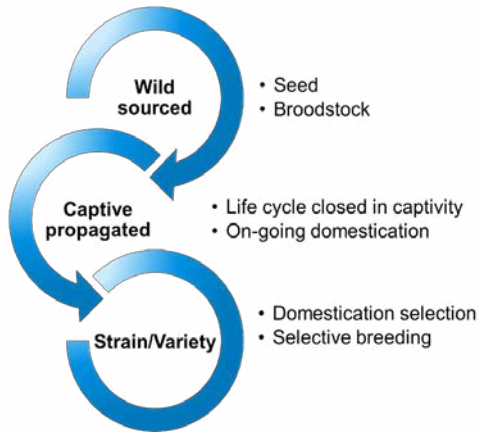
What is a "farmed type"?

The term was coined in a 2016 FAO workshop[1] as a descriptor

A "farmed type" refers to a farmed aquatic organism that could be a strain, variety, hybrid, triploid, monosex group, or other genetically altered form or wild type.

1. FAO. 2016. *Report of the expert workshop on incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives.* FAO Fisheries and Aquaculture Report No. 1173. Rome. (also available at **www.fao.org/3/a-i6373e.pdf**).

FIGURE 1
Illustration of the domestication continuum and the classification of three levels of associated farmed types



of farmed AqGR below the level of species. All aquatic organisms found in aquaculture should be defined by their species and by one or more farmed types. Subsequent to the identification of the specific farmed types by experts in the 2019 workshop, it was resolved to categorize these further into primary and secondary farmed types. Primary farmed types describe the status of domestication and improvement, typically through selective breeding as the core technology, along a domestication continuum. In addition, there is a range of genetic technologies that can be and are applied to "add value" to the domestication or selective breeding process. The results from the application of these value-adding technologies are the secondary farmed types. Examples of these secondary farmed types can be found in the main species groups used in aquaculture.

The domestication continuum – primary farmed types

Humans started to domesticate terrestrial animals and plants around 10 000 years ago, and most of our modern-day livestock and crops have been fully domesticated for over 5 000 years (Duarte, Marbá and Holmer, 2007).[2] Many are barely recognizable compared to their wild relatives. Domestication of aquatic species, with a few exceptions,[3,4] started only around a hundred years ago and most of our current aquaculture species were domesticated in the past few decades. As a result, most of our domesticated farmed types are largely indistinguishable from their wild relatives. One positive aspect of this recent domestication is that current farmed types can still retain much of the genetic variation present in wild stocks. Also, the Report confirms that wild relatives of all farmed species can still be found in nature, which is far from the case for many of our terrestrial agriculture species. The Report also showed that some of our cultured species are still harvested directly from the wild (either as wild collected seed or as offspring of wild caught broodstock). The expert workshop defined such farmed types as "wild sourced".

The life cycle of many cultured aquatic species has been closed in captivity, and the seed of these species can now be produced in hatcheries using broodstock that were themselves spawned in captivity. Some of these farmed types have developed and become genetically changed, either through genetic drift, domestication selection[5] or using deliberate selective breeding, to the point that they are clearly distinguishable from other farmed types of the same species (in a similar, but less extensive way, Friesian and Holstein breeds of cattle are distinguishable from each other). This distinctiveness permits these farmed types to be classed as strains (for animals) or varieties (for plants). Given the early stage of domestication and genetic improvement in aquaculture, the majority of farmed types for which the life cycle has been closed in captivity are not yet differentiated to the point where they can be considered as strains or varieties.

It is nevertheless important to record these farmed types if they make an important contribution to production. The expert workshop coined and defined the term "captive propagated" to describe these "transitional" farmed types that are no longer wild sourced but have not yet differentiated to the point that they can be described as strains or varieties. It is extremely useful to note that all aquacultured organisms can be allocated to one of the four primary farmed types (see Figure 1 and Table 1).

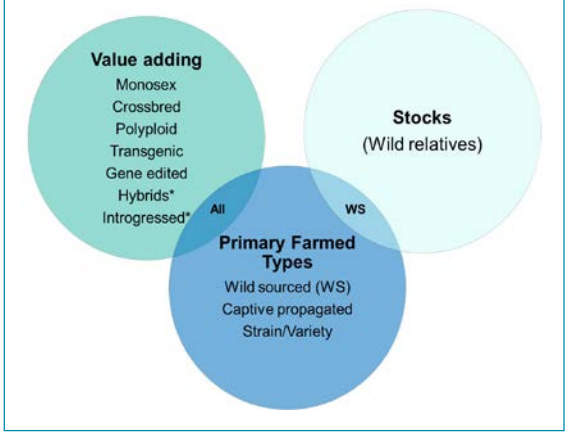
Secondary farmed types

There is a range of genetic technologies that can be applied to many aquatic organisms and that can be used to add value to a domestication or selective breeding programme. These technologies can be used to produce a range of secondary farmed types within the primary farmed types. These include the following:

- monosex generated by genetic manipulation of sex determination;
- hybrid (F1 crosses between species) and crossbred (crosses between primary farmed types within a species);
- introgressed – hybridization that goes beyond the initial F1 cross;
- polyploid, mostly commonly triploid – induced to produce sterile organisms; and

2. Duarte, C. M., Marbá, N., & Holmer, M. 2007. Rapid domestication of marine species. Science, 316(5823): 382-3.
3. Harland, J. 2019. The origins of aquaculture. Nature Ecology and Evolution, 3: 1378–9.
4. Teletchea, F. & Fontaine, P. 2014. Levels of domestication in fish: implications for the sustainable future of aquaculture. Fish and Fisheries, 15: 181–195.
5. The equivalent of "natural selection" in an artificial environment.

FIGURE 2
Diagram illustrating the relationship between primary and secondary farmed types and wild relative stocks



– genetically engineered farmed types resulting from transgenesis or gene editing.

Figure 2 illustrates that secondary farmed types can be produced from all primary farmed types.

Also, wild-sourced primary farmed types can be related to natural stocks of wild relatives.

What is the value of an information system on farmed types?

The development of an information system of farmed types will deliver a number of benefits to key stakeholders:

– promote utilization and understanding of standardized terminology;
– advance the development and harmonization of national and international information systems;
– facilitate recording of farmed types and their use and exchange;
– build a deeper understanding of the development and properties of each farmed type, the needs and opportunities associated with them, and their capacity to contribute to national aquaculture production;
– enable more informed policy development and decision-making regarding AqGR; and
– enable the collation of data and the development of indicators on the status and health of AqGR, including indicators for monitoring and reporting trends in relation to a future Global Plan of Action, conservation goals and Sustainable Development Goal target 2.5.

TABLE 1 – A list of primary and secondary farmed types including definitions and examples

FARMED TYPE	DEFINITION	EXAMPLES
	Primary farmed types	
Strain (animals)	A farmed type of aquatic species having relatively homogeneous appearance (phenotype), homogeneous behaviour, breeding history and/or other characteristics that distinguish it from other organisms of the same species in that country and that can be maintained by propagation	Selectively bred Pacific oysters with resistance to Pacific Oyster Mortality Syndrome caused by the virus OsHV-1 (oyster herpes virus)
Variety (plants)	A plant grouping, within a single botanical taxon of the lowest known rank, defined by the reproducible expression of its distinguishing and other genetic characteristics*	Registered cultivars of *Pyropia, Undaria* and *Saccharina* in the Republic of Korea
Captive propagated	A farmed type for which the life cycle has been closed in captivity (i.e. not wild sourced) at least for one generation and aquaculture seed is derived from broodstock that have been spawned and reared in captivity, but does not meet the criteria as a strain or variety	Hatchery-raised Indian major carp across many states of India having been domesticated since as early as the 1970s but not subjected to deliberate selective breeding
Wild sourced	A farmed type in which aquaculture seed or broodstock are sourced from wild stocks, i.e. have not been bred in captivity	Bluefin tuna in Australia and Japan, harvested from the wild and grown out in cages. *Penaeus monodon* produced from broodstock harvested from the wild
	Secondary farmed types	
Hybrid	The F1 progeny of a cross between two different species	F1 hybrid between female *Clarias microcephalus* and male *C. gariepinus* cultured in Thailand
Introgressed	A farmed type based on a genetic mix of two or more different species beyond the F1 generation	Cold-tolerant tilapia in the Philippines – derived from crosses between farmed types of *Oreochromis niloticus* and *O. aureus* and *O. spilurus*
Crossbred	The F1 progeny of a cross between two primary farmed types within a species	Dongfang No. 6 kelp, a cross between a native and an introduced kelp (*Saccharina japonica*) produced in China
Polyploid	An animal or plant having more than two sets of chromosomes	Sterile triploid oysters that do not spawn and thus retain condition and market value during the breeding season
Monosex (genetic)	A single sex cohort of a given species generated through genetic manipulation of sex determination rather than direct manipulation of sex differentiation	Genetically male tilapia in *Oreochromis niloticus* produced from YY male sires, all male hybrid tilapia (*O. niloticus* female × *O. aureus* male) or all female salmonids produced from XX male sires
Transgenic	An organism in which a foreign gene (a transgene) is incorporated into its genome. The transgene is present in both somatic and germ cells, is expressed in one or more tissues, and is inherited by its offspring	Atlantic salmon (*Salmo salar*) in Canada, United States and Panama transgenic for the Chinook salmon growth hormone gene and an ocean pout promoter gene. Ornamental zebra danios (*Brachydanio rerio*) transgenic for fluorescing proteins
Gene edited	A farmed type created by the targeted insertion, deletion or replacement of DNA at a specific site in the genome that is inherited by its offspring	There are currently no gene edited farmed types being used in commercial aquaculture, although a gene edited tilapia has been developed and is under consideration for aquaculture in Argentina
	Wild relatives	
Stock (wild relative)	A group of individuals in a species occupying a well-defined spatial range independent of other stocks of the same species. Random dispersal and directed migrations due to seasonal or reproductive activity can occur. Such a group can be regarded as an entity for management or assessment purposes	Gulf of Maine stocks of Atlantic cod (*Gadus morhua*)

* From the International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2009, **www.fao.org/3/a-i0510e.pdf**).