Week 2

Biological characteristics of aquaculture species

A major characteristic that determines the suitability of a species for aquaculture is the rate of growth and production under culture conditions.
Although certain slow-growing species may be candidates for culture because of their market value, it is often difficult to make their culture economical. Growth rates of many species can be improved through the use of heated water, but commercial grow-out using such methods has not yet proved very successful. In principle, a faster growth rate, as obtained in many tropical species, allows them to grow to marketable size in a shorter time, making it possible to have more frequent harvests.
The size and age at first maturity is also an important consideration, as it will be preferable to have them reach marketable size before they attain first maturity so that most of the feed and energy are used for somatic growth. Early maturity would ensure easier availability of breeders for hatchery operations, but early maturity before the species reaches marketable size will also be a great handicap, as in the case of tilapia species.
It is certainly preferable to culture a species that can be bred easily under captive conditions.
This permits hatchery production of seed in adequate quantities. If it is a speices that matures more than once a year, it should be possible to have several crops of seed and possible adults, if other conditions are suitable.
High fecundity can be an advantage, as can frequency of spawning; however, small-sized eggs and small larvae make hatching operations more difficult. A shorter incubation period and larval cycle often contribute to lower mortality of larvae and greater survival in hatcheries.
Larvae that would accept artificial feeds would be easier to rear in hatcheries. The raising of live foods is comparatively more difficult and often expensive.
In cases where controlled breeding techniques have not been perfected, the aquaculturist may have to depend on seed available from the wild. But as has been experienced in many situations, it proves to be an unreliable source in large-scale farming as their abundance in nature depends on a number of unpredictable factors. Further, large-scale collection of wild spawn and fry has given rise to conflicts with commercial fishermen, who ascribe the decline in catches of the species concerned to the removal of early stages, despite the lack of any scientific evidence. So, even from a public relations and biodiversity point of view, it is better to select species that can be propagated in hatcheries and to start hatchery production as early as possible.
In modern aquaculture, feeding is one of the major elements of production cost and may amount to 50 per cent or more (generally 60).
In most traditional aquaculture practices, herbivorous or omnivorous species have been preferred as they feed on natural food organisms in water, the growth of which can be enhanced through fertilization and water management. In such cases, the cost of feeding will be relatively low and, because of this, species low in the food chain are preferable

for the production of low-priced products. However, even with such species, supplementary feeding with artificial feedstuffs has to be adopted in intensive culture systems. The feed efficiency in relation to growth and productivity then becomes an important criterion. Some of the low trophic level feeders can also be highly selective in their feeding habits, as in the case of filter-feeders that require plankton of a particular size and shape. The need to grow the species to market size within a limited season or period often makes it necessary to resort to artificial feeding. Further, with improved feed conversion efficiency, manipulable through N and P reduction in artificial feeding, a reduction in nutrient loading can be achieved, thus leading to more eco-friendly and sustainable culture systems, as shown for example in salmon (Makinen, 1991; Bergheim, 2000) and carp (Jhan et al., 2001).

Carnivorous species generally need a highprotein diet and are therefore considered to be more expensive to produce, even though the costs will depend largely on local availability and price of the required feedstuffs.

To compensate for feeding costs, most carnivorous species command higher market prices.

Such species generally have greater export markets and therefore attract substantial investments.

Species that are hardy and can tolerate unfavourable conditions will have the advantage of better survival in relatively poor environmental conditions that may occur occasionally in culture situations. The temperature and oxygen concentration can fluctuate in ponds and other enclosures and deterioration of the water quality may unavoidably occur. In such situations, hardier species will obviously fare better. Besides the possible effects of poor water quality on the candidate species, it is also necessary to consider the influence of the species on the environment. Soil erosion that may be caused by the feeding habits of carp has been referred to in Section 2.1. Species that easily escape into natural bodies of water and upset their ecology would need special protective measures, leading to higher costs and environmental concern.

In intensive and semi-intensive culture, dense populations are confined in a limited space. In such cases, behaviour patterns of species in confinement are of special significance. Increases in transmission of disease, cannibalism in the early stages and accumulation of waste products are related to overcrowding. Species that have better resistance to such unfavourable conditions are better candidates for culture.

Economic and market considerations

To an aquaculturist economic considerations are as important as or even more important than biological factors in the selection of species to be cultured.

When discussing national priorities and investment requirements. The availability of proven technologies of culture, backed by economic viability, should guide an investor or an aquaculturist in the selection of a species or a culture system. Despite the scarcity of this type of information and the variability of economic returns of enterprises, it is of such crucial importance that even incomplete information from actual commercial or pilot operations would be useful in validating available experimental results.

Consumer acceptance and availability of markets for the species are very intimately interlinked with the economics of raising them. There are several instances where culture techniques were in existence for many years but never resulted in any large-scale production until new or improved markets developed, whether for domestic consumption or for export. Markets can, of course, be developed in places where none existed for a species, but this would require very considerable time and effort. Public and/or private organizations will have to undertake very intensive promotional activities to achieve this in a reasonable period of time.

The above considerations appear to be the main reasons for the widespread interest in introducing exotic species. The species concerned are generally those for which established culture technologies exist and the economics of production and marketability have been demonstrated.

5.3 Introduction of exotic species

The advantages of limiting the number of aquaculture species and the scarcity of really domesticated species for culture have been referred to at the beginning of this chapter. The economic and market considerations that create interest in the introduction of exotic species, have also been mentioned in the previous section. Considering the natural geographic ranges of distribution of proven species, there is a strong argument for the introduction and transplantation of exotic species where necessary. However, the problem very often is how to decide whether it is necessary and, if so, what procedures and precautions should be taken to prevent possible undesirable consequences.

History reveals that several indiscriminate introductions and transplantations have been made in the past for establishing sport and commercial fisheries, for ornamental purposes and for biological control. Some of them have had detrimental effects on the local fauna and have contributed to the spread of communicable diseases. There is no gainsaying the need for preventing such consequences by following appropriate procedures and effective national regulations. However, expanding aquaculture may find it very difficult to avoid the introduction or transplantation of species, or selected strains of local species, for experimentation or commercial production. Munro (1986) lists some of the aquaculture species that have already colonized outside their historical distributional range: tilapia species, cyprinids (common carp, Chinese carps), rainbow trout, walking catfish, Japanese and European oysters and fresh-water crayfish (Pacifastacus sp.). The majority of them have been introduced for valid reasons, but it is most doubtful whether any of these or other successful introductions have been preceded by detailed screening procedures. To this can be added the more recent introductions of several penaied shrimps (especially Penaeus monodon and P. (= Litopenaeus) vannamei) and the giant freshwater prawn (Macrobrachium rosenbergii) of proven performance in various tropical and semi-tropical countries. Atlantic salmon, an exotic, has established itself so well in cage farming in Chile that the farmed production of the species in 2001 (501 000 tons) exceeds that of Norway.

The criteria to be considered in introducing new species. The species should:
(a) fill a need, because of the absence of a similar desirable species in the locality of transplantation;
(b) not compete with valuable native species to the extent of contributing to their decline;
(c) not cross with native species and produce undesirable hybrids;
(d) not be accompanied by pests, parasites or diseases which might attack native species; and
(e) live and reproduce in equilibrium with its new environment

Common aquaculture species

As mentioned at the beginning of this chapter, there are several species of finfish, shellfish and plants that are used in experimental or commercial aquaculture. Several new species including unconventional members are being recruited to aquaculture recently, as signified by the increasing list of producer species in annual production reports.

The list of farmed aquatic organisms presented here is based on species listings in FAO aquaculture production statistics. It should be noted that besides finfishes, crustaceans and molluscs the list includes amphibians (frogs) and reptiles (turtles, but not crocodiles) and a single ascidian, as given in the FAO report.

Family	Species	Common name (lead producer country) and world production in tons in 2000[1]
Finfish		
Acipenseridae	*Acipenser sturio*	Sturgeon (Latvia)
	Acipenser ruthenus	Sterlet sturgeon (Uruguay) 70
	Acipenser baeri	Siberian sturgeon (France) 95
	Huso huso	Beluga (Ukraine)
Chanidae	*Chanos chanos*	Milkfish (Indonesia) 461 857
Salmonidae	*Salmo trutta*	Brown/Sea trout (Russian Fed) 6938
	Salmo salar	Atlantic salmon (Norway) 883 558
	Salvelinus fontinalis	Brook trout (France) 609
	Salvelinus alpinus	Artic char (Iceland) 1093
	Hucho hucho	Huchan (Macedonia) 173
	Oncorhynchus mykiss	Rainbow trout (Chile) 448 141
	Oncorhynchus kisutch	Coho (Silver) salmon (Chile) 108 626
	Oncorhynchus keta	Chum/Dog salmon (Russian Fed)
	Oncorthynchus masou	Masu (Cherry) salmon (Chile)
	Oncorthynchus tshawytscha	Chinook/King salmon (Canada) 16 664
Thymallidae	*Thymallus thymallus*	Grayling (Slovenia)
Plecoglossidae	*Plecoglossus altivelis*	Ayu, Sweet fish (Japan) 9324
Coregonidae	*Coregonus lavaretus*	Common whitefish (Finland) 131
Esocidae	*Esox lucius*	Northern pike (France) 619
Osteoglossidae	*Heterotis niloticus*	African bonytongue (Ghana) 19
	Arapaima gigas	Arapaima (Peru)
Notopteridae	*Papyrocranus afer*	Knifefish (Nigeria) 281
Gymnarchidae	*Gymnarchus niloticus*	Aba (Nigeria) 1538

Family	Species	Common name (lead producer country) and world production in tons in 2000[1]
Callichthyidae	*Hoplosternum littorale*	Atipa (Guyana) 75
Pangasidae	*Pangasius pangasius*	Catfish, pangas (Thailand) 6630
	Pangasius hypophthalmus	Striped catfish (Singapore)
Anguillidae	*Anguilla anguilla*	European eel (Netherlands) 10 690
	Anguilla japonica	Japanese eel (China) 220 043
	Anguilla rostrata	American eel (Dominican Rep.)
	Anguilla australis	Australian eel (Australia) 213
Muraenosocidae	*Muraenesox cinereus*	Wam eel/pike conger (Taiwan)
Gadidae	*Gadus morhua*	Atlantic cod (Norway) 167
Gastrosteidae	*Gastrosteus aculeatus*	Stickleback (Russian Fed.)
Mugilidae	*Mugil cephalus*	Flathead grey mullet (Egypt) 89 078
	Liza vaigaiensis	Squaretail mullet (Thailand) 50
	Liza ramada	Thinlip grey mullet (Tunisia)
Synbranchidae	*Monopterus albus*	Lai (Thailand) 19
Centropomidae	*Centropomus undecimalis*	Common snook (Mexico)
	Lates calcarifer	Asian seabass/barramundi (Thailand) 20 066
	Lates niloticus	Nile perch (Nigeria) 1367
Serranidae	*Epinephelus akaara*	Red/Hong Kong grouper (Hong Kong)
	Epinephelus areolatus	Areolate grouper (Hong Kong) 104
	Epinephelus tauvina	Estuarine/greasy grouper (Malaysia) 1636
	Epinephelus coloides	Orange spotted grouper (Kuwait) 6
	Epinephelus malabaricus	Grouper (Thailand)
	Plectropomus maculatus	Spotted coral grouper (Singapore)
	Argyroperodon leucogrammicus	Slender grouper (Thailand) 1250
	Lateolabrax japonicus	Japanese seabass (Korea Rep.)
	Siniperca chuatsi	Mandarin fish (China) 98 859
Terapontidae	*Bidyanus bidyanus*	Silver perch (Australia) 320
Moronidae	*Dicentrarchus labrax*	European seabass (Greece) 26 668
	Morone chrysops x M. saxatilis	Bass hybrid (USA) 5394
Percichthyidae	*Maccullochella peelii*	Murray cod (Australia)
	Macquaria ambigua	Golden perch (Australia)
Centrachidae	*Lepomis macrochirus*	Bluegill (Puerto Rico)
	Micropterus salmoides	Largemouth black bass (Mexico) 136
Percidae	*Perca fluviatilis*	European perch (France) 133
	Stizostedion lucioperca	Pike-perch (France) 200
Pomatomidae	*Pomatomus saltatrix*	Bluefish (Tunisia)
Rachycentridae	*Rachycentron canadum*	Cobia (Taiwan) 2626
Carangidae	*Seriola quinqueradiata*	Yellowtail/amber jack (Japan) 137 328
	Seriola dumerili	Greater amber jack (Spain)
	Trachurus japonicus	Japanese Jack mackerel (Japan) 3052
	Trachynotus blochii	Stubnose pompano (Taiwan) 32
Lutjanidae	*Lutjanus argentimaculatus*	Red snapper (Malaysia) 3158
	Lutjanus russelli	Russel's snapper (Hong Kong) 263
Sciaenidae	*Sciaenops ocellatus*	Red drum (Ecuador) 2115
	Umbrina cirrosa	Shi drum (Cyprus)
	Argyrosomus regius	Meagre (France) 33
Sparidae	*Pagrus pagrus*	Red porgy (Greece)
	Pagrus auratus	Silver seabream (Japan) 82 811

Family	Species	Common name (lead producer country) and world production in tons in 2000[1]
Characidae	*Piaractus (= Colossoma) brachypomus*	Pirapatinga (Columbia) 14 997
	Piractus mesopotamicus	Paco (Argentina) 700
	Colossoma macropomum	Cachama (Brazil) 6589
	Brycon moorei	Dorada (Colombia) 30
Hepsetidae	*Hepsetes odoe*	Kafua pike (Nigeria) 518
Curimatidae	*Ichthyoelephas humeralis*	Bocachico (Ecuador)
	Prochilodus reticulatus	Netted prochilod (Peru) 810
Cyprinidae	*Catla catla*	Catla (India) 653 440
	Carassius auratus	Goldfish (Romania) 1761
	Carassius carassius	Crucian carp (China) 1 375 378
	Cirrhinus molitorella	Mud carp (China) 200 102
	Cirrhinus mrigala	Mrigal (India) 573 294
	Ctenopharyngodon idellus	Grass carp (China) 3 447 474
	Cyprinus carpio	Common carp (China) 2 718 217
	Hypophthalmichthys molitrix	Silver carp (China) 3 473 051
	Hypophthalmichthys nobilis	Bighead carp (China) 1 636 623
	Labeo rohita	Rohu (India) 795 128
	Leptobarbus hoeveni	Hoven's carp (Malaysia) 915
	Mylopharyngodon pliceus	Black carp (China) 170 786
	Notemigonus chrysoleucas	Golden shiner (USA) 6330
	Osteochilus hasselti	Nilem (Indonesia) 12 780
	Abramis brama	Freshwater bream (Macedonia) 126
	Parabramis pekinensis	White amur bream (China) 511 730
	Probarbus jullieni	Isok barb (Thailand)
	Pelecus cultratus	Sichal (Ukraine)
	Aspis aspicus	Asp (Kazakstan)
	Puntius gonionotus	Tawes, Thai silver barb (Thailand) 50 693
	Puntius javanicus	Java barb (Indonesia) 31 967
	Rutilus rutilus	Roach (France) 2500
	Scaerdinus erythrophthalmus	Rudd (France) 321
	Tinca tinca	Tench (France) 1626
	Alburnus alburnus	Bleak (Macedonia) 110
	Misgurnus anguillicaudatus	Pond loach (Korea Rep.) 882
Siluridae	*Silurus glanis*	Wels catfish (France) 725
	Silurus asotus	Amur catfish (China/Taiwan) 2312
Bagridae	*Chysichthys nigrodigitatus*	Bagrid catfish (Nigeria) 96
	Mystus nemurus	Asian redtail catfish (Malaysia) 586
Ictaluridae	*Ictalurus punctatus*	Channel catfish (USA) 269 257
	Ameiurus melas	Black bullhead (Italy) 550
Claridae	*Clarias batrachus*	Catfish, Asian (Cambodia) 550
	Clarias gariepinus (= lazera)	African catfish (Netherlands) 3703
	C.gariepinus x C.macrocephla	Catfish hybrid (Thailand) 71 210
	Clarias fuscus	Hong Kong catfish (Hong Kong)
	Clarias anguillaris	Mudfish (Egypt) 654
	Heterobranchus bidorsalis	African catfish (Liberia)
	Heterobranchus longifilis	Sampa (Liberia)
Pimelodidae	*Rhamdia sapo*	S. American catfish (Uruguay)
	Sorubim lima	Duckbill catfish (Columbia) 10
	Pseuduplatystoma fasciatum	Sacred sorubim (Columbia) 20