

Aquaculture

Characteristics, structure and resources of the sector

Summary

Freshwater aquaculture has been practiced since the 1930s (El-Zein, 1997). More than 90 percent of aquaculture production in Lebanon is rainbow trout, *Onchorhynchus mykiss*. They are grown in semi-intensive growing systems which were introduced in 1958. There are currently about 220 fish farms or holdings. Tilapia farming was recently tried out through several private initiatives.

Aquaculture is mainly practiced in the following regions of the country: Bekaa, Akkar district of Northern Lebanon, Mount Lebanon and South Lebanon.

In 1960 the Ministry of Agriculture (MOA) established the Anjar Center for Aquaculture in the Bekaa area to develop the sector and a new center was established in Hermel for trout production. The Center started as a hatchery service producing rainbow trout fingerlings and distributing them free of charge to growers to encourage more intensive and semi intensive growing of the species.

There is no marine aquaculture except for one shrimp farm initiative by a private investor in the north of Lebanon. The Oceanographic Institute of the MOA is undertaking pilot production of marine species.

According to the MOA's data aquaculture production in 2003 was 600 tonnes, the 2014 estimation is 1 200 tonnes. In 2014 the total amount of imported fish, whether live, fresh or frozen (including crustaceans and molluscs) amounted to about 20 921 tonnes at an approximate value of USD 95 million. This indicates that there is potential for development in the aquaculture sector.

The directorate of rural development and national resources under the MOA is responsible for aquaculture development.

Various private and public bodies carry out research. However, research in this sector is still limited and not coordinated. Moreover, additional funds and human resources would be required to acquire more detailed data and to develop comprehensive and accurate statistics on the sector.

History and general overview

Freshwater aquaculture has been carried out in Lebanon since the 1930s (El-Zein, 1997). Semi intensive growing was introduced in 1958. More than 90 percent of aquaculture production in Lebanon is rainbow trout, *Onchorhynchus mykiss*. Production of *Salmo trutta fario*, tilapia and some carps is also being attempted. Trout production was further boosted and developed in the early 1960s when the MOA established the Anjar Center for Aquaculture in the Bekaa area. This was the first hatchery among countries in the region. The center started as a hatchery service producing rainbow trout fingerlings and distributing them free of charge to growers to encourage intensive and semi intensive growing of the species.

The oldest farm was established in 1965 in the Hermel area. However, most of the farms (about 41 percent) were established during the years 1985-1990, mainly in the Anjar and Hermel areas and a few in Zahle. About 11 percent were established in the period 1991-1994 and 2 percent followed in the period 1995-1997. After 1997 another 90 farms were established. The industry now accounts for 220 farms distributed mainly in the Bekaa area along the river Assi with some smaller ones along the northern coast. However, this was not accompanied by the development of support infrastructure such as feed mills.

The production system used is mostly semi-intensive. The average annual production of trout is around 1 200 tonnes (MOA figures). This is produced by 220 farms, 90 percent of which are in

Hermel-North Bekaa, at a total value of USD 4.0 million and an estimated average yield of 10-12 tonnes (at approximately 1.5 Kg/litre/minute).

Marine aquaculture is almost absent. However, a new farm for shrimp production has emerged very recently in the Akkar area of northern Lebanon.

Total fish production (capture and aquaculture) accounts for less than 33 percent of local consumption. Aquaculture contributes about 10 percent of local production and 4 percent of local fish consumption.

Human resources

There are about 200 farms or holdings. In most cases, they are family owned businesses. Most of the farmers own their raceways or ponds. Average age of the producers is 40 years and they have an intermediate level of education. Most hire full time labourers to take care of daily farming activities on the farm.

The main growers of Bekaa are organized into four main groups: the Aquaculture and Fish Marketing Cooperative of Oyoum Urgush in Baalbeck, Aquaculture and Fish Marketing Cooperative of Anjar, and two Aquaculture and Fish Marketing cooperatives of the Assi Basin in Hermel.

There are also restaurant owners (30) who invest in their aquaculture enterprise and depend on it for their living.

Farming systems distribution and characteristics

Lebanon has 15 permanent short flowing rivers. Only Nahr Il-Kabir Al Janoubi is a relatively long river (571 km). Three flowing rivers (Assi 46 km, Litani 160 km, and Hasbani 21 km) are in the interior planes limited by Mount Lebanon from west side and by Anti-Lebanon on the east side. As a result, there are five hydrographical regions where aquaculture is practiced, as follows:

Region	Name	Location/district
I	Watershed of Assi	Bekaa / Bekaa
II	Northern coast	North/North-Lebanon
III	Watershed of Litani	Bekaa, South-Lebanon
IV	Central and southern coast	Central Lebanon /Mount- Lebanon & south/Nabatieh
V	Watershed of Hasbani	South / Nabatieh

There are around 220 trout culture stations or farms in Lebanon. These farms can be grouped into four different regions by virtue of the same water source. These farms are concentrated in four areas of Bekaa: Zahle – Qaa El-Rim (in Zahle Caza (district)), Anjar (in western Bekaa Caza), Yammouneh (in Baalbeck Caza) and Hermel (in Hermel Caza). The rest are scattered in Bekaa mainly in Baalbeck, West Bekaa and North-Lebanon in different hydrolytic isolated points. Average annual production is about 600 tonnes (rainbow trout). (According to FAO statistics, annual production for the years 2002 and 2003 has been approximately 700 tonnes).

Most of the farms are artisanal family owned businesses, small to medium in size. Forty-seven percent of the farms are small (surface area less than 500 m²), 38 percent of the farms are medium sized (501 – 1 500 m²) and 15 percent are large (over 1 500 m²).

With respect to the physio-chemical characteristics of the water in the Bekaa area the water environment presents very favourable conditions for trout growing. The pH (7-8.2), water flow and temperature (8-17 °C) are favourable.

Cultured species

The fauna and flora of freshwater of Lebanon account for 987 species (Al-Zein, 1997). There are 25 fish species pertaining to different families: Cyprinidae, Cyprinodontidae, Cobitidae, Salmonidae,

Anguillidae, Cichlidae, Mugilidae, Puciliidae, Blenniidae, Lutjanidea.

In addition to these, other species have been introduced: rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta fario*; Al Zein, 1997), brook trout (*Salvelinus fontinalis*), common carp (*Cyprinus carpio*), mosquito fish (*Gambusia affinis*), silver carp (*Hypophthalmichthys molitrix*), mangrove red snapper (*Lutjanus argentimaculatus*), nomadic jellyfish (*Rhopilema nomadica*), narrow-barred Spanish mackerel (*Scomberomorus commerson*) and obtuse barracuda (*Sphyraena obtusata*). Some were introduced from other countries/regions such as the Red Sea (*Rhopilema nomadica*, *Scomberomorus commerson*). Others were introduced for sports purposes in addition to aquaculture (*Salvelinus fontinalis*). Other species were introduced to control different pests, for example snails (*Cyprinus carpio*), mosquitoes (*Gambusia affinis*) and weed (*Hypophthalmichthys molitrix*). An overview of some introduced fish species is as follows:

Species	Common name	Reasons for Introduction	Status
<i>Gambusia affinis</i>	mosquito fish	Mosquito control	Established through natural reproduction
<i>Cyprinus carpio</i>	common carp	Snail control, research and aquaculture	Established through natural reproduction
<i>Hypophthalmichthys molitrix</i>	silver carp	Aquaculture and weed control	Established through continuous restocking
<i>Lutjanus argentimaculatus</i>	mangrove red snapper	Diffused from other countries	Not established
<i>Oncorhynchus mykiss</i>	rainbow trout	Aquaculture (introduced from Denmark in 1960 and introduced to Syria from Lebanon and Germany in 1968)	Not established and assisted/ artificial reproduction
<i>Rhopilema nomadica</i>	nomadic jellyfish	Diffused from other countries (Red Sea in 1980)	Established through natural reproduction
<i>Salvelinus fontinalis</i>	brook trout	Angling sport and aquaculture	Not Established
<i>Scomberomorus commerson</i>	narrow-barred Spanish mackerel	Diffused from other countries (red sea)	Established
<i>Sphyraena obtusata</i>	obtuse barracuda	Diffused from other countries	Established

Source: Database on Introductions of Aquatic Species (DIAS - FAO)

Freshwater Aquaculture

The trout species farmed are brown trout and rainbow trout. Brown trout *Salmo trutta fario* was identified in Lebanon in 1930 as indigenous to the Asi River (North Bekaa). From 1962 it was introduced to other areas. It is now practically extinct due to illegal fishing. It can tolerate water temperatures up to 20 °C and can reach a length of 30-60 cm and a weight of 2-8 kg. A record of 35 kg (over 30 years old) fish has been observed. The rainbow trout *Oncorhynchus mykiss* was introduced into Lebanon in 1958. Lebanon introduced this species to Syria in the late 1960s. It is characterized by a fast growth rate. It was observed to grow up to 2 kg/year in natural water bodies. This species is employed in aquaculture in Lebanon.

With respect to water requirements, trout is raised in areas where a constant supply of high quality water is available all year round. Most trout farms and hatcheries use springs, wells, or streams as their source of water. Production of food-sized fish requires the largest volumes of water. Water flows of at least 2-8 m³ /minute are needed, depending on the operation size. The amount of eggs hatched is 0.5l/1 000 eggs. The number of fries produced up to 1 month is 1l/1 000 eggs. Increase water flow by 1 l monthly till 12 l/1 000 at age of 12 months . Abundant supplies of high quality water are essential for a commercial trout hatchery. Dissolved oxygen, temperature, suspended solids, dissolved gases, pH, mineral content, hardness, and alkalinity of the water are key

elements for trout production. Lebanese waters are predominantly calcareous and suitable for trout production. Water temperature is usually the most critical water quality factor. Temperature affects survival, growth and egg production. Trout hatcheries should have an adequate supply of high quality water ranging from about 7-18 °C, otherwise growth will be slowed. The optimum temperature for commercial production has been observed to be 11-16 °C with a maximum of 20 °C, with high oxygen level. Since trout requires high levels of oxygen, the oxygen content of the water supply must be high. Oxygen levels should never fall below 5 parts per million (ppm.) in the hatchery effluent. In general, dissolved oxygen concentrations of incoming water should be above 90 percent saturation. An oxygen concentration of 6-9 mg/l is required. Proper aeration of the incoming water and control of numbers of fish raised in the rearing system can be used to overcome low oxygen problems. Small waterfalls (10 cm high) have proved feasible in Lebanon.

The second most cultured fish in Lebanon today is tilapia. There are three farms which grow tilapia commercially. One practices intensive production. Tilapia (*Oreochromis niloticus*) was introduced into Lebanon in 1965. It was bred locally and distributed to small-scale farmers, backyard growers (50 m² ponds) and introduced to coastal rivers. In the areas where it has been introduced it has been a success and became abundant in the Qasmeih River (South Lebanon). It became extinct in 1975. In 2000 the MOA put out a tender for the construction of a hatchery and grow-out facility for tilapia and other warm freshwater fishes. The private sector was faster than the government to establish the first commercial hatchery and grow-out farm. A small farm (Hadath Fish Farm) was established near to the MOA's site. Recirculation, bio-filters, UV disinfectants, and greenhouses are among the new technologies introduced into Lebanon. These are already employed at Hadath Farm.

One of the biggest challenges facing tilapia farming in Lebanon is the cold climate and sub-optimal water temperatures. Tilapias are tropical species which grow poorly when water temperatures drop below 25 °C. It is claimed that the Hadath Tilapia Farm recycles over 98 percent of its water so as to maintain 'high-residence-times,' allowing 'free' solar energy to heat the tank water inside a plastic greenhouse tunnel (the kind used for crop production in Lebanon). The technology is called the IFF "ONE TANK" Fish Farming System and is entirely air driven using one (plus coupled standby) low pressure centrifugal fan running at 7 000 Pa' sto drive one or more RBCs (Rotating Biological Contactor) for ammonia conversion, specially designed air lift aerators (in-tank water circulation and aeration) and airlift-pods (low head water pumps) used to pull water through a centrally located water reconditioning system.

Other species produced in freshwater aquaculture are some common carp, bighead carp, silver carp, grass carp and leather carp which are being grown in some of the trout farms. Sales are low and mainly to Syria. Some also raise catfish, *Clarias* spp., in some ponds.

Marine Aquaculture

There are around 1 685 species in the marine ecosystem. There is only one saltwater aquaculture facility in Lebanon: a penaeid shrimp (*Penaeus vannamei*) farm in the northern town of Abdeh.

Practices/systems of culture

Trout Farms

Nearly all of the trout farms use a semi intensive system. The farms are mostly artisanal family owned businesses. Farmers grow the fish to market size in concrete flow-through raceways or ponds. Water is aerated by flowing down small terraces. The type of raceways used is of earth and concrete, and the size depends on water quality. They are rectangular (2-3x10-20x0.5-1.5 m) or circular (5-6x 0.65-1.3 m). The most common form of raceways or ponds used is the rectangular one. The circular type is very rare (only two such farms are present in Hermel). An average yield of 30 kg/m² is common. Yields of 40-50 kg/m² have been observed at some locations. Raceways 3x12 m yield 1 tonne/year in Baaklin (Elevation: 450 m). Raceways 2.5x11 x (0.6-1.5) m yield 40 kg/m² (high intensive) in Barouk (Elevation: 1 000 m). With respect to feeding practices, feed conversion should be regularly monitored. Generally, feed conversions (FC) of between 1.0 and 2.0 are acceptable. If the FC fluctuates significantly, then feeding practices should be adjusted accordingly. Moreover, a change in

FC can also indicate disease or stress problems before physical signs appear. Sixty percent of the ponds are placed in a chapel like shape, the others are in parallel form (33 percent) and serpent type. The ponds are either engraved or elevated where the ponds are mounted in a cascade formation and where the water flows through the ponds continuously. The foundation of the ponds depends on the growers' choice and on the soil nature. Most of the ponds are of concrete and few are of soil and concrete.

With respect to fish health management, raceway disinfection is done by the sun, CaCO₃ 25 percent, potassium permanganate and CuSO₄. Good management practices involve providing a healthy environment for fish while minimizing stress and meeting proper nutritional requirements. Many disease problems can be prevented as long as stress levels are kept at a minimum. Viruses, bacteria, fungi, protozoans, and many invertebrate animals can cause diseases in fish. These disease-agents may be present in a water supply and not cause serious problems as long as the trout are not stressed by poor water quality or overcrowding. Another factor which may cause disease problems is poor quality or old feed. The following were observed in Lebanon: physiological disorders (stress), psychological diseases (fin nipping), external parasites (Gyrodactylus, Trematodes, Copepodes, Glochidie, Protozoa, Costiase, Chilodon, Trichodina, Tuberculosis, Necrosis, tail disease, gill & tail rot), internal parasites (Nematodes, Cestodes, Trematodes), protozoa (Amoebae), bacterial diseases (Furunculosis, Streptococcus), fungal diseases (Oidium, Blindness).

On the shrimp farm the fish are stocked into half-acre earthen ponds filled with paddle wheel-aerator seawater and equipped with paddlewheel aerators. Water is exchanged as required. In 2003 the farm imported a new species from Florida, but survival was less than 20 percent. In 2004 it imported from Malaysia. The farm manager reported that 20 tonnes shrimp are sold live for USD 12/kg.

Sector performance

Production

During the years 2013 and 2014 according to the MOA, average annual production of trout was around 1 200 tonnes and the value of production was around USD 4 million. This is far below the potential production which could be attained given the favourable conditions in Lebanon for trout growing where many studies suggest that trout production can be boosted to 3 000-4 000 tonnes if properly developed in both technical and marketing aspects.

The graph below shows total aquaculture production in Lebanon according to FAO statistics:

- Chart
- Table

the Lebanese

Republic 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 05001 0001 500

Total aquaculture production for the Lebanese Republic (tonnes)

Source: [FAO FishStat](#)

- Chart
- Table

Freshwater Brackishwater 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 05001 0001 500

Aquaculture production by culture environment the Lebanese Republic (tonnes)

Source: [FAO FishStat](#)

Market and trade

Medium size trout fish are sold live to restaurants which have their own concrete holding tanks. Value added product is still lacking on the Lebanese market. Some farmers sell their products to supermarkets, but most sell it at their farms or restaurants. The marketable size is 250-350 g. Larger sizes (1-3 kg) are also demanded. However, no certification is yet available.

Compared to other Mediterranean countries, Lebanese fish consumption is still limited at 5 kg per capita per annum. Consumption trends vary according to regions. Inhabitants of cities and coastal areas prefer marine fish, whereas inhabitants of Bekaa prefer beef and chicken to fish and they mostly consume trout. Domestic consumption is estimated at 30 000 tonnes per year.

According to the Lebanese Customs Office, the total amount of imported fish in 2014, whether live, fresh or frozen (including crustaceans and molluscs) amounted to about 20 921 tonnes (approximately USD 95 million). Turkey is number one exporting country (23 percent of total imports), followed by Viet Nam (15 percent), Egypt (10 percent), the United Kingdom (9 percent), Norway (8 percent), and India (7 percent).

However Lebanese fish exports amounted in 2014 to only USD 1 164 000, of which prepared products comprised the bulk of exported fish products. The main markets for the Lebanese fish exports is the Syrian Arab Republic. Other exports go mainly to Qatar, Saudi Arabia, Iraq, Kuwait and Liberia.

Contribution to the economy

After crop production, aquaculture is the second main economic activity of the Hermel, Yammouneh and Anjar areas and constitutes an income generating activity linked especially with restaurants and tourism in the areas. Restaurants usually serve trout at the table at a price of USD 10/kg. Trout cooking and meals are considered a specialty for the Hermel and Anjar communities. Most of the Lebanese prefer marine fish and still do not know about different recipes which could include trout. However, this source of fish is growing and is increasingly becoming known to the Lebanese consumer. It represents a good potential and an additional food source if higher production can be attained. This must be coupled with marketing strategies and advertising. This is particularly the case compared with the volume of imported meat quantities in general and fish in particular.

Several restaurants, particularly in the Bekaa Valley, have live trout holding raceways, so customers can select the fish which is then prepared. Around 60 restaurants in Anjar and Hermel areas serve fresh trout on their menus. Anjar is considered a tourist area where visitors from nearby villages, Beirut and other cities come for trout meals and enjoy the area with its landscape and water sites.

Recent investments have been made in the Anjar and Hermel areas to support for tourist activities such as the emergence of new hotels (2 hotels, one in Anjar and one in Hermel area) and enlarging and maintaining existing restaurants.

In Lebanon, the market is not selective, so grading and packaging are not important or carried out. Trout is usually sold chilled whole or gutted. The farm price is USD 2-3/kg, whilst the retail price is USD 3-5/kg.

Promotion and management of the sector

The institutional framework

The Ministry of Agriculture is responsible for aquaculture development. The Directorate of Rural Development and Natural Resources of the MOA issues fishing licenses. The MOA aquaculture facilities are summarized as follows:

- Batroun (Institute of Oceanography and Fisheries) is 53 km north of Beirut and was developed by the MOA, in the early 1970s, in order to accommodate various maritime activities in particular, a technical fishing school, a public aquarium, laboratories, etc. The 3 ha site consists of marine research laboratories, an administration/accommodation block, an aquarium/museum, a mariculture hatchery and grow-out facility and a workshop. Considerable parts of the buildings were vandalized and damaged during the 17 years of the war. The laboratories and administration/dormitory buildings have recently been restored and partially equipped. The aquarium/museum requires restoration and equipping. Moreover, a mariculture hatchery and grow-out pilot project facility was constructed in 2000. The facility needs some modifications and additions to the water supply and aeration so as to become functional. The hatchery and raceways are under one greenhouse (1 000 m²) which comprises a spawning and maturation room, algae room, larvae room, nursery room, and raceways.
- Chouaifat (Aquaculture Centre) is about 5 km south of Beirut and has a hatchery and grow-out concrete tanks. These are intended as a pilot project for tilapia and other freshwater fish species. The facilities require equipping, instrumentation and some further construction.
- The Anjar Center for Aquaculture is 56 km east of Beirut in the Bekaa Valley (Central Plateau) at an elevation of about 900 m. It was constructed in 1961. The Centre is a trout hatchery and breeding facility designed to produce 2-3 million fingerlings a year. In 2004 it hatched 1600 000 eggs. Some modifications are needed to ensure the breeding and hatching of other species of fish to help re-populate the Lebanese rivers with endogenous fish species. The Anjar Center has a 40 000 m² natural reserve in which many fauna and flora are being protected and subject to Anjar center supervision and development. In addition, the Anjar Center releases around 200 thousands fingerlings into the rivers, water sources and lakes. Anjar also hosts research projects in association with the Lebanese University and the National Center for Marine Research (NCRM). One recent research project was the introduction of noble crayfish (*Astacus astacus L*). Experiments on different fish size, fertilisation, water indicators and negative effects on fish yield of trout have been conducted in collaboration of the American University of Beirut.
- Hermel is 140 km East of Beirut in the Bekaa Valley (Central Plateau) at an elevation of about 650 m. A very recent pilot facility to produce trout was established. The aim is to provide the same service as Anjar does for the Hermel region.

The governing regulations

MOA has no licensing requirement for the establishment of farms. However, the establishment of marine aquaculture farms is regulated by the Ministry of Environment which requires an Environment Impact Assessment study. The start-up of such enterprises is also subject to local authority control whereby such farms are treated as classified enterprises subject to local authority licensing. However, current related regulations are under revision by the MOA.

Applied research, education and training

Research institutions for aquaculture are private and public. They are as follows:

- Aquaculture research projects involve trout growing and technology transfer at the Anjar Center for Aquaculture Hatchery.
- Public research institution - the National Center for Marine Research (NCRM) under the National Council for Scientific Research (NCRS) is also responsible for marine aquaculture research.
- American University of Beirut research which currently focuses on rabbitfish, *Siganus spp.* and white seabream, *Diplodus sargus*. Other projects include work on grouper, *Epinephelus spp.* and the health benefits of fish consumption as well as dual water usage technology in semi-arid regions.
- The Lebanese University, the national university, conducts research in collaboration with NCRM and the Anjar center.

- Balamand University is planning to construct a research facility to conduct research studies into marine aquaculture.
- The government's Oceanographic and Fisheries Institute of Batroun in North Lebanon.

There is little cooperation among institutions, but this is being remedied by the researchers themselves who are now attempting to develop a joint aquaculture initiative for Lebanon. Although the Anjar Center is trying to transmit new findings and technologies to growers, a lot still remains to be done on the dissemination of information, training and technology transfer.

Trends, issues and development

Aquaculture production and productivity in Lebanon can be boosted in relation to water availability and quality and the favourable growing conditions. Apart from Morocco, Lebanon is the only Arab country growing trout.

Farming practices and technologies used need to be enhanced. Investments are needed to develop the sector along with the support infrastructure.

Research is needed to improve feed conversion, health management and growing techniques for different species.

Target/proposed species are:

- European seabass (*Dicentrarchus labrax*), onshore and submerged offshore cages.
- Gilthead seabream (*Sparus aurata*), onshore and submerged offshore cages.
- Red snapper (*Chrysophrys* spp).
- Green tiger prawn (*Penaeus semisulcatus*).
- Kuruma prawn (*Penaeus japonicus*).
- Rabbitfish (*Siganus* spp).
- Trout (*Salmo* spp).
- Carps (*Hypophthalmichthys* spp).
- Catfish (*Silurus glanis*).

Legislation and regulations relating to aquaculture production, establishment of enterprises and effects on the environment need to be developed and enforced. Comprehensive and accurate statistics concerning the sector are needed.

Lack of funds and human resources are the two factors limiting development of the sector.

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