An overview on desert aquaculture in Egypt

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Sadek, S. 2011. An overview on desert aquaculture in Egypt. *In* V. Crespi & A. Lovatelli, eds. *Aquaculture in desert and arid lands: development constraints and opportunities. FAO Technical Workshop. 6–9 July 2010, Hermosillo, Mexico*. FAO Fisheries and Aquaculture Proceedings No. 20. Rome, FAO. 2011. pp. 141–158.

SUMMARY

Today, Egyptian desert aquaculture comprises more than 100 intensive tilapia rural farms and 20 commercial aquaculture farms scattered throughout seven different provinces. The approximate combined surface area of the desert commercial farms is ~893 hectares, with an approximate annual production of 13 000 tonnes. These 20 commercial farms are capable of producing up to 6 000 tonnes/year, the remaining 7 000 tonnes/year are produced in ~100 rural farms. Various finfish species are reared, particularly Nile tilapia (*Oreochromis niloticus*), red tilapia (*Oreochromis mossambicus* x *Oreochromis niloticus*), North African catfish (*Clarias gariepinus*), common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idellus*), flathead grey mullet (*Mugil cephalus*), European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*) and a number of exotic species, mainly koi (*Cyprinus* spp.), fantail (koi variety) and molly (*Poecillia* spp.). The water source comes from underground water reserves and/or agricultural drainage. The latter varies in salinity, ranging from 0.5 to 26 g/litre, and in temperature from 22 to 26 °C. Most of the commercial farms have adopted flow-through systems (FTS) which irrigate agricultural land, giving them the advantages of producing three different crops (fish/plant/sheep). While most of the farms are strictly dependent on FTS, two of them have upgraded their systems to include recirculation aquaculture system (RAS). Among other edible and ornamental fish species, tilapia (*Oreochromis niloticus* and *O. aureus*, or sex-reversed red tilapias) are one of the most promising species. Production of tilapia (in densities of 20–30 kg/m^3 to market size of 250–400 g in 6–8 months) is possible due to the suitable warm climate and abundant warm underground water present throughout the year. Although the brackish water used for aquaculture purposes varies in salt concentrations (>25 g/litre), it is utilized for integrated agriculture, e.g. the irrigation of *Salicornia* crops combined with intensive European seabass and gilthead seabream aquaculture, with a yearly production of 100 tonnes per year for both species. Most commercial farms are purchasing their fish fry from the local market, and only five have their own hatchery. Issues that affect the development of these commercial aquatic desert farms are associated with the quantity/quality of water; excess of effluent water; fingerling supply; feed quality; feed prices; production overheads cost; lack of technical experience; marine fish diseases; and poor availability of credit.

RÉSUMÉ

À l'heure actuelle, l'aquaculture égyptienne en milieu désertique compte plus de 100 exploitations rurales d'élevage intensif de tilapia et 20 exploitations aquacoles commerciales réparties dans sept provinces différentes. La superficie totale des exploitations commerciales est d'environ 893 hectares, avec une production annuelle de plus ou moins 13 000 tonnes. Les 20 exploitations commerciales peuvent produire jusqu'à 6 000 tonnes de poissons par an alors que les 7 000 tonnes restantes sont produites par la centaine d'exploitations rurales. Diverses espèces de poissons sont élevées, en particulier le tilapia du Nil (*Oreochromis niloticus*), le tilapia rouge (*Oreochromis mossambicus* x *Oreochromis niloticus*), le poisson-chat nord-africain *(Clarias gariepinus)*, la carpe commune (*Cyprinus carpio*), la carpe argentée (*Hypophthalmichthys molitrix*), la carpe herbivore (*Ctenopharyngodon idellus*), le mulet à grosse tête (*Mugil cephalus*), le bar commun (*Dicentrarchus labrax*), la dorade royale (*Sparus aurata*), ainsi que des espèces exotiques, principalement les carpes koïs (*Cyprinus* spp.), notamment celle à nageoires en voile, et le molly (*Poecillia* spp.). L'eau provient des nappes phréatiques et/ou du drainage agricole. La salinité de ces dernières est comprise entre 0,5 et 26 g/litre, leur température entre 22 et 26 °C. La majorité des exploitations commerciales ont adopté des systèmes ouverts (FTS), qui irriguent les terres agricoles et offrent l'avantage de permettre trois types différents de productions (poissons, végétaux et ovins). Alors que la plupart des exploitations n'ont recours qu'aux systèmes ouverts, deux d'entres elles ont modernisé ces derniers pour y introduire des technologies de recyclage de l'eau (RAS). Les tilapias (*Oreochromis niloticus* et *O. aureus*, ou les tilapias rouges à réversion sexuelle) font partie des espèces de poissons les plus prometteuses. Grâce à un climat chaud approprié et à d'abondantes eaux chaudes souterraines, la production de tilapias est possible tout au long de l'année, à des taux de mise en charge compris entre 20 et 30 kg/m^3, qui permettent d'obtenir une taille commerciale de 250 à 400 g en l'espace de 6 à 8 mois. Même si l'eau saumâtre utilisée à des fins aquacoles n'a pas toujours la même concentration en sel (> 25 g/litre), elle est utilisée dans l'agriculture intégrée, par exemple pour irriguer les cultures de *Salicornia* associées à l'élevage aquacole intensif de bars communs et de dorades royales. La production annuelle de chacune de ces deux espèces est de 100 tonnes. La plupart des exploitations commerciales vendent leurs poissons sur le marché local et seules cinq d'entre elles disposent de leur propre écloserie. Les problèmes qui affectent le développement de ces exploitations en milieu désertique sont liés à la quantité et à la qualité de l'eau, à l'excès d'effluents, à l'approvisionnement en alevins, à la qualité et au prix des aliments, aux frais généraux de production, au manque d'expérience technique, aux maladies des poissons marins et à un mauvais accès au crédit.

ملخص

تتألف تربية الأحياء المائية المصرية اليوم من أكثر من مائة مزرعة ريفية مكثفة لتربية البلطي و عشرون مزرعة تجارية في تربية الأحياء المائية تتوزع عبر سبعة محافظات مختلفة. والمساحة السطحية الإجمالية للمزارع الصحراوية التجارية هي تقريبا 893 (ثمانمائة وثلاثة وتسعون) هكتارا مع إنتاج سنوي تقريبي عند 13000 (ثلاثة عشر الف) طن. وهذه المزارع العشرين قادرة على الإنتاج حتى 000 6 (ستة الاف) طن/السنة، و 000 7 (سبعة الاف) طن/السنة المتبقية يتم إنتاجها في المزارع الريفية البالغ عددها مائة. ويتم تربية أنواع سمكية زعنفية عديدة، وبالأخص البلطي النيلي (*Oreochromis niloticus*)، والبلطي الأحمر (*Oreochromis mossambicus* x *Oreochromis niloticus*)، أسماك قرموط شمال افريقيا (*Clarias gariepinus*)، والمبروك العادى او الشبوط الشائع (*Cyprinus carpio*)، والمبروك الفضي او الشبوط الفضي (*Hypophthalmichthys molitrix*)، ومبروك الحشائش او الشبوط العشبي (*Ctenopharyngodon idellus*)، البوري الرمادي مفلطح الرأس (*Mugil cephalus*)، والقاروص الأوروبي (*Dicentrarchus labrax*)، والدنيس (*Sparus aurata*) وعددا من الأنواع المجلوبة وبشكل أساسي الكوي (*Cyprinus* spp.)، واسماك الزعنفة المروحية (تشكيلات من الكوي) والمولي (*Poecillia* spp.). ويأتي مورد المياه من احتياطيات المياه الجوفية و/او التصريف الزراعي. ويتنوع

الأخير في الملوحة، وتتراوح ما بين 0.5 الى 26 جرام/لتر وفي درجة الحرارة ما بين 22 الى 26 م°. ومعظم المزارع التجارية قد طبقت أنظمة التدفق المستمر (*FTS*) والتي تقوم بري الأراضي الزراعية، مما يعطيها ميزات إنتاج ثلاثة محاصيل مختلفة (أسماك/نباتات/خراف). وفي حين ان معظم المزارع تعتمد بشكل صارم على أنظمة التدفق المستمر (*FTS*)، فان اثنتين منهما قد قامتا بتطوير أنظمتها لتتضمن تقنيات نظام التدوير (*RAS*). ومن بين أنواع الأسماك الصالحة للأكل واسماك الزينة، فان اسماك البلطي (*Oreochromis niloticus* و *O. aureus*، او البلطي الاحمر المحول جنسيا)، هي واحدة من أكثر الأنواع الواعدة. ان إنتاج البلطي (بكثافات 20 30 كجم/م^3 الى الحجم التسويقي 250 400 جرام في 6 8 أشهر) هو أمر ممكن بسبب المناخ الحار المناسب والمياه الجوفية الحارة الوفيرة المتوفرة على مدار السنة. وعلى الرغم من ان المياه شبه المالحة المستخدمة في أغراض تربية الأحياء المائية تتنوع في تركيزات الملح (< 25 جرام/لتر) الا انها تستخدم في الزراعة التكاملية، وعلى سبيل المثال، ري محاصيل الساليكورنيا سوية مع تربية الأحياء المكثفة للقاروص الأوروبي والكوفر ذهبي الرأس، مع إنتاج سنوي يبلغ 100 (مائة) طن لكل سنة للنوعين. ومعظم المزارع التجارية تقوم بشراء الزريعة السمكية من السوق المحلية، وخمسة مزارع فقط لديها مفرخاتها الخاصة. ان القضايا التي تؤثر على تطوير هذه المزارع الصحراوية المائية التجارية مرتبطة بجودة/كمية المياه؛ وزيادة في مياه التصريف؛ والمعروض من الاصبعيات؛ وجودة العلف؛ وأسعار العلف؛ وتكاليف الإنتاج؛ والنقص في الخبرة الفنية؛ وأمراض الأسماك البحرية وضعف التوافر الائتمانى.

GENERAL OVERVIEW OF DESERT AND ARID LANDS AQUACULTURE DEVELOPMENT

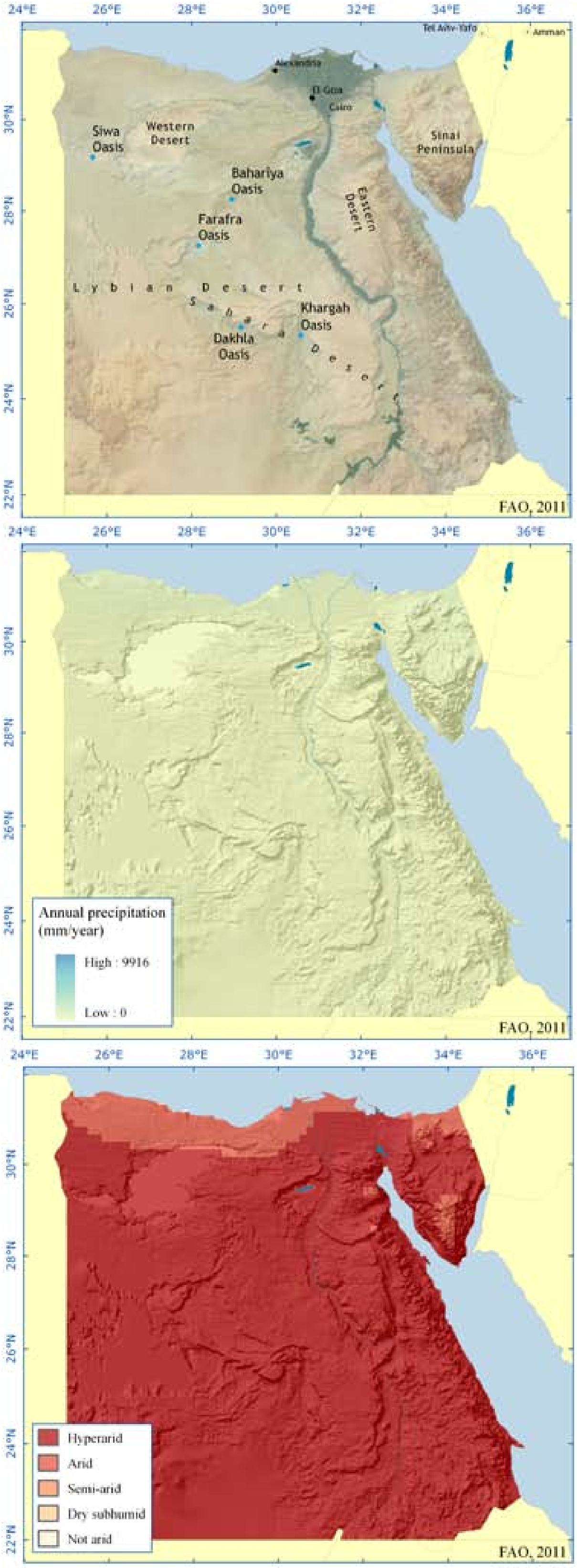
The Arab Republic of Egypt, a country almost entirely covered by desert, is located in the northeastern corner of Africa. It is bounded to the north by the Mediterranean Sea, from the east by Occupied Palestinian Territory and Israel, from the south by Sudan, and from the west by the Libyan Arab Jamahiriya. Ninety-nine percent of the entire population lives in just 5 percent of its land, all concentrated along the valley of the Nile and the northern delta. The Nile Delta, with its 230 km length and 360 km width, has a unique triangular shape covering an area of ~33 000 km^2, accounting for less than 4 percent of the total area. The desert is divided into three regions: the Western Desert (671 000 km^2), the Eastern Desert (225 000 km^2) and the Sinai Peninsula (61 000 km^2). Together, they experience an annual rainfall of only 60–100 mm and are inhabited only by 2–3 percent of the Egyptian population. Egyptians depend primarily on the Nile as a source for drinking water and irrigation. The Western Desert extends from the Nile Valley in the east to the Libyan borders in the west, and from the Mediterranean in the north to Egypt's southern borders. The southwestern section includes five major oases: Farafra, Bahria, Dakhla, Khargah and Siwa (Figure 1).

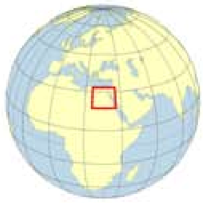
Egypt has built the largest aquaculture industry in Africa, accounting for four out of every five fish farmed on the continent. Egyptian fish landings were estimated at 1 092 888 tonnes in 2009, of which 705 490 tonnes were produced from fish farms (about 65 percent of the total freshwater and marine fish production), providing a cheap source of protein for the country's 80 million people. Due to a shift to intensive rearing methods and to faster growing species such as monosex tilapia, aquaculture activity has increased more than threefold in the past ten years, having been only 226 000 tonnes in 1999 (GAFRD, 2010).

Two decades ago Nile tilapia (*O. niloticus*) and grey mullets (*Mugil cephalus* and *Liza ramada*) were the main species reared in extensive earthen ponds. Today seven finfish: tilapia, mullet, carp, North African catfish (*Clarias gariepinus*), bayad (*Bagrus* spp.), gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*), as well as four crustacean species: giant river prawn (*Macrobrachium rosenbergii*), green tiger prawn (*Penaeus semisulcatus*) and kuruma prawn (*P. japonicus*) and Indian white prawn (*Penaeus indicus*) are playing an important role in the national aquaculture production (Sadek, Osman and Mezayen, 2006) and (Sadek, 2010).

The production of aqua-agriculture integrated activities in the desert and arid zones of Egypt originates from earthen ponds (84.8 percent), cage culture (9.7 percent), common carp paddy fields (5.3 percent) and cement tanks rearing tilapia (0.2 percent), see Figure 2.

FIGURE 1
Maps of Egypt





Egypt

Country area: 100145 (1000 Ha)
Source: FAOSTAT. Estimated, 2007

Land area: 99545 (1000 Ha)
Source: FAOSTAT. Estimated, 2007

Agricultural area: 3538 (1000 Ha)
Source: FAOSTAT. Official data, 2007

Aquaculture Production Average 2004-2008: 587000 tonnes
Source: FISHSTAT. Official data

Aridity:
Approx. areas of hyperarid regime: 91658 (1000 Ha)
Approx. areas of arid regime: 7727 (1000 Ha)

A typical landscape of an arid region in Egypt.

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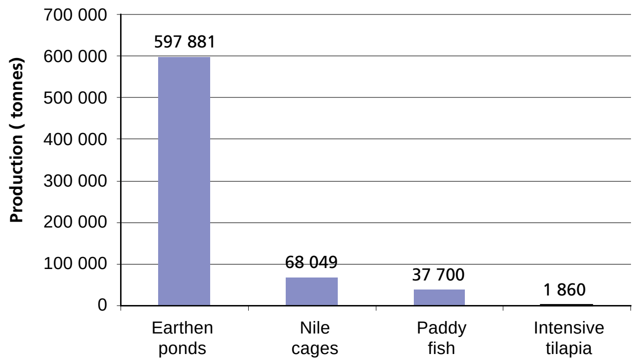
The General Authority for Fish Resources Development (GAFRD) has set a goal of 1.1 million tonnes of farmed fish annually by 2017, corresponding to about 75 percent of total fish production. Its two-pronged strategy aims to increase the productivity of aquaculture operations using underground water, while encouraging investment in marine aquaculture (Mohamed Fathy Osman, GAFRD's Chairman personal communication, 2010).

FIGURE 2
Egyptian aquaculture production systems in 2009



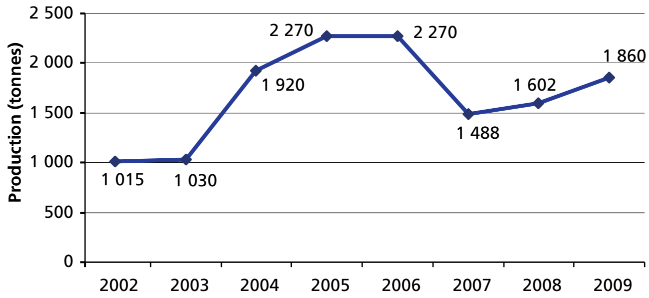
Source: GAFRD, 2010.

EGYPTIAN DESERT AQUACULTURE

The General Authority for Fish Resources Development in 2010 reported that intensive fish farming in the Egyptian desert had reached 1 860 tonnes in 2009 (Figure 3), but unofficial estimates are that production is about ten times greater than this.

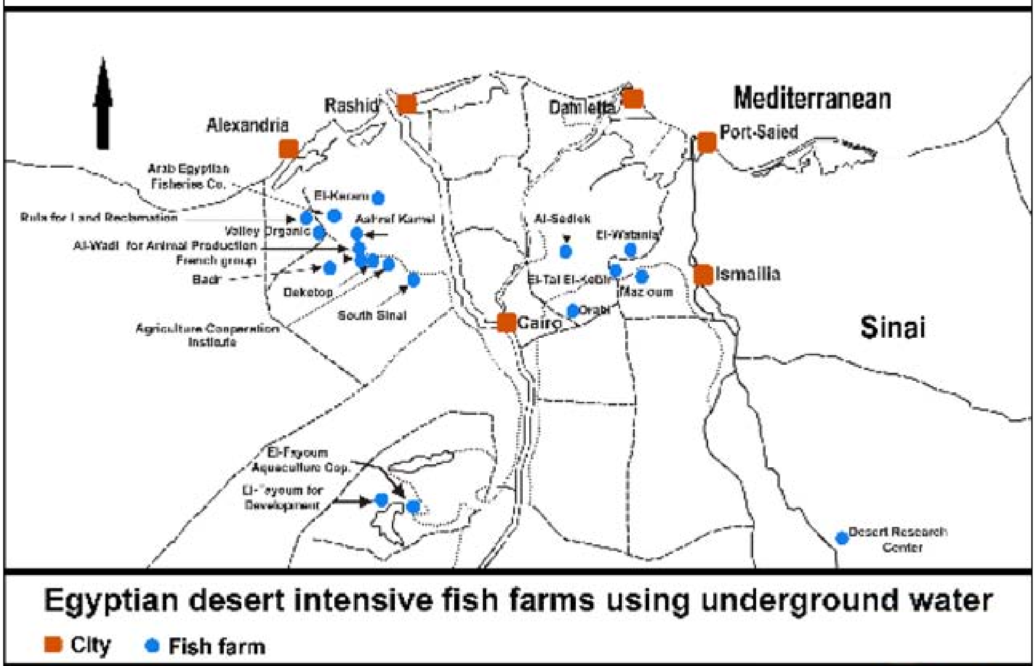
Today, more than 100 intensive tilapia rural farms and 20 pioneer commercial fish farms are using the underground water from the Egyptian desert and its effluent water, which are very important sources for irrigation and animal production (Figure 4).

FIGURE 3
The production of the intensive fish farming systems from 2002 to 2009



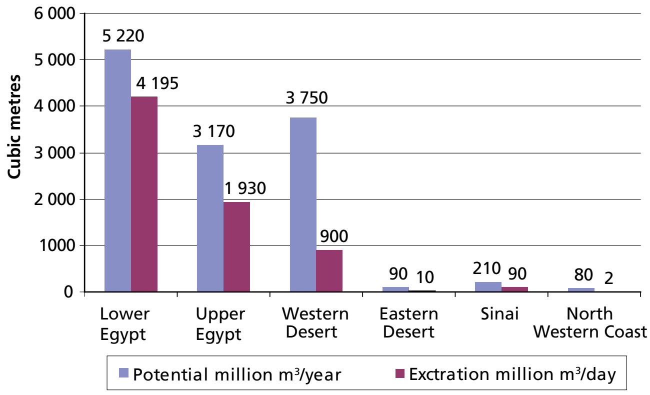
Source: GAFRD, 2010.

FIGURE 4
Commercial intensive tilapia farms integrated with agriculture activities in the Egyptian desert



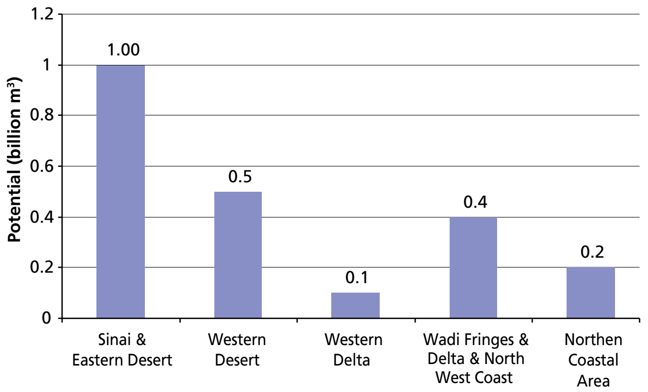
Source: Prepared by Aquaculture Consultant Office, Egypt.

FIGURE 5
Current and potential extraction of fresh groundwater in Egypt



Source: El-Guindy, 2006.

FIGURE 6
Potential of non-fresh groundwater in Egypt



Source: El-Guindy, 2006.

WATER SOURCE AND QUALITY

Underground water

The main water sources utilized for aquaculture purposes are underground water and agricultural drainage water (El-Guindy, 2006), which vary in salinity from 1–30 g/litre and temperature from 22 to 26 °C. This author raised concerns about the use of groundwater aquifer systems in Egypt, estimating a potential safe pumping yield of 1 744 million m^3 per year (Figure 5).

El-Guindy (2006) also noted that brackish water and brine could play a significant role in the sustainable development of desert aquaculture (both environmentally and socially) by implementing:

- economically and technically feasible options, obtained through desalination of the underground brackish water; and
- cost-effective technological solutions related to underground brackish water extraction and exploitation for: human food (crops and fish); fodder (crops and aquatic products); fuel (wood and biofuel); existing plant species (halophytes); and new and more salt-tolerant agricultural products and other commodities (oils, lubricants, pharmaceuticals, fibres, etc.).

In addition, El-Guindy (2006) defined several key issues that should be taken into consideration to achieve a sustainable intensive use of underground water (Figure 6). Firstly, there are gaps in the existing capacities for effectively using brackish water and no work on how these gaps should be filled. Secondly, the action plans considering underground brackish water resources for developmental initiatives (quantity, quality, potential uses and time perspective) need to be developed. Finally, a mechanism for interministerial coordination for brackish water utilization needs to be established.

Other water sources

Underground water with a salinity of 2–4 g/litre appears in open-cut sand mines and can be utilized to irrigate open-cut mine banks for the production of vegetables and flowers, along with extensive fish polyculture (tilapia, carps and mullets). In addition, one open-cut mine with a total water surface of 10 hectares is already developing its pit lake beside the agriculture and aquaculture activities for tourism, by constructing simple bungalows and adjusting its perimeter to facilitate fishing with lines (Figure 7).

A preliminary study (Anonymous, 2002) has shown that the brine effluent water from the desalination plant of the El-Gouna resort that is located 22 km north of Hurghada in the Red Sea Governorate is suitable for growing hybrid red tilapia,

FIGURE 7
Fishing in sand mine water depression located in Ismailia Governorate, Egypt

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grey mullet, gilthead seabream and European seabass. Water is supplied from three different sources: effluent brackish water (salinity 12 g/litre) from the desalination unit with a daily production of 3 000 m^3; groundwater (salinity 60 g/litre) with a capacity of 60 m^3/hr from different wells near the fish farm project and groundwater (4.5–6 g/litre) originating from the agriculture farm which belongs to the Orascom Company behind the mountains. The water requirements of the fish farm can be adjusted from the three above-mentioned water sources to meet a daily requirement of 3 000 m^3. Salinity is adjusted for each species, at 12–20 g/litre for the hybrid red tilapia during the various rearing phases (nursing, pre-growing and growing tanks) and 4.5–6 g/litre for the broodstock maintenance and breeding tanks. Water salinity is adjusted to a maximum of 20 g/litre for marine finfish species. The effluent from the fish farm does not drain into the Red Sea; it is used to culture mangrove trees in artificial shallow lakes.

CULTURED SPECIES

For desert aquaculture farms to be successful, many factors must be considered when selecting the species to be reared: low cost of feeding; ease of propagation; resistance to disease and tolerance to adverse climatic conditions; rapid growth and high survival. These factors facilitate management in relatively high population density culture systems such as those developed in the Egyptian desert areas.

Egyptian desert fish farms, both artisanal and commercial, produce various finfish including Nile tilapia, hybrid red tilapia, North African catfish, common carp, silver carp, grass carp, European seabass, gilthead seabream and ornamental species such as koi, fantail and molly. In the desert and arid lands of Egypt, Nile tilapia and North African catfish are the main cultured species when freshwater from underground reservoirs is used. However, European seabass and gilthead seabream are also reared in areas where most of the brackish and saline underground waters (>26 g/litre) are found (Sadek *et al*., 2011).

CULTURE PRACTICES

Aquaculture integrated with agriculture

Integrated aquaculture and agriculture has expanded rapidly in the Egyptian desert since 2000. This is the most common farming system and a large number of desert land owners have established fish rearing facilities. Desert aquaculture began with growing fish in the tanks that are used as water reservoirs for irrigation. Success in this activity encouraged some farm owners to seek technical support towards integrating fish farming with their agriculture businesses. Recently, as the efficient and economical utilization of water sources becomes a necessity, aquaculture production systems are being developed. Integrated systems are particularly attractive to farmers, as water sources enriched with organic fish wastes from intensive aquaculture ponds serve as a fertilizer for land crops (such as corn and alpha-alpha), as well as providing water for breeding sheep and goats, thus, resulting in the production of three different crops from the same quantity of water.

The Qattara Depression and the Egyptian Sand Sea in the Libyan Desert, nearly 560 km from Cairo, are wellknown for their agriculture cultivation systems, as well as their medicinal and restorative properties. More than 1 500 water reservoirs with a total water volume of 1 million m^3 are used for irrigation, particularly in the cultivation of dates, olives and basketry. A few farmers have cultivated tilapia in 400 m^3 tanks and have succeeded in producing between 350 to 400 kg of tilapia per tank over a period of 6 to 7 months (Mustapha Said, personal communication, 2010).

Egyptians have learned how to design desert fish farming systems, manage the fish, market the final product and increase profitability on their farms by using water from the fish ponds to irrigate crops. Recently, the cities of Wadi Alnatroon (El-Beheira Governorate) and El-Salihia (Sharkia Governorate) have been selected for developing desert aquaculture farms. In total, there are currently, twenty commercial aquaculture desert farms in Egypt, located in seven different governorates, with a total surface area of approximately 893 hectares and a yearly production of approximately 13 000 tonnes. These commercial farms have a production capability up to 6 000 tonnes/year, while the remaining 7 000 tonnes are produced in ~100 rural farms. The species reared include various finfish species, of which the main two are Nile tilapia and North African catfish. Nowadays, most commercial farms are using FTS that provide irrigation for agriculture and the opportunity to produce three different crops (fish/plant/sheep). Only two commercial farms have upgraded their FTS system to RAS.

Most commercial desert aquaculture farms purchase their fish fry from private tilapia hatcheries, but five have their own hatchery with a production of 20 million fry/year. Based on a field survey, the development of these commercial farms is affected by various issues, including: feed price (34.1 percent); lack of technical experience (14.6 percent); water supply (12.2 percent); feed quality (7.3 percent); cost of electricity (4.9 percent); marine fish diseases (4.0 percent); credit availability (22.9 percent); fingerling supply; and other factors (Sadek *et al.*, 2011).

Management

Some Egyptian producers operate highly intensive desert fish farms (>10 kg/m^3) without using an adequate aeration system. During the last decade, fish in several tanks in desert regions have experienced high mortality rates due to this cause. However, during the same period, other desert fish farms have invested in paddlewheel, air-injector and splasher aeration systems to provide sufficient dissolved oxygen. With the application of aeration (3 HP/350 m^3 tank volume), these commercial tilapia farms have succeeded in reaching a biomass production ranging from 20 to 35 kg/m^3 (Sadek *et al.*, 2008).

Algazzar, Osman and Sadek (2008) carried out experiments in a private intensive fish farm (Al-Wadi for Animal Production Company) in the Wadi-El-Natroun area (El-Beheira Governorate) on growth performance, feed utilization and pond productivity. Twelve circular 250 m^3 concrete ponds were divided into four groups. Each was stocked with 8 500 fish with an initial body weight of 50 g. The experiment lasted 180 days. Underground water was used to exchange water at percentage rates of 5, 5, 10 and 20 on a daily basis for groups one, two, three and four, respectively. All experimental ponds were provided with paddlewheels (2 HP), except in group 2 where a 2 HP air injector operated in conjunction with the paddlewheels. The study also determined the feed conversion ratio (FCR). The results indicated that 20 percent water exchange with the sole use of paddlewheel aerators resulted in the highest pond productivity (4 250 kg/pond, equating to 17 kg/m^3), the lowest FCR (1.3:1) and higher fish individual weight gain (510 g/fish). In conclusion, Group 4 showed the most cost-efficient production scenario and was the most suitable for desert aquaculture; the production costs have been estimated to USD0.73/kg. The results of the present field study concluded that a higher water exchange rate in intensive fish farms improved productivity in aerated concrete ponds.

Integrated aquaculture systems seem to be the most cost-efficient in Egypt for several reasons:

- They allow the farm to store water; an important factor, since ordering water from the irrigation district can take time.
- They aid irrigation in pressurized systems like drip or sprinkler systems.
- The fish wastes provided crops fertilization. Farmers have used fish water effluent for many crops, from vegetables and fruits to wheat.
- Productivity and income can be increased by using the same volume of water for two, or possibly even three crops (fish, plant and animal products).

FIGURE 8

D-ended shape tilapia raceway (145 m^3) with 2 HP air-injector, in Valley Organic company, El-Beheira Governorate, Egypt

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SUCCESS STORIES

The following section describes two success stories involving tilapia, some data on production costs in Egyptian desert aquaculture, and the results of an experimental study with marine fish.

Tilapias possess an impressive range of characteristics that make them suitable for widespread culture in the desert and arid zones. They also display varying degrees of salt tolerance, a trait resulting in the expansion of their culture into brackish water and saline water. Several tilapia farms have already been integrated into Egyptian desert activities; more than 100 are intensive tilapia rural farms and 20 are pioneer commercial fish farms (Figure 8). The most successful pioneer desert farms are described below.

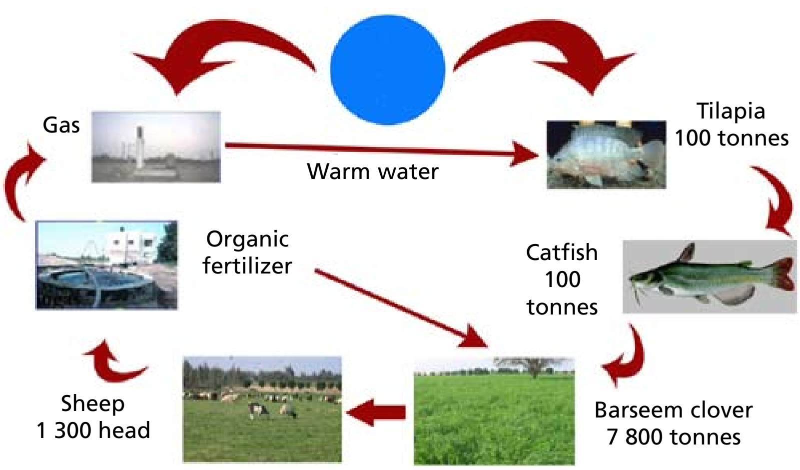
El-Keram – El-Keram, a trading investment company that is located between Cairo and Alexandria in the desert of Beheira, about 100 km northwest of Cairo, has applied a methodology that involves nutrient sharing and waste recycling. Since 1990, El-Keram has demonstrated the efficient utilization of every drop of water (= water drop or droplet is a small column of liquid, bounded completely or almost completely by free surfaces) pumped from its desert wells (100 m^3/hr). The El-Keram aquaculture systems have been carefully designed so that each output stage forms the input for the next stage, as summarized by El-Guindy (2006) in Figure 9 and Table 1. Adopting this strategy, the

FIGURE 9

El-Keram agriculture system in the Egyptian desert

El-KERAM SYSTEM (series)

only one source of water



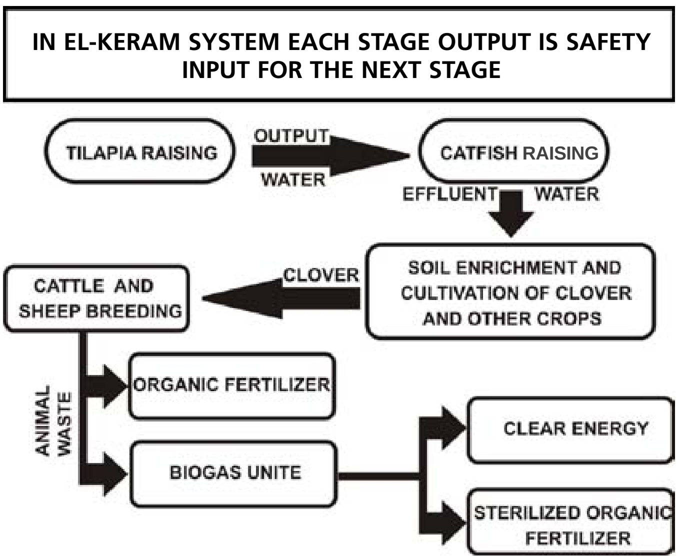
Source: Redesigned by Aquaculture Consultant Office from El-Guindy, 2006.

TABLE 1
Comparison between the non-integrated agriculture system and El-Keram agriculture integration project system (fish/clover/sheep/organic-fertilizer/biogas) in the Egyptian desert

Non-integrated agriculture production systems	Item	El-Keram integration systems
3	Water units	1
100 tonnes	Tilapia	100 tonnes
100 tonnes	Catfish	100 tonnes
4 500 tonnes	Clover	7 800 tonnes
1000	Sheep (head)	1 300
Nil	Warm water	Yes
Nil	Organic fertilizer	Yes
Variable	Waste	Nil
42	Irrigated land (hectares)	55
0%	Water conservation	67%

Source: Estimated by Aquaculture Consultant Office.

FIGURE 10
The integration of El-Keram agriculture system in the Egyptian desert



Source: Redesigned by Aquaculture Consultant Office from El-Guindy, 2006.

farm has been able to integrate the production of two different fish crop types each year, as well as arable, animal and biogas production. One hundred tonnes of tilapia can be produced alongside 100 tonnes of catfish annually. The effluent water from the fish farm is used to produce 7 800 tonnes/year of Egyptian clover, which provides fodder for 1 300 sheep/year. Ultimately, the manure of the livestock is used to produce biogas to heat water for the tilapia hatcheries (Figure 10).

Wataneya Fish Farm – Van der Heijden and Verdegem (2009) reported that the commercial tilapia desert farm El-Wataneya Fish Farm began in 1998 on 25 hectares of unused land as an integrated farm producing tilapia, chicken, vegetables (cucumbers, tomatoes, bananas, wheat, peppers, mangos, etc.) and flowers, mainly gladiolas. For crop production, freshwater is used from the Ismailia Canal, which is connected to the Nile River, together with groundwater and fish farm effluent. The only difference between these three sources is that the groundwater is used entirely for fish culture. Water in the concrete fish basins is normally replaced at a rate of 25–35 percent/day but can be as high as 60 percent/day in the latter stages of the fish production cycle. Even though water is already available at a depth of 3 m, the farm pumps water from 70 m. All fry and nursery tanks are aerated with blowers, while grow-out tanks are equipped with 2 HP paddlewheels which maintain constant levels of oxygen. In terms of profitability, tilapia is on top of the list, followed by bananas, vegetables and flowers.

Tilapia, grass carp, common carp and silver carp are placed in the drainage ponds; this results in a yield of 2 000 kg/year without any supplementary feeding. The waste water flows from the drainage ponds to the sprinkler irrigation systems, which are maintained in good working condition by the labourers. Until two years ago, the El-Wataneya farm also raised ducks, although this activity was then terminated, as the demand for ducks is only seasonal (holidays, special events, etc.).

COSTS AND RETURNS OF INTENSIVE TILAPIA FARMS IN EGYPT

Under good management, Algazzar, Osman and Sadek (2008) have shown that the intensive culture of tilapia in Egyptian desert zones has a production cost of USD1.00/kg with two crops per year. Depreciation is taken on a straight line basis over a 20-year period. Feed was the major cost (63 percent). The production costs were fish seed (9.0 percent), labour (8.7 percent), energy (7.4 percent), depreciation (5.9 percent), water consumption (5.1 percent) and animal health maintenance (0.9 percent). The net return for tilapia production at a harvesting density of 25 kg/m^3 was USD1.6/kg. The net income kg/fish was USD0.6.

FIGURE 11
European seabass growing facilities (total water volume 2 040 m^3) covered by plastic in Rula land reclamation company, Wadi Group, El-Beheira Governorate, Egypt

COURTESY OF S. SADEK

EUROPEAN SEABASS AND GILTHEAD SEABREAM: A GROWTH EXPERIMENT IN THE EGYPTIAN DESERT

A study was conducted to evaluate the rearing techniques practised for European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) at a private intensive desert fish farm (Rula Land Reclamation Company, Wadi Group) in the Wadi-El-Natroun area (El-Beheira Governorate); this examined growth, water consumption, feed utilization and tank productivity (kg/tank and kg/m^3 of water). Fourteen D-ended concrete raceways and circulation tanks with various water volumes (100, 180 and 340 m^3) were used for the three rearing phases (nursery, pre-growing and growing under a flow through system) as shown in Figures 11, 12, 13 and 14. Tanks from each phase were stocked with 2.5, 5 and 10 kg/m^3 with an initial body weight of 0.15 to 0.20, 38 to 51 and 200 to 270 g/fish, respectively (Sadek *et al.*, 2011).

The aim of these commercial experiments was to determine the general behaviour and effect of fish stocking density on fish growth, feeding and mortality during three critical periods of growing (5 months for nursery; 7 months for pre-growing and 16 months for growing). All commercial experiments were run at 26 °C with a salinity of 26 g/litre. The nursery used a RAS with a mechanical filter (97 m^3/hr) connected to a biological tower (25 m^3 media); the pre-growing and growing phase used a FTS.

FIGURE 12
European seabass nursery raceway tanks (100 m^3) with air-diffusers in Rula land reclamation company, Wadi Group, El-Beheira Governorate, Egypt

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FIGURE 13
D-ended shape European seabass raceway (185 m^3) with 2 HP paddlewheel, in Rula land reclamation company, Wadi Group, El-Beheira Governorate, Egypt

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FIGURE 14
European seabass circular tank (340 m^3) with 2 HP paddlewheel, in Rula land reclamation company, Wadi Group, El-Beheira Governorate, Egypt

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Stocking rates: European seabass

1. Two duplicate groups of fish were stocked in the nursery tanks at a density of 2.5 kg/m^3 (mean initial wet body weight 0.15±0.09 g) and reared RAS for five months using two different sources of fry and 5–10 percent daily water exchange.
2. Two groups of fish were stocked in the pre-growing tanks at a density of 5 kg/m^3 (mean initial body wet weight 37.8±1.6 g and 51.2±1.2 g). Each group was reared FTS with a 20–40 percent daily water exchange for seven months.
3. Two groups of fish were stocked in the growing tanks at a density of 10 kg/m^3 (mean initial body wet weight 200±5.0 g [Group 1] and 270.8±5.1 g [Group 2]) and reared FTS with a 30–50 percent daily water exchange for 16 months.

Stocking rates: gilthead seabream

1. One group of fish was stocked at a density of 2.5 kg/m^3 (mean initial body wet weight 0.11±0.08 g) and reared RAS for 4 months with a 5–10 percent daily water exchange.
2. One group of fish was stocked at a density of 10 kg/m^3 (mean initial body wet weight 16±1.5 g) and reared FTS with 20–40 percent daily water exchange for 10 months.

Feed – Floating extruded pelleted feeds were used for all experiments. The diet used in the nursery phase had a 55 percent protein and 13 percent crude fat content, while the diet for the pre-growing and growing phases was 45 percent crude protein and 13 percent crude fat. The unit feed costs were USD1.68/kg for the high protein diet and USD1.51/kg for the low protein feed.

Water consumption – The average water consumption during three growing stages to produce one kilogram of European seabass or gilthead seabream was 26 m^3 (Figure 15). The efficiency of the RAS in the nursery phase meant that water consumption was modest; consumption was higher in the two FTS phases. The positive results gained through the utilization of the RAS during the nursery phase should be applied for all the growing phases in order to minimize total water consumption.

Growth rate – European seabass gained weight throughout all growing phases and showed no significant differences in growth rates between the two different sources of fry. During the seven months of the nursery phase, fry grew to 31.5 g with an average specific growth rate (SGR) of 3.7 percent (Figure 16).

FIGURE 15
Water consumption for the three production stages per kilogram of European seabass and gilthead seabream in Rula intensive fish farm, Egypt

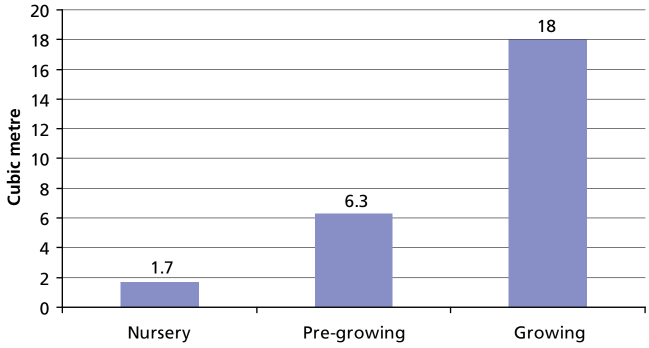
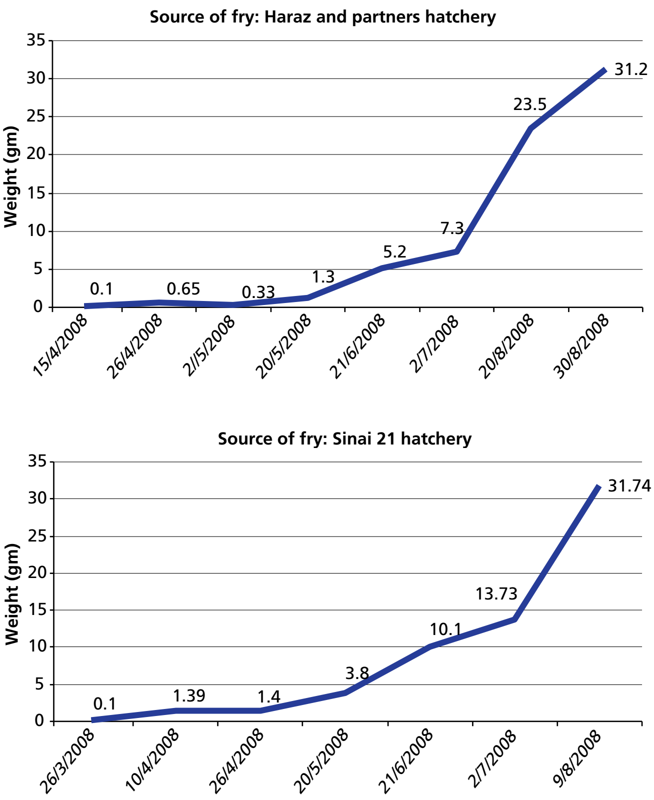


FIGURE 16
Average growth rate of European seabass fry using different sources of fry during the nursery phase (April–August, 2008)



During the seven months of the pre-growing stage (September 2008 – February 2009), European seabass achieved a final body weight of 255±10 g, with an SGR of 0.9 percent (Figure 17).

The European seabass growing stage took about 17 months, during which fish body weights reached final average weights of 770±15 g (Group 1) and 900±10 g (Group 2), respectively. This represented 9.50 and 14.50 kg/m^3 for the two groups, respectively; the SGR were 0.25 to 0.3 percent for Groups 1 and 2, respectively (Figure 18).

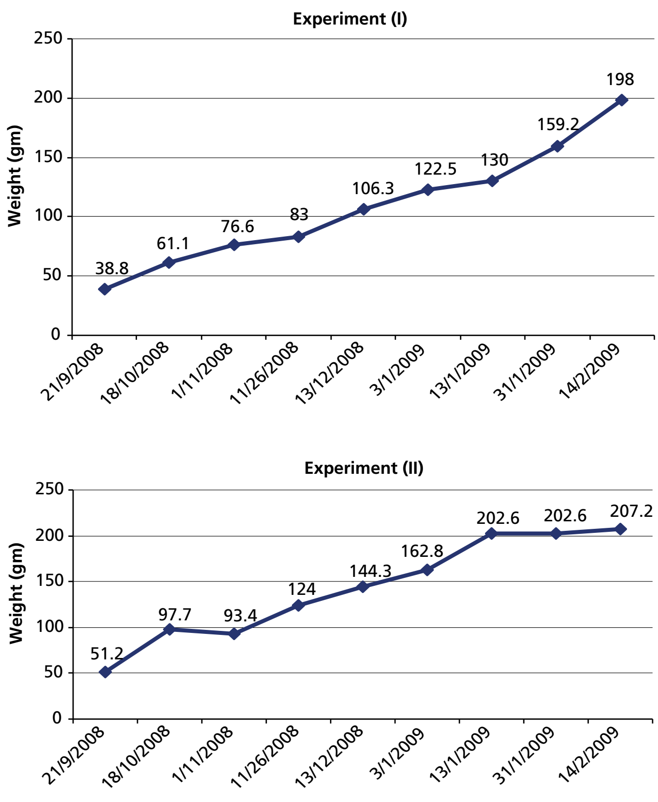
All the gilthead seabream gained weight during the two growing phases. During the four months of the nursery phase the fish grew to an average of 16.0 g. The observed average SGR during this period was 4.14 percent (Figure 19).

During the following 10 months of the growing stage the gilthead seabream reached a final average weight of 250.6 g. The observed SGR for the grow-out phase was lower than in the previous phase, at 0.91 percent (Figure 20).

Survival rate – High mortalities were observed in the European seabass experiment during the first phase, compared to the later phases. The mortalities were expected, as the fish matured over time. Figure 21 illustrates the values reported for the initial and final population for each phase, together with their survival rates.

The survival rate of gilthead seabream was estimated at 23.5 percent during the nursery phase and 99 percent for the growing phase (Figure 22). The reason for the high mortality during the nursery phase was contamination with the dinoflagellate Oodinium (*Amyloodinium ocellatum*), a saltwater itch which usually attacks the gills and reaches densities of 30 parasites per microscopic field (magnification x 20). Oodinium outbreaks can occur rapidly in short periods of time and, if not diagnosed and treated immediately, the disease reaches overwhelming levels – enough to cripple the entire fish population. A treatment using 2 ppm commercial copper sulphate for a period of 14 days was adopted in an attempt to eradicate the infestation. Although mortalities occurred as a consequence of the dinoflagellate outbreak, some results were obtained from this study.

FIGURE 17
Growth rate of the European seabass during the pre-growing stage (September 2008–February 2009)



Feed conversion ratio – The feed conversion ratio (FCR) for the three separate phases of European seabass rearing (nursery, pre-growing, and growing) was calculated to be 1.1:1, 1.3:1, and 3.3:1, respectively. The overall FCR during the total 29-month period (nursery through growing phase) was calculated to be 1.9:1. Figure 23 illustrates that an ideal FCR was achieved during the first two phases of the production cycle, but FCR greatly increased in the last phase.

The FCR of gilthead seabream during the two growing phases were calculated to be 1.75:1 and 1.85:1 respectively (Figure 24). The overall FCR was 1.84:1, during the whole 14-month period. These results indicate that FCR for the gilthead was good throughout both phases.

Harvest – Approximately 50 percent of the European seabass harvested weighed 700–800 g, while 25 percent were 400–600 g and 15 percent 200–300 g. The remaining 10 percent weighed 1 kg, which suits an existing niche market.

Around 66 percent of the gilthead seabream harvested weighed 200–300 g, while 19 percent weighed >300 g, and 15 percent weighed <200 g.

Production costs – The total production costs for the European seabass over the 29-month period were calculated to be USD6.20. Depreciation was taken on a straight line basis, over a period of 15 years. The total production cost break shows feed to be the highest at 40 percent. The other costs consisted of water consumption (16 percent), fish seed (14.4 percent), depreciation (13.6 percent), labour (8 percent), energy (5.6 percent) and animal health maintenance (2.4 percent). The net return for European seabass production was USD3.5/kg and the cost-benefit ratio was 0.56.

The total production cost for gilthead seabream over the 14-month period was calculated to be USD4.20/kg. Depreciation is taken on a straight line basis, over a period of 15 years. Feed and fish seed both shared the same proportion of costs (40.0 percent each), followed by water consumption (5 percent), energy (5 percent), labour (4 percent), depreciation (3.6 percent), and animal health maintenance (2.4 percent). The net return for gilthead seabream production was USD5.5/kg and the cost-benefit ratio was 1.3.

FIGURE 18
Growth rate of European seabass during the growing stage (April 2009–August 2010)

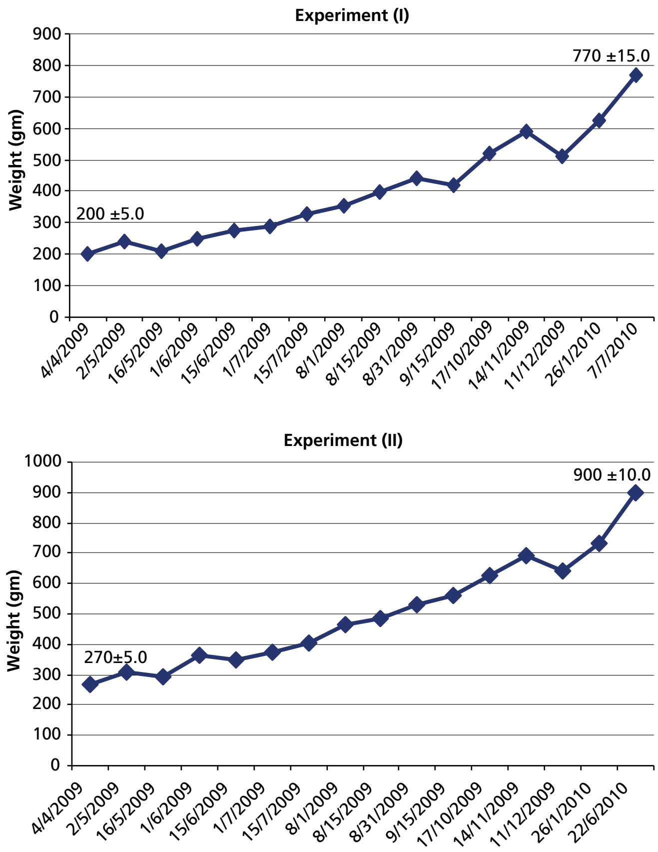


FIGURE 19
Growth rate of gilthead seabream during the nursery stage (April–August 2009)

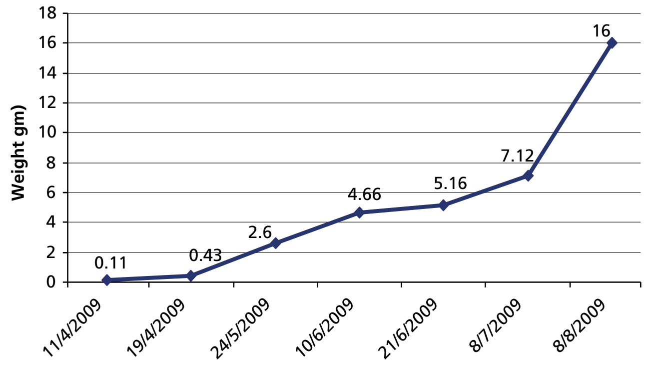


FIGURE 20
Growth rate of gilthead seabream during the growing stages (August 2009–May 2010)

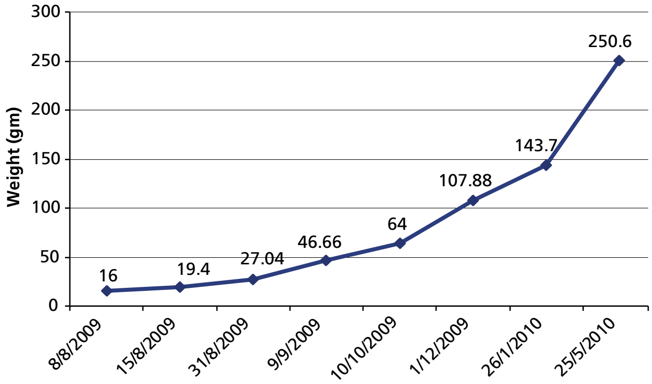
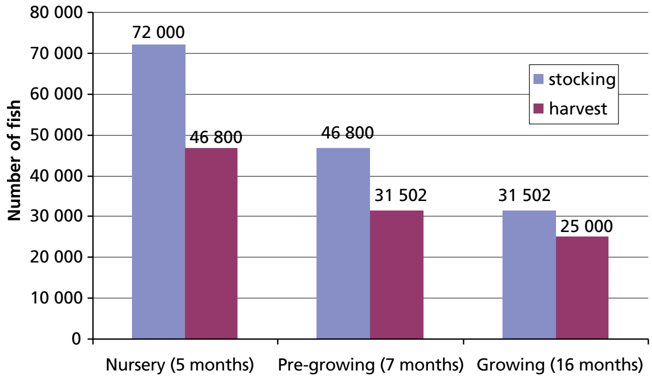


FIGURE 21
Survival rate during three growing stages of European seabass in the Rula Intensive Fish Farm, Egypt



Note: The European seabass survival rates for the nursery, pre-growing and growing stages were 65 percent, 79 percent and 91 percent, respectively.

FIGURE 22
Survival rates for gilthead seabream during the nursery and growing stages (April 2009–May 2010)

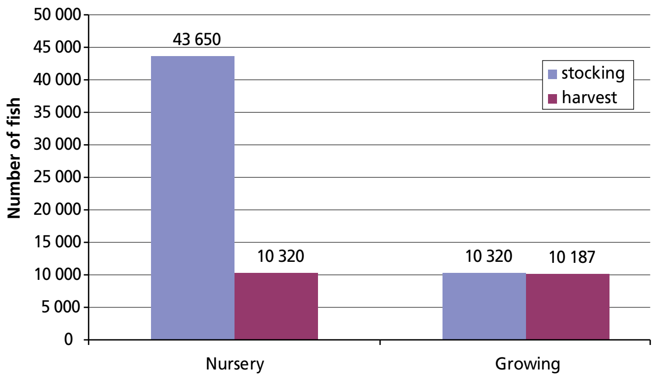


FIGURE 23
FCR of European seabass during three growing stages

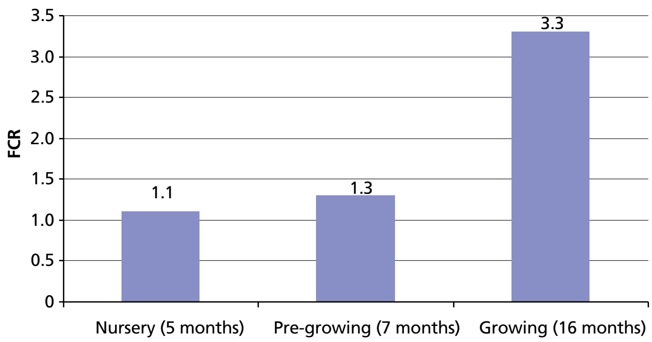
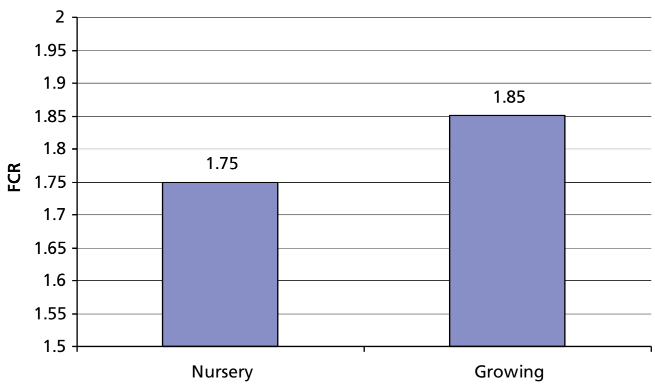


FIGURE 24
FCR of gilthead seabream during the nursery and growing stages (April 2009–May 2010)



WAY FORWARD

Desert aquaculture in Egypt is a potential alternative to other food production activities where opportunities for agriculture are limited. It may be useful to recall the triple "F" message: fish do not consume water, they merely use it; fish farming is a clean production system; and fish farming discharge water has value for agriculture.

The following suggestions are provided in order to assist in achieving durable arid aquaculture developments in Egypt:

- Carry out environmental, social and economic assessments on the potential use of fresh and brackish groundwater for desert-based production systems.
- Estimate the water requirements and salinity tolerance of common Egyptian crops (fish, crustaceans, cloves, animal production).
- Encourage the use of RAS in feasible desert aquaculture projects.
- Evaluate specific research projects that have studied the integration of aquaculture with crop irrigation and animal production.
- Conduct research to identify non-conventional crops that will tolerate the use of brackish water.
- Study the characteristics of water and effluent use in integrated aquaculture in other countries.
- Establish pilot projects that integrate small-scale intensive fish farming with agriculture and demonstrate the economic and water conservation opportunities of such activities (focusing on Bedouins in the Central Sinai Area may be beneficial).

- Examine the opportunities for aquaponics.
- Provide credit facilities for artisanal and commercial desert aquaculture.
- Develop regulations for water use through an interministerial task force.

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