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# Investigating Aquaculture Management Practices and Challenges in Selective Aquaculture Hatcheries Across Khyber Pakhtunkhwa, Pakistan

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## ABSTRACT

Aquaculture is a rapidly expanding food production industry worldwide, involving the controlled or semi-controlled rearing of aquatic animals. This study aimed to gather data on the management practices and challenges in aquaculture hatcheries across Khyber Pakhtunkhwa, Pakistan. The data were collected through structured surveys, field visits, interviews, and focus group discussions with aquaculture hatchery managers, workers, and relevant government officials, focusing on the management practices of fish hatcheries. Warm-water hatcheries had a larger proportion than cold-water hatcheries in terms of surface area, and the numbers of ponds varied between 10 and 80, with a ratio of 60% technical to 80% non-technical staff. The most commonly cultured fish in warm-water hatcheries include *Cirrhinus mrigala*, *Hypophthalmychthys molitrix*, *Ctenopharyngodon idella*, *Labeo rohita*, *Catla catla*, and *Carassius auratus*. Cold-water hatcheries contained *Salmo trutta*, *Oncorhynchus mykiss*, and *Oncorhynchus mykiss kamloops*, while semi-cold water hatcheries had *Tor putitora* and *Carassius auratus*. Only 46.70% of hatcheries use hormonal applications for breeding success, such as ovaprim, ovatide, and MS-222. Brooders in hatcheries were fed with oryza, AMG, aqua Feed, wheat bran, rice bran, soybean oil, and grasses. The feed of fries consisted of a combination of oryza, AMG, aquafeed, supreme feed, rice bran, wheat bran, egg yolk, soybean, and Chenab feed. The common diseases found in hatcheries across Khyber Pakhtunkhwa were fin rot, proliferative kidney disease (PKD), saprolegnia, branchiomycosis, lernaesis, argulosis, fish ulcer, dropsy, and whirling diseases. The study concluded that most of the hatcheries in Khyber Pakhtunkhwa faced problems, such as the unavailability of laboratories, incomplete staff, electricity problems, water scarcity, infected stream water, and waterlogging. The government is recommended to overcome these basic problems and improve hatchery production to stimulate the province's economy.

## INTRODUCTION

Aquaculture is the rearing of aquatic animals under controlled or semi-controlled conditions and is one of the world's fastest-growing food production industries. In recent years (1970– 2008), it has noted an average annual growth of 8.3%, three times the rate of the world's meat production **(FAO, 2018)**. A hatchery is an establishment where eggs of certain organisms as fish and poultry are hatched under artificial conditions. The purpose of a hatchery may vary, ranging from conservation efforts, such as raising rare or endangered species under controlled conditions, to economic reasons **(Adekoya *et al*., 2006)**. The gradually rising importance of fish farming has enforced developments in the technologies necessary for securing the initial and fundamental necessities for productive aquaculture such as the production of fish seed for stocking. Without the artificial propagation of seeds of favored cultivable fish species, fish culture today is almost impossible **(Akankali *et al*., 2011)**.

Efficient fish hatchery management is the backbone of an intensive fish culture **(Ali *et al*., 2005; Adekoya *et al*., 2006)**. The number of nurseries, rearing, and production ponds in a hatchery is determined by the expected number of fry and fingerlings **(Ali *et al*., 2014; Rahman *et al*., 2015)**. The size of these ponds is influenced by factors, such as the number of brooders, species bred, fecundity of the species, hatchable eggs, and the number of surviving fries to fingerlings **(Akankali *et al*., 2011)**.

The process involves meticulous considerations, from the size and number of ponds influenced by factors, such as brooder quantity, species bred, fecundity, and hatchable eggs, to external influences on sexual maturation, including temperature, photoperiod, pH, water volume, and salinity **(Olaoye *et al*., 2011)**. Maintaining the health of brood fish through proper feeding before spawning, sexing of fish, and addressing nutritional requirements are crucial steps **(Bisht *et al*., 2013; Migaud *et al*., 2013; Wang *et al*., 2015)**. Numerous procedures of spawning are used to yield fry and fingerlings, such as natural spawning without hormonal treatments, natural spawning with hormones, and artificial spawning with or without hormone treatment. Nursery management begins from the hatching phase to the free-swimming feeding fry stage **(Akankali *et al*., 2011)**. Larva are separated from eggshell and spoiled eggs for their growth and development. The yolk sac provides a sufficient high-quality reserved food for the larvae. Young larvae, about 3- 5 days old, are transported from hatchery tanks to nurseries where they remain for about 15- 40 days. The rearing of larvae is the most serious stage of the entire culture. The management of fish hatcheries is a meticulous and technical process that requires thorough investigation from the larval stage to the marketable size. Even slight negligence or lack of facilities can lead to problems for hatcheries. Therefore, the present study was conducted to examine the management system and highlight the issues associated with public sector hatcheries in the province of Khyber Pakhtunkhwa, Pakistan.

## MATERIALS AND METHODS

### Study area

The study was conducted in eight districts, namely Chitral, Dera Ismail Khan (DI Khan), Kohat, Malakand, Mardan, Peshawar, Shangla, Swat, and Upper Dir of Khyber Pakhtunkhwa, Pakistan (Fig. 1). The selection of these districts was based on their geographic diversity, ecological factors within the province, and the presence of a significant number of public sector hatcheries, making them suitable for studying the management system of such facilities.

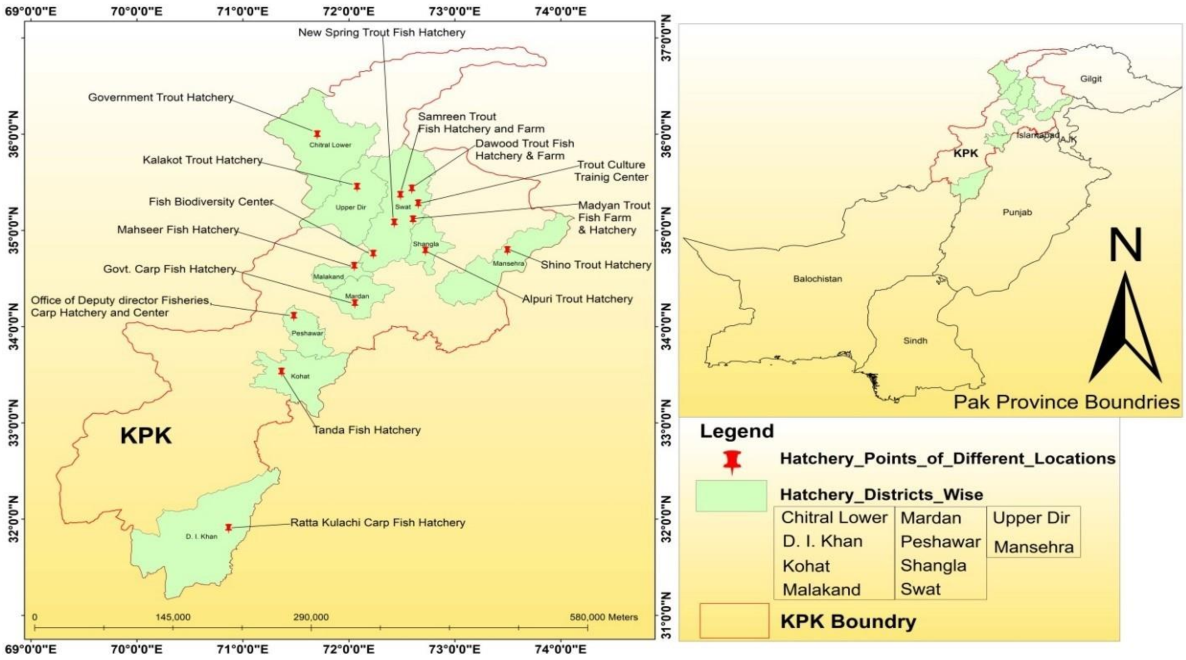


**Fig. 1.** Study area map showing sites of hatcheries among different districts

### Data collection

The data were collected through structured surveys, field visits, interviews, and focus group discussions with aquaculture hatchery managers, workers, and relevant government officials. The structured surveys were designed to gather quantitative data on aquaculture management practices, production metrics, and challenges faced by the hatcheries. In-depth interviews and focus group discussions were conducted to provide qualitative insights into the nuances of aquaculture management, with open-ended questions used to encourage detailed responses. The survey questions were developed based on a thorough literature review and expert consultation.The overall study and data collection were recorded in a well-designed and properly documented questionnaire. During the study, a total of 15 hatcheries from both government and private sectors were surveyed which included 10 cold water hatcheries, 1 semi-cold water, and four warm water hatcheries, as mentioned in Fig. (1).

**Statistical analysis**

The statistical analysis was conducted using SPSS 20 (20 IBM, USA) software.

## RESULTS

### 1. Survey of hatcheries in Khyber Pakhtunkhwa: Water sources, species composition, and pond function

During the study survey, hatcheries were subject to a study where 11 of them belong to the government and 4 belong to the private sector. Fresh and well-oxygenated water is very necessary for the growth of fries, fingerlings, and brooders. The supply of water may be continuous or non-continuous. All of the visited, cold-water hatcheries have a continuous supply of water. It was observed during the survey that all of the cold-water hatcheries and one warm-water hatchery (Tanda Dam Kohat) received water from continuous sources such as streams and springs i.e. 73.3%. Tanda Dam Kohat is the main source of water for the Kohat hatchery, while two warm water hatcheries such as Rutta Kulachi carp fish hatchery from District Dera Ismail Khan (DI Khan) and the Government Carp Fish Hatchery from District Mardan received water from tube wells (13.3. %). Moreover, Mahseer and carp hatchery center district Malakand received water from both continuous and discontinuous sources (13.3%). The composition of species in hatcheries is different based on the water temperature to which fish are adopted. Cold-water hatcheries have different species composition than warm-water hatcheries. In cold-water hatcheries like the Kalakot Trout Hatchery in District Dir Upper, the Government Trout Hatchery in District Lower Chitral, and the Madyan Trout Hatchery in District Swat, monoculture of Rainbow trout is practiced. While, in other hatcheries, polycultures of different fish species occur. In the case of cold-water hatcheries, rainbow trout and brown trout culture occur in the Trout Culture Training Center in Swat and Alpuri Trout Hatchery in district Shangla. Rainbow Trout, silver, grass, goldfish, and mahseer in Fish Biodiversity Center District Swat. In other hatcheries of the District Swat such as New Spring Trout Fish Hatchery, Dawood Trout Fish Hatchery and Farm, and Samreen Trout Fish Hatchery and Farm polyculture of salmon, Kamloops, brown trout, and rainbow trout is practiced. At Shinu Trout Hatchery, rainbow trout and Kamloops are present, while in semi-cold-water hatcheries such as the Mahseer Fish Hatchery in District Malakand, poly culture of Mahseer and goldfish is practiced. All the warm water hatcheries perform poly culturing of *Cirrhinus mrigala* (mori), *Hypophthalmychthys molitrix* (silver carp), *Ctenopharyngodon idella* (grass carp), *Labeo rohita* (Rohu), *Catla catla* (thaila), *Carassius auratus* (goldfish). Proportionally, warm-water hatcheries have more surface area than cold-water hatcheries. For instance, both the carp hatchery in District Peshawar and the government carp fish hatchery in Mardan have a surface area exceeding 5 acres (13.3%). In warm-water hatcheries, the Peshawar carp hatchery has a larger surface area (72 acre) while the government carp hatchery in Mardan covers an area of 9.3 acre. The Mahseer and Carp Hatchery Center in districts Malakand and Rutta Kulachi Carp Fish Hatchery consist of an area within the range of 2.5- 5 acre (13.3%). All of the cold-water hatcheries and warm-water hatcheries in Tanda Dam in District Kohat have a surface area between 0.1 and 2.5 acre (73.3%). On the basis of function, ponds are classified as spawning ponds, nursery ponds, rearing ponds, and stocking ponds. In cold-water hatcheries, raceways are constructed (Table 1).

**Table 1.** Survey of hatcheries in Khyber Pakhtunkhwa: Water Sources, species composition, and pond function

| Name of hatchery | Area (Acre) | No of pond /hatchery | Fish species | Type of water supply | Water sources | |
|---|---|---|---|---|---|---|
| Trout Culture Training center | 0.125-2.5 | 32 | Brown trout and rainbow trout | continuous | Spring and stream water | |
| Alpuri Trout Hatchery | 0.125-2.5 | 20 | Brown trout and rainbow trout | continuous | Spring and stream water | Cold water |
| Fish Biodiversity Center | 0.125-2.5 | 13 | Rainbow trout, Silver, grass, goldfish and mahseer | continuous | Spring water | |
| Kalkot Trout Hatchery | 0.125-2.5 | 15 | Rainbow trout only | continuous | Spring and stream water | |
| Government Trout Hatchery | 0.125-2.5 | 8 | Rainbow trout only | continuous | Spring and stream water | |
| Shinu Trout Hatchery | 0.125-2.5 | 34 | Kamloop and rainbow trout | continuous | Spring and stream water | |
| New Spring Trout Fish Hatchery | 0.125-2.5 | 37 | Salmon, kamloop, brown trout and rainbow trout | continuous | Spring and stream water | |
| Dawood Trout Fish Hatchery and Farm | 0.125-2.5 | 17 | Salmon, brown trout and rainbow trout | continuous | Stream water | |
| Samreen Trout Fish Hatchery and Farm | 0.125-2.5 | 36 | Salmon, brown trout and rainbow trout | continuous | Stream water | |
| Madyan Trout Fish Farm and Hatchery | 0.125-2.5 | 24 | Rainbow trout only | continuous | Spring and stream water | |
| Mahseer Fish Hatchery | 2.5-5 | 11 | Mahseer and gold fish | Continuous/ non-contnous | Spring and stream water | Semi cold water |
| Ratta Kulachi Carp Fish Hatchery | 2.5-5 | 21 | Mori, silver, grass | non-contnous | Well water | |
| Tanda Fish Hatchery | 0.125-2.5 | 14 | Rohu, mori, silver, grass | continuous | Dam water | Warm water |
| Govt. Carp Fish Hatchery | >5 | 15 | Mori, rohu, thaila, silver, grass, goldfish, China | non-contnous | Well water | |
| Office of Deputy Director Fisheries, CarpHatchery and training Center | >5 | 90 | Rohu, mori, silver, grass, China, goldfish | Continuous/ non-contnous | River water and tube well water | |

## 2. Assessment of laboratory facilities and staffing in hatcheries of Khyber Pakhtunkhwa, Pakistan

The laboratory is one of the basic needs of a hatchery, and only three hatcheries have a laboratory (20%). The disease diagnostic laboratories are present only in the Trout Culture Training Center in Swat and the Carp Hatchery and Training Center in Peshawar (13.3%), while the water testing laboratory is present only in Mahseer fish hatchery

District Malakand (6.6%). It was noticed during the field surveys that about 80% of hatcheries have no laboratory which is alarming for hatchery production. To run a hatchery effectively, both technical and non-technical staff are needed. Watchers are also employed to check streams and rivers to prevent illegal fishing. Most hatcheries (60%) have between 1- 10 technical staff members, followed by more than 20 and 11- 20 staff members. In terms of non-technical staff, most hatcheries have between 1- 10 workers, followed by 11- 20 in 13.30% of hatcheries, and more than 20 in 6.7% of hatcheries (Fig. 2).

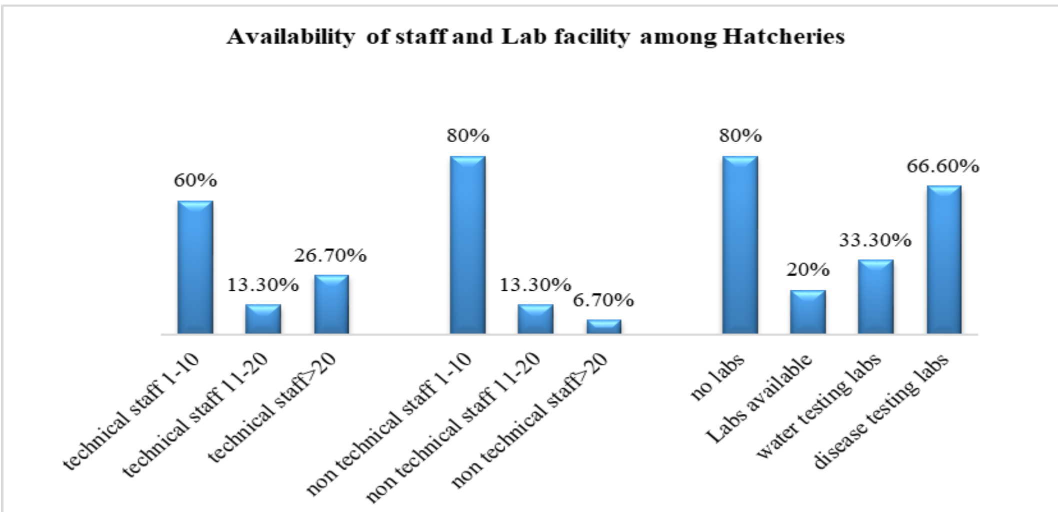


**Fig. 2.** Assessment of laboratory facilities and staffing in hatcheries of Khyber Pakhtunkhwa, Pakistan

**3. Brooder management and production techniques in hatcheries of Khyber Pakhtunkhwa**

The number of brooders directly influences the production of a hatchery. Hatcheries that have more numbers of brooders, i.e., >2000, include cold water hatcheries, such as Trout Culture Training Center, Alpuri Trout Hatchery, Fish Biodiversity Center, Kalakot Trout Hatchery, New Spring Trout Fish Hatchery, Dawood Trout Fish Hatchery, and farm and warm water hatcheries, such as Thanda Fish Hatchery, Govt. Carp Fish Hatchery, Mardan, and Office of Deputy Director Fisheries, Carp Hatchery, and Training Center Peshawar constitute 66.6% of the total number of visits. Shinu Trout Hatcheries contain 1000– 2000 brooders (6.6%), while the numbers of brooders in the remaining three hatcheries, such as Dawood Trout Fish Hatchery and Farm, Madyan Trout Fish Farm and Hatchery, Mahseer Fish Hatchery, and Rutta Kulachi Carp Fish Hatchery, are between 500- 1000 (26.6%). Adequate care of brooders is very important to enhance the production level of a hatchery. Oryza, AMG, and aqua feed are given to brooders in cold-water hatcheries, while wheat bran, rice bran, soybean oil, and grasses are given to brooders in warm-water hatcheries. Some government hatcheries directly stock fry or fingerlings in rivers or dams, while private and some other government hatcheries sell or rear them up to a marketable size. Different hatcheries have different stocking frequencies. In fish, hormonal control of reproduction is controlled by the secretion of successive hormones by various organs, but for pre-ovulation, we used different hormones. Hormones also reduce the latency time, due to which the gonads ripen in the early stages. The production of eggs varies with species. If an adequate care is given to the brooders, healthy eggs will be produced. Only post-vitellogenin or dormant oocytes respond to the hormone treatment. Only the transparent oocytes in which pre-ovulation occurred would be discharged into the ovaries and be fertilized. The mortality is too high at this stage, therefore proper care is necessary to increase fertilization success and production at the hatchery. The fertilized eggs are incubated in stagnant or running water in incubation troughs. Fertilized eggs swell and become sticky when they are in contact with water. The hatching percentage is 80– 90% when small quantities of eggs are incubated. A total of 70% of healthy larvae can be obtained through this method. Similarly in the field survey, only 2 warm water hatcheries, such as Carp Fish Hatchery DI Khan and Thanda Fish Hatchery Kohat, perform an occasional hybridization (13.3%), which shows the best results. Sometimes, brooders are stocked from the outside when there is high mortality or a smaller number of brooders in the hatchery. During the field survey, five hatcheries added brooders from outside (33.3%) to enhance their production rates (Table 2).

**Table 2.** Brooder management and production techniques in hatcheries of Khyber Pakhtunkhwa

| Hatchery | No. of brooder | Feed of brooder | Fertilization success (%) | No. of Egg produced | Type of hormone used | Occasional hybridization | Brooder stocking from outside |
|---|---|---|---|---|---|---|---|
| Trout Culture Training center | >2000 | oryza pellet | 60 | >1000000 | ovaprim | Absent | Yes |
| Alpuri Trout Hatchery | >2000 | oryza pellet | 60 | 100000-1000000 | Nil | Absent | No |
| Fish Biodiversity Center | >2000 | oryza pellet | 0 | 0 | Nil | Absent | No |
| Kalkot Trout Hatchery | >2000 | oryza pellet | 60 | 100000-1000000 | ovaprim | Absent | No |
| Government Trout Hatchery | >2000 | oryza pellet | 60 | 100000-1000000 | Nil | Absent | No |
| Shinu Trout Hatchery | 1000-2000 | oryza pellet | 60 | 100000-1000000 | MS-222 and ovaprim | Absent | No |
| New Spring Trout Fish Hatchery | >2000 | AMG imported | 60 | >1000000 | Nil | Absent | Yes |
| Dawood Trout Fish Hatchery and Farm | 500-1000 | AMG imported | 60 | 100000-1000000 | Nil | Absent | No |
| Samreen Trout Fish Hatchery and Farm | >2000 | AMG imported | 60 | 100000-1000000 | Nil | Absent | No |
| Madyan Trout Fish Farm and Hatchery | 500-1000 | AMG imported | 80 | 100000-1000000 | Nil | Absent | Yes |
| Mahseer Fish Hatchery | 500-1000 | oryza pellet | 90 | 1000-100000 | MS-222 | Absent | Yes |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ratta Kulachi Carp Fish Hatchery | 500-1000 | Rice bran, Wheat bran and soyabean cake | 50 | >1000000 | ovaprim | Present | No |
| Tanda Fish Hatchery | >2000 | Rice bran, Wheat bran and soyabean cake | 70 | 1000-100000 | ovaprim | Present | No |
| Govt. Carp Fish Hatchery | >2000 | Rice bran, Wheat bran and soyabean cake | 55 | >1000000 | ovaprim | Absent | No |
| Office of Deputy Director Fisheries, CarpHatchery and training Center | >2000 | Rice bran, Wheat bran and soyabean cake | 70 | >1000000 | ovaprim and ovatide | Absent | Yes |

## 4. Fingerling production and feeding practices in hatcheries of Khyber Pakhtunkhwa, Pakistan

Fingerlings are fry that are four weeks or older. The number of fingerlings directly depends on the rearing of fries. Most hatcheries sell them to increase their revenue. Food selectivity and acceptability are very crucial factors for the survival and development of fingerlings. Cold-water and warm-water hatcheries use different types of feed for the rearing of fry. Similarly, newly hatched larvae depend entirely on the yolk sac for energy, growth, and development. When the yolk sac is desorbed, the fish fry accepts artificial diets 10– 18 days after hatching, and this is the major turning point in the life of a nursed fish (Fig. 3).

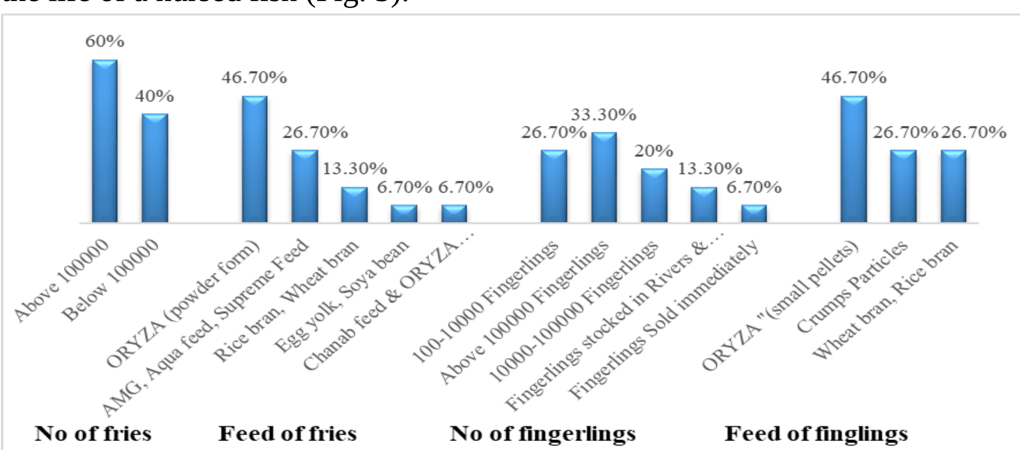


**Fig. 3.** Fingerling production and feeding practices in studied hatcheries

## 5. Assessment of annual revenue and income sources in hatcheries of Khyber Pakhtunkhwa, Pakistan

The annual revenue shows the production of a hatchery. Depending on different factors, each hatchery has its own annual income. The government gives a specific target to hatcheries which shows their income and progress. The annual revenue of surveyed hatcheries is given in Fig. (4).

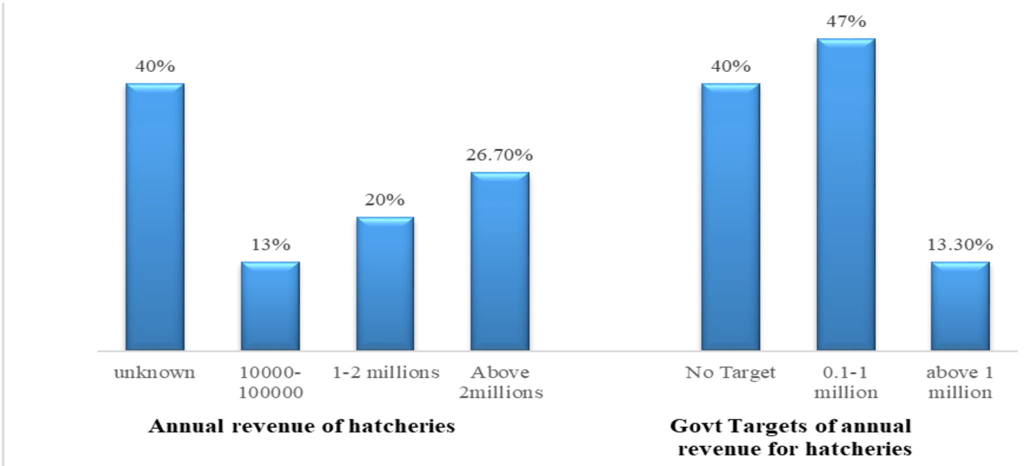


**Fig. 4.** Assessment of annual revenue and income sources in hatcheries of Khyber Pakhtunkhwa, Pakistan

**6. Disease prevalence and management in studied hatcheries**

Like all other animals, fish also suffer from various diseases. From a causative point of view, fish diseases are infectious and non-infectious. Their methods of treatment are external, systemic (via diets), and parenteral. It was observed during the survey that the most prevalent diseases among warm-water hatcheries are fin rot and proliferative kidney disease (PKD), which are caused by bacteria and viruses (53.3%). One warm water hatchery faces fungal diseases such as Saprolegnia along with PKD and fin rot (6.7%). The management system regarding the hygienic condition in the Madyan Trout Fish Farm and Hatchery in District Swat was found to be efficient, and no diseases were yet reported (6.7%). Semi-cold-water hatchery faced fungal diseases such as Saprolegnia and Brachymeiosis (6.7%). The prevalence of diseases in warm water hatcheries is in the following ratios: 6.7% of hatcheries have diseases caused by bacteria and crustacean ectoparasites (Laernia spp. and Argulus), such as fish ulcers, lernaesis, and argulosis, respectively. Additionally, 6.7% of hatcheries have saprolegnia, fin rot, and dropsy diseases caused by fungi and bacteria, respectively. Another 6.7% of hatcheries have diseases such as lerniae, Saprolegnia, and branchiomycosis. Similarly, 6.7% of hatcheries face diseases such as whirling disease, argulosis, fin rot, and branchiomycosis caused by cnidarians (*Myxbolus cerebralis*), crustaceans, bacteria, and fungi, respectively (Table 3).

**Table 3.** Types of diseases reported among visited hatcheries

| Prevalent disease | Pathogen | Frequency | Hatchery |
|---|---|---|---|
| **Fin rot** | Bacterial | 8 (53.3%) | Trout Culture Training center,<br>Alpuri Trout Hatchery<br>Kalakot Trout Hatchery<br>Government Trout Hatchery Chitral<br>Shinu Trout Hatchery<br>New Spring Trout Fish Hatchery<br>Dawood Trout Fish Hatchery and Farm<br>Samreen trout fish |
| **Pyloric kidney disease** | Viral | | |
| **Fin rot** | Bacterial | 1 (6.7%) | Fish Biodiversity Center |
| **Pyloric kidney disease** | Viral | | |
| **Saprolegnia** | Fungal | 1 (6.7%) | Mahseer Fish hatchery |
| **Saprolegnia** | | | |
| **Branchiomycosis** | | | |
| **Fish ulcer** | Bacterial | 1 (6.7%) | Ratta Kulachi Carp Fish Hatchery |
| **Lernaesis** | Argulos spp. (Crustaceans Ectoparasite) | | |
| **Argulosis** | Lernae spp. Crustaceans Ectoparasite | | |
| **Saprolegnia** | Fungal | 1 (6.7%) | Thanda Fish Hatchery |
| **Fin rot** | Bacterial | | |
| **Dropsy** | Bacterial | | |
| **Lernaea,** | Lernae spp. | 1 (6.7%) | Govt. Carp Fish Hatchery Mardan |
| **Saprolagnia,** | Fungal | | |
| **Branchiomycosis (gil rot)** | Fungal | | |
| **Argulosis** | Fungal | 1 (6.7%) | Office of Deputy Director Fisheries, Carp Hatchery and training Center Peshawar |
| **Fin rot** | Bacterial | | |
| **Whirling disease** | Parasitic Cnidarian | | |
| **Branchiomycosis** | Fungal | | |
| **No diseases reported** | Nil | 1 (6.7%) | Madyan Trout Fish Farm and Hatchery |

Prominent aquatic weeds include floating, marginal, emergent, submerged, and algal weeds. These must be removed, as if left unchecked, they may cause serious damage to pisciculture. 10 of the visited hatcheries perform only netting methods for weed control (66.6%). While in 2 hatcheries, along with netting, chemical methods such using diesel, karosin oil, and limestone are used for weed control (13.3%). 13.3% hatchery only used chemical methods. In one hatchery such as a government trout hatchery, chitral basements are cemented and hence are weed-free (6.6%). According to field surveys, the majority of government hatcheries face major problems including climate change, incomplete staff, water scarcity, electricity, unavailability of labs, least surface area, among others. These basic problems must be overcome to boost the production and economy of hatcheries (Fig. 5).

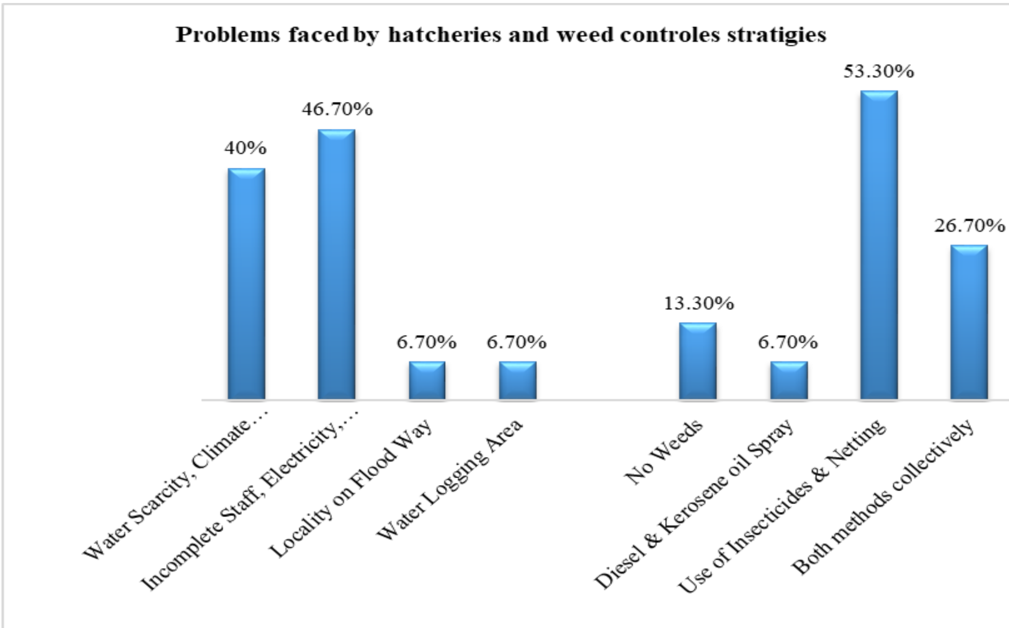


**Fig. 5.** Major problems faced by the visited hatcheries

## DISCUSSION

The findings of present study reveal crucial insights into the aquaculture management practices and challenges within hatcheries across Khyber Pakhtunkhwa, Pakistan. The identified 15 hatcheries in the region, with 11 in the government sector and 4 in the private sector, play a pivotal role in the aquaculture landscape. Hatcheries were categorized based on water temperature, resulting in cold-water, semi-cold-water, and warm-water hatcheries. Cold-water hatcheries, benefitting from continuous water supply from streams and springs, primarily focused on monoculture of rainbow trout. In contrast, warm-water hatcheries engaged in polyculturing of various fish species. The composition of species within hatcheries varied based on water temperature, influencing the overall surface area, with warm-water hatcheries generally exhibiting larger areas.

The study aligns with general principles of aquaculture and hatchery management, as illustrated by **Valenti and Daniels (2007)**. The classification of hatcheries into flow-through and recirculation systems further emphasizes the diversity in management approaches.

Despite the diversity, a common challenge emerged—most hatcheries in Khyber Pakhtunkhwa lack laboratories for diagnosing diseases or testing water quality. Peshawar and Madyan stand out as exceptions, emphasizing the need for laboratory expertise in these facilities. Drawing parallels, **Russel's (2019)** fish health laboratory in Augusta exemplifies the role of diagnostics, disease management, and prevention in hatchery operations.

The water supply emerges as a fundamental need for hatcheries, resonating with the findings of **Mundorff (1962)** and **Tekwombuo *et al.* (2013)**. The study noted variations in pond sizes and surface areas between warm-water and cold-water hatcheries, with Peshawar hatchery standing out as the largest. The significance of adequate water supply and proper sizing aligns with the general principles of hatchery management. Brooder stocking density and feed types were highlighted as crucial factors influencing fish health and productivity **(De-silva, 2008)**. The study echoes the importance of balanced feed, as suggested by **Alikunhi (2011)** and **Titcomb *et al.* (2020)**. Additionally, the focus on fertilization success and fingerling production rates underscores the need for effective breeding strategies and improved care. Induced breeding methods, as noted in the field survey, align with the studies of **Akankali *et al*. (2011)** and **Nwadukwe *et al*. (1993)**, providing insights into the dosage and methods employed in Khyber Pakhtunkhwa hatcheries. Despite the observed challenges, the study emphasizes the economic potential of the fisheries sector in Khyber Pakhtunkhwa. Aligning with **Laghari's (2018)** assessment of challenges and opportunities in Pakistan's fisheries sector, it underscores the need for immediate actions by the government to overcome basic problems, enhance hatchery production, and boost the country's economy. The findings of the present research indicate that a significant percentage of hatcheries in Khyber Pakhtunkhwa produce a large number of eggs, with a notable proportion achieving high fertilization success. However, the study also revealed that a few number of hatcheries lack the expertise to run laboratories for diagnosing diseases or testing water quality. The limitation of the fertilization period in fish, as noted by **Akankali *et al.* (2011)**, resonates with the present research. The immediate swelling of fish eggs upon contact with water, leading to micropyle closure, underscores the importance of timely and controlled breeding practices. This insight from the literature coincides with the observed variations in fertilization success across the surveyed hatcheries. The findings of the present research indicate that approximately 33.3% of hatcheries in Khyber Pakhtunkhwa produce more than one-lac fingerlings, with 26.7% producing 100- 10000 fingerlings, and 20.0% producing 10000- 100000 fingerlings. This is consistent with the importance of fingerling production as a bottleneck to the continued expansion of aquaculture, as noted by **Bartholomew (2006)**. Throughout Asia, the Americas, and Africa, the tilapia aquaculture continues to expand and represents an important source of fish to domestic and export markets. The development of effective techniques for mass production of mono-sex (male) tilapia fingerlings, specifically sex reversal technology, was an important factor contributing to the rapid development of tilapia aquaculture during the past decade.

On the other hand, fish suffer from various diseases, including infectious and non-infectious ones, and their treatment methods include external, systemic, and parenteral approaches. The present research discusses the prevalence of various diseases in fish hatcheries and the different treatment methods used to manage them. The Madyan Trout Fish Farm and Hatchery in District Swat was found to have an efficient management system with no reported diseases. However, some warm-water hatcheries face diseases caused by bacteria and viruses, while semi-cold-water hatcheries are affected by fungal diseases.

The government is reported to overcome these basic problems and improve hatcheries production boosting the economy of the country. **Muhammad Younis Laghari (2018)** studied the challenges and opportunities in the fisheries sector of Pakistan. He stated that in recent years, the fisheries sector is facing numerous challenges including natural and anthropogenic, such as natural disasters, climate change, and industrialization, environmental pollution and overfishing. These factors collectively threaten food security and the community's income. Therefore, immediate actions are required by the government and policymakers.

## CONCLUSION

The study conducted on the management system of public sector hatcheries in Khyber Pakhtunkhwa, Pakistan revealed that most of the hatcheries face problems, such as unavailability of laboratories, incomplete staff, electricity problems, water scarcity, infected stream water, and waterlogging. The government is recommended to overcome these basic problems to improve hatchery production and boost the economy of the country. The study also found that the composition of fish species in hatcheries varies based on the water temperature, and the most common diseases found in hatcheries were fin rot, proliferative kidney disease, Saprolegnia, branchiomycosis, lernaesis, argulosis, fish ulcer, dropsy, and whirling diseases. Efficient fish hatchery management is crucial for an intensive fish culture, and the production of fish seed for stocking is essential for productive aquaculture.

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## REFERENCES

**Adekoya, B. B.; Ayansanwo, T. O.; Iduwu, A. A.; Kudoro, O. A. and Salisu, A. A.** (2006). In Directory of Fish Hatcheries in Ogun State. Ogun StateAgricultural Development Programme. (OGADEP).Abeokuta, 18pp.

**Akankali, J. A.; Seiyaboh, E. I. and Abowei, J. F. N. (2011).** Fish hatchery management in Nigeria. Adv. J. Food Sci. Technol., 3: 144-154. https://maxwellsci.com/jp/abstract.php?jid=AJFST&no=106&abs=09

**Ali, M.; Iqbal, F.; Salam, A.; Iram, S. and Athar, M.** (2005). Comparative study of body composition of different fish species from brackish water pond. Int. J. Environ. Sci. Technol., 2: 229-232. https://doi.org/10.1007/BF03325880

**Ali, S. M.; Riar, M. G. S.; Pavel, M. S. F and Mahmud, Y**. (2014). Primary nursery rearing of Crucian carp fry under different stocking densities. J. Bangladesh Soc. Agric. Sci. Technol., 11:25-30.

**Ali, S. S.** (1993). An introduction to freshwater fishery biology. Published by University Grants Commission, Islamabad, 55-57.

**Amin, A. R.;Bapary,M.A..;Islam, M.s.;Shahjahan,M and Hossain,M.A.R.** (2005). Amin, A. R. (2005). The Impacts of Compensatory Growth on Food Intake, Growth Rate and Efficiency of Feed Utilization in Thai Pangas (*Pangasius hypophthalmus*).Pak.J,Biol.Sci.,8: 766-770. https://doi.org/10.3923/pjbs.2005.766.770

**Bartholomew, S and Smith, A. D.** (2006). Improving survey response rates from chief executive officers in small firms: The importance of social networks. Entrepreneurship Theory and Practice., 30: 83-96. https://doi.org/10.1111/j.1540-6520.2006.00111.x

**Bhatt, J. P and Pandit, M. K.** (2016). Endangered Golden mahseer Tor putitora Hamilton: a review of natural history. Rev Fish Biol Fisheries., 26:25-38. https://doi.org/10.1007/s11160-015-9409-7

**Bisht, A.; Anand, S.; Bhadula, S and Pal, D. K.** (2013). Fish seed production and hatchery management: A Review. New York Science Journal. 6: 42-48.http://www.sciencepub.net/newyork

**Chattoraj, D. K.; Bose, A. N.; Sen, M and Chatterjee, P.** (1979). Physico-chemical studies of model meat emulsion in relation to the preparation of stable sheep and goat meat sausage. Journal of Food Science., 44: 1695-1699. https://doi.org/10.1111/j.1365-2621.1979.tb09118.x

**Cosson, J.** (2010). Frenetic activation of fish spermatozoa flagella entails short-term motility, portending their precocious decadence. J. Fish. biol., 76: 240-279. https://doi.org/10.1111/j.1095-8649.2009.02504.x

**De Silva, S. S.; Nguyen, T. T and Ingram, B. A.** (2008). Fish reproduction in relation to aquaculture. A book of Fish reproduction in relation to aquaculture. Science Publishers, Enfield, New Hampshire, USA., 535-575.

http://hdl.handle.net/10536/DRO/DU:30021451

**FAO.** (2018). The State of World Fisheries and Aquaculture 2018-Meeting the sustainabledevelopment goals.https://www.fao.org/3/i9540en/i9540en.pdf

**Faruk, M. A. R.; Alam, M. J.; Sarker, M. M. R and Kabir, M. B.** (2004). Status of fish disease and health management practices in rural freshwater aquaculture of Bangladesh. Pak.J,Biol.Sci., 7: 2092-2098. https://doi.org/10.3923/PJBS.2004. 2092. 2098

**Hafeez-ur-Rehman, M.; Ashraf, M.; Abbas, F.; Iqbal, K. J.; Qureshi, I. A and Andleeb, S.** (2015). Effect of different synthetic hormones and/or their analogues on induced spawning in *Channa marulius*. Pakistan J. Zool., 47:745-752.http://www.zsp.com.pk/pdf47/745-752%20(19)%20PJZ-1812-14%208-4-15%20Dr.%20Induced%20Spawning%20of%20Channa%20 marulius.pdf

**Herrmann, M and Greenberg, J. A.** (1994). A revenue analysis of the Alaska pink salmon fishery. North American Journal of Fisheries Management. 14: 537-549.
https://doi.org/10.1577/1548-8675(1994)014%3C0537:ARAOTA%3E2.3.CO;2

**Hong, W and Zhang, Q.** (2003). Review of captive bred species and fry production of marine fish in China. Aquaculture. 227:305-318.
https://doi.org/10.1016/S0044-8486(03)00511-8

**Hossain, M. B.; Nur, A. A. U.; Ahmed, M. M.; Ullah, M. A.; Albeshr, M. F and Arai, T.** (2022). Growth, Yield and Profitability of Major Carps Culture in Coastal Homestead Ponds Stocked with Wild and Hatchery Fish Seed. Agriculture., 12: 1131.
https://www.mdpi.com/2077-0472/12/8/1131

**Inland fisheries: ecology and management.** John Wiley & Sons. 2008.
https://www.wiley.com/en-ae/Inland+Fisheries%3A+Ecology+and+Management-p-9780470995686

**Laghari, M. Y.** (2018). Aquaculture in Pakistan: Challenges and opportunities. IJFAS., 6: 56-59.
https://www.fisheriesjournal.com/archives/2018/vol6issue2/PartA/6-1-14-432.pdf

**Migaud, H.; Bell, G.; Cabrita, E.; McAndrew, B.; Davie, A.; Bobe, J and Carrillo, M.** (2013). Gamete quality and broodstock management in temperate fish. Reviews in Aquaculture., 5: 194-223. https://doi.org/10.1111/raq.12025

**Mundorff, M. J and Travis, W. I.** (1962). *Water supply for a fish hatchery site, Clearwater Valley, Idaho*, Report. (No. 62-94). US Geological Survey. https://doi.org/10.3133/ofr6294

**Nwadukwe, F. O.** (1993). Inducing oocyte maturation, ovulation and spawning in the African catfish, Heterobranchus longifilis Valenciennes (Pisces: Clariidae), using frog pituitary extract. Aquaculture Research., 24:625-630.
https://doi.org/10.1111/J.1365-2109.1993.TB00638.X

**Olaoye, O. J.; Idowu, A. A.; Omoyinmi, G. K.; Ezeri, G. O and Oke, A. O.** (2011). Factors determining fish hatchery operations in Ogun State, Nigeria. J. Agric. Ext. Rural Dev., 3: 172-181. https://doi.org/academicjournals.org/JAERD

**Opuszynski, K and Shireman, J. V.** (2019). Book Herbivorous Fishes Culture and Use for Weed Management. CRC Press. https://doi.org/10.1201/9780429266461

**Rahman, M. A.; Lee, S. G.; Yusoff, F. M and Rafiquzzaman, S. M.** (2018). Hybridization and its application in aquaculture. Sex control in aquaculture., 1: 163-178. 10.1002/9781119127291.ch7

**Rahman, M. A.; Ullah, M. R.; Kabir, M. A.; Alam, M. A.; Rahman, M and Hossen, M. F.** (2020). Artificial propagation of indigenous yellowtail catfish (Pangasius pangasius): Experiences and challenges. Aquaculture., 523; 735215 https://doi.org/10.1016/j.aquaculture.2020.735215

**Russell, D. J.** (2008). Towards responsible native fish stocking: identifying management concerns and appropriate research methodologies. http://era.daf.qld.gov.au/id/eprint/2408/1/FRDC_2008-Towards-responsible-native-fish-stocking.pdf

**Stickney, R. R.** (2005). Aquaculture. In book: Encyclopedia of Coastal Science., 33-38 (pp. 33-38). Springer Netherlands http://doi.org/10.0.3.239/1-4020-3880-1_9

**Tekwombuo, J and Thorarensen, H.** (2013). Hatchery design and brood stock management policy as a tool for sustainable aquaculture: case of Cameroon. The United Nations University, Fisheries Training Program, Final Project report, 22. http://www.unuftp.is/static/fellows/document/joseph13prf.pdf

**Titcomb, T. J.; Bisht, B.; Moore III, D. D.; Chhonker, Y. S.; Murry, D. J.; Snetselaar, L. G and Wahls, T. L.** (2020). Eating pattern and nutritional risks among people with multiple sclerosis following a modified paleolithic diet. Nutrients., 12: 1844. https://doi.org/10.3390/nu12061844

**Valenti, W. C and Daniels, W. H.** (2007). Recirculation Hatchery Systems and Management. Freshwater Prawn Culture: The Farming of *Macrobrachium Rosenbergii*., 69-90. https://doi.org/10.1002/9780470999554

**Wang, Q.; Cheng, L.; Liu, J.; Li, Z.; Xie, S and De Silva, S. S.** (2015). Freshwater aquaculture in PR C hina: trends and prospects. Reviews in Aquaculture., 7: 283-302. https://doi.org/10.1111/raq.12086