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Evaluation of Growth Performance, Survival Rate, and Proximate Composition of Garra (*Garra quadrimaculata*) Cultured in Earthen Ponds Using Local Feed Ingredients

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List of Acronyms

CD	Cattle dung
CFF	Commercial fish feed
CP	Crude protein
DGR	Daily growth rate
DO	Dissolved oxygen
EC	Electric conductivity
FAO	Food and Agriculture Organization
FCF	Fulton’s’ condition factors
FCR	Food conversion ratio
GIS	Geographic Information System
pH	potential of hydrogen
PM	Poultry manure
RGR	Relative growth rate
SR	Survival Rate
TDS	Total dissolved solid
WG	Weight gain

Abstract

Garra is one of the fish species found in sub-Saharan Africa and it is a bottom feeder in their environment. Even though there is no proven evidence explaining why genus Garra is hardly used for food in Ethiopia, there are some assumptions. These include small size of the fish, absence of scientific reports demonstrating the acceptable macronutrient and mineral composition of the fish for human consumption, and a lack of awareness on aquatic resource utilization in the country. Therefore, this study aimed to evaluate the biological characteristics, feed utilization and nutritional values of cultured Garra and compare these with wild Garra based on existing literature for human consumption. Fish feed ingredients were collected from locally available sources and formulated at contain 35% of crude protein (CP). Fingerlings of Garra were collected from Gilgel Gibe reservoir, then stocked with the average weight 0.28g. A total 120 Garra fish fingerlings with same initial size was introduced into two ponds aquaculture and feed on the same basal diets for three months. Growth performance (weight and length) was measured every fortnight and survival rate was assessed. Finally fish was randomly selected from the ponds for nutritional analyses. The proximate composition results were compared with wild, whole Garra. Further, the data collected was subjected for statistical analysis. The average weight gain of the fish was 6.7 ± 0.77*g, specific growth rate was 1.41 ± 0.25g and food conversion ratio (FCR) was 1.84 ± 0.01%. The result revealed that the crud protein (13.47%) wet weight, fat (11.94%), ash (2.39%) and moisture (71.35%) content in cultured Garra except carbohydrate (1.6) were higher than wild Garra of, which had crude protein (9.58%), fat (2.73%), moisture (69.1-77.6%). Thus proximate composition cultured Garra higher than the wild Garra due to the supplementation of local feed. The average weight gain was 3.433 ± 0.768g and 96.67% of fish survived. The water quality parameters showed no significant difference between ponds. Moreover, the plankton diversity in the ponds during the culture period was not significantly different; however, since Garra is a bottom feeder, the ponds were frequently covered by algal blooms. Further study, including the analysis of essential and heavy metal accumulation and the blood biochemistry of the fish, is needed before recommending Garra as a full aquaculture candidate species.*

Key words: - *Cultured Garra, Garra quadrimaculata, Gilgel Gibe, Proximate composition, Wild Garra*

1. Introduction

1.1 Background of the study

Fishes are an important source of dietary protein and other nutrients for humans, contributing significantly to food security in many countries worldwide (FAO, 2009). However, the fact that, capture fisheries production is declining while culture fisheries production provides approximately 50% (63 million tons) of the fish consumed globally is no longer a breaking news story (Omosowone *et al*., 2018).

Among the aquaculture fish species the genus *Garra*, which has roughly 12 species of tiny barbs in the family *Cyprinidae*, is extensively dispersed throughout Ethiopia water bodies (Getahun, 2000). The groups of cyprinid fish species commonly known as stone lapping minnows of the genus *Garra* are distributed from Borneo, China and Southern Asia through the Middle East, Arabian Peninsula and East Africa to West Africa (Stiassny & Getahun, 2007).

To date, close to 78 species have been recognized in the genus (Zhang, 2005), 17 being from Africa (Getahun, 2000). Most *Garra* species occur in freshwaters, though there appears to be a report on one species from brackish or salt water (*G. tibanica* later synonimized with *G. quadrimaculata*) (Trewavas, 1941). No fossil evidence of *Garra* has so far been found. Although no clear center of origin or route of dispersal for the genus is proposed, a variance-dispersal based on recovered phylogeny and the geologic history was suggested by Getahun (2000). This assumption considers India or coastal Africa as center of origin.

The Ethiopian water systems have been described basins alone contain 75% of *Garra* species found in Ethiopia; however, these small-sized species have not received much attention because most studies in northeastern Africa tend to focus on the biology or fishery potential of commercially valuable fish species such as Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*), and *Labeobarbus* spp. (Dejen *et al*., 2002 and Getahun, 2007). Although there is no conclusive proof as to why the genus *Garra* is rarely used for food in the nation, there are some hypotheses, such as the small size of the fish, the lack of scientific studies demonstrating the acceptable macronutrient and mineral composition of the fish for human consumption, and the lack of knowledge regarding the utilization of aquatic resources in the nation (Bayissa *et al.*, 2022).

Smaller fish species may be even more nutrient-dense than the bigger fish (Larsen *et al*., 2000). Smaller fish species may be even more nutrient-dense than larger fish (Larsen *et al*., 2000). Additionally, the genus Garra has ecological importance in fisheries, serving as prey for commercially important fish species like African catfish (*Clarias gariepinus*) and Labeobarbus (*Labeobarbus intermedius*) in the country (Elias Dadebo, 2000). Despite this, the numerous species of the genus Garra have been overlooked, even though they could play a significant role in aquatic food production. Scientific work is needed to evaluate their biological characteristics and explore how these species can be integrated into aquaculture for human consumption (Bayissa et al., 2022).

Garra *quadrimaculata* in the lake consumes widea range of foods, including phytoplankton, detritus, *macrophytes*, insects, fish eggs, and zooplankton (refrences). Among this Fish eggs, *macrophytes,* phytoplankton, and insects made up the majority of the food volume among this detritus and were more commonly observed in the guts of G. *quadrimaculata (references)*. On the other hand, zooplanktons contribute relatively little to the food volume and were only present in a limited number of the studied guts, according to (Tekle *et al*., 2016).

The feeding and culturing of *Garras'* in earthen pond is crucial for the development aquaculture. Proper management and utilization of this resource require fundamental knowledge on culturing, feeding, and understanding of nutritional profile both from wild and under culture condition. However, there have been no studies in Ethiopia *Garra* rearing and feeding in fish pond, the differences in nutritional profile of cultured *Garra*, or the preparation of feed for this species under cultured conditions.

Therefore, the aim of this study was to investigate the biological characteristics, including growth performance and survival rate, as well as the nutritional values and feed utilization of *Garra* under controlled conditions. This study aims to provide baseline scientific information on how this species can be integrated into aquaculture for human consumption.

1.2 Statement of problem

Even though the use of *Garra* in commercial fisheries and aquaculture has not yet fully developed (Driessen, 2002), proper management and utilization of this resource require basic knowledge on its biological needs for further culturing in an aquaculture setting. This includes understanding growth performance, feed utilization, survival rate, and nutritional quality for human consumption standards. So far, the nutritional values of whole *Garra* from the wild have been reported (Bayissa *et al*., 2022).

To the best of my knowledge, there is no report on the culture trial, adaptability, and nutritional value of *Garra* under human-controlled conditions. However, understanding the proximate composition Garra cultured pond environments will enhance knowledge on the culturing and biology of *Garra* species, which is important for aquaculture development.

Therefore, the present study focused on the growth performance, feed utilization, survival rate, and nutritional quality for human consumption standards of *Garra* (*Garra quadrimaculata*) cultured in earthen ponds. These results were then compared with the nutritional values of wild *Garra* based on existing literature.

1.3. Objectives

1.3.1. General Objective

- To evaluate growth performance, survival rate, and proximate composition of garra (*Garra quadrimaculata*) cultured in earthen ponds using local feed Ingredients

1.3.2. Specific Objectives

- To evaluate the growth performance and feed utilization of *Garra* reared in earthen ponds,
- To compare the proximate composition of *Garra* from cultured and wild sources
- To assess the pond zooplankton and phytoplankton diversity during culture period.

1.4. Significance of the Study

The findings of this study will provide scientific information on the effects of rearing *Garra quadrimaculata*, in earthen fish pond on its growth performance, feed utilization parameters, survival rate, proximate composition and mineral accumulation compared with wild *Garra* fish species. In addition, it provide the baseline information on the aquaculture *Garra* in earthen fish pond and their difference on proximate composition in earthen fish pond and contributes to practical knowledge on *G. quadrimaculata* culture and feeding *Garra* aquaculture development in Ethiopia. Further the findings of this study will serve as baseline information for further researches.

2. Literature Review

2.1 Global Aqua Culture

Over the past 20 years, wild aquatic catches have stagnated while aquaculture has been growing rapidly over the world (FAO, 2020a). The earliest species to be domesticated for food production was the common carp, and aquaculture has a long history, having begun in China at least 1000 BCE (Rabanal, 1988). Aquaculture stayed a low-tech, small-scale industry for centuries. However, there was a major change in the late 20th century. Modern, intense aquaculture practices emerged as a result of technological advancements and worldwide information sharing (Rabanal, 1988). With continuous developments in culture methods, selective breeding for genetic improvement, and feed production, these breakthroughs are revolutionizing the sector (Naylor *et al.*, 2021).

Production from fisheries and aquaculture worldwide is at an all-time high, and in the future, this sector will become more and more important for supplying food and nutrition. With 87.5 million tons of aquatic animals valued at USD 264.8 billion and 35.1 million tons of algae valued at USD 16.5 billion, the world's aquaculture production hit a record high of 122.6 million tons in 2020. Around 54.4 million tons were generated by inland aquaculture, compared to 68.1 million tons by marine and coastal aquaculture (FAO, 2022). Approximately 97 percent of the 120 million people who rely on fishing for a living are in developing nations, and over 90 percent of them engage in small-scale fishing. Small-scale fisheries produce more than half of the world's fish catch, with 90–95% of that catch being consumed locally (FAO, 2020).

2.2 African Aquaculture

The First Regional Workshop on Aquaculture in Sub-Saharan Africa (SSA) was arranged by FAO in July 1975 (Huntington, T. et al., 2009). This workshop acknowledged the sector's significance and the importance that numerous governments have placed on it. The 1976 FAO Conference on Aquaculture, which took place in Kyoto, Japan, followed this and established a strategy for the growth of aquaculture (Huntington, T. et al., 2009). This strategy was technology-centered and concentrated on using regional initiatives to transfer tried-and-true technologies. Aquaculture production in Africa has been rising over the past few years, but expansion in the sector has been sluggish despite the continent having some of the highest untapped potential for aquaculture (Msangi and Batka, 2015).

Aquaculture production in Africa has begun a steady phase of increase, despite its current small size. An estimated 121 905 tonnes were produced in 1997, which is more than three times the 36 685 tonnes that the Food and Agriculture Organisation of the United Nations (FAO) recorded in 1984. Aquaculture's share of total fish intake, while still very small at 1.3%, increased from 50 g per person in 1984 to 100 g per person in 1992, while the production of catch fisheries has stagnated at roughly 8 kg per person (FAO, 1995). It will take a new interactive partnership between researchers and farmers to implement an evolutionary method in Africa (Brummett and Haight, 1997). The bulk of agricultural producers operate at the smallholder level, where this transition will most profitably start. The incorporation of aquaculture into current farming systems is a possible entrance point. Studies conducted in Malawi (Stewart, 1993; Brummett and Noble, 1995; Scholz and Chimatiro, 1995) and Ghana (Prein, 1994; Ruddle, 1996) have demonstrated the potential to boost productivity and profitability when a fish pond is integrated into a farm in a way that recycles waste from other household and agricultural businesses.

In terms of the technology used, the natural resources accessible, and the value chain designs, Africa's aquaculture business is tremendously diversified. 82% of production quantities are in inland waters, which is where it primarily happens (FAO, 2021). The top ten countries in the world for aquaculture production value growth (2018) Rank Value growth by nation, US$ '000, 2009–2018 CAGR (%) for each nation 1 Egypt (803,476), Burundi 49 3 Rwanda 60 2 Lesotho 40 5 Nigeria 408,993 Tunisia 60,955 Ghana 252,846 Benin 52,915; Tanzania 45 4; Uganda 95,385 34 6 Tanzania Senegal 30 7 46,788 Madagascar 45,160 Zambia; 27,9 Ghana; 29, 8 Angola; 38,851 Malawi 22 38,072 South Africa, 40,072 Kenya, and 26 10 Niger.

Table 1. Top ten countries in the world for aquaculture production value growth (2018)

Rank	Country	Volume growth 2009-2018 (tons)	Country	CAGR (%)
1	Egypt	888,741	Rwanda	50
2	Nigeria	138,527	Burundi	41
3	Ghana	69,476	Lesotho	37
4	Uganda	27,083	Benin	32
5	Zambia	21,060	Senegal	32
6	Tunisia	16,919	Ghana	27
7	Tanzania	11,130	Angola	21
8	Kenya	10,825	Malawi	19
9	Sudan	10,000	Mauritius	17
10	Zimbabwe	8,255	Tunisia	16

Note: Calculated for countries with >1000 tonnes of aquaculture production (2018); CAGR = compound annual growth rate Data source: FAO (2021).

The procedures used in modern aquaculture are very varied. The most intense rearing regimens are demonstrated by recirculating aquaculture systems, which provide high production per unit area and effective economies of scale (Ebeling & Timmons, 2012). Innovative technologies such as the biofloc system, which turns waste into useable feed components, and plant-based alternatives have replaced the need of wild-caught fishmeal and fish oil in animal feed (Avnimelech, 2009; Bossier & Ekasari, 2017; Kuhn *et al.*, 2010).

2.2.1 Aquaculture in East Africa

The breeding of aquatic organisms, or aquaculture, has come to light as a potential way to supply East Africa's expanding fish demand. Capture fisheries are at capacity, but aquaculture provides a sustainable way to augment diminishing fish populations. Even though it has been used in the area since the 1900s, its share of the overall fish yield is still quite small (Mwanja *et al*., 2017).

Fish farming, or aquaculture, has gained popularity as a potential way to supply East Africa's expanding fish demand. Aquaculture provides a sustainable substitute to augment diminishing fish stocks, as catch fisheries have reached their maximum capacity. It has been around since the 1900s, although its contribution to the region's overall fish production is still quite little (Mwanja *et al*., 2017). Key constraints must be addressed in order to realize this potential. Getting access to investment cash, finding high-quality fish feed, and learning about profitable and sustainable fish farming techniques are all obstacles that East African aquaculture must overcome. Another limitation is the supply of young fish for aquaculture, or fingerlings, of high quality (Mwanja *et al*., 2013).

2.2.2 Aquaculture in Ethiopia

Ethiopia has abundant freshwater and fish resources, a climate that is favorable for farming, a lot of labor, and unmet neighborhood demand for fish. However, the country's aquaculture industry is not progressing as quickly as other agricultural sectors (Zewdie, 2016). The advancement of agriculture and economic growth have benefited greatly from Ethiopian agricultural research. Given the growing need for food and feed while the available resource base is diminishing, overcoming the issues of the future is probably going to be considerably harder than it is now. The hard-won advancements in agricultural growth made in the past must be maintained in the current climate, and this requires robust research support (Alemu *et al*., 2016).

Ethiopia's fishing industry is hindered by a number of issues, including inadequate supply chain management systems, inadequate infrastructure at fishing locations, inadequate transportation, and a lack of technologies for harvesting and processing fish. (Wake *et al*., 2019). According to Alemu et al. (2016), the Ethiopian government has suggested aquaculture as a way to increase food security and reduce poverty, and it is currently seen as a crucial component of plans and strategies for rural and agricultural development.

2.3 Role of Aquaculture in Development

While most African nations saw an increase in aquaculture's share of their national GDP between 2009 and 2018, it remained very small, at less than 2 percent in 2018.

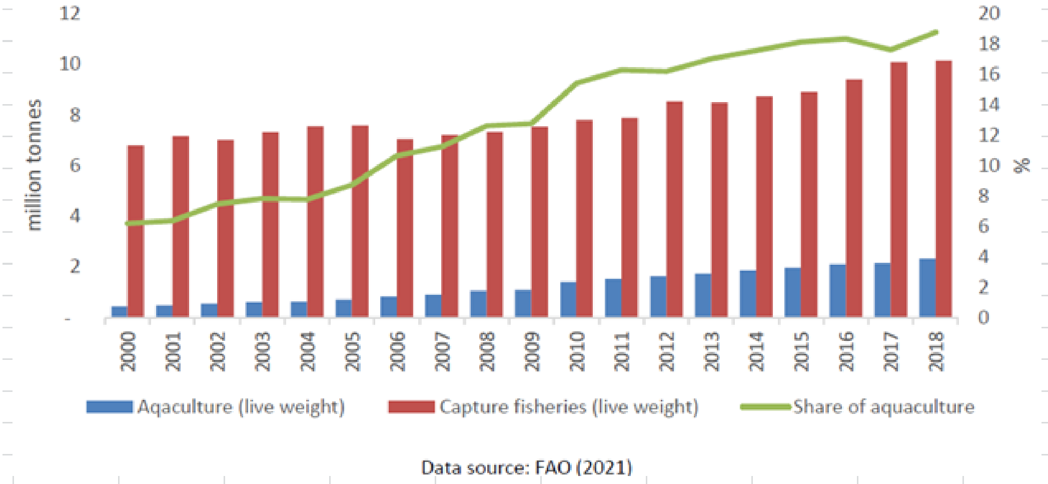


Figure 1.Contribution of aquaculture in total production of aquatic foods in Africa

2.3.1 Contribution to Food Security and Nutrition

Food Security and Nutrition: Especially in developing nations, aquaculture is essential to improving food security and dietary diversity. For millions of people, it offers a dependable source of vitamins, vital fatty acids, and protein. Aquaculture contributes to Sustainable Development Goal (SDG) 2: Zero Hunger by raising fish output, which reduces hunger and malnutrition (FAO, 2020).

The transformation of global food production and distribution systems is necessary to achieve the goals of food and nutrition security within environmental constraints. This dual challenge will become increasingly important to address as the world's population approaches 10 billion by 2050, as socio-economic demographics change, and as dietary trends shift towards more resource-intensive foods (Tilman and Clark 2014; Springmann *et al*. 2018; Willett *et al*. 2019).

Increasing aquaculture production will have an environmental cost, just like any other method of producing food. Around 460 species/groups of algae, shellfish, and finfish are raised in freshwater, brackish, and marine environments using a wide range of technologies. As a result, production systems and feed requirements are highly diverse. As a result, environmental impacts, including those related to energy use, water reliance, feed inputs, genetic risks, and nutrient and pollutant release, vary greatly (Troell *et al*. 2014; Tacon 2020). The effects of production on ecosystems are mostly determined by local and regional environmental conditions, including those pertaining to effluent accumulation and the susceptibility of wild species (Aguilar-Manjarrez *et al*. 2017).

In the global effort to fight poverty and malnutrition, aquaculture is essential. Via fish and other aquatic products, it offers vital protein, fatty acids, vitamins, and minerals. Moreover, aquaculture advances development through producing revenue, opening up job possibilities, and encouraging the effective use of resources. In Asia alone, aquaculture reportedly directly generated 12 million full-time jobs by 2004 according to the Food and Agriculture Organization of the United Nations (FAO, 2006b). Several developing nations in Asia and Latin America rely heavily on it for their gross domestic product (GDP) (FAO, 2006c). Aquaculture can help ensure global food security by filling the projected shortage of fish in the upcoming decades, provided it is managed responsibly.

The availability, accessibility, and utilisation of food for optimal health and nutrition are all aspects of the complex notion of food security. By boosting the supply of aquatic items through local farming and international trade, aquaculture increases the availability of food (Subasinghe *et al.*, 2009). By producing nutrient-dense and high-energy aquatic goods, it also improves the quality of food. Fish consumption has been linked to several health advantages, including the prevention of heart disease and support for vulnerable populations such as pregnant women, newborns, and young children (Subasinghe *et al.*, 2009). Fish consumption is still lower in developing countries even if it has increased dramatically in wealthy ones. Nevertheless, by 2002, fish from aquaculture as well as fisheries accounted for 12% of all protein consumed worldwide (FAO, 2006g). Access to food is critically dependent on affordability. Through increased revenue from product sales and job opportunities, aquaculture gives farmers more authority and improves their household's discretionary income and capacity to buy food. Furthermore, aquaculture can lower prices and make aquatic products more affordable for local customers by expanding their availability in domestic marketplaces (Subasinghe *et al.*, 2009).

2.3.2 Economic Benefits and Sustainability of aquaculture

Beyond the advantages for individuals and households, aquaculture generates profits, tax income, and export earnings that support the economic prosperity of a country. The productivity of labour and capital can be greatly increased by well-developed infrastructure and human capital investments, which will help local enterprises and promote rural development. It is possible to expand aquaculture for the production of food fish in a sustainable manner using current resources and technological developments. That being said, it is imperative to guarantee that the socio-economic advantages of the industry are distributed over a wide range of society (Subasinghe *et al.*, 2009). The main task facing development organizations and legislators is creating a "enabling environment" that will allow aquaculture to expand sustainably. According to (Subasinghe *et al.*, 2009) climate calls for strong political, consistent policies, public sector support, and ongoing investment. Long-term sustainability depends on finding a balance between the requirements of society, protecting the base of natural resources, and sustaining the sector's growth.

2.4 The *Garra* Species Distribution

The groups of cyprinid fish species commonly known as stone lapping minnows of the genus *Garra* (Hamilton 1922) are distributed from Borneo, China and Southern Asia through the Middle East, Arabian Peninsula and East Africa to West Africa. To date, close to 78 species have been recognized in the genus (Zhang, 2005), 17 being from Africa (Getahun, 2000). Most *Garra* species occur in freshwaters, though there appears to be a report on one species from brackish or salt water (*G. tibanica later synonimized* with *G. quadrimaculata*) (Trewavas, 1941). No fossil evidence of *Garra* has so far been found. Although no clear center of origin or route of dispersal for the genus is proposed, a vicariance-dispersal based on recovered phylogeny and the geologic history was suggested. This assumption considers India or coastal Africa as center of origin (Getahun, 2000).

The genus *Garra* is widely distributed in Ethiopia and contains about 12 species of small barbs that belong to the family *Cyprinidae*. The minnow *G. quadrimaculata* is mainly found in the Arabian Peninsula (Saudi Arabia and Yemen), south-eastern Eritrea, south-eastern Ethiopia, and possibly also in Somalia (Froeser and Pauly, 2000).

The species is indigenous and it is found in many of the Ethiopian Rift Valley lakes including Lake Hawassa. It is benthopelagic, non-migratory, freshwater fish that thrives in tropical climate (Froeser and Pauly, 2000). *G. quadrimaculata* grows to a maximum of 15 cm (TL) and a weight of 40 g (Elias Dadebo, unpublished data). Different *Garra* species eat foods of animal and plant origin. The proportion of these food items is usually correlated with the gut length of the fish (Froeser and Pauly, 2000).

2.5 Feeding habit *Garra quadrimaculata*

According to Tekle *et al*., (2016), *G. quadrimaculata* fed on a variety of food items including, phytoplankton, detritus, macrophytes, insects, fish eggs and zooplankton. The feed habit of *Garra quadrimaculata* in Lake Hawasa detritus was the most dominant food item and it occurred in 54.9 % of the guts and accounted for 27.1 % of the total volume. Fish eggs were the second important food items occurring in 16.2% of the guts and comprising 22.2 % of the food volume. Macrophytes occurred in 43.9 % of the guts and accounted for 18.2 % of the total volume. Phytoplankton occurred in 56.4 % and contributed 18.2% of the volume of the food. Among the identified phytoplankton, diatoms and green algae were plentiful and frequent food.

They accounted for 9.4% and 6.9% of the total food volume, respectively. Among insects, Diptera (7.4% by volume) and Ephemeroptera (6.4% by volume) were the most important while Coleoptera and Hemiptera had minor contribution as food items. Again among identified zooplankton in the gut, copepods had relatively more contribution (0.2%) than rotifers (0.02%) (Tekle *et al.*, 2016). No published work is available on the food and feeding ecology of *G. quadrimaculata* in water body of Ethiopia and the present will compare the cultured *Garra* with Geligel gibe reservoir. Accordingly, compared to *G. quadrimaculata* in Lake Hawassa, the food item of *G. rufa* in Asi River and its tributaries (Turkey) is dominated by benthic algae (*Cyanobacteria*, *Chrysophyta* and *Chlorophyta,)* with being the most common, as well as rotifers and protozoans (Yalçin-Özdilek and Ekmekçi, 2006).

2.6 Reproduction of *Garra*

The Gonad Somatic Index (GSI) for *Garra* species varied with between seasons (periods). Higher GSI values were recorded between March and June. After June the GSI values progressively dropped and lower values were recorded during January and November. The cycle in GSI was also reflected in the monthly variation in the frequency of females with ripe ovaries (Geremew *et al.,* 2007).

2.7 Chemical composition of *Garra*

Important trace elements like Zn and Fe appear to be present in high concentrations over the entire *Garra*, although this was not the case for the entire *Labeobarbus*. Since *Garra* is more benthic than pelagic, for example, these distinctions may have their roots in the lake fishes' feeding habits (Bayissa *et al.,* 2022).Therefore shortly nutritive value of fishes differs greatly in the types of food they consume, and the differences in nutrient composition between wild and farmed fish of even identical species as Bayissa *et al.* (2022) those researchers (Hossain, 2011; Kaushik *et al.,* 2006; Orban *et al.,* 2003). There is some research done that described about the chemical composition of another *Garra* species in developed country under human control but, in developing countries like Ethiopia only from the natural water bodies the *Garra* species of chemical composition was studied. However, research did not studied about chemical composition of *Garra* species cultured in earthen ponds.

2.8 Water Quality and Its Effects on the Growth of Garra

As stated by Arulampalam et al. (1998). A vital component of every aquaculture system is water quality. It is crucial to fish health, and any decline in water quality stresses and sickens fish (Arulampalam et al., 1998). Every water quality metric influences and interacts with the others, sometimes in intricate ways. Fish require healthy water conditions to survive and flourish because their entire life cycle is reliant on the quality of their surroundings (Devi et al., 2017).

The term "water quality" refers to the general state of the water that is necessary for aquatic creatures to thrive to their full potential. The physical, chemical, and biological components of water quality affect how it should be used for fish culture. Dissolved oxygen, pH, hardness, turbidity, alkalinity, ammonia, and temperature are some of these variables. Additional factors, such chemical and biological oxygen demands, show how contaminated a particular body of water. The physico-chemical properties of the water body influence productivity (Keremah et al., 2014). In a larger sense, water quality is the culmination of all a water body's physical, chemical, and biological properties (Boyd, 1990). Water that is contaminated or lacking in optimal physical and chemical characteristics (pH, dissolved oxygen, total nitrogen, total phosphorus, nitrite, nitrite and ammonia) and poor management practices can cause a series of physiological alteration on growth and even survival of aquatic animal (Ni Meng *et al*., 2018).

2.8.1 Temperature

Fishes are cold blooded animals whose body temperature is governed by their surrounding environment and hence their metabolism and physiology is ultimately affected by their environment (Bhatnagar & Devi, 2013). Water temperature is controlling factor for all aquatic life. All biological and chemical processes in an aquaculture operation are influenced by temperature. It is one of the most important external factors which influence fish production. At temperatures above or below optimum, fish growth is reduced and mortalities may occur at extreme temperatures (Buttner, 1993). The range of water temperature from 26.06 to 31.97ºC is suitable for warm water fish culture and temperature range between 25 and 32ºC is ideal for tropical fish culture (Devi *et al.*, 2017).

2.8.2 Ammonia (NH3)

Ammonia is the principal nitrogenous waste produced by aquatic animals, via metabolism and is excreted across the gills (Cao *et al.*, 2007). Ammonia strongly influences the dynamics of the dissolved oxygen in water, since 4.6 mg of oxygen is needed to oxidize 1.0 mg of ammonia. Ammonia levels between 3 and 4 mg/l may be toxic for tropical fish (Boyd, 2001). Ammonia in the range >0.1 mg L^{-1}1tends to cause gill damage, destroy mucous producing membranes, “sub- lethal” effects like reduced growth, poor feed conversion, and reduced disease resistance at concentrations that are lower than lethal concentrations, osmoregulatory imbalance, kidney failure (Bhatnagar & Devi 2019).

2.8.3 Dissolved Oxygen (DO)

Dissolved oxygen is an important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. DO concentration of 5 mg/l throughout the year in the reservoir is productive for fish culture (Devi *et al*., 2017).

Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of shrimps and other aquatic organisms (Bhatnagar & Devi, 2019). The principal source of oxygen in water is atmospheric air and photosynthetic planktons. Obtaining sufficient oxygen is a greater problem for aquatic organisms than terrestrial ones, due to low solubility of oxygen in water and solubility decreases with factors like- increase in temperature; increase in salinity; low atmospheric pressure, high humidity, high concentration of submerged plants, plankton blooms. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth and more fish mortality, either directly or indirectly (Bhatnagar & Garg, 2000).

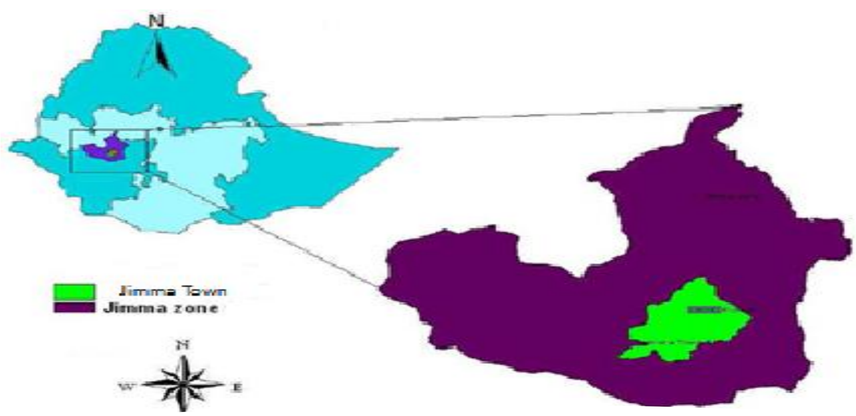
2.8.4 pH

Physico-chemical parameters exert an immense influence on growth and survival of different stages of the fish embryo, larvae, fry, and fingerlings, and thus determining the optimal water quality variables is highly important for any aquaculture fish farming. Among the variables, water pH is considered the main factors affecting water quality (Marimuthu *et al*., 2019). Hydrogen ion concentration plays a significant role in the productivity of a reservoir. Normally pH range from 6.4 to 8.3 is favorable for fish growth. The pH limit for protection of aquatic life is 6.0 to 8.5 (Devi, *et al*., 2017). For most freshwater fish species, the ideal pH value is reported to be from 6.5-9.0 (Boyd, 1990). The deviation in water pH from the normal range will adversely affect fish growth, survival, and reproduction and causes high mortality in fish culture ponds (Zweig *et al*., 1999). A water pH level of 6.7 – 7.5 is highly recommended for optimal hatching and larval survival for African catfish seed production and hatchery management (Marimuthu *et al*., 2019).

3. Materials and Methods

3.1 Description of the study area

This study was conducted at Jimma University main campus, College of Natural Sciences, Department of Biology. Jimma University is located in the city of Jimma, around 352 km southwest of Addis Ababa, Ethiopia, at latitude of 7°40´N and a longitude of 36°50´E. Jimma has an altitude of 1780 m above mean sea level (masl) with the mean daily temperature and annual rainfall of the study area is 20.71°C and 123.01mm, respectively (Jimma Meteorological Station, 2019).



Map of Jimma Town (*Solomon and Ketema, 2011*)

3.2. Study design

The total of 120 *Garra* was cultured in two equal earthen ponds with the same average weight and length at the same stocking density of 60 fish randomly. The stocked experimental fish was fed a local basal diet that was formulated at 35% CP from local ingredients for three months. 60 *Garra were* captured from natural water body to determine the different of proximate composition content of wild and cultured meat using the *Garra*.

3.3. Local Feed Ingredients Collection and Preparation

First the feed ingredients were identified based on low cost, presence and protein content planed. Those local available feed ingredients used were poultry manure, rumen liqueur and cattle blood. Those ingredients were collected and prepared in different ways and place. For instance, poultry manure was dried using sun light by poultry farm workers by the procedure of (Ghaly *et al*., 2012). The cattle blood collected from Jimma City Abattoir and dried using tent dry that was constructed 2m width, 4m length, 0.7m height from ground at Jimma university main campus aquaculture site. It was taken seven days to dry (Hasan *et al*., 2019). Rumen liqueur was collected again from Jimma City Abattoir and dried in one of house which found there by air and it taken two weeks to dry (Fig 2).

Figure 2. Drying the collected cattle blood and rumen liquor

3.4 Experimental diet formulation

After preparing all the experimental diet ingredients, for experimental diets were formulated to have the same nitrogen content. This was achieved by adjusting the crude protein content to 35% based on the major ingredients content using Pearson's square method. In this methods, the ingredient with a higher protein content than required was placed in the top left corner of the square, while those with lower protein content were placed in the bottom left corner. The difference between the two was placed in the opposite position in the top right corner. This value was then divided by the sum of the differences to determine the quantity required. All the ingredients were thoroughly mixed; water was added to form dough. The dough was then pelletized using a pelletizing machine with a 3mm die. The pellets were air-dried, packed in plastic bags, and stored in a moisture-free environment until used in the experiments (Fig.3).

Figure 3. Feed formulation from different ingredients and processing

Table 2.Mean weights (± SD) (g) changes of Garra fed on basal diet

Ingredient	Crude protein in %	Information sources
Poultry manure	24.5	Ghaly *et al*., 2012
Dried rumen liqueur	19.56	Agbabiaka *et al*.(2012)
Dried cattle blood	80	Hasan *et al*., 2019: Tacon, (1995).

3.5. Source of experimental fish

Garra fingerling was collected from Gilgel gibe using net. The fingerlings were transported to Jimma University main campus aquaculture site following the fish fingerling transportation procedure of Woynarovich & Horváth (1980). The fingerlings were acclimatized for 14 days during which they fed on basal diet. Then total fishes' weight and lengths were measured nearest to 0.01g and 0.01cm respectively before stocked. Fish with same average weight and length were stocked randomly in two earthen fish ponds, that each has $20m^2$ areas. The *Garra* have uniform size (about 0.282g) were stocked in two earthen ponds with the 60 fish per pond stocking densities (Fig.4).

Figure 4. Experimental fingerlings of Garra selection to stock in earthen ponds

3.6 Feeding *Garra*

The stocked *Garra* was fed a local basal diet that was formulated at 35% crude protein. The *Garra* was feed two times per a day (at 10am and 4pm) during this study conducted for three months with 10% of their body weight. The fed given to the fish was adjusted every fortnight after weight determination was did.

3.7 Measuring Water Quality Parameters

Water quality parameters (temperature, Dissolved oxygen, electric conductivity and total dissolved solids) were measured and record daily morning and afternoon to evaluate the impact of *Garra* rearing in earthen pond with feeding local basal diet. The T ^{0}c (temperature of water), DO mg/L (dissolved oxygen), EC µs/cm (electric conductivity), salinity/ppt and TDS mg/L (total dissolved solids) were measured weekly using the *multi physic parameters (Palintest MICRO 800 model)* before feeding the fish at 9 am and 4 pm two times per day. Nitrogen compounds such as Ammonia nitrogen (NH_3-N), Ammonium (NH_4^+), Nitrate (NO_3-N), and Nitrite (NO_2-) were measured three times (at the beginning, middle, and at the end) of the experiment using *multi-parameter of palintest (Photometer 7500 model) (Fig.5).*

Figure 5.Measuring water quality parameters of experimental ponds

3.8 Measuring growth performance of *Garra*

The growth performance parameters (weight and length) of this study data was recorded by randomly selecting 50% of fish from each fish pond. During the sampling fish was collected using a net from the pond. The total weight and length of fish was recorded by using electronics balance and measuring board, respectively, at every two weeks intervals. Total length and weight was measured to the nearest 0.1 cm and 0.1 g, respectively. At end of experiment the final weight and total length of randomly taken the *Garra* from each fish pond was recorded (Fig. 6).

Figure 6. Measuring length and weight of experimental fish

3. 9 *Garra* Whole Sampling

The 50% whole fish were sampled from each fish ponds totally 60 fish from two ponds and fish from Gilgel gibe reservoir was sampled with different weights (small, medium fish and large fish) compared the proximate composition with the cultured in earth pond for three months. The whole fish sampled was done at the end of study period from both culture and wild *Garra*, namely in March 2023 at the same time.

3. 10 Proximate Composition analyses

Analyses the fish samples for moisture, ash, crude protein and fat contents were carried out according to the standard AOAC methods (Horwitz *et al.*, 1970; Ayuba & Iorkohol, 2010). Moisture content was determined using oven drying method at 105 ^{0}C until to constant weight whereas ash content was determined by incineration of the dried fish sample in a muffle furnace at 550^{0}C for 3 hours (AOAC 920.153). Crude protein was determined by estimating the nitrogen content (% protein = N x 6.25) of the fish samples using the micro-Kjeldahl procedure (AOAC 928.08), while total fat was determined by Soxhlet extraction used methanol (AOAC 991.36) (Isah *et al*., 2021).

3.11 Identification and Quantification of Plankton

Plankton sampling was conducted using plankton net every two weeks for identification and quantification following standard procedures. The plankton samples were examined under the compound microscope with magnification power of 40X and 100X. Genus or species identification was made using identification key of Hlilarv and Erica (1976) and Fernando (2002). Following identification, the numerical abundance of major taxa was quantified.

3.4 Data Analysis

In this experiment, the proximate composition of *Garra quadrimaculata* of wild (Gilgel gibe) and the cultured ponds mean differences between the two groups were checked using the two-sample-T-test. In addition, the growth performance of Garra (L-W, WG, DGR, FCF, FCR, RGR and SGR) and water quality parameters (DO, T, EC, TDS, salinity and nitrogen compounds) of the cultured ponds were analyzed using the formula described by Lugert *et al. (*2016) and the result expressed as mean ±standard deviation (SD). At the end of the experiment, the final weight and total length of randomly caught *Garra* from all fish ponds were recorded as row data.

The growth performance parameters, Fulton condition factors and feed conversion ratio were calculated as follows:

(a) Weight gain (g) = Final total weight (g) - Initial total weight (g)

(b) Daily growth rate (g/day) = $\frac{\text{Final Weight – Initial Weight (g)}}{\text{Culture period (days)}}$

(c) Fulton condition factors (K) = $\frac{\text{Mean final weight (g)}}{\text{Mean final total length (cm) 3}} * 100$

(d) Feed conversion ratio = $\frac{\text{Total feed consumed by fish (g)}}{\text{Weight gain of fish (g)}}$

(e) Specific growth rate (%) = $\frac{\text{(Ln Final weight – Ln Initial weight)}}{\text{Culture period (days)}} * 100$

(f) Relative growth rate (%) = $\frac{\text{Final Weight – Initial Weight (g)}}{\text{Initial Weight (g)}} * 100$

(g) Fish survival rate (%) = $\frac{\text{No of fish counted at end}}{\text{No of fish stocked first}} * 100$

4. Results

4.1. Growth performance of Garra

The growth performances of cultured Garra are presented in Table 4.1. The total amount of supplied experimental feed were 1598g and the total weight gain were 837.6g. However, weight gain, survival rate, specific growth rate and conversion factor (K) shown in table 3. The mean value of the cultured Garra fish were presented in Table 3.

Table 3 .The growth performance and survival rate of Garra during cultured in earthen pond

Parameters	Nº	Average	P-
TIW (g)	1	0.28 ± 0.07	0.09
TIL (cm)	1	0.32 ± 0.14	0.22
TFW (g)	1	6.98 ± 0.87	0.08
TFL (cm)	1	3.98± 0.13	0.05
WG (g)	1	6.7 ± 0.77	0.87
DGR (%/day^{-1})	1	0.04 ± 0.01	0.96
K (%)	1	1.3 ± 0.42	0.45
FCR (%	1	1.84 ± 0.01	0.97
SGR (%/day)	1	1.41 ± 0.25	0.91
RGR (%)	1	1213.3 ± 0.12	0.09
SR (%)	1	96.67± 0.13	0.21

Note: Values represent mean ± standard deviation of duplicated tests

4.2 Weight gain of *Garra* per week

The mean weight gained by the cultured Garra at every two weeks were indicated in figure 8. The highest weight gain were recorded at week 12th and the least in the 2nd week. The result displayed as a distinct exponential growth curve throughout 90 experimental days (Fig. 7).

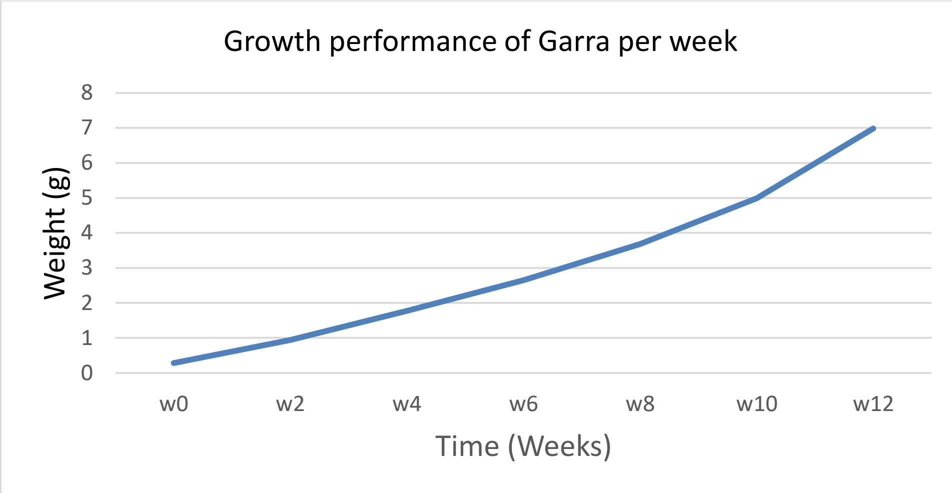


Figure 7. Mean weights gain (µ± SD) (g) changes of Garra fed on basal diet

4.3 Water Quality in ponds during Garra Culture

The water quality parameters in the Garra rearing ponds are detailed in Table 4. Although there were slight differences among the tested parameters, there were no statistically significant differences ($p > 0.05$) in the tested parameters (temperature, DO, total dissolved solids, salinity, and electric conductivity and nitrogen compounds) between culture treatments.

Table 4 .Water quality parameter in earthen pond

Parameters	Nº	Average	P-Value
T°c	24	20.9 ± 1.9	0.29
DO(mg/L)	24	6.565 ± 1.02	0.3
TDS(mg/L)	24	54.308 ± 5.8	0.05
Salinity/ppt	24	0.027 ± 0.04	0.19
EC (µS/cm)	24	84.404 ± 7.41	0.45
NH_3 (mg/L)	3	0.08 ± 0.02	0.11
NO_3^- (mg/L)	3	2.09 ± 0.01	0.21
pH	3	6.61 ± 0.06	0.17

Note: values represent means ± standard deviation.

4.4 Proximate composition

The sample of Garra from both cultured earthen ponds were taken for analysis of the whole Garra body chemical composition in dry weight bases, and the analyzed values of moisture, Ash, protein and fat results were presented in Table 5. However, the analyzed parameters shows that there were no statistically significant differences (p>0.05) between ponds.

Table 5. Proximate composition of Garra

Parameters	Nº	Cultured *Garra*	Wild Garra	p
Moisture (%)	1	71.35±1.6	73±0.23	0.21
Crude Protein (%)	1	13.47±0.8	11.5±0.1	0. 35
Crude Fat (%)	1	11.94±0.66	11±0.6	0.41
Ash (%)	1	2.39±0.155	3.9±0.2	0.11
Carbohydrate	1	1.6±0.55	2.1±1.3	0.06

4.5 Proximate composition of Cultured and wild Garra

The proximate composition of the whole Garra cultured in earthen pond and wild analyzed were moisture, Ash, protein and fat results were presented in figure 9. The parameters analyzed shows there were no statistically significant differences (p > 0.05) across all ponds. However, the proximate composition of wild and cultured Garra result was significant different.

4.6 Plankton abundance

4.6.1. Phytoplankton

A total of 26 species, representing four phytoplankton groups were identified over the study period. Chlorophyceae, Euglenophyceae, Bacillariophyceae, and Cyanophyceae were the most dominant groups in terms of abundance (Table 6)

Table 5 . List of identified phytoplankton species in the experimental ponds

Chlorophyceae		Euglenophyceae	Bacilariophyceae	Cyanophyceae
Chlorella	Eudorina	Euglena	Surirella,	Ocillatoria
Spirogyra	Oedogonium	Phacus	Navicula,	Anabaena
Ankistrodesmus	Pandorina		Synedra	Nostoc
Scenedesmus	Zynema		Melosira	
Gonium	VolVox		Gomphonema	
Pediastrum	Mougeotia		Fragilaria	
Clostrium	Tetraedron			

Generally, the most commonly observed genera were Chlorella, Spirogyra, Ankisdesmus, Gonium, Eeudorina, Oedogonium, Pandorina, Scenedesmus, Zyneme, Volvox, Pediastrum, Mougeotia, Clostrium, Coelastrum and Tetrahedron belong to Chlorophyta group. Euglena and Phocus belong to Euglenophyta goup while Surirella, Navicula, Synedra, Melosira, Fragilaria and Gomphonema belong to Bacilariophyta group and Ocillatoria, Anabaena and Nostoc belongs to Cyanophyta group. To understand which groups contributed more to total abundance, individual phytoplankton groups were analyzed. The result of phytoplankton was summarized in (Table 7) and some of microscopic observation photos of plankton (Fig.8)

Table 6 . Mean abundance of phytoplankton (X 103 cell/L) in pond water under different treatments.

	No	Pond 1	Pond 2
Chlorophyta	3	7.4285714×10^3	7.3285714×10^3
Euglenophyta	3	4.3571429×10^3	4.7142857×10^3
Bacilariophyta	3	3.5714286×10^3	3.7142857×10^3
Cyanophyta	3	1.2857143×10^3	1.5857143×10^3
Total phytoplankton	3	16.6428572×10^3	17.5428571×10^3

4.7. Zooplankton

During the study period 13 zooplankton species, representing copepod, rotifers, and Cladocera groups were identified (Table 8).

Table 7 List of zooplankton species identified during the study period in experimental pond

Copepoda	Rotifera	Cladocera
Cyclop	Filinia terminals	Daphnia
Calanoid	Cephalodella Gibb	Moina
Nauplius larvae	Filinia longiseta	
Paracyclops fimbriatus	Euchlanis dilatata	
	Trichocerica elongate	
	Trichocerca pusilla	
	Brachionus calyciflorus	

Table 8 Mean abundance of zooplankton (X 103 cell/1) in pond water under different organic manure treatments**.**

	P1	*P2*
Copepod	4.0428571×10^{3}	4.3857143×10^{3}
Rotifers	3.6142857×10^{3}	3.4285714×10^{3}
Cladocera	1.8571429×10^{3}	1.5714286×10^{3}
Total zooplankton	9.5142857×10^{3}	9.3857143×10^{3}

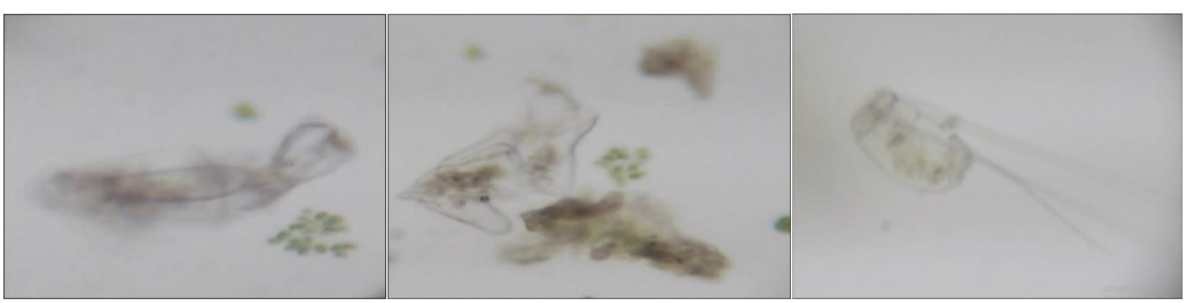


Figure 8. Microscopic observation photos of planktons (detailed pictures were presented in Annex 3)

5. Discussion

5.1. Water Quality of ponds during Garra Cultured

In this study the water quality parameters (Temperature, DO, TDS, salinity, EC, and nitrogen compounds) were no significance different between the two ponds (Table 4) due to regular water changing time and interval, the same feed amount and stocking density. Temperature (T°c): the average temperature (20.996 ± 1.940 °c) was within the acceptable range for Garra culture (18-25 °c). According to Ahmed & abdel-aziz (2022), this temperature range fosters healthy growth and survival rates. Dissolved Oxygen (DO): The average DO level (6.565 ± 1.024 mg/L) is slightly lower than the recommended minimum of 5 mg/L for optimal fish health. While statistically insignificant, maintaining DO closer to the recommended level can improve fish activity, feeding efficiency, and disease resistance Boyd (2018).

Total Dissolved Solids (TDS), Salinity, and Electrical Conductivity (EC): TDS (54.308 ± 5.807 mg/L), salinity (0.027 ± 0.004), and EC (84.404 ± 7.411 μS/cm) were all adequate for freshwater Garra culture in ponds. As mentioned in Timmons and Ebeling (2010), these parameters influence osmotic pressure and can have an impact on fish physiology if they fall outside of the recommended range.

Nitrogen Compounds (NH3 and NO3: For the majority of fish species, the ammonia (NH3) levels (0.049 ± 0.0015 mg/L) were much below the toxic threshold, which is often above 0.2 mg/L. Fish can become stressed out by ammonia, even at low concentrations. The importance of routine monitoring is highlighted by Rakocy (2009) the levels of nitrate (NO3) in aquaculture ponds (2.09 ±0.0045 mg/L) are recorded. The ultimate result of the nitrification process, which degrades hazardous ammonia, is nitrates.

PH: The average pH of 6.61 ± 0.06 is within the 6.0–8.5 range that is commonly advised for aquatic life (Devi et al., 2017). As Summerfelt (2000) explains, a constant pH is essential for a number of physiological functions in fish. However, according Bayissa *et al*. (2021) the result of water quality parameters (temperature ($23.245c^0$), DO (5.84), electric conductivity (79.945 μS/cm), NH_3 (0.0695 mg/L) and NO_3^-(2.81mg/L) recorded from Gilgel Gibe reservoir.

5.2. Plankton abundance

The distribution and abundance of different phytoplankton species in the cultured pond, which can provide insight into the ecological dynamics of these aquatic ecosystems. The abundance of different types of phytoplankton in the pond is presented in units of x 10^3 (thousand). The data suggests that the pond have a variety of phytoplankton, with differing quantities of Chlorophyta, Euglenophyta, Bacilariophyta, and Cyanophyta. In the cultured pond, chlorophyta is the dominant phytoplankton type. In addition, there are various species of zooplankton within the groups of Copepoda (more abundant), Rotifera, and Cladocera. Zooplankton are a critical component of aquatic ecosystems, playing key roles in nutrient cycling, energy transfer, and food web dynamics. These numbers indicate the distribution and abundance of different zooplankton species can provide insight into the ecological dynamics of aquatic ecosystems. As the pond share the same water source, geology and history, and interconnected reducing chance effects of dispersal with colonization of zooplankton and phytoplankton (Shurin et al., 2000)

In this study the shared water source, geology, and history of the ponds, it is likely that similarities exist in the zooplankton community structures across these interconnected ponds. The consistent environmental conditions and historical background may lead to commonalities in species composition, abundance, and diversity, indicating a cohesive and interconnected zooplankton community within the ponds. Shared factors such as nutrient availability, habitat characteristics, and biotic interactions are likely to contribute to the parallel patterns observed in zooplankton and phytoplankton community structures (Cottenie, 2005).

Historical contingency the ponds' shared history, possibly including simultaneous formation or similar anthropogenic influences, means they have been subjected to comparable environmental pressures over time. This historical contingency can lead to convergent evolution or similar successional stages in zooplankton communities. Biotic interactions similar predator and competitor species across these ponds can further homogenize zooplankton community structure. For instance, the presence of certain fish species might regulate zooplankton populations in a consistent manner across all ponds. Climatic conditions being in the same geographical area, the ponds likely experience similar climatic conditions, such as temperature, precipitation, and seasonal changes. These factors influence the reproductive cycles, survival rates, and overall dynamics of zooplankton and phytoplankton communities. Human activities if the ponds are subject to similar land use patterns or management practices (e.g., agriculture, urbanization, and conservation efforts), the anthropogenic impacts could similarly shape the zooplankton communities across the ponds. Dispersal mechanisms natural dispersal mechanisms, such as wind, birds, and other animals, can facilitate the movement of zooplankton between ponds, leading to similar community compositions (Lévêque and Mounolou, 2001).

5.3. The growth performance of Garra

Rigorous stocking procedures ensured homogenous starting conditions for the Garra in both ponds. Initial weight (0.28 ± 0.07 g) and length (0.32 ± 0.14 cm) exhibited minimal variation between ponds, indicating successful standardization. While standard deviations suggest some inherent size discrepancies within each pond, these could be attributed to subtle age variations or preceding rearing environments of the fingerlings.

Employing histograms to analyze the initial weight and length distribution would be a valuable approach to assess data normality and identify any potential outliers that might influence subsequent interpretations. Notably, the highly similar final weight gains observed in both ponds 1 (3.433 g) and Pond 2 (3.417 g), with no statistically significant difference ($p > 0.05$), suggest that both pond environments effectively supported Garra growth. Daily growth rates in both ponds showed identical values (0.040%), which demonstrated an incredibly stable growth pattern over the course of the trial. This shows that the Garra fish's daily growth rate was sustained by comparable environmental factors and feeding schedules in both ponds.

In this study, Garra gained 3.433 ± 0.768 g. However, the results were lower than those of Mosha et al. (2020), who indicated that tilapia gained 45.35 ± 0.04 g in a three-month feeding trial. According to Çelik (2021), on the 75^{th} day at varying temperatures, the maximum total length (38.41±1.99mm) and weight (0.56±0.07g) were achieved. Garra grew relatively little weight as compared to other fish species such as tilapia. The decreased weight gain could be attributed to the fact that the feed ingredients employed had different chemical compositions. The present study found that Garra can be employed as an aquaculture species in ponds, with a survival rate of 96.67%. This suggests Garra is a candidate species for pond aquaculture, and the increased survival rate could be attributed to the regulated culture environment and nutritional value of the fish diet.

Specific growth rate and relative growth rate: An analysis of growth rate metrics revealed remarkably consistent and favorable rearing conditions across both ponds for Garra. Specific Growth Rate (SGR), a measure of daily body weight increase expressed as a percentage, exhibited minimal variation (0.25%) with near-identical values (approximately 1.41%) in each pond. This consistency in SGR strongly supports the conclusion that both pond environments effectively promoted Garra growth. Further bolstering this notion, the average Relative Growth Rate (RGR) of 1213% indicates excellent overall growth in both ponds. However, a lower p-value (0.089) for RGR compared to other parameters suggests a potential statistically significant difference between the ponds. This variance might be attributed to subtle variations in initial fish weights or, more likely, larger variations in final weights.

Condition factor (k), feed conversion ratio (FCR) **and survival rate (SR):** The average condition factor (K) of 1.28% suggests the overall health of the Garra in both ponds. However, the observed variation (0.42%), examining water quality parameters and monitoring for any signs of illness could shed light on the cause of this variation. A lower K value in certain fish could indicate issues of food quality or environmental stressors impacting their health.

On a positive note, the feed conversion ratio (FCR) were 1.84% in ponds demonstrates efficient feed utilization by the Garra. A lower FCR signifies better conversion of feed into fish growth. Factors like fish activity levels, feeding practices, and feed quality all influence FCR. Since FCR remained consistent between ponds, it suggests that other factors potentially affecting growth, such as disease presence, deserve closer attention when evaluating overall pond performance and stress. Ponds have high average survival rates (96.7%), the small variance (1.7%), which has a high p-value, is not statistically significant, it may be the result of random mortality events. For aquaculture output to be effective, high survival rates are necessary.

5.4. Chemical composition of cultured Garra

Protein and fat: Cultured Garra contains better protein (13.47%) than wild Garra (11.5%). This makes cultivated Garra could be more nutritious and good sources of protein. Protein is an essential component for humans, aiding in cell growth, repair, and maintenance (Bayissa *et al.*, 2021). The greater protein content of cultivated Garra could be attributed to the controlled feeding regimes used in aquaculture, which ensure that the fish receive all of the nutrients they require for growth. Compared to wild Garra, cultured Garra has a greater fat content (11.94%) than 11%. Fish can have different amounts of fat depending on their age, species, and food. Omega-3 fatty acids, which are critical for heart and brain function, are generally found in fish. But a high fat content can also make the fish consume more calories.

Moisture contents of cultured Garra (73%) and wild Garra (71.35) showed noticeable differences. This difference is minor and may not be relevant depending on the planned usage of the fish. For example, if the Garra is being processed into fishmeal, a higher moisture content could result in cheaper processing costs. Compared to wild Garra (3.9%), cultured Garra has less ash level (2.39 %). The higher ash level may be a sign of increased mineral content, such as calcium, phosphorus, and potassium, which are vital for healthy bones and other bodily functions. It is crucial to remember that figuring out the nutritional worth of the ash would need knowing its precise mineral makeup.

Overall, cultured Garra appears to have a higher content of protein and ash, while wild Garra has a higher moisture and fat content. This could be due to a number of factors, including Cultured fish are typically fed formulated feeds specifically designed to meet their nutritional needs. This can result in a higher protein and ash content compared to wild fish, who forage for food in their natural environment. Aquaculture practices can influence the growth rate and composition of fish. For instance, factors like stocking density, water quality, and feeding regimes can all play a role Younger fish tend to have a higher moisture content and lower fat content compared to mature fish.

The proximate composition of the whole cultured Garra crud protein (13.47 %), fat (11.94 %), ash (1.6 %) and moisture (71.35 %) was higher than the whole Garra of wild, while CP (9.58%), fat (2.73%), moisture (69.1-77.6%) as reported by Maryam *et al*. (2020). Also, the composition of fat and protein in the whole Garra cultured were higher than the wild whole Garra as reported by Bayissa *et al*. (2021). This may be due to different feed and environment of water the Garra was cultured and the natural water.

6. Conclusion and Recommendation

6.1 Conclusion

Based on the experimental results, this study concluded that culturing the Garra fish in earthen pond showed better protein content than Garra. It is due to a number of factors including cultured fish are typically fed the formulated feeds that designed to meet their nutritional needs. This can result in a higher protein and ash content compared to wild fish. However, it is possible to culture Garra fish in pond and the proximate composition of the cultured fish is similar to that of the wild.

6.2 Recommendation

This study recommended that due to Garra fish species become stressed because of various surrounding factors, the cultured earthen pond must be stable from their environment. Additionally, their small size, the community cannot use it for commercial purposes but these fish species have good growth performance and the best appearance in earthen pond than the wild. Moreover, the proximate composition of Garra cultured is better than that of wild Garra except for the moisture contents. Therefore Garra cultured in the earthen pond is good for human consumption, and thus, giving awareness to the community is required.

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Appendix

Annex.1 Mean growth performance in two weeks interval

Sampling Weeks	*Mean weight gained in g*	*Mean length gained in cm*
W0	0.28	0.27
W2	0.94	1.7
W4	1.77	3.3
W6	2.65	4
W8	3.68	4.7
W10	4.99	5.4
W12	6.98	7.1

Annex.2 The means of water quality data

Pond	Weeks												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Temp-1	17.2	17.5	18.2	18.6	19.1	20.7	20.5	19.2	18.3	19.2	20	19	19.9
Temp-2	17.5	17.1	18.6	18.1	19.3	20.1	20.2	19.4	18.6	19.1	20.3	19.1	20.2
DO-1	7.6	6.7	6.3	6.0	6.3	6.2	6.7	6.5	7.9	7.2	7.6	6.9	6.2
DO-2	7.8	6.1	6.5	6.4	6.4	6.8	7.2	6.7	7.2	6.5	7.3	6.8	6.7
Sal-1	0.03	0.01	0.01	0.01	0.04	0.02	0.03	0.05	0.02	0.03	0.02	0.01	0.02
Sal-2	0.01	0.4	0.02	0.01	0.03	0.01	0.02	0.03	0.03	0.03	0.03	0.02	0.02
EC-1	86	93	88.5	86	91.5	86.5	87	81.5	80.5	91	96	86	93
EC-2	87	89	86.5	72.5	89.5	86	78	75	84	82	97	86	87
pH-1	7.0	7.3	7.1	7.3	6.9	7.0	7.3	7.2	6.9	7.0	7.3	7.0	7.0
pH-2	7.2	7.1	6.9	6.8	7.1	7.1	7.0	6.8	7.1	7.2	7.0	7.4	7.2

Annex **3:** Plankton sample identified during the study period

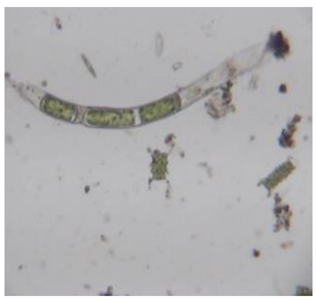
Phytoplankton

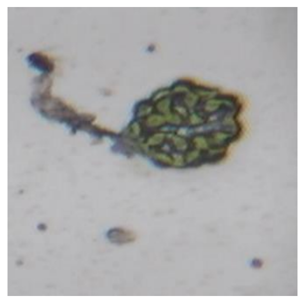
Chlorophyta group

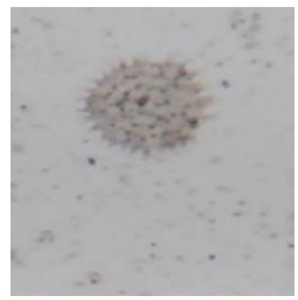

Zynema

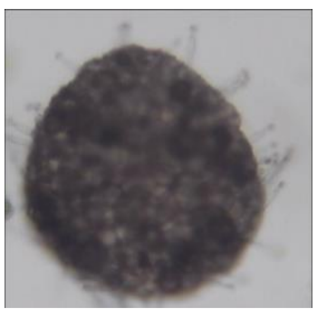

X

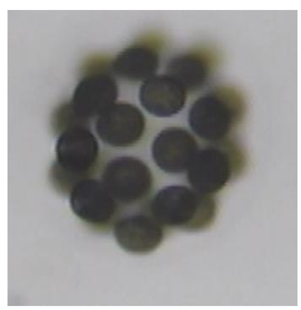

Closterium


Mougeotia

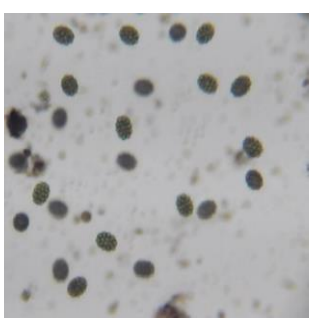

Coelastrum




Pediastrum

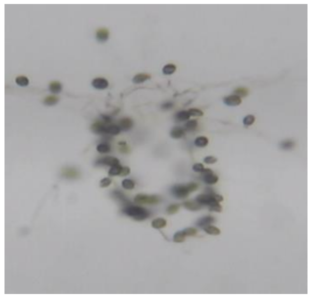
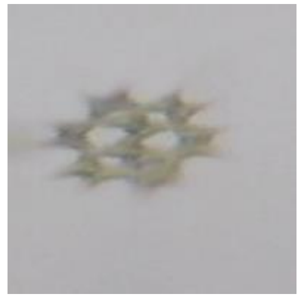
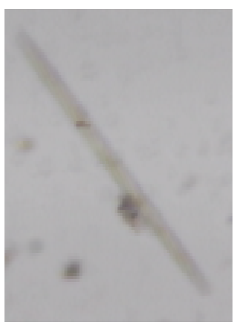

Gonium

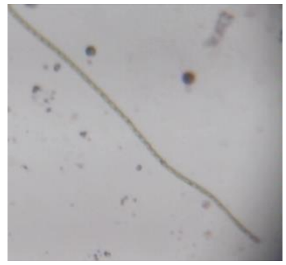
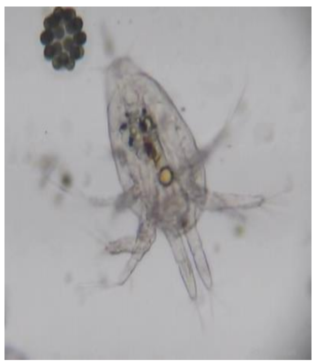

Ankistrodesmus

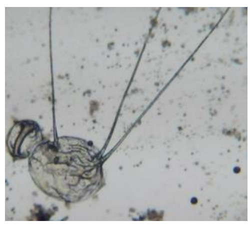
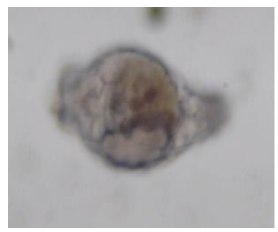

Oedogonium


Pandorina


Spirogyra

	 Chlorella	 Tetraedron	 Scenedesmus
Euglinophyta group	 Euglena	 Phocus	
Bacillariophyceae	 Synedra	 Gomphonema	
	 Navicula	 Fragilaria	

Cyanoph  Nostoc  Trichodesmium  Anabaena
Zooplankton
Copepods group   

Rotifer group		 	 
Cladocera group	 Daphnia	 Moina	