

2022 年臺灣國際科學展覽會 優勝作品專輯

作品編號 050017

參展科別 動物學

作品名稱 **The Population Structure of the Orange
River mudfish (*Labeo capensis*) in
Allemanskraal Dam and Its potential as a
Fishery Species**

得獎獎項

國家 **South Africa**

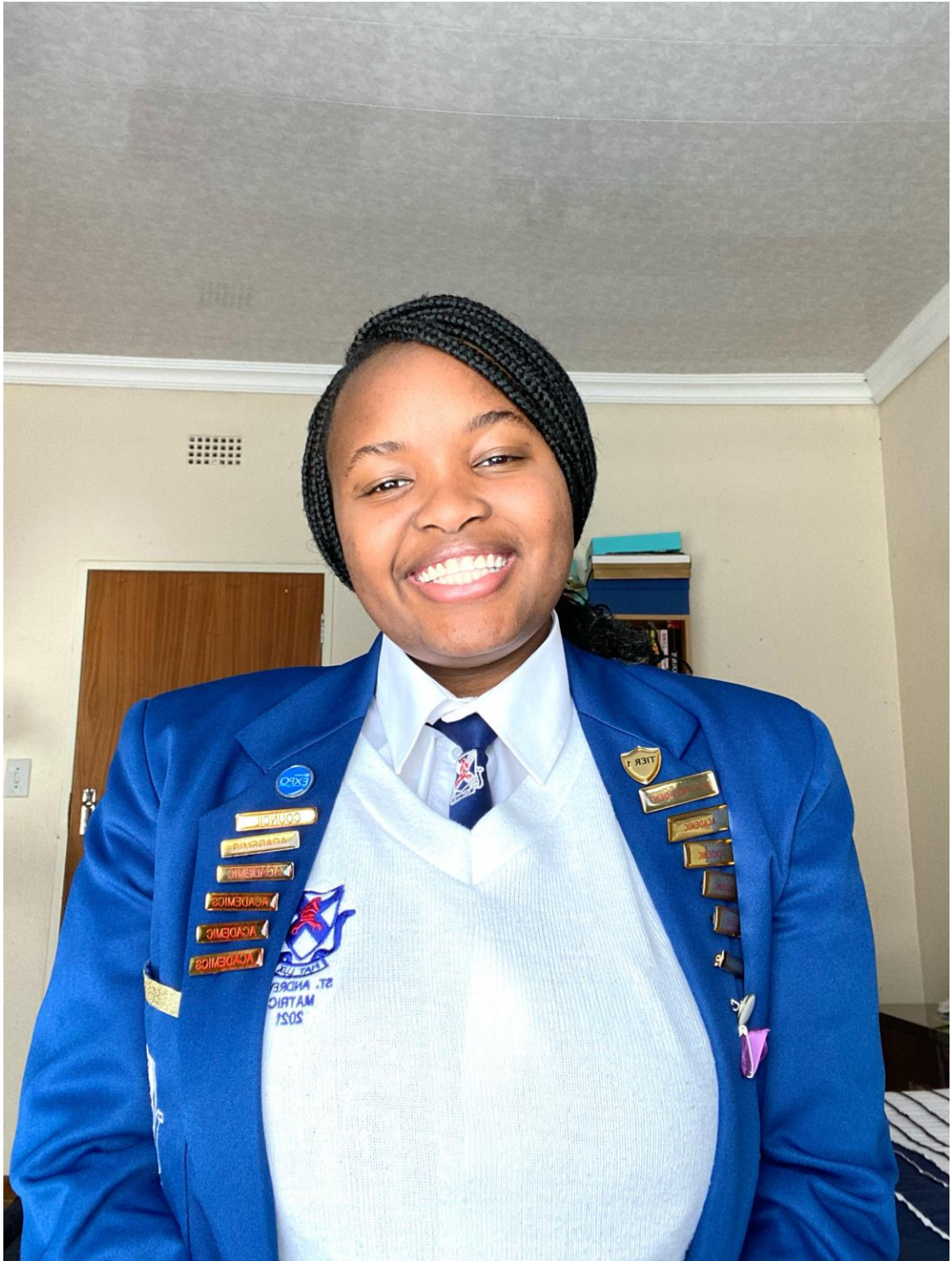
就讀學校 **St Andrew's School, Welkom**

指導教師

作者姓名 **Kudzaishe Nhiwatiwa**

關鍵詞

作者照片



Introduction

Population structure is the composition of a population in terms of its average size, the male-female ratio, length frequency of individuals and their ages. Orange River mudfish *Labeo capensis* individuals that have a Standard Length (SL) of 0-100mm are considered ‘young-of-the-year’. Those with an SL of 101-300mm are considered ‘juveniles’ while those with an SL of more than 300mm are considered ‘adults’ (i.e., sexually mature) (Barkhuizen, 2015).

Fisheries play an important role in the upkeep of the economy, availability of jobs and a wide variety of resources available to the public and provide food security. This research, determining whether the Orange River mudfish *Labeo capensis* is a good candidate for a fishery species in Allemanskraal Dam, would give an opportunity for this species to be used as such, which would therefore further widen the various fish species available for fishing. Furthermore, this would prevent the overfishing of already-utilized fish species in aquaculture and would help in the control of this fast-breeding species. This research would also familiarize us with the population structure of the *L. capensis*, thus providing an opportunity to take advantage of the species’ best characteristics. It is important to know the length frequency distribution and population structure of suitable fishery species to determine sustainable harvesting levels of said species.

During August 2021, the South African cabinet approved the National Freshwater Wild Capture Fisheries Policy to guide the development of this sector in South Africa. It is thus critical that research is to be done on the ecology and biology of prospective fishery species to ensure of sustainable utilisation of these fisheries and to ensure that they are economically viable.

Literature Review

The species name of the Orange River mudfish is *Labeo capensis* (Smith, 1841). It is endemic to the Orange-Senqu and Vaal River systems in the Orange-Senqu River Basin (Skelton, 1993). (see Figures 1-4)



Figure 1: Map of Africa.
 (Source: <https://whereig.com/africa/>)



Figure 2: Map of South Africa.
 (Source: <https://ontheworldmap.com/south-africa/>)

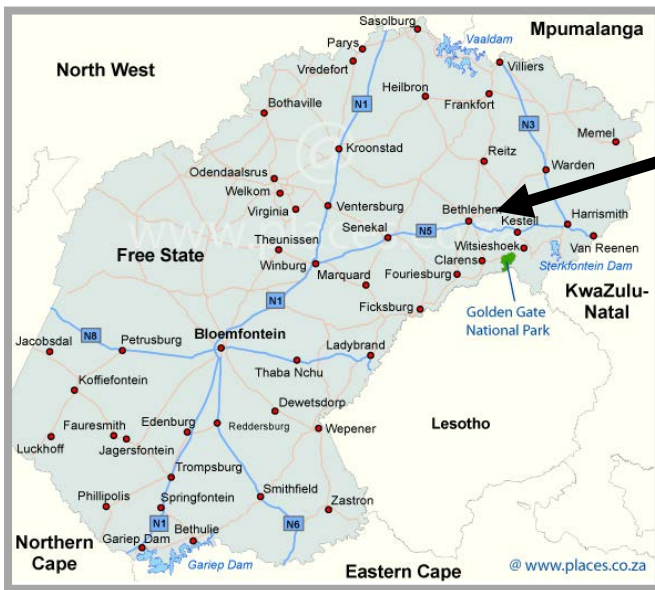


Figure 3: Map of the Free State showing the approximate location of Allemanskraal Dam.
 (Source: https://www.places.co.za/html/free_state_map.html)

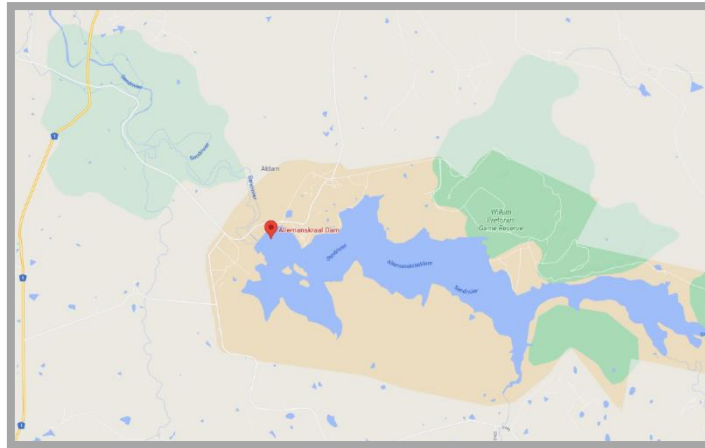


Figure 4: Map of Allemanskraal Dam.

(Source: <https://www.google.co.za/maps/place/Allemanskraal+Dam/>)

Its genus, *Labeo*, comes from the Latin term meaning ‘one who has large lips’. Alongside their thick lips, *L. capensis* have a protrusive snout and 2 pairs of short barbels. They have small scales that range in varying shades of soft, blotchy grey-brown and fins that are usually darker than their scales. (de Moor and Bruton, 1998). (see Figure 5).



(Source: <https://www.fishdex.org/fish/orange-river-mudfish/labeo-capensis>)

Figure 5: Photo of *Labeo capensis*.

Orange River mudfish (*L. capensis*) tend to only mature fully once they have reached an advanced size as they have a low adult mortality rate (i.e., it is more likely that the pond is filled with adults rather than juveniles for example); this describes them as a ‘periodic strategist’, which explains their tendency to be overfished. This fish species prefers to lay a large number of eggs at once when the environmental conditions are favourable (Winker *et al.*, 2011). The females can lay up to 257 000 eggs at once and the incubation period is brief. Hatching of the eggs can start within just two days after fertilization (Tomasson *et al.*, 1983a) which further proves their high numbers. They tend to lay their eggs in slow and shallow flowing rapids, of which they prefer to inhabit (Winker *et al.*, 2011; Cambray, 1985; Skelton,

1993; 2001). They are bottom dwelling omnivores that feed on algae, insects such as flies, and dead particulate organic material (de Moor and Bruton, 1998).

The *L. capensis* is the ‘second most abundant species in the rivers draining into the Katse Dam attachment’, can grow to a maximum length of 50cm, and can live to be up to 8-9 years old (de Moor and Bruton, 1998; Skelton, 2001) but most only grow to about 45cm (de Moor and Bruton, 1998; Lévêque and Daget, 1984) and weigh around 3.8kg. They breed in the spring-summer and are known for their rapid growth after hatching, as the young fish reach 80-90mm SL, slightly older females reach 240mm SL, and slightly older males reach around 220mm SL (Skelton, 2001). They reach sexual maturity once they are around 4-6 years of age. Both males and females have similar growth rates up until sexual maturity, at which females grow faster (Winker *et al.*, 2011). Due to their mature size, the *L. capensis* are usually immune to predation, besides the potential threat posed by humans (Gaigher *et al.*, 1961). Their adaptability gives them the potential to compete with other native fish species (Erasmus *et al.*, 2019). Numerous spawns may occur during a breeding season of spring-summer. However, each female only spawns once per season, and high-water levels are needed for the juveniles of the species to survive (Tomasson *et al.*, 1983b). The *Labeo capensis* can also hybridise with other *Labeo* species (Erasmus *et al.*, 2011).

The length of a fish is measured in various ways. This includes Standard Length (SL), Fork Length (FL) and Total Length (TL). Standard Length is method of measuring fish that entails measuring from the snout of the fish until the posterior side of its last vertebra. This is done for ‘bony’ fish of which have an easily identifiable last vertebra. The Fork Length of a fish is measured from the snout of the fish to the middle of the fork in the fish’s tail. This is best for fish with a forked tail. The Total Length is measured from the snout of the fish to the tip of the longest lobe of its tail. This is best suited for fish with uneven tail lobes, like sharks (Lynch, 2014).

The fish is mostly measured while straightened out on its right side, snout to the left, on a flat, stable surface. The measurements could be taken using a measuring board, measuring tape, or callipers. Measurements are often done in pairs, one to measure the fish and call out the length and another to accurately scribe the values (Holden *et al.*, 1974).

The *L. capensis* are adapted in a way that allowed them to survive most environmental resistance factors but are not able to survive against human activities such as overfishing (Winker *et al.*, 2011). This easy adaptation would make them less specific or ‘picky’ about their habitat, and they are able to co-exist with other fish species. As a type of cyprinid, they are resistant to disease, and contain no OIE-reportable diseases that could be a threat to humans (U.S. Fish & Wildlife Service, 2014; DeVault, 2006). OIE-reportable diseases are animal diseases, infections and infestations that are a hazard to animals, humans included (OIE, 2006). As described before, the *L. capensis* is a fast-breeding, rapid-growing species, which would allow them to be utilized in fisheries. They would produce more offspring that would be a quicker inflow of resources for the fishery. They are also not endangered, and have a Red List Status of ‘Least concern’ (IUCNRedList, 2017).

Problem Statement

Job and food insecurity are prevalent problems in South Africa. Fisheries, and any potential fishery species, are not being utilised fully to combat these problems. Fish species with fast-breeding characteristics and a high average size at adulthood (i.e., ones that have a lot of ‘flesh’) have potential to be used to feed the human population around their habitat, as well as promote job creation, in a sustainable manner.

Aim

To investigate the ecology and biology of the *Labeo capensis* and conclude whether it could be utilized as a potential fishery species in Allemanskraal Dam.

Research Question or Hypothesis

Research Question: Can the Orange River mudfish *Labeo capensis* be utilized as a potential fishery species in Allemanskraal Dam?

Hypothesis: The population of Orange River Mudfish *Labeo capensis* in Allemanskraal Dam is a suitable species for use in small-scale fisheries due to the species’ biological and ecological characteristics.

Method

Variables

Independent – different types of nets used to catch *L. capensis* –gill, seine and fyke nets

Dependent - Fork length (from the snout to the fork in the tail)

Controlled/fixed variables - the same type of nets were used

the same measurement instrument was used

the sampling happened in the same time frame

Materials

-Three fleets of multifilament, green nylon gill nets, each 100 metres in length with 5 x 20 metre panels of varying mesh sizes of 44mm, 50mm, 75mm, 100mm and 144mm in numerical order.

-A 10m x 2m multifilament, green nylon seine net

-Four double-ended brown multifilament fyke nets, each with nine hoops on either side, forming a cone-shape.

-Measuring tape.

Experimental design

STUDY SITE:

The study site of this investigation is Allemanskraal Dam in the Free State province. It is a large, 61-year-old impoundment surrounded by the Willem Pretorious Nature Reserve. The Dam's main purpose is the irrigation via canals. Sport and recreational fisheries make use of the dam. Allemanskraal Dam is 22 kilometres away from its nearest town, Ventersburg.

The Allemanskraal Dam has a surface area of 2 667 hectares and a capacity of 178 136 000 cubic metres. The average depth at full supply level (FSL) is 6.7 metres, and its catchment area is 3 628 square kilometres. The Dam's wall type is Earthfall & Gravity and stands at a height of 37.7 metres with a crest length of 1 347 metres. During the sampling period of 9th April 2021 to 10th April 2021, Allemanskraal Dam was at 100% capacity.

FISH SAMPLING METHODS:

This research was conducted using three types of nets: gill nets, seine nets and fyke nets.

GILL NETS

Three fleets of multifilament, green nylon gill nets were used. The nets were each 100 metres in length with 5 x 20 metre panels of varying mesh sizes of 44mm, 50mm, 75mm, 100mm and 144mm in numerical order.

1. Three fleets of the gill nets were set at 10:00 on Thursday the 8th of April 2021, parallel to the shore.
2. On Friday the 9th of April 2021, one fleet was lifted and the fish were collected by hand at 15:00.
3. The two remaining fleets were lifted on Saturday the 10th of April 2021 at 09:30 and the fish were collected by hand.

SEINE NETS

A 10m x 2m multifilament, green nylon seine net was used to collect the fish in the littoral zone of the study site.

1. On Saturday the 10th of April 2021, a distance of 10 metres from the shore was measured.
2. Two researchers stood at each end of the net. The top line of the net was held in-hand, and the bottom line was tied around the researchers' ankles.
3. The net was pulled for 10 metres within the littoral zone, after which the researcher in the deeper end moved in a semi-circle such that the researchers and the net were parallel to the shore. The researchers made sure to maintain the bag in the middle of them.
4. The net was then pulled towards the shore of the dam.

5. The fish were collected by hand and put into buckets.
6. This procedure was repeated four times.

FYKE NETS

Four double-ended brown multifilament fyke nets were used. The nets had nine hoops on either side, forming a cone-shaped.

1. The fyke nets were set parallel to the shore on Friday the 7th of April 2021 at 10:00 and were left for two nettings nights.
2. The nets were lifted on Saturday 10th April 2021 at 11:00 and the fish were collected by hand into buckets.

FISH SAMPLES:

The fish caught in the nets were sorted according to their species, and all *L. capensis* were measured for Fork length (from the snout to the fork in the tail) using measuring tape to the nearest millimetre.

ESTABLISHMENT & POPULATION STRUCTURE:

The *L. capensis* caught were sorted into 100mm fork length size classes. These represent the fish's growth, and therefore their relative ages/ period in their life history.

Results

41 Orange River mudfish *Labeo capensis* individuals were caught during the study period of 9th April 2021 – 11th April 2021.

Table 1: The Total number of *L. capensis* and fork length caught in all gear at Allemanskraal Dam. From observation, it seems that majority of the fish caught were small and young-of-the-year. Only seven of the *L. capensis* caught had a fork length over 100mm (fish 1-7).

Number	Fork length in mm
1	300
2	195
3	207
4	190
5	225
6	195
7	154
8	63
9	35
10	69
11	64
12	67
13	55
14	52
15	61
16	67
17	70
18	68
19	68
20	60
21	57
22	62
23	60
24	56
25	54
26	40
27	70
28	63
29	58
30	60
31	52
32	55
33	35
34	45
35	67
36	54
37	38
38	40
39	39
40	46
41	35

Table 2: Length frequency distribution of *Labeo capensis* caught in all gear at Allemanskraal Dam.

Length/Size class in mm	Number
0-100	34
101-200	4
201-300	3
301-400	0
41	

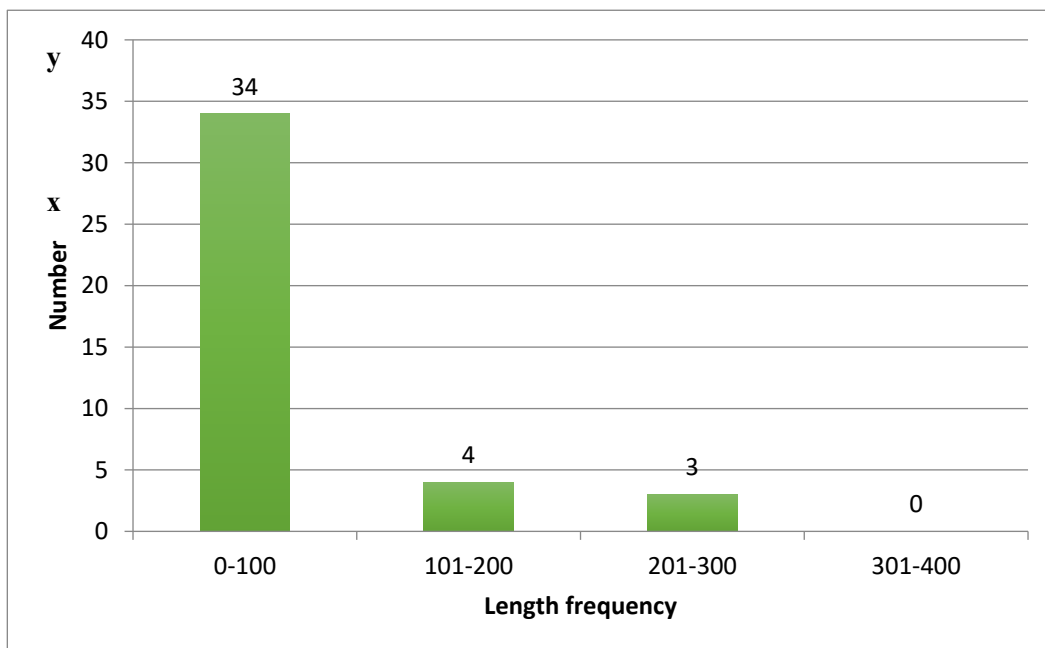


Figure 6: Length frequency distribution of *Labeo capensis* in Allemanskraal Dam

Analysis:

The majority (34/41) of the fish caught were within the 0-100 mm size class. The 101-200mm and 201-300mm size class contain similar numbers of fish (4/41 and 3/41 respectively), while no fish were caught in the 301-400mm size class.

The 0-100mm size class contained 82.93% of the fish caught, while the 101-200mm and 201-300mm size classes contained 9.76% and 7.32% of fish caught respectively. The 301-400mm size class contained 0%.

Discussion

Due to the fact that there were individuals of the Orange River mudfish *Labeo capensis* species found in most of the size classes (although some substantially more than others), it can be concluded that the population of *Labeo capensis* in Allemanskraal is established.

The results of the research show that 82.93% of the *L. capensis* caught had a fork length of between 0 and 100mm. According to literature research done, sexually mature individuals of the *L. capensis* species tend to be around 200-300mm SL (Skelton, 2001; Barkhuizen, 2015). Furthermore, their age of sexual maturity is 4-6 years. As their breeding season is spring-summer (Winker *et al.*, 2011), it is almost certain that the population of *L. capensis* in Allemanskraal Dam had made use of the suitable environmental conditions to reproduce. This means that during the study period of 9th April 2021 to 10th April 2021, the majority of the population of *L. capensis* would be young-of-the-year.

A study done by L.M. Barkhuizen (2015) displays a similar set of results as the April 2021 study. This study resulted in a substantial number of *L. capensis* individuals found in every size class, up to 500mm fork length. The size class of 0-100mm held the highest percentage of individuals of this species at Allemanskraal Dam (42.73%). This shows that the population of *L. capensis* at the Allemanskraal Dam at that time was slightly more mature than what was observed during the April 2021 study.

Therefore, although the results of the practical research done during the period of 9th April 2021 to 10th April 2021 suggest that the population of *L. capensis* in Allemanskraal Dam consists of mostly young-of-the-year, historical data – such as that of Skelton- motivate that the largely-immature population of *L. capensis* in Allemanskraal Dam will grow into a sexually mature population within the next 4-6 years if the suitable conditions are maintained.

Limitations and errors

Due to the extensive procedures, that accurately weighing the fish would have entailed -such as cleaning between each reading- and the struggles that would have occurred when it came to weighing some of the smaller fish, the weight of the fish caught could not be taken. Furthermore, as majority of the *L. capensis* population in Allemanskraal Dam had not reached sexual maturity at the time of the study period, the sex of each individual could not be determined.

Being a Matric student, there was limited time for this study to be repeated. This, coupled with lockdown regulations that restricted our movement and access to the study site, created an obstacle resulting in the conduction of only one sample being possible. Furthermore, the practical investigation of this study had to be done under the supervision of an Aquatic Scientist and Ichthyologist, who is a busy person as well.

Recommendations for Future Research

As the study period was only from the 9th to the 11th of April 2021, a longer investigation over a longer course (possibly a week) should be conducted in the future. This will allow more accurate results to be obtained. The investigation should be done during a different season, i.e. winter, to compare the ecology and biology of *L. capensis* during the seasons. Furthermore, the investigation should be conducted in 4-5 years, as majority of the *L. capensis* population would have reached sexual maturity and would have reached their

maximum size. The weight of the fish could also be investigated, as they would have grown large enough to weigh accurately.

Conclusion

This study's hypothesis has been accepted.

According to the practical research done during the study period of 9th – 10th April 2021, majority of the Orange River mudfish *Labeo capensis* individuals caught were within their young-of-the-year stage of life, as they were mostly between the 0-100mm fork length frequency.

Allemanskraal Dam, as of the study period, has a very small juvenile fish population of *L. capensis*, as only 7 out of 41 fish individuals caught were within the 101- 300mm fork length size class.

These results would therefore show that the population of *L. capensis* is not established as of yet, as the research done was right after their breeding season. However, historical research has shown that sexually mature individuals of the *L. capensis* species tend to be a minimum of 300mm SL, 4-6 years after hatching.

Therefore, if suitable conditions are maintained, the population of *L. capensis* in Allemanskraal Dam would be established within 3-4 years (after sexual maturity) (Winkler *et al.*, 2011), which would make this species a suitable fishery species. Establishing this species' potential will therefore allow economically viable fisheries to utilise them sustainably and to their full economic potential, thus making an effort to combat food and job insecurity.

Acknowledgments

Ms. Anina Nel- For her mentorship and encouragement throughout this study.

Dr. Leon Barkhuizen- For his expert advice and professional assistance with the practical investigation (Appendix 1).

References

Journals:

- Alauddin, MHR. Santoso, H. Mulalinda, P. 2019, 'Exploitation rate before and after moratorium in fisheries management area 714, 715, and 716 fishermen fishing ground in Bitung, North Sulawesi of Indonesia' *Russian Journal of Agricultural and Socio-Economic Sciences*. Vol 94. pp. 187-192.
- Cambray, JA. 1985. 'Observations on spawning of *Labeo capensis* and *Clarias gariepinus* in the regulated lower Orange River, South Africa'. South Africa. *South African Journal of Science*. Vol 81(6). pp. 318-321.
- Erasmus, JH. Malherbe, W. Gerber, R. Weyl, OLF. Sures, B. Wepener, V. Smit, Nj. 2019. 'First record of *Labeo capensis* (Smith, 1841) in the Crocodile River (West) system: another successful non-native freshwater fish introduction in South Africa'. *African Journal of Aquatic Science*. Vol 44 (2). pp. 177-181.
- Gaigher, IG. Hannan, KCD. Thorne, SC. 1961. 'Possible adaptive significance of sex ratio and sexual differences in size at maturity in the Orange River *Labeo*, *Labeo capensis*'. *Journal of the Limnological Society of Southern Africa*. Vol 6 (1). pp. 35-38.
- Winker, H. Weyl, OL. Booth, AJ. Ellender, BR. 2012. 'Life history strategy and population characteristics of an unexploited riverine cyprinid, *Labeo capensis*, in the largest impoundment in the Orange River Basin'. *African Zoology*. Vol 47 (1) pp. 93-96.

Reports:

- Bruton, M. Jackson, PBN. Skelton, PH. 1982. 'Pocket guide to the freshwater fishes of Southern Africa'. Centaur, Cape Town, South Africa.
- Lévêque, C. Daget, J. 1984. Check-list of the freshwater fishes of Africa (CLOFFA), Vol1. pp. 217-342. ORSTOM, Paris, and MRAC, Tervuren, Belgium.
- Tomasson, T. Bruton, MN. Cambray, JA. Eccles, DH. 1983a. Limnology and fisheries potential of Lake Le Roux. South Africa National Scientific Programs Report No. 77. pp. 108-121. CSIR, Pretoria, South Africa.

- Tomasson, T. Bruton, MN. Cambray, JA. Eccles, DH. 1983b. Limnology and fisheries potential of Lake Le Roux. South Africa National Scientific Programs Report No. 77. pp. 153-160. CSIR, Pretoria, South Africa.

Theses:

- Schrijvershof, J. 2015, 'Biology and ecology of fishes of the Senqu River, Lesotho'. PhD thesis, North-West University, Potchefstroom.
- Barkhuizen, L. 2015, 'An Assessment of Fish and Fisheries in Impoundments in the Upper Orange-Senqu River Basin and Lower Vaal River Basin.' PhD thesis, University of the Free State.

Online articles:

- DeVault, G. 2006. Backyard Fish Farming. Mother Earth News (Online). Available: <https://www.motherearthnews.com/homesteading-and-livestock/backyard-fish-farming> . **Date Accessed: 14 March 2021.**
- Holden, MJ. Raiit, DFS. 1974. *MANUAL OF FISHERIES SCIENCE Part 2 - Methods of Resource Investigation and their Application*. (Online). Rome. **Date Accessed: 14 March 2021.**
- IUCNRedList. 2017. Orange River Mudfish *Labeo capensis*. IUCN Red List of Threatened Species. (Online). Available: <https://www.iucnredlist.org/species/63280/100161272#text-fields> . **Date Accessed: 14 March 2021.**
- Lynch, A. 2014. Length. Fishionary Alphabet. (Online). Available: <https://fishionary.fisheries.org/tag/fork-length/> . **Date Accessed: 14 March 2021.**
- World Organisation for Animal Health. 2021. OIE-Listed diseases, infections and infestations in force in 2021. OIE- World Organisation for Animal Health. (Online). Available: <https://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2021/> . **Date Accessed: 14 March 2021.**

Figures:

- Figure 1: <https://whereig.com/africa/>
- Figure 2: <https://ontheworldmap.com/south-africa/>
- Figure 3: https://www.places.co.za/html/free_state_map.html

- Figure 4: <https://www.google.co.za/maps/place/Allemanskraal+Dam/>
- Figure 5: <https://www.fishdex.org/fish/orange-river-mudfish/labeo-capensis>
- Figure 7-8 (Appendix 2): Kudzaishe Nhiwatiwa

Appendix

(1)



Reference: Aquatic Research / Ichthyology

Enquiries: Dr. L. Barkhuizen
barkhl@destea.gov.za / 083 256 9446

21 July 2021

To whom it may concern

**Mini-research projects on freshwater fish, small-scale fisheries and water quality of
Grade 12 learners from St. Andrew School, Welkom**

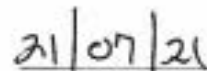
I, Dr. Leon M. Barkhuizen, Aquatic Scientist and Ichthyologist from the Free State Department of Economic, Small Business Development, Tourism and Environmental Affairs (FS DESTEА), and Research Associate, Department of Zoology and Entomology, University of the Free State, hereby confirms that the Grade 12 Life Science learners from St. Andrew School, Welkom, implemented various mini-research projects on freshwater fish, small-scale fisheries and water quality under my guidance and mentorship at Allemanskraal Dam in the Free State Province.

The mini-research projects done by the learners, form part of Provincial level research projects on the occurrence, distribution and relative abundance of freshwater fish, investigations in to small-scale fisheries development, and water quality parameters in aquatic systems in the Free State under supervision of Dr. Barkhuizen. The research is done under authorisation of an approved Research permit, Permit number NC.8679/2018 issued by the FS DESTEА on 17 November 2018 with an expiry date of 31 December 2021. All fish caught during the mini-research projects at Allemanskraal Dam were treated humanely according to guidelines and most were released back into the dam after biological data were collected.

Yours sincerely,



Dr. L.M. Barkhuizen *Pri.Sci.nat*



21/07/21

Photos taken during the study period:

(2)



Figure 7: A photograph of one of the fyke nets lifted on 10 April 2021 alongside the seine net used on the same day.

(Photograph taken by Kudzaishe Nhiwatiwa)



Figure 8: A photograph of the researchers lifting the fyke nets on 10 April 2021.

(Photograph taken by Kudzaishe Nhiwatiwa)

Timeline:

Discussion with Dr L. Barkhuizen, external mentor and expert – **18th February 2021**

Part A of project (Introduction to proposed method) completed and revised with mentor – **5th March 2021**

Practical investigation at Allemanskraal Dam – **9th to 11th April 2021**

Part A and B of project (including data handling, discussions, analysis etc.) completed and revised with mentor – **12th June 2021**

Revision of project – **26th to 29th July 2021; 8th to 11th September 2021; 26th to 28th November 2021**

【評語】 050017

This study is to investigate the ecology and biology of the *Labeo capensis* and Dam.

1. Since the main purpose of this study is to evaluate the potential fishery species, more information should be provided about the fishery in South Africa.
2. The methodology needs to modify. This study only performed experiment once, that is not enough to provide the solid data to reach the aim.
3. Ecology study is not only focus the fish number and size. The environmental changes should be included. The effect of different catching methods on fish number should be also investigated.