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Original Research Articles

Threatened fishes of the world: *Diptychus maculatus* and *Aspiorhynchus laticeps*

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In order to deeply analyze the individual biological characteristics of unique fish in China, lay a solid foundation for the effective protection of its germplasm resources, and further enrich and consolidate the basic biological data system of endemic fish in the world. According to the ethical norms and fishing licenses, 5 samples of *Diptychus maculatus* and 3 samples of *Aspiorhynchus laticeps* were collected from the Tarim River system in Baicheng County from 2023 to 2024. The morphological characteristics, age identification and anatomical observation of the two fishes were analyzed by classical biological methods. Both fish belong to Cypriniformes, Cyprinidae, Schizothoracinae. *D. maculatus* has a long body, a conical head, and a lower mouth with a pair of fish whiskers. The mouth is slightly blunt and arcuate, and the lateral line is complete. *A. laticeps* has a long, slightly flattened body, a round abdomen, and a large head that is flattened at the front. It also has a pair of fish whiskers located at the corners of the mouth. Age identification materials: *D. maculatus* lapillus 6+, asteriscus 6+, vertebra 6+, anal scales 6+, opercular bone 5+, A. laticeps lapillus 7+, asteriscus 7+, vertebra 7+, anal scales 7+, opercular bone 7+. The peritoneal wall of *D. maculatus* is black or brown the tooth type was 3·4-4·3; the external behavior of gill rakers was 8-13; and the internal behavior was 12-16. *A. laticeps* pharynx teeth 3 lines, tooth type is 2·3·5-5·3·2; the external behavior of gill rakers was 11-13; and the internal behavior was 15-18. *D. maculatus* and *A. laticeps* are special species distributed in the Tarim River system. Their evolutionary adaptation is closely related to the uplift of the Qinghai-Tibet Plateau. This study provides important data for better understanding the individual biological characteristics of these two endangered fish species and lays the foundation for their germplasm resource conservation.

INTRODUCTION

The Tarim River system is a crucial water body in China's arid inland region, known for its long history and complex ecology.[1] As China's longest inland river, it originates in the Tianshan Mountains, flows through the Tarim Basin, and eventually empties into the Tarim Salt Lake.[2] The unique geographical and climatic conditions along the river support distinct biodiversity, particularly in fish resources, which are of significant interest for scientific research and ecological restoration. The diverse fish populations in the Tarim River system reflect the area's ecological characteristics.[3] Among them, *Schizothorax* is famous for its unique biological characteristics and adaptability, and has become a hot topic in academic research. Their importance in the food chain has led researchers to conduct in-depth discussions on the ecological habits, reproductive behavior, and adaptability to the water environment of this group.[4]

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The Tarim River system has bred a variety of fish species, among which the representative species of Schizothoracine fishes, *Diptychus maculatus* and *Aspiorhynchus laticeps,* have attracted wide attention[5,6]. *D.maculatus* belongs to Cypriniformes and Cyprinidae (Institute of Zoology, Chinese Academy of Sciences, 1979).[7] It is a flagship species in the Tarim River system. It is distributed in alpine cold waters and is a rare fish endemic to China.[7] Steindachner first recorded and described *D.maculatus* on the basis of specimens collected at Upper Source Leh on the Indus River, and named it *D.maculatus* in 1866.[8] In recent years, due to the construction of a large number of reservoirs and dams, the breeding habitat and migration channels of *D.maculatus* have been severely damaged, resulting in a sharp decline in its wild population.[9] Due to its endangered status, *D. maculatus* has attracted wide attention. In 2021, the *D. maculatus* was listed in the 'List of National Key Protected Wild Animals (Grade Ⅱ)'.[10] According to its ecological characteristics, the research of *D.maculatus* mainly focuses on distribution, external morphology, physiological ecology, artificial reproduction and disease control. The *A. laticeps* also belongs to the Cyprinidae, and its habits tend to inhabit large lakes and slow-flowing waters, which has rich economic value.[11] The distribution of this fish has been seriously affected by human activities, and there are only a few distribution points left in the area where it was originally widespread.[3] The *A.laticeps* was listed in the 'List of National Key Protected Wild Animals (Grade Ⅰ)' and was included in the 'China red data book of endangered animals (Fish)' as early as 1988.[10,12]

D. maculatus is characterized by its prominent spots on the sides of its body, bright colors, and strong adaptability, allowing it to thrive in various aquatic environments. It plays an important role in natural ecosystems and fishery production.[8] *A. laticeps* is widely recognized for its unique kiss-shaped mouth and living habits; its flat snout is adapted for a specific feeding method, yet its population size and distribution are significantly affected by changes in the water environment.[13] Although these two fish species have different biological characteristics, they are both vital for the stability and health of the Tarim River ecosystem. Studying their ecological habits and adaptation mechanisms is of great significance for protecting the fragile ecosystem of the Tarim River Basin. Furthermore, protecting the habitat of *D. maculatus* is crucial for maintaining the ecological balance of *A. laticeps* and further promoting the protection of regional biodiversity.[11,14] Therefore, the comprehensive study of these two fish species can promote the ecological protection of the Tarim River system and help to establish a more stable natural habitat and biodiversity conservation framework.[15]

To deeply analyze the biological characteristics of the two endangered fishes, effectively protect the germplasm resources of the world's endemic fishes, and consolidate the basic data system of the biology of the world's endemic fishes. This study mainly collected and analyzed the morphological characteristics, age and growth characteristics of the two rare fish species distributed in the Tarim River system from 2023 to 2024, and discussed the adaptive behavior of these two rare fish species. It is hoped that the in-depth study of the two endangered fish species will promote the protection of aquatic biodiversity and ecological balance, provide important data and information for the development of biology, ecology, and other related disciplines, and lay the foundation for the conservation of fish germplasm resources.

MATERIALS AND METHODS

SAMPLE COLLECTION

In this study, which was approved by the Science and Technology Ethics Committee of Tarim University (approval code:2023027). From 2023 to 2024, 5 samples of *D. maculatus* samples and 3 samples of *A. laticeps* were collected by using gillnets and surface cages (mesh 2a = 20 mm) in the Tarim River (81°57'E, 41°92'N) system, China (**Figure 1**). Biological determination and gender identification were performed on site, and three pairs of otoliths were removed and stored in 0.2 mL centrifuge tubes; 4-9 vertebrae and anal scale were fixed with 95% ethanol in 2 mL centrifuge tubes for use; and other tissues were fixed with 10% formalin solution and brought back to the laboratory for further treatment.

METHODS

Treatment with 5 kinds of age identification materials, embedding and fixing of lapillus, sandpaper grinding, polishing, acetone dissolution, turning and fixing, continue polishing until the center core is clear; The growth rings were observed with xylene drops in asteriscus and photographed with SMZ 1270i. The vertebra were boiled in water for 5-10 min, the connective tissue was removed, and the xylene was transparent. The opercular bone was boiled for 1 min, and the connective tissue was removed and photographed by microscope. The anal scale was washed with warm water and the mucous membrane was removed.

CT scanning was performed on the whole fish (Micro CT μ80 microCT instrument). Scanning conditions were as follows: voltage (70 kVp), current (114 μA), 360° rotation scanning, scanning 180 min, resolution 14 μm, average frame 4, Angle gain 0.4°. The skeletal system was reconstructed by pCT Ray v4.0-1.

DATA PROCESSING AND ANALYSIS

SPSS 18.0 and ORIGIN 9.0 were used and expressed as Mean and standard deviation (Mean ± S.D.).

RESULTS

MORPHOLOGICAL CHARACTERISTICS

D. maculatus is cylindrical anteriorly and slightly flattened posteriorly. Head obtusely conical. Anastomosis prominent. Mouth inferior, transverse or arcuate; mandibles with acute angular margins; right and left lobes of lower lip nar-

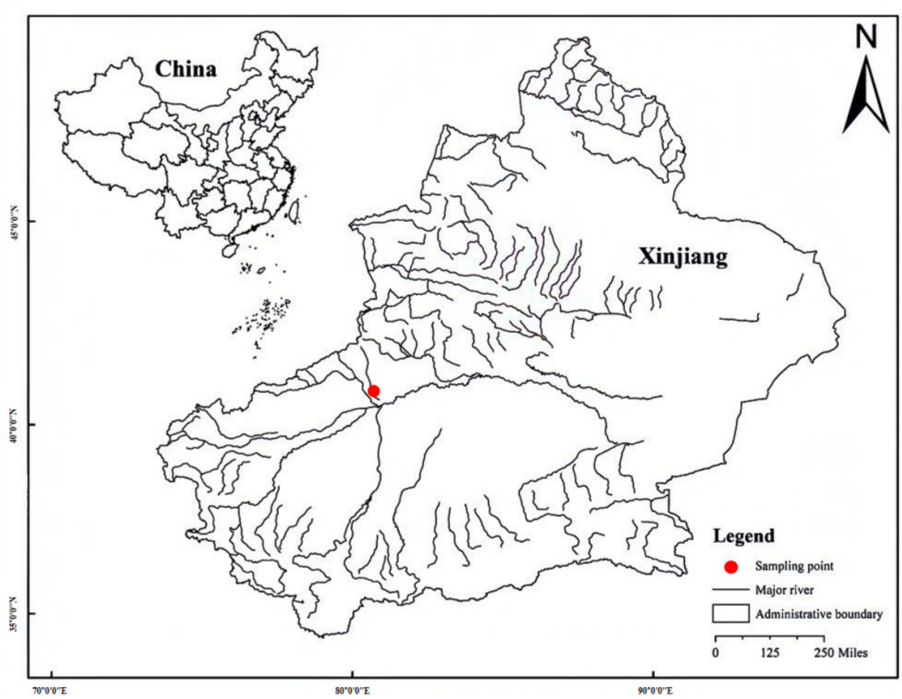

Figure 1. Schematic diagram of the sampling sites of *D. maculatus* and *A.laticeps*

Figure 2. *D. maculatus* (This picture shows the largest captured individual)

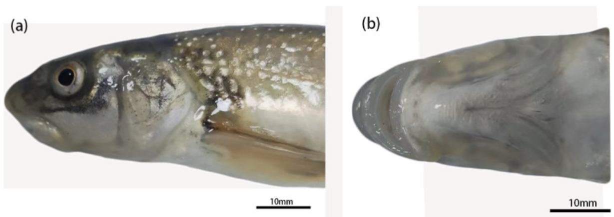

Figure 3. Lateral view and ventral view of head of *D. maculatus*

row, with granular surfaces; postlabial sulcus interrupted. Whiskers 1 pair, stout, shorter than or equal to eye diameter. Eyes equal in size, laterally superior. Pharyngeal teeth columnar, apically pointed, hooked. Hypopharyngeal bones narrow and long. Thorax and abdomen naked and scale-free; gluteal scales and lateral line scales larger; lateral body scales arranged above and below lateral line in imbricate or very sparse. Lateral line complete, laterally median (Figure 2, Figure 3). Dorsal fin pattern Ⅱ, 8, anal fin pattern Ⅱ, 5, pectoral fin pattern Ⅰ, 7~8, ventral fin pattern Ⅰ, 7~8;

Figure 4. *A.laticeps* (This picture shows the largest captured individual)

A. laticeps ellipsoidal, slightly oblate. Big head. Kiss flat, wedge-shaped ; wide mouth, front; the jaw is in the upper collar, and there is no qualitative edge. Must be short, 1 pair. Eyes small, oval, side upper, close to the snout. The hypopharyngeal bone is narrow, 5 ~ 6 times wider than the width of the pharynx. The pharynx is columnar, apically pointed, and hooked. The gill cake is sparse and short. The scale is small, the side line is complete, and the side is medium. The distance from the starting point of dorsal fin to the rostrum is greater than that from the caudal fin base. The anal fin is close to the anus. The starting point of the ventral fin is located below or slightly behind the starting point of the dorsal fin. Caudal fin forked. Body color changes slightly with individual size.Aged individuals over 900 mm in length have brown spots on both sides of the head and each scale. The upper side is thicker and the lower side is lighter. The dorsal fin is brown, and the pectoral, ventral, anal fins and the lower leaves of the caudal fin are bright orange (Figure 4, Figure 5). Dorsal fin pattern Ⅲ, 8, anal fin pattern Ⅱ, 5, pectoral fin pattern Ⅱ, 7~8, ventral fin pattern Ⅰ, 8~9.

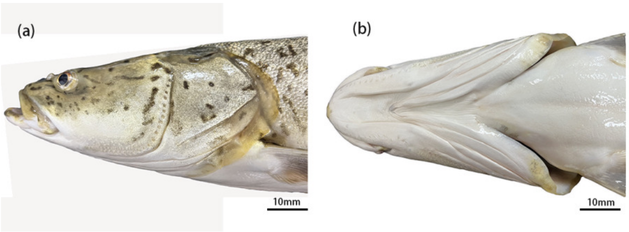

Figure 5. Lateral view and ventral view of head of *A.laticeps*

Table 1. Measurable Characters of *D. maculatus*

Measurement project	Mean ± S.D.	Range
TW	173.69 ± 221.31	5.5 - 563.46
TL	206.86 ± 126.66	88.35 - 394.46
BL	178.13 ± 113.57	71.75 - 346.79
BD	31.31 ± 20.77	11.81 - 62.07
BW	17.33 ± 13.79	5.11 - 44.80
HL	39.15 ± 22.61	17.25 - 73.65
SL	13.90 ± 8.53	5.51 - 27.49
ED	5.92 ± 1.78	4.38 - 9.33
EI	13.06 ± 8.45	5.17 - 28.59
CPL	25.33 ± 12.83	12.78 - 44.25
CPH	14.43 ± 9.93	4.83 - 28.61
Pectoral fin length	24.37 ± 1.39	22.48 - 26.38
Ventral fin length	20.47 ± 1.41	19.07 - 22.62
Anal fin length	32.53 ± 2.93	29.12 - 37.02

QUANTIFIABLE CHARACTER ANALYSIS

The standard deviations of body height, body width, head length, snout length, eye diameter, eye distance, caudal stalk length and caudal stalk height were 20.77, 13.79, 22.61, 8.53, 1.78, 8.45, 12.83 and 9.93, respectively. The standard deviation of body mass is 125.19, indicating that the size of body mass is different. The standard deviations of total length and body length were 61.55 and 67.44, respectively, indicating that the population size of *D. maculatus* covered a wide range (**Table 1**). The standard deviations of body height, body width, head length, snout length, eye diameter, eye distance, caudal stalk length and caudal stalk height were 5.00, 4.75, 10.02, 2.81, 0.99, 2.43, 5.67 and 0.04, respectively. The standard deviation of body mass is 125.19, indicating that the size of body mass is different. The standard deviations of total length and body length were 22.72 and 19.51, respectively, indicating that the population size of *A. laticeps* covered a wide range (**Table 2**).

From the ratio of measurable traits (**Table 3** and **Table 4**), it can be observed that the BL/ED ratio shows the widest variation range among the two fish species, while the HL/CPL and BD/TW ratios exhibit the smallest variation range.

Table 2. Measurable Characters of *A.laticeps*

Measurement project	Mean ± S.D.	Range
TW	1036.64 ± 77.54	959.1 - 1114.17
TL	514.92 ± 22.72	492.2 - 537.63
BL	453.52 ± 19.51	434.01 - 473.02
BD	70.97 ± 5.00	65.97 - 75.97
BW	56.54 ± 4.75	51.79 - 61.28
HL	125.62 ± 10.02	115.6 - 135.64
SL	35.42 ± 2.81	32.61 - 38.23
ED	10.05 ± 0.99	9.06 - 11.04
EI	25.43 ± 2.43	23.00 - 27.85
CPL	56.60 ± 5.67	50.93 - 62.27
CPH	33.29 ± 0.04	33.25 - 33.32
Pectoral fin length	64.20 ± 4.39	59.81 - 68.58
Ventral fin length	52.97 ± 3.72	49.25 - 56.68
Anal fin length	60.63 ± 8.14	52.49 - 68.76

Table 3. Ratio of measurable characters of *D. maculatus* (n=2)

Trait Ratio	Mean±S.D.	Range
BL / BD	5.88 ± 0.46	5.19 - 6.49
BL / HL	4.37 ± 0.33	3.97 - 4.83
BL / CPL	6.59 ± 1.00	5.61 - 8.05
BL / ED	27.49 ± 10.94	15.91 - 44.41
HL / ED	6.14 ± 2.01	3.82 - 9.20
HL / CPL	1.50 ± 0.15	1.31 - 1.67
HL / CPH	3.05 ± 0.59	2.45 - 3.97
CPL / CPH	2.06 ± 0.47	1.48 - 2.79
BD / TW	3.10 ± 4.05	1.24 - 12.15

Body length ranges from 5.19 to 6.49 times the body height, 3.97 to 4.83 times the head length, and 5.27 to 8.82 times the caudal stalk length. The head length varies from 3.82 to 9.20 times the eye diameter, and the caudal stalk length is 1.48 to 2.79 times the caudal stalk height. These observations indicate that *D. maculatus* has a long body, a slender structure, a relatively small head, small eyes located at the front of the head, and a slightly rectangular tail stalk.In contrast, the BL/ED and HL/ED ratios of *A. laticeps* display significantly greater variation compared to those of *D. maculatus*. This suggests that *A. laticeps* possesses a long and slightly flattened body, along with a larger head.

AGE DETERMINATION

The age of *D. maculatus* was determined using five age determination materials (**Figure 6**), 6^+ (a) for lapillus, 6^+ (b)

Table 4. Ratio of measurable characters of *A.laticeps* (n=2)

Trait Ratio	Mean±S.D.	Range
BL / BD	6.40 ± 0.18	6.23 - 6.58
BL / HL	3.62 ± 0.13	3.49 - 3.75
BL / CPL	8.04 ± 0.46	7.60 - 8.52
BL / ED	45.29 ± 2.53	42.85 - 47.90
HL / ED	12.52 ± 0.24	12.29 - 12.76
HL / CPL	2.22 ± 0.05	2.18 - 2.27
HL / CPH	3.77 ± 0.30	3.48 - 4.07
CPL / CPH	1.70 ± 0.17	1.87 - 1.53
BD / TW	0.07 ± 0.00	0.07 - 0.07

for asteriscus, 6^+ (c) for vertebra, 6^+ (d) for anal scale, and 5^+ (e) for opercular bone.

The age of *A. laticeps* was determined using five age determination materials (**Figure 7**), 7^+ (a) for lapillus, 7^+ (b) for asteriscus, 7^+ (c) for vertebra, 7^+ (d) for anal scale, and 7^+ (e) for opercular bone.

ANATOMICAL OBSERVATION

The anus of *D. maculatus* is not advanced and the abdominal cavity is large, the peritoneal wall is black, and the mesangium keeps the organs in a relatively fixed position in the body cavity (**Figure 8-a**). There are no gnathic teeth, oral teeth and free tongue in the mouth, but there are pharyngeal teeth in the oropharyngeal cavity, only on the fifth branchial arch (pharyngeal bone), columnar, apical, and hooked, powerful teeth with few grains and distinct grains, teeth of 3·4 - 4·3; It has two rows of pharyngeal teeth on the inside: the first row has the largest four, the second row has three smaller ones. Gill harrows are 14 to 19 for outsiders and 19 to 24 for insiders (**Figure 8-b,c**). Anterior chamber (bladder body) 37 mm, posterior chamber 10 mm (**Figure 8-d**). *D. maculatus* has no stomach, and the intestine is closely connected with the esophagus and coiled in the abdominal cavity. The intestinal recursion area is smaller than other parts, so the intestine is divided into four parts: anterior intestine, midintestine, posterior intestine and rectum. The intestinal length is 205 mm (**Figure 8-e**).

A. laticeps ventral and dorsal scales are small, and the body side scales are larger. There is a line of extra-large anal fins on both sides of the anus and the gluteal fin base, and the gluteal scales are developed (**Figure 9-a**). Wide mouth, front ; the mandible is longer than the maxilla and has no horny margin. The hypopharyngeal teeth are columnar, and the apex is sharp and slightly curved. There are three rows of pharyngeal teeth, tooth type 2·3·5 ~ 5·3·2, gill raker outer row 11 ~ 14, inner row 15 ~ 18 (**Figure 9-b,c**). The swim bladder in *A. laticeps* has two chambers, the anterior chamber is enlarged, and the length of the posterior chamber is about 1.6 times that of the anterior chamber (**Figure 9-d**). The intestine is short, only 1.2 times the body length (**Figure 9-e**).

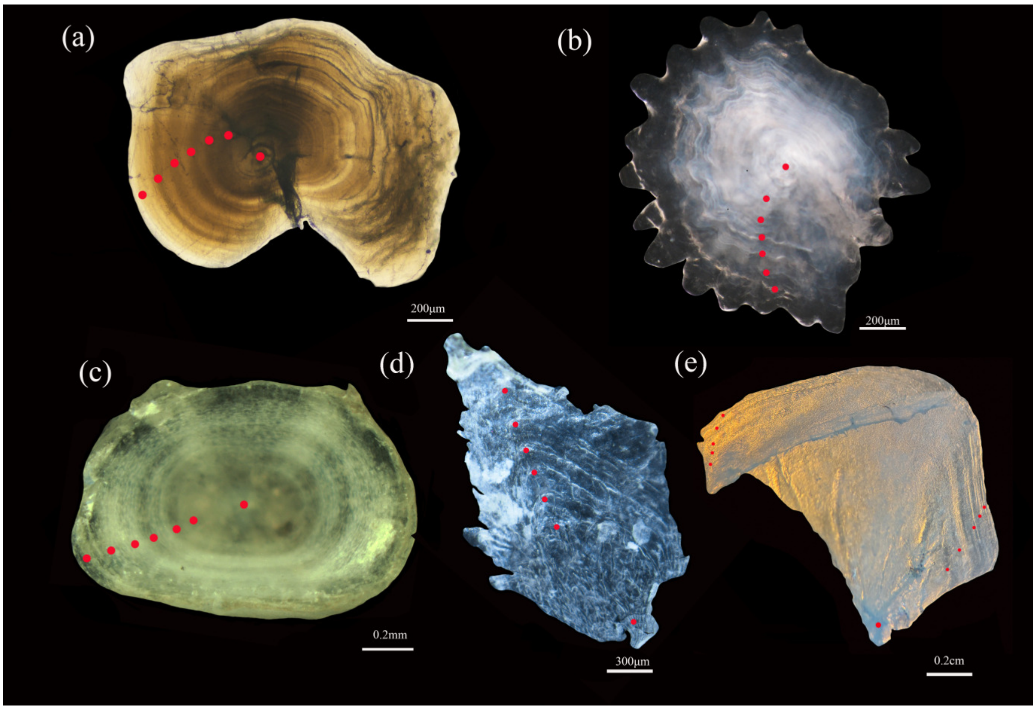

Figure 6. 5 kinds of age identification materials of *D. maculatus*

Note: (a) Lapillus, (b) Asteriscus, (c) Vertebra, (d) Anal scale, (e) Opercular bone

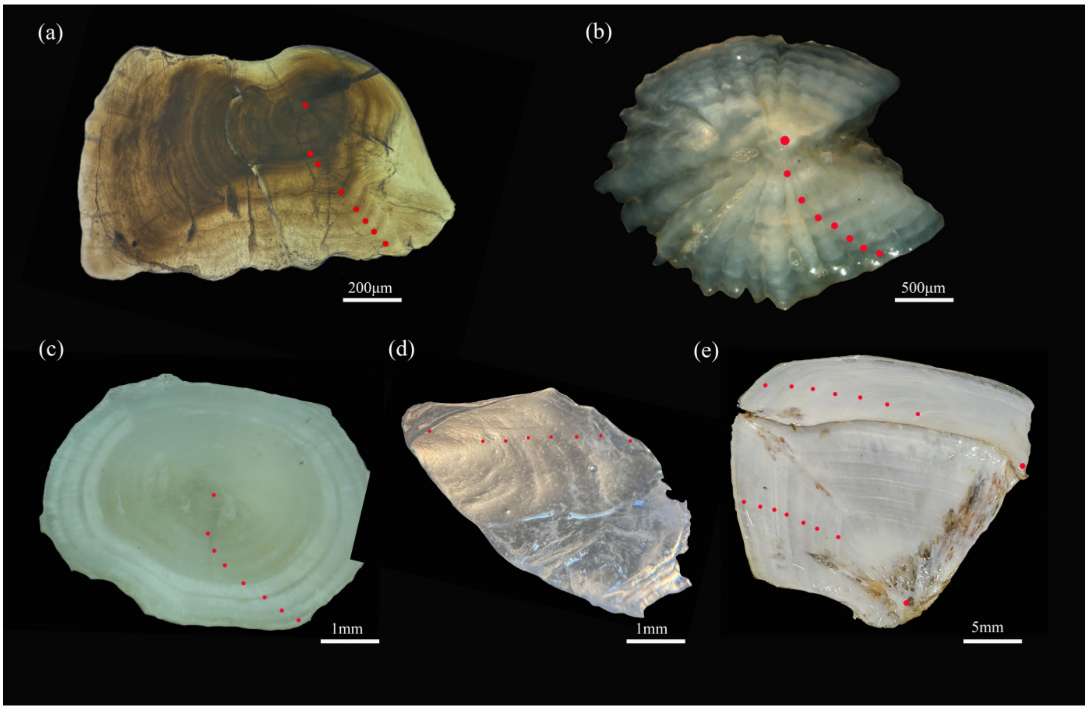

Figure 7. 5 kinds of age identification materials of *A.laticeps*

Note: (a) Lapillus, (b) Asteriscus, (c) Vertebra, (d) Anal scale, (e) Opercular bone

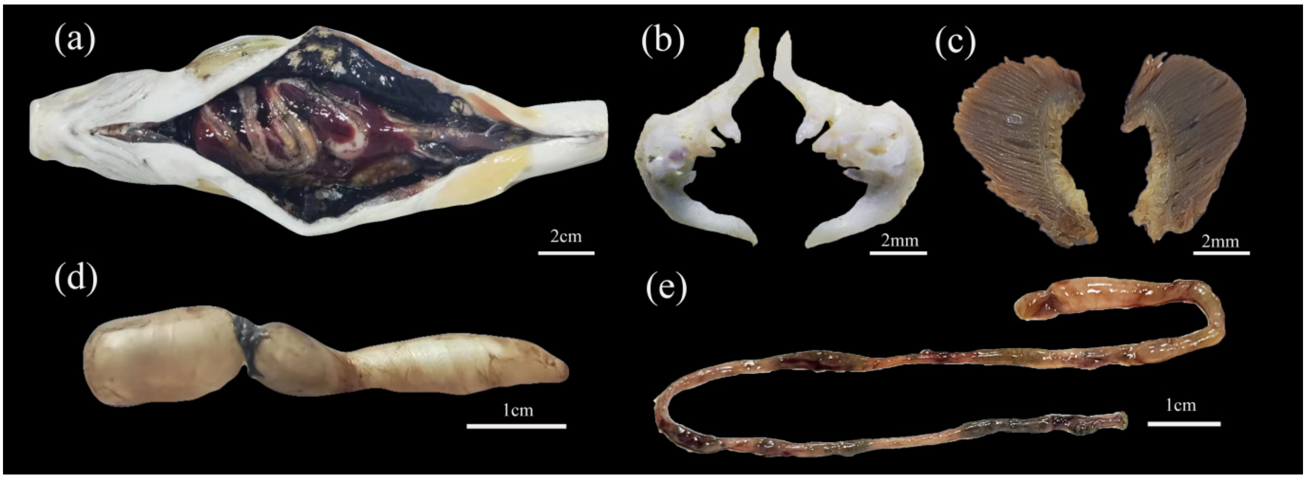

Figure 8. Anatomical observation of *D. maculatus*

Note: (a) Viscera, (b) Pharyngeal teeth, (c) Gill harrow, (d) Swim bladder, (e) Gut

DISCUSSION

MORPHOLOGICAL STRUCTURE

The shape characteristics of fish can be divided into three categories: morphological traits, countable traits and proportional traits.[16] We found that the *D. maculatus* gill harrow was 8~12 for laymen and 12~14 for experts, wich dorsal fin pattern Ⅱ, 8, anal fin pattern Ⅱ, 5. Comparing the morphological characteristics of *D. maculatus* from other regions, that the *D. maculatus* from the Ili River gill harrow was 16~20 for laymen and 21~27 for experts, wich dorsal fin fin form Ⅱ, 8~9, anal fin fin form Ⅱ, 5; *D. maculatus* from the Taxkorgan River gill harrow was 9~13 for laymen and 14~16 for experts, wich dorsal fin type Ⅱ, 8~9, anal fin type Ⅱ, 5. It can be seen that the differences in the number of fin rakers of *D. maculatus* in the three rivers were not significant (P>0.05),[8] but the number of gill rakers of *D. maculatus* in the Ili River was much larger than that in the Tarim River, and the number of gill rakers of *D. maculatus* in the Taxkorgan River did not differ much from that of the present study.[17,18] Some researchers have investigated intraspecific variation in the morphological traits of *Galaxias brevipinnis*, *G. gollumoides*, and *G. vulgaris* across different hydrological environments, distinguishing between rapid-flowing and slow-flowing habitats.[19] Additionally, they

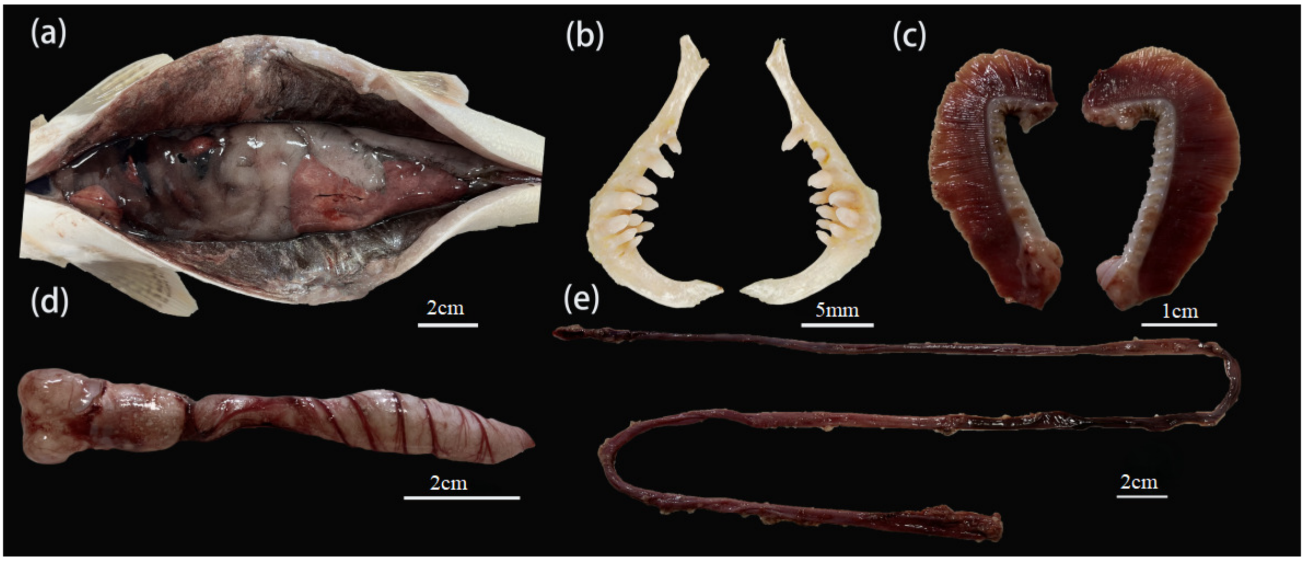

Figure 9. Anatomical observation of *A.laticeps*

Note: (a) Viscera, (b) Pharyngeal teeth, (c) Gill harrow, (d) Swim bladder, (e) Gut

compared intraspecific morphological differences between *Bryconops caudomaculatus* and *Biotodoma wavrini* in two Neotropical habitats: a river and a lagoon ($p < 0.05$).[20] These findings suggest that the differentiation of morphological traits in fish is closely associated with the environmental conditions in which they live.[21] Geographically, the Ili River originates in the western part of the northern slopes of the Tianshan Mountains and eventually flows into Lake Balkhash[22]; the Taxkorgan River originates in the Karakorum Mountains and is a major tributary of the middle and upper reaches of the Yarkand River in the Tarim River system.[23] Therefore, the morphological characteristics of *D. maculatus* from the Taxkorgan River did not differ much from the present study ($P > 0.5$), whereas those of *D. maculatus* from the Ili River were more different from the present study ($P < 0.5$).[24]

Compared with most fish, the most significant feature of *A.laticeps* is the significant enlargement of its head, commonly known as ' bighead ', which not only gives it a distinctive appearance, but also reveals its unique evolutionary path to adapt to the aquatic environment.[25] In contrast, many common fish, such as *Cyprinus carpi*o (Cyprinus carpio),[26,27] have round heads and do not exhibit the distinctive head features of *A.laticeps*. The shape of *A.laticeps* is slender, the back is slightly protuberant and the abdomen is flat. In addition, the fine and neatly arranged scales are shining with silvery white luster, which together constitute its streamlined shape, effectively reducing water resistance and improving swimming efficiency. This is in stark contrast to the wider and flat fish such as *Perca fluviatilis* (perch).[28] Although the latter has its own unique way of swimming, *A.laticeps* is better in reducing water resistance. The snout of *A.laticeps* is flat and broad, which enhances the perception ability and improves the predation accuracy. Compared with predators such as *Serrasalminae* known for their sharp snout, *A.laticeps* shows a better predation strategy.[29] In addition, the *A.laticeps* fins, especially the caudal fin, are broad and powerful, providing them with excellent swimming and the ability to evade predators, which is similar to many fish that rely on speed and agility to survive, such as *Thunnus*, but there are still significant differences in specific morphology and adaptive strategies.[30] Furthermore, the characteristics of *A.laticeps* body color changing with the environment are also rare in fish. This protective color mechanism enables it to be effectively concealed in different water environments and reduce the risk of predation, which echoes the strategy of some coral reef fish to integrate into the surrounding environment by camouflage, but the adaptability of *A.laticeps* is more extensive and flexible (Ahi et al., 2020; Donohue et al.[31]).

AGE

Age is not only the basic parameter of fish growth, reproduction and population structure, but also an important research content of fishery ecology.[32,33] Accurate age data of fish are helpful to evaluate population resources and analyze population dynamics. In this study, the age structure of *D. maculatus* ranged from 2 to 8 years old, and the dominant ages were 6 years old. The age of *A. laticeps* is 5-8 years old, and the dominant age is 7 years old. Five age-identified materials showed differences in age, with otolith identification being the most accurate, followed by vertebrae, scales, and opercular bones. In many comparative studies of age-identified fish, otolith readings were found to be more accurate than other age-identified materials. Ma[34] found that otoliths were the most suitable age material for age identification in three age materials (otoliths, vertebrae, and opercular bones) for *Schizothorax o'connori* and *Racoma waltoni*, respectively, and Huo[35] found that otoliths were better than vertebrae for age identification in the age materials of *Oxygymnocypris stewartii*, and that otoliths were also the best age material for the age identification of *Gadus morhua* and *Triplophysa rosa*.[32,33] Moreover, otoliths are also the best age material for *Schizothorax pseudaksaiensis*, *Gymno-*

cypris selincuoensis, *Schizopygopsis malacanthus*, and *Gymnocypris przewalskii*. The reasons for this are that the vertebrae is not easy to determine age because the vertebrae is thickened at the base of the vertebrae and the central whorl is not easy to identify; the scales are prone to wear and tear or stagnation with age, which usually underestimates the age of older and slower-growing individuals, and is only suitable for ageing younger, faster-growing fishes.[36]

FEEDING

During the feeding process of fish, the morphology and structure of feeding organs are closely related to the acquisition and processing of food, in which the first contact with food is the mouth, lips and other external feeding organs.[37,38] The size of the mouth slit determines the range of food volume that can be utilized by the fish, and directly affects the bite force. The hypopharyngeal tooth type of *D. maculatus* was conical, which suggests that *D. maculatus* has increased the variety of food taken and the degree of omnivory in order to adapt to the colder environment. Numerous studies have found that the intestinal tract of phytophagous fishes is generally narrower and longer, curved and coiled in the abdominal cavity, so that food rich in plant fibers can be fully digested and absorbed by prolonging the retention time of the food in the intestinal tract, whereas carnivorous fishes, whose ingested food has a higher content of protein and fat, is easier to be digested and absorbed, and thus has a shorter intestinal tract. In the present study, *D. maculatus* had no stomach and a long intestine, consistent with its omnivorous diet.[39-41]

A.laticeps has a slender body, a micro-bulge on the back, and a flat abdomen. Its streamlined appearance reduces water resistance and improves swimming efficiency, which is crucial for long-term foraging in water.[42] The silvery white scales form a subtle reflection in the water, which helps *A.laticeps* to remain hidden in the underwater environment and thus more effectively approach the prey.[43] The flat and broad characteristics of the snout are particularly significant, which enhances the perception ability of *A.laticeps*, enables it to locate the food source in the water more accurately, and also facilitates its predation.[44] *A.laticeps* uses its broad snout to search for benthic organisms, small fish or aquatic insects in the sediment, showing its unique foraging strategy. The powerful caudal fin also plays an important role in the predation process, helping *A.laticeps* quickly adjust its direction or accelerate the pursuit of prey. These unique structures make *A.laticeps* efficient foraging strategies in specific ecological environments.[45,46]

CONSERVATION STATUS

According to genetic studies, *D. maculatus* may have migrated from central China to the Xinjiang region. This fish is mostly found in the upper reaches of rivers at high altitudes, and is a cold-water fish that prefers to inhabit rivers below 20°C. Due to the high requirements of the living environment and the increase of pollution from human activities in recent years, the population of *D. maculatus* has declined, and in 2021 the *D. maculatus* was listed in the ‘List of National Key Protected Wild Animals (Grade Ⅱ)’. Therefore, it is extremely important to strengthen the research on its ecological habits and reproduction patterns to provide a basis for its protection, management and sustainable utilization.[47,48]

As a unique rare aquatic wild animal in Xinjiang, the protection status of *A.laticeps* has attracted much attention. Due to the limitations of its own biological characteristics, such as mature age, low fecundity, and the interference of environmental changes and human activities, *A.laticeps* was once on the verge of extinction. Since the 1980s, *A.laticeps* has been listed as a first-class protected animal in China and included in the ’ Redbook of Endangered Wildlife ’ and the ’ National Key Protected Wildlife List of China.[49-51] In recent years, in order to protect *A.laticeps*, a number of measures have been taken in Xinjiang, including the establishment of aquatic wildlife rescue centers and protection bases, artificial breeding and proliferation.[52] The scientific research team successfully hatched and cultivated a large number of healthy fry by selecting mature gonadal broodstock and implementing artificial spawning. At the same time, the proliferation and release activities have also achieved remarkable results. *A.laticeps* has re-formed its population in waters such as Bosten Lake, and the population has recovered. However, the protection of *A.laticeps* still faces many challenges, such as the continuous change of ecological environment and the invasion of alien species.[53] Therefore, it is necessary to continue to increase protection, strengthen scientific research, and explore more effective protection methods and technologies.[54-56]

The study results showed that the morphological features and age structure of fishes are closely related to their living environment. Regarding morphological features, *D. maculatus* and *A. laticeps* demonstrate unique adaptations. These features include the number of gill rakers, body size, and changes in body color, which are strategies developed by fish to adapt to different ecological environments. Regarding the age structure, otoliths are the most accurate material for identifying the age of fishes due to their resistance to abrasion and clear annual rings. The study of feeding organs shows that the size of the mouth slit, the type of pharyngeal teeth, and the structure of the digestive system are all closely related to the food acquisition and processing ability of fishes.

In terms of conservation biology, both *D. maculatus* and *A. laticeps* are facing the challenges of ecological changes, including pollution and invasive alien species. Population recovery and ecosystem stabilization of these endangered species can be facilitated by strengthening scientific research and developing effective conservation strategies. This is important for the conservation of biodiversity and the sustainable use of ecosystems.

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AUTHORS CONTRIBUTION

Conceptualization: Linghui Hu (Equal), Aizhi Han (Equal), Liting Yang (Equal), Gulden Serekbol (Equal). Formal Analysis: Yong Song (Equal), Jiaxuan Liu (Equal). Investigation: Yong Song (Equal), Jiaxuan Liu (Equal). Methodology: Liting Yang (Equal), Gulden Serekbol (Equal). Writing – original draft: Liting Yang (Lead). Supervision: Bin Huo (Equal), Daoquan Ren (Equal). Writing – review & editing: Chengxin Wang (Equal), Shengao Chen (Equal).

COMPETING OF INTEREST – COPE

No competing interests were disclosed.

ETHICAL CONDUCT APPROVAL – IACUC

All experimental protocols were approved by the Science and Technology Ethics Committee of Tarim University (approval code:2023027) and adhered to animal welfare laws, guidelines and policies.

INFORMED CONSENT STATEMENT

All authors and institutions have confirmed this manuscript for publication.

DATA AVAILABILITY STATEMENT

All are available upon reasonable request.

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REFERENCES

1. Yaning C, Yapeng C, Chenggang Z, Yang W, Xingming H. Ecohydrological effects of water conveyance in a disconnected river in an arid inland river basin. *Scientific reports*. 2022;12(1). doi:10.1038/s41598-022-14524-z

2. Lu S, Wang Y, Zhou J, et al. Active water management brings possibility restoration to degraded lakes in dryland regions: a case study of Lop Nur, China. *Scientific reports*. 2022;12(1). doi:10.1038/s41598-022-23462-9

3. Cheng L, Song D, Yu X, Du X, Huo T. Endangered Schizothoracin Fish in the Tarim River Basin Are Threatened by Introgressive Hybridization. *Biology*. 2022;11(7). doi:10.3390/biology11070981

4. Xiao S, Mou Z, Fan D, et al. Genome of Tetraploid Fish Schizothorax o'connori Provides Insights into Early Re-diploidization and High-Altitude Adaptation. *iScience*. 2020;23(9):101497. doi:10.1016/j.isci.2020.101497

5. Deng X, Long AH, Ling H, Deng M, Zhang S. Effects of Climate Change and Human Activities on Runoff in the Headstream Areas of Tarim River Basin. *Journal of Environmental Accounting*. 2015;3(1):31-45. doi:10.5890/JEAM.2015.03.003

6. Zhang C, Tong C, Ludwig A, et al. Adaptive Evolution of the Eda Gene and Scales Loss in Schizothoracine Fishes in Response to Uplift of the Tibetan Plateau. *Int J Mol Sci*. 2018;19(10). doi:10.3390/ijms19102953. PMID:30262767

7. Hao CL, Zhang WR, Arken K, et al. Identification of a new species of *Gyrodactylus* von Nordmann, 1832 (Monogenoidea Gyrodactylidae) isolated from *Diptychus maculatus* in Yarkand River, Xinjiang, China. *International journal for parasitology Parasites and wildlife*. 2024;24:100949. doi:10.1016/j.ijppaw.2024.100949

8. Guo Y. *Xinjiang of Fishery*. Xinjiang Science and Technology Press; 2012.

9. Li G, Tang Y, Zhang R, Zhao K. Phylogeography of Diptychus maculatus (Cyprinidae) endemic to the northern margin of the QTP and Tien Shan region. *BMC evolutionary biology*. 2016;16(1). doi:10.1186/s12862-016-0756-3

10. Chen JF, Wu XJ, Lin H, Cui GF. A comparative analysis of the List of State Key Protected Wild Animals and other wildlife protection lists. *Biodiversity Science*. 2023;31(06):190-202. doi:10.17520/biods.2022639

11. Wang C, Hu L, Song Y, et al. The Evolution of Three Schizothoracinae Species from Two Major River Systems in Northwest China Based on Otolith Morphology and Skeletal Structure. *Biology*. 2024;13(7). doi:10.3390/biology13070517

12. Yue PQ, Chen YY. *China Red Data Book of Endangered Animals*. Science Press; 1998.

13. Wu YF. *Fish of Qinghai-Tibet Plateau*. Sichuan Science and Technology Press; 1992.

14. Niu J, Zhang R, Hu J, et al. Chromosomal-scale genome assembly of the near-extinction big-head schizothorcin (*Aspiorhynchus laticeps*). *Sci Data*. 2022;9(1). doi:10.1038/s41597-022-01671-1

15. Li H, Wang W, Fu J, Wei J. Spatiotemporal heterogeneity and attributions of streamflow and baseflow changes across the headstreams of the Tarim River Basin, Northwest China. *The Science of the total environment*. 2023;856(Pt 2):159230. doi:10.1016/j.scitotenv.2022.159230

16. Parvin F, Jannat S, Tareq SM. Abundance, characteristics and variation of microplastics in different freshwater fish species from Bangladesh. *The Science of the total environment*. 2021;784:147137. doi:10.1016/j.scitotenv.2021.147137

17. Mamilov NS, Tursynali M, Khassengaziyeva GK, et al. Alien Rainbow Trout *Oncorhynchus mykiss* in the Balkhash Basin (Kazakhstan, Central Asia): 50 Years of Naturalization. *Animals: an open access journal from MDPI*. 2024;14(20). doi:10.3390/ani14203013

18. Mee JA, Yap E, Wuitchik DM. Pelvic spine reduction affects diet but not gill raker morphology in two polymorphic brook stickleback (*Culaea inconstans*) populations. *Ecology and evolution*. 2023;13(9):e10526. doi:10.1002/ece3.10526

19. Dunn NR, O'Brien LK, Burridge CP, Closs GP. Morphological Convergence and Divergence in Galaxias Fishes in Lentic and Lotic Habitats. *Diversity*. 2020;12(5):183-183. doi:10.3390/d12050183

20. Langerhans R, Layman C, Langerhans A, Dewitt T. Habitat-associated morphological divergence in two Neotropical fish species. *Biological Journal of the Linnean Society*. 2003;80(4):689-698. doi:10.1111/j.1095-8312.2003.00266.x

21. Caiger PE, Croq C, Clements KD. Environmentally induced morphological variation in the temperate reef fish, *Forsterygion lapillum* (F. Tripterygiidae). *Marine Biology*. 2021;168:131. doi:10.1111/j.1095-8312.2004.00314.x

22. Zheng LL, Yu D, Sun N, et al. DNA barcoding and cryptic diversity in fishes from the Ili River Valley in China, Xinjiang. *Ecology and evolution*. 2024;14(10):e70352. doi:10.1002/ece3.70352

23. Pei Y, Qiu H, Yang D, et al. Increasing landslide activity in the Taxkorgan River Basin (eastern Pamirs Plateau, China) driven by climate change. *CATENA*. 2023;223:106911. doi:10.1016/j.catena.2023.106911

24. Volynkin AV, Saldaitis A, Chen L, et al. Description of the female of Catocala toropovi Saldaitis et al. 2014 (Lepidoptera, Erebidae). *Zootaxa*. 2016;4139(3):424-426. doi:10.11646/zootaxa.4139.3.7

25. Rivera SF, Rimet F, Vasselon V, Vautier M, Domaizon I, Bouchez A. Fish eDNA metabarcoding from aquatic biofilm samples: Methodological aspects. *Molecular ecology resources*. 2022;22(4):1440-1453. doi:10.1111/1755-0998.13568

26. Jens A, Frank J, Tony S. Interactions between predator- and diet-induced phenotypic changes in body shape of crucian carp. *Proceedings Biological sciences*. 2006;273(1585):431-437. doi:10.1098/rspb.2005.3343

27. Omid J, Mansour E, AliAkbar SH. Integration of Morphometrics and Machine Learning Enables Accurate Distinction between Wild and Farmed Common Carp. *Life*. 2022;12(7):957-957. doi:10.3390/life12070957

28. Franz L. Spermatozoa of the teleost fish Perca fluviatilis (perch) have the ability to swim for more than two hours in saline solutions. *Aquaculture*. 2011;314(1-4):221-224. doi:10.1016/j.aquaculture.2011.02.024

29. Luz LA, Reis LL, Sampaio I, Barros MC, Fraga E. Genetic differentiation in the populations of red piranha, Pygocentrus nattereri Kner (1860) (Characiformes: *Serrasalminae*), from the river basins of northeastern Brazil. *Brazilian journal of biology = Revista brasleira de biologia*. 2015;(4):838-845. doi:10.1080/03946975.2012.679390

30. Hsieh CL, Chang HY, Chen FH, Liou JH, Chang SK, Lin TT. A simple and effective digital imaging approach for tuna fish length measurement compatible with fishing operations. *Computers and Electronics in Agriculture*. 2010;75(1):44-51. doi:10.1016/j.compag.2010.09.009

31. Donohue CG, Hemmi JM, Kelley JL. Countershading enhances camouflage by reducing prey contrast. *Proceedings Biological sciences*. 2020;287(1927):20200477. doi:10.1098/rspb.2020.0477

32. Marquez JF, Saether BE, Aanes S, Engen S, Salthaug A, Lee AM. Age-dependent patterns of spatial autocorrelation in fish populations. *Ecology*. 2021;102(12):e03523. doi:10.1002/ecy.3523

33. Xu Y, Jing Y, Zhou J, et al. Age, growth, and energy storage of the subterranean fish *Triplophysa rosa* (Cypriniformes: Nemacheilidae) from Chongqing, China. *BMC ecology and evolution*. 2023;23(1):72. doi:10.1186/s12862-023-02186-y

34. Ma BS. *Study on the Biology and Population Dynamics of* Schizothoraxo'connori. PhD dissertation. Huazhong agricultural university; 2011. https://kns.cnki.net/kcms2/article/abstract?v=Mw9fkKjKljoqvqb96hMYCGfHxKIerLlnOhLko8J317inACz3AIqZ3ASTxPqORetqyFwJnwH3U9NqnSBXIkSid8EQY-Hsh8soqRQe1cAiDByAi61nnF17I-lrevEsnWSNmz2trbogZKdRGpz4M-U-rdiVNd8AFYJlGAYxPwh336XqtrikzFHkyJSfKwo4I5jk&uniplatform=NZKPT&language=CHS

35. Huo B. *Study on the Biology and Population Dynamics of* Oxygymnocypris Stewartil. PhD dissertation. Huazhong Agricultural University; 2014. https://kns.cnki.net/kcms2/article/abstract?v=VcTOyLYtvEwL%20SabpiOikXihn6brom-NAfrKWUL8Sa7t8nZ2pn2WTnD9CyIDST_BQiMxHwOOKybNPOlk64h0fKWv8nIkJ858%201kUwESJm5QzyHe8NFZQ6rbI-ce0cRk8kGDpuA1r-cLKYdQd3RnZu9ILnX5MrsooUoat03UtrgxPn12LnZB-p%20kyn437VVrLXaW&uniplatform=NZKPT&language=CHS

36. Kumbar SM, Lad SB. Estimation of age and longevity of freshwater fish Salmophasia balookee from otoliths, scales and vertebrae. *Journal of environmental biology*. 2016;37(5):943-947.

37. Assan D, Huang Y, Mustapha UF, Addah MN, Li G, Chen H. Fish Feed Intake, Feeding Behavior, and the Physiological Response of Apelin to Fasting and Refeeding. *Front Endocrinol (Lausanne)*. 2021;12:798903. doi:10.3389/fendo.2021.798903

38. Sánchez-Velázquez J, Peña-Herrejón GA, Aguirre-Becerra H. Fish Responses to Alternative Feeding Ingredients under Abiotic Chronic Stress. *Animals: an open access journal from MDPI*. 2024;14(5). doi:10.3390/ani14050765

39. Jiang X, Wang J, Pan B, Li D, Wang Y, Liu X. Assessment of heavy metal accumulation in freshwater fish of Dongting Lake, China: Effects of feeding habits, habitat preferences and body size. *Journal of environmental sciences (China)*. 2022;112:355-365. doi:10.1016/j.jes.2021.05.004

40. Soe KK, Hajisamae S, Sompongchaiyakul P, Towatana P, Pradit S. Feeding Habits and the Occurrence of Anthropogenic Debris in the Stomach Content of Marine Fish from Pattani Bay, Gulf of Thailand. *Biology*. 2022;11(2). doi:10.3390/biology11020331

41. Wang S, Zhang C, Pan Z, et al. Microplastics in wild freshwater fish of different feeding habits from Beijiang and Pearl River Delta regions, south China. *Chemosphere*. 2020;258:127345. doi:10.1016/j.chemosphere.2020.127345

42. Nauen JC, Lauder GV. Hydrodynamics of caudal fin locomotion by chub mackerel, Scomber japonicus (Scombridae). *The Journal of experimental biology*. 2002;Pt 12:1709-1724. doi:10.1242/jeb.205.12.1709

43. Denton EJ, Nicol JAC. Studies on reflexion of light from silvery surfaces of fishes, with special reference to the bleak, Alburnus alburnus. *Journal of the Marine Biological Association of the United Kingdom*. 1965;45(3):683-703. doi:10.1017/S0025315400016520

44. Chen Y, Tan H, Lin PC, Zhang C, Wang L, He DK. Taxonomic revision of the sisoridae (osteichthyes: siluriformes) fishes of the lower Yarlung Tsangpo River, with descriptions of three new species and one new record in China. *Acta hydrobiologica sinica*. 2024;48(06):920-949. doi:10.7541/2024.2024.0002

45. Guo C, Li S, Ke J, et al. The feeding habits of small-bodied fishes mediate the strength of top-down effects on plankton and water quality in shallow subtropical lakes. *Water Res*. 2023;233:119705. doi:10.1016/j.watres.2023.119705

46. Hamidian AH, Sheikhzadeh H, Boujari A, Eagderi S, Ashrafi S. Comparative assessment of human health risk associated with heavy metals bioaccumulation in fish species (Barbus grypus and Tenualosa ilisha) from the Karoon River, Iran: Elucidating the role of habitat and feeding habits. *Marine pollution bulletin*. 2023;188:114623. doi:10.1016/j.marpolbul.2023.114623

47. Feng X, Jia Y, Zhu R, Li K, Guan Z, Chen Y. Comparative transcriptome analysis of scaled and scaleless skins in *Gymnocypris eckloni* provides insights into the molecular mechanism of scale degeneration. *BMC Genomics*. 2020;21(1):835. doi:10.1186/s12864-020-07247-w

48. Shi B, Jiang Y, Yang J, et al. Ecological risks induced by consumption and emission of Pharmaceutical and personal care products in Qinghai-Tibet Plateau: Insights from the polar regions. *Environment international*. 2023;178:108125. doi:10.1016/j.envint.2023.108125

49. Bertucci JI. Editorial: Environmental regulation of feeding, growth, and reproduction in fish: influence of nutrition and physical parameters on the endocrine system. *Front Endocrinol (Lausanne)*. 2023;14:1281959. doi:10.3389/fendo.2023.1281959

50. Lema SC, Luckenbach JA, Yamamoto Y, Housh MJ. Fish reproduction in a warming world: vulnerable points in hormone regulation from sex determination to spawning. *Philosophical transactions of the Royal Society of London Series B, Biological sciences*. 2024;379(1898):20220516. doi:10.1098/rstb.2022.0516

51. Vissio PG, Di Yorio MP, Pérez-Sirkin DI, Somoza GM, Tsutsui K, Sallemi JE. Developmental aspects of the hypothalamic-pituitary network related to reproduction in teleost fish. *Frontiers in neuroendocrinology*. 2021;63:100948. doi:10.1016/j.yfrne.2021.100948

52. Guo Y, Xie C, Luo G. Status and conservation of aquatic germplasm resources in Xinjiang Uygur Autonomous Region. *China Fisheries*. 2021;3:67-71. https://kns.cnki.net/kcms2/article/abstract?v=XRdBcB-NO4SQPn1JC4nXHmvS9icxaY3mWeieqVafjfBIn9EF0_bkqlF0BMF5Df9mgXKy2Qxh7vrlyyOgvCPnyyv7j7krIYjB6TGS_fwgRF8Cci844Je6kYM5hvIqJl4T1kVhuJLyEuu5MuvQ_PeEu_qTVA2sYCoYiHP8priCPCgWiF6RgomNR-TgKQHh2jKi&uniplatform=NZKPT&language=CHS

53. Liang Y. Practice and exploration of biodiversity conservation in Xinjiang. *Financial Development Review*. 2022;3:44-53. doi:10.19895/j.cnki.fdr.2022.03.005

54. Li A, Tang Q, Kearney KE, et al. Persistent and toxic chemical pollutants in fish consumed by Asians in Chicago, United States. *The Science of the total environment*. 2022;811:152214. doi:10.1016/j.scitotenv.2021.152214

55. Sunde J, Yıldırım Y, Tibblin P, et al. Drivers of neutral and adaptive differentiation in pike (*Esox lucius*) populations from contrasting environments. *Molecular ecology*. 2022;31(4):1093-1110. doi:10.1111/mec.16315

56. Watson AS, Hickford MJH, Schiel DR. Interacting effects of density and temperature on fish growth rates in freshwater protected populations. *Proceedings Biological sciences*. 2022;289(1967):20211982. doi:10.1098/rspb.2021.1982