DISSERTATION

THE FRESHWATER FISHES OF ARABIA: SYSTEMATICS AND CONSERVATION

Submitted by

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY HMOUD FARES AL KAHEM ENTITLED THE FRESHWATER FISHES OF ARABIA: SYSTEMATICS AND CONSERVATION BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Committee on Graduate Work

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ABSTRACT

THE FRESHWATER FISHES OF ARABIA: SYSTEMATICS AND CONSERVATION

This work reports on one of the most extensive scientific collections of freshwater fishes yet made from Arabia. Fifteen species are recorded from the Peninsula. Five of these species are each represented by two subspecies. Skeletal studies are presented for the first time. Unusual specimens of *Garra*, *Barbus* and *Cyprinion* indicate the occurrence of other undescribed species.

An extensive appraisal of geological, geographical and climatic events correlated with zoogeographical evidence and an interpretation of the degree of divergence in living species can provide an interpretation of factors explaining the present taxonomy and distributon of Arabian freshwater fishes.

Well-rounded religious and non-religious rationales are presented for preserving and protecting the native fishes of Arabia as a part of Arabian biological heritage. Several recommendations for fish protection are presented.

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The drawings of maps and species are the work of Mrs. Doris M. Rust, Colorado State University. Skeletal illustrations, the illustration of the unknown <u>Garra</u> and the mental disc of <u>G. tibanica</u> and unknown <u>Garra</u> are the work of Mark Scott Jones, Colorado State University.

Last, my thanks to my mother, Norah Al Kahem, and to my wife, Feddah Al Kahem, for their patience and understanding.

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INTRODUCTION

Arabia consists of several nations. The largest is the Kingdom of Saudi Arabia, which occupies some four-fifths of the Peninsula. During the Mesozoic and most of the tertiary, Arabia was part of a continuous African-Asiatic land mass. The Red Sea rift developed as a terrestrial trough in the Oligocene (Roberts 1975). The Mediterranean Sea invaded this trough in the Miocene and was continuous with the Indian Ocean in the late Miocene or Pliocene.

Thus, Arabia became isolated from Africa for a time (Roberts op. cit.). The Arabian Gulf is a shallow tectonic depression formed late in the Tertiary in front of the rising Zagros Mountain (Kassler 1973). Primary freshwater fishes are the best evidence of past land connections with Arabia serving as a bridge between northeast Africa and Asia.

Little is known of Arabian freshwater fishes. Berg's (1934) map of fish zoogeography has a question mark (?) on the Arabian Peninsula. The literature of freshwater fishes of Arabia is very sparse. Boulenger (1887) described a new species of cyprinid fish from Muscat of the east coast of Arabia. Trewavas (1941) described three new species of cyprinids based on collections from southwest Arabia. Fowler and Steinitz (1956) described a new cyprinid species from Oman. Banister and Clarke (1977) described four new cyprinids species and one new subspecies of Garra barreimiae. Balletto and Spano (1977) described nine subspecies of Garra tibanica from the Republic of Yemen. Howes (1982) revised the genus Cyprinion. Biancoi and Banarescu (1982) recognized Oman Cyprinion as a subspecies of watsoni. Al Kahem and Behnke (1983) described a new cyprinid from Saudi Arabia. Krupp (1983) described three new species and two subspecies from southwestern Arabia. Krupp (op. cit.) recognized the Oman Cyprinion as a subspecies of microphthalmum. All Arabian cyprinid species are endemic to Arabia, indicating the long isolation of Arabia from direct freshwater access routes of invasion. This work reports on the native freshwater fishes of Arabia, their taxonomy, distribution, habitats and conservation. Fifteen species and ten subspecies are recognized. Undescribed species of Barbus, Cyprinion, and Garra are recorded. The comparative skeletal studies are the first yet made on Arabian cyprinids. Ichthyological studies can be of critical significance for interpretation of the climatic and hydrographic history of the country. Also, freshwater fish can become a more important part of the Arabian economy by increasing the supply of protein, by providing recreational and esthetic values and as biological control agents. In order to protect Arabian fish species, well-reasoned religious and non-religious arguments are developed.

It is important that further studies be initiated soon to increase the knowledge of the freshwater fauna before industrial and agricultural development occur on a large scale and inalterably change or destroy the fragile freshwater habitats. Groundwater pumping has already dried springs in some areas. Water development projects will dramatically alter much of the present aquatic habitats and exotic species are planned for introduction. Unless the present fish fauna is studied and documented, species may become extinct before they were known to exist.

It is hoped that this work may, in some small way, encourage understanding and appreciation of the natural resources of my country and enlighten and encourage the people to protect our biological heritage.

SECTION ONE. SYSTEMATICS AND ZOOGEOGRAPHY

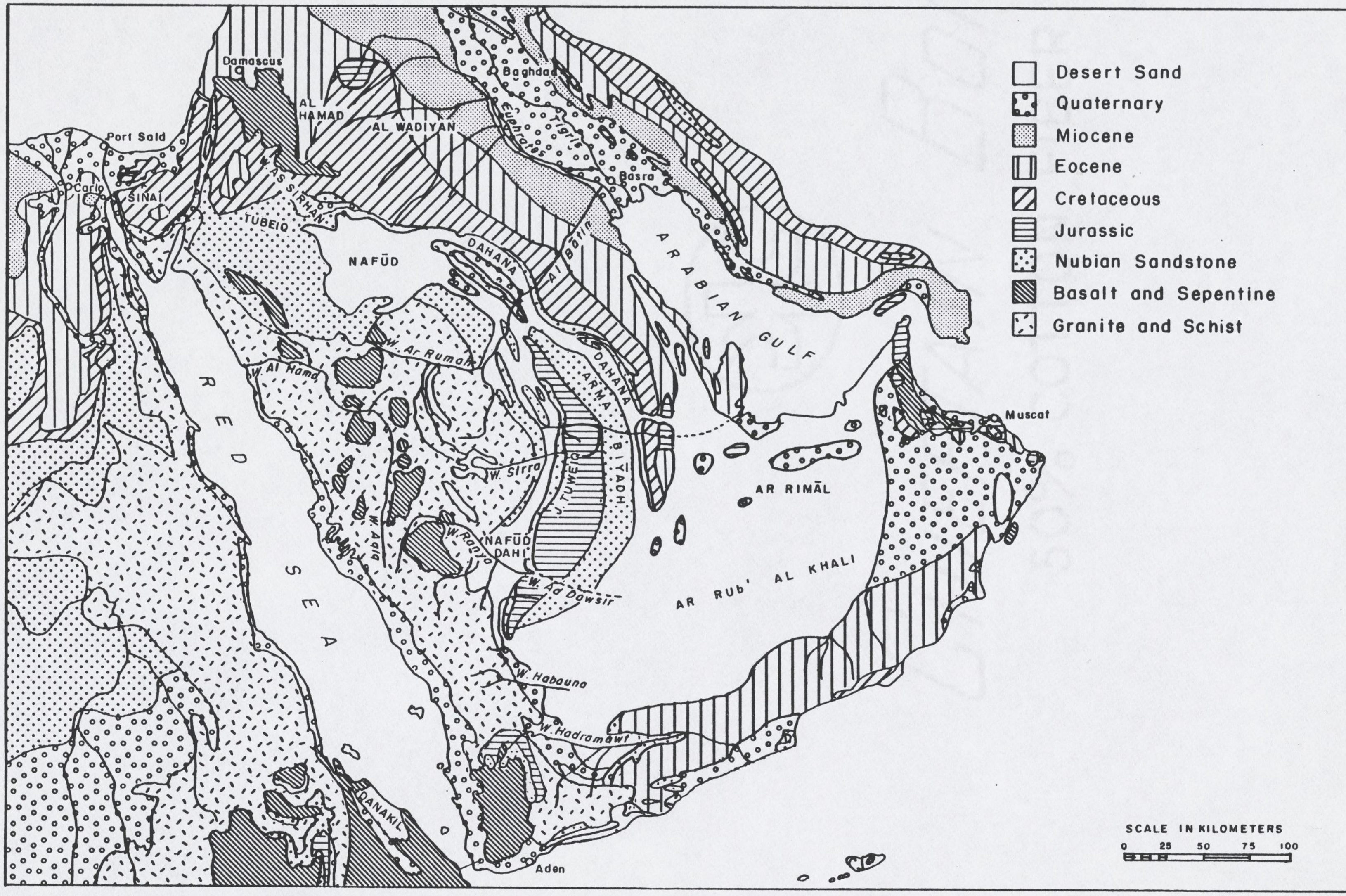
GEOLOGICAL AND CLIMATIC HISTORY OF ARABIA

Arabia is a huge crustal plate composed of ancient sedimentary and volcanic rocks (Fig. 1). In pre-Cambrian times, long before the formation of the Red Sea, the peninsula was attached to Africa as a part of the African shield (Chapman 1978, Krupp 1983).

At the beginning of the Cambrian, a great sedimentary basin or geosyncline (The Tethys) had developed north and east of Arabia in the area now occupied by Turkey, Iraq and southwestern Iran (Chapman op. cit.). Throughout Paleozoic, Mesozoic and early Cenozoic periods, many thousands of meters of sediments accumulated in the deep, slowly-sinking Tethys trough (Chapman op. cit.). The arm of the Tethys which united the Mediterranean Sea and the Indian Ocean, while Palestine, Lebanon, Syria, Jordan, Iraq and Iran - partly or completely - submerged, existed up to the Miocene, when it was obliterated by rising land masses (Steinitz 1954). Between the Tethys Sea and the Arabian Peninsula lay epicontinental seas. These spread over the eastern part of Arabia, depositing on it a relatively thin succession of almost flat-laying Paleozoic, Mesozoic and early Cenozoic strata (Chapman op. cit.).

The Tethys Sea spread between southern Europe and Africa and continued right to the Indian Ocean (Steinitz op. cit.). Thus the question arises at once whether the faunal element common to Asia and

Figure 1. Geological map of Arabia.


Desert Sand
Quaternary
Miocene
Eocene
Cretaceous
Jurassic
Nubian Sandstone
Basalt and Sepentine
Granite and Schist
Damascus
AL HAMAD
AL WADIYAN
Baghdad
Euphrates
Tigris
Basra
Port Said
Cairo
SINAI
W. AS SIRHAN
TUBEIQ
NAFŪD
DAHANA
Al Batin
ARABIAN GULF
W. Ar Rumah
W. Al Hamd
RED SEA
ARMA
DAHANA
BIYADH
J. TUWEIQ
W. Sirra
W. Aqiq
W. Ranya
NAFŪD DAHI
W. Ad Dawasir
AR RIMĀL
AR RUB' AL KHALI
Muscat
W. Habauna
W. Hadramawt
DANAKIL
Aden
SCALE IN KILOMETERS
0 25 50 75 100

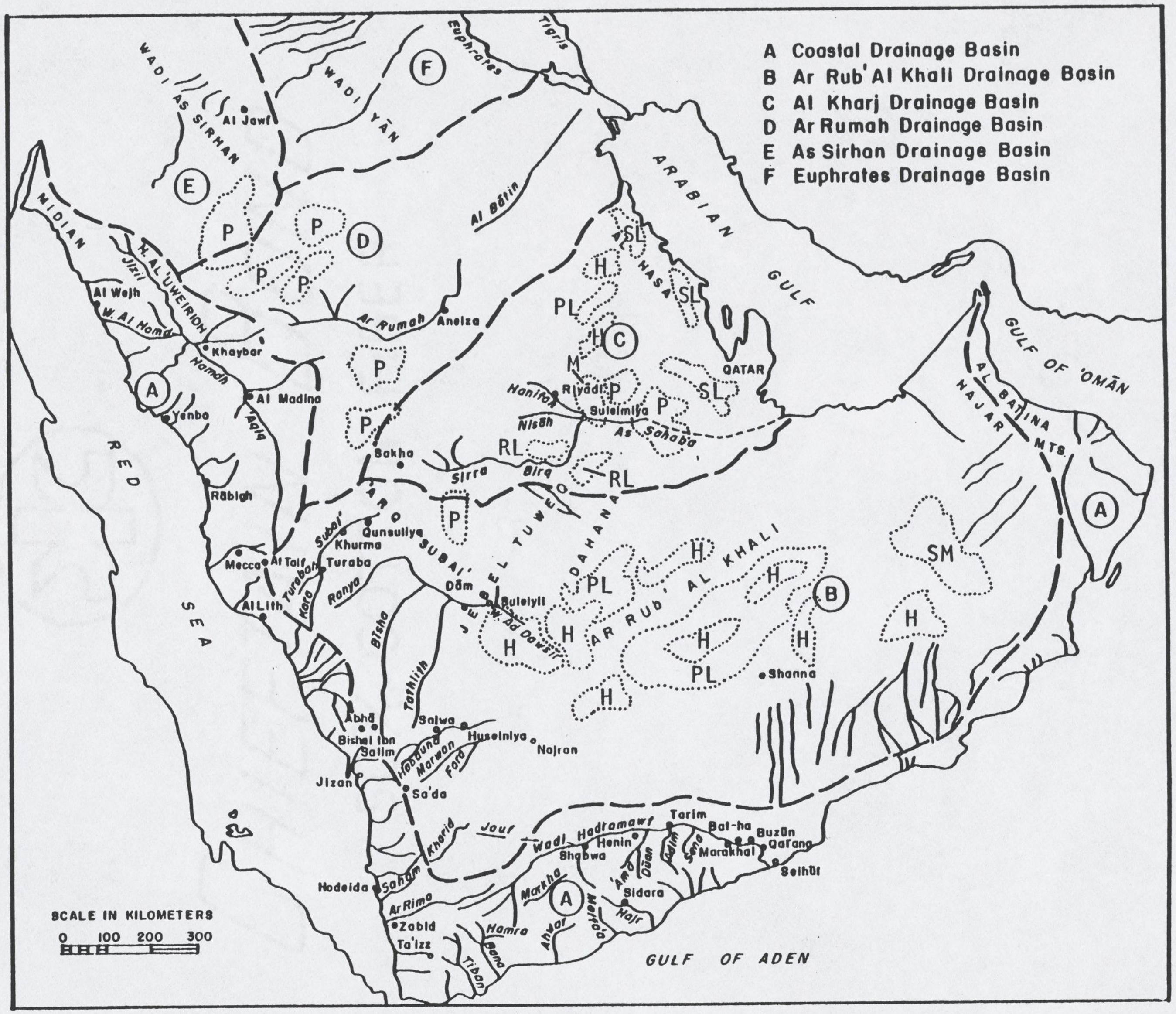
Africa belong to the earlier period of communication or to the time when a new faunal exchange became possible after the reunion of the continents in the Tertiary (Steinitz op. cit.). Steinitz (1954) concluded that most of the fishes found in both continents are Tertiary intruders. The Mesozoic era was mainly a time of uplift and non-deposition (Brown 1970). The Red Sea rift developed as a terrestrial trough in the Oligocene (Roberts 1975). The Mediterranean Sea invaded this trough in the Miocene and was continuous with the Indian Ocean in the late Miocene or Pliocene. Thus, Arabia became isolated from Africa for a time (Roberts op. cit.). The separation of Arabia from the African shield is accompanied by extensive volcanism in the western part of the peninusla and the Zagros Orogeny in the east (Krupp 1983). Both processes influence drainage patterns of Arabia. The extant drainage system was mainly formed during the Pliocene (Krupp op. cit.). Late in the Pliocene, uplift probably created a temporary land connection across the strait of Bab el Mandeb (Roberts op. cit.).

The Arabian Gulf is a shallow tectonic depression formed late in the Tertiary in the front of the rising Zagros Mountain (Kassler 1973). The sea level fell by as much as 120 m during the Pleistocene. During the period of low sea level the Gulf became a freshwater lake from the outflow of the Tigris and Euphrates Rivers (Kassler op. cit.). Freshwater fishes are the best evidence of past land connections with Arabia serving as a bridge between northeast Africa and Asia, because primary freshwater fishes (mainly of order Cypriniformes) are restricted to freshwater and can only disperse by freshwater routes (Al Kahem and Behnke 1983). Miocene freshwater fish fossils are known from the Jizan basin near Tihama north of Yemen. Brown (1970) stated that the fossil species recognized by Dunkel include two families of freshwater fishes; Cichlidae and Cyprinidae. One of the Miocene fossils falls within the structural range of the recent genus Barbus. The other is close to the genus Tilapia (Brown op. cit.). It is assumed that these Miocene fossils represent the fish fauna during the time Arabia still had direct connections to Africa.

Flint (1971) stated that in the late Cenozoic there were cooler climate and glacier periods over the world. The former glaciers of Turkey, Syria, Lebanon and Iran were confined entirely to the mountains and were fed by westerly winds bringing moist air from the Atlantic to the Mediterranean and the Black Sea. Thus, it can be assumed that during the cooler glacial epochs with increased precipitation, the drainages of Arabia were much more extensive than in the recent past with numerous perennial rivers providing routes for fish dispersion.

Flint (1947) described conditions in the northern hemisphere which tended to produce the so-called Pluvial Periods in the tropical latitudes, corresponding with the gradual growth of ice sheets in North America, Siberia, and Europe and the growth of sea ice in the Arctic. Thus, it is not surprising to find evidence of Pleistocene Pluvial lakes and rivers on the Arabian Peninsula (Fig. 2). It is assumed that during cooler, wetter periods rivers discharged their waters to the surrounding seas or into large inland lakes in what is now a vast desert region. Such Pluvial freshwater lakes and rivers were widespread throughout the coastal and the internal basins of the Peninsula (Krupp op. cit.). For example, the Wadi Ar Rumah (26° 12' N 44° 04' E) and Wadi Al Batin (30°

Figure 2. Assumed pluvial lake system of Arabia. Miocene (M), Pliocene (P), Pleistocene (PL), Holocene (H), Recent freshwater lakes (RL), Salt Lakes (SL) and Salt Marshes (SM).


A Coastal Drainage Basin
B Ar Rub' Al Khali Drainage Basin
C Al Kharj Drainage Basin
D Ar Rumah Drainage Basin
E As Sirhan Drainage Basin
F Euphrates Drainage Basin
SCALE IN KILOMETERS
0 100 200 300
ARABIAN GULF
GULF OF 'OMĀN
RED SEA
GULF OF ADEN
Euphrates
Tigris
WADI AS SIRHAN
WADI YĀN
Al Jawf
Al Bātin
MIDIAN
W. AL 'UWEIRID
Jizil
Al Wejh
W. Al Hamd
Khaybar
Hamdh
Al Madina
Yenbo
Ar Rumah
Aneiza
AL HASA
QATAR
Hanifah
Riyadh
Nisāh
Suleimiya
As Sahaba
Sakha
Sirra
Birq
Rābigh
Mecca
At Taif
Subai'
Qunsuliya
Khurma
Turaba
Turabah
Kara
Ranya
Al Lith
Bīsha
Dām
Suleiyil
W. Ad Dawasir
DAHANA
AR RUB' AL KHALI
Shanna
AL BATINA
HAJAR MTS.
Tathlith
Abha
Salwa
Huseiniya
Najran
Bishat Ibn Salim
Habauna
Marwan
Fara
Jizan
Sa'da
Kharid
Jauf
Wadi Hadramawt
Tarim
Bat-ha
Buzūn
Qafana
Henin
Shabwa
Marakhai
Seihūt
Hodeida
Sahām
Ar Rima
Zabid
Ta'izz
Hamra
Markha
Sidara
Hajr
Ahwar
Tiban
Bana

25' N 47° 35' E) formed a large river draining the Harrat Khaybar mountains region and surrounding areas toward Shat Al Arab (mouth of Euphrates and Tigris Rivers). Freshwater fishes had opportunities to disperse into Arabia from the Tigris and Euphrates and the Gulf drainage systems. Ripley (1954) mentioned paleoliths of a crude Levalloisian type from Hadramaut (15° 00' N 50° 00' E) indicating a degree of Paleolithic culture. He also mentioned a gravel spread on the north side of the Ar-Rub 'Al Khali with stone artifacts of Neolithic culture.

This might be correlated with the Neolitic wet phase found at Alfyoum in Egypt and the Pluvial conditions in Palestine (Ripley op. cit.). Neolithic culture - 'Ubaid culture' - is evident in eastern Arabia; on the fringe of the desert as well as among the gardens and coves of the coast. At Ain Qannas, a spring mound at the oasis of Jabrin, half way to the coast from Ar Rub' Al Khali, the lowest sequence of levels show 1,000 years or more of prepottery flint tools, the earliest carbon-14 dating is about 4935 B.P. The flints are those of the lakeshore people (Mandaville 1980). Thus, there is evidence that wetter climatic periods occurred allowing human habitation in the present desert regions during the recent geological past.

Beydoun (1966) cited unpublished data by Wetzel and Morton who noted a widespread occurrence of 75-100 cm terraces with Aeolian silt deposits in the Wadi Hadramaut and Al Masilah (15° 10' W 51° 05' E) in South Yemen indicating the former existence of a large lake. Distinctive patches of lake deposits of presumed Miocene and Pliocene age are of general occurrence in Al Kharj city (Powers et al. 1966). Lake terraces of presumed Pliocene age are known only at the northwestern edge of Harrat Hutayam mountain region; freshwater ostracod fossils occur in the upper part of the rocks (Powers et al. op. cit.). Similar deposits of light-gray marl with gastropods and ostracods have recently been discovered near Lat. 27° 26' N 38° 34' E. This fauna is modern in aspect and can be scarcely older than late Tertiary (Powers et al. op. cit.). Freshwater fishes during that time might have dispersed to the Wadi Assirhan and its tributaries from the central drainages or lakes when these rivers and lakes were a permanent continuous system. Farrand (1971) interpreted the climate phases in the Red Sea to be parallel of those in the east Mediterranean as well as those of the open oceans. Brown (1970) mentioned that Pliocene freshwater ostracods were collected from fine silty lake beds near Tyma, 27° 38' N 38° 29' E. He also mentioned other lake deposits throughout the Arabian Shield which are very probably of Pliocene Age, following the development of undrained depressions on the widespread terminal middle Tertiary Peneplain.

Humid periods created freshwater lakes and the deposition of the sandy limestone as in Al Hufuf (Hotzl et al. 1978), but their age is unknown, probably Pleistocene or recent. Neolithic spears and fish hooks prove that a good deal of fishing was done during the middle Holocene in the Al Hufuf area (McClure 1978). future investigations of Neolithic sites of habitation ("kitchen middens") should yield evidence (fish bones) of fish species that were consumed by the people. Numerous gastropods aged 2180 years were found in drainage channels northeast of Al Hawtah city in Saudi Arabia (Hotzl et al. 1978). Human settlement in the early Holocene, revealed by artifacts and implements, extend east of

Al Hasa. This allows the conclusion that the present oasis must have had its drainage towards the Gulf until relatively recent times (Hotzl et al. 1978).

Fossil lake beds of the Ar Rub' Al Khali (Fig. 2) serve as a framework on which to hang a time-stratigraphic column for the late Quarternary (McClure op. cit.). Paleolithic flint tools are commonly associated with these backslope deposits which are probably largely the results of Pleistocene Pluvial periods. During wet phases of the Pleistocene, old Pliocene alluvium was partially cemented locally in deflation hollows and lower areas and centripetal run-off filled these shallow depressions with lakes (McClure op. cit.). The latest of this series of Pleistocene Ar Rub' Al Khali lakes are still preserved and have radiocarbon dates ranging from about 36,000 to about 17,000 years B.P. (McClure op. cit.).

In the Pliocene periodically there was a considerable moisture. Pleistocene climates probably fluctuated widely, relatively cool, moist intervals or Pluvial periods alternated with relatively long, warm semiarid and arid intervals (Chapman 1978). The Holocene was a time of fluctuating climate. McClure (1978) mentioned that hyperaridity set in about 17,000 years B.P., concurrent perhaps with the approximate end of the maximum ice coverage in the rest of the world. It became increasingly clear that the Post-Pleistocene period's moister and cooler climatic conditions prevailed, lasting roughly from 8,000 to 2,000 B.P. (Zarins 1982). This epoch had a substantial effect on both the flora and fauna of the Arabian Peninsula, including the human population. Fossil lake beds in the Ar Rub' Al Khali and at Jubbah, 28° 02' N 40°

56' E, have yielded not only evidence of human activity along the lacustrine shorelines during this time, but also radiocarbon dates from snail shells and carbonized sediments (Zarins op. cit.). Water flows in Wadis (river beds) and lakes was clearly active in this epoch, probably sustained by increased rainfall - a significant difference from today's climate (Zarins op. cit.). Freshwater fishes had opportunities to disperse into Wadi Assirhan and its tributaries from Wadi Ar Rumah and its tributaries.

Recently, the popular conception of the Peninsula as a hot land is justified by the fact that the Peninsula is nearly bisected by the Tropic of Cancer. The temperature is variable in Arabia; for example, during the summer the average temperature is 31-37 °C in Jeddah, while the average temperature in Turayf during winter is 3-5 °C. Arabia is not nearly as rainless as is commonly supposed. It can probably be said that no part of the Peninsula escapes occasional showers, and heavy storms which fill the Wadis with water occur every year. The water disappears shortly below the source and continues below the surface. The central courses of the wadis are often restricted to a series of pools which form a refuge for freshwater fishes (Krupp 1983). The annual precipitation values are variable; for example Al Wajh City on the western side of Saudi Arabia has an annual average precipitation of 20.9 mm while Khamis Mushayt in the Asir highlands at an elevation of about 3,000 m has an annual average precipitation of 270.9 mm.

DRAINAGES OF ARABIA

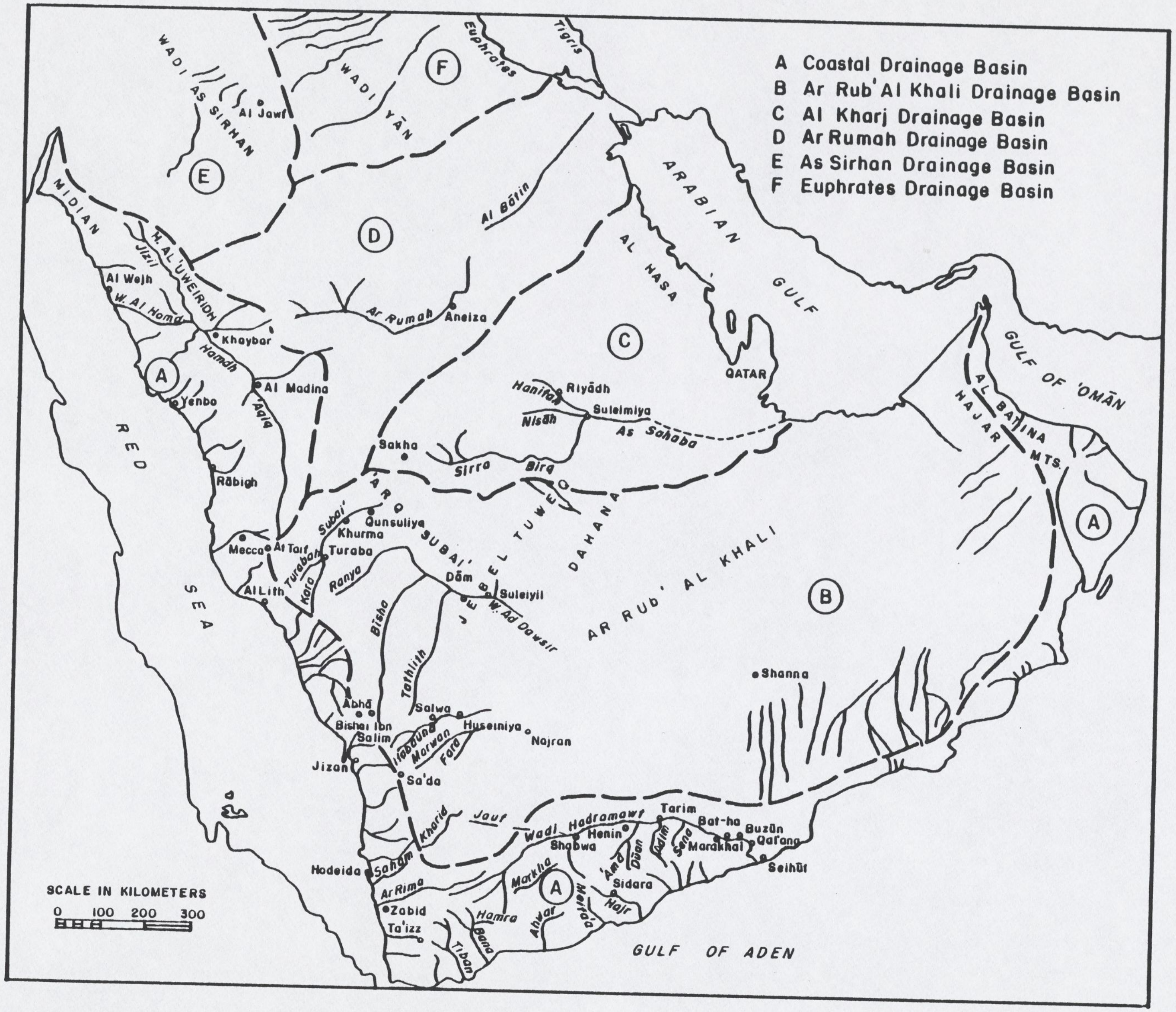
Arabia is dominated by a plateau that arises abruptly from the Red Sea and dips gently toward the Arabian Gulf. In the north, the western highlands are upward of 1500 m above sea level, decreasing slightly to 1200 m in the vicinity of Al Madinah and increasing southward to over 3000 m. There are no permanent large rivers but wadis (riverbeds) with river terraces are numerous. The wadi is a typical feature of Arabia.

Figure 3 (and Plate 1, on a larger scale) illustrates the drainage pattern of Arabia. Basically, the drainages of the Arabian Peninsula can be divided into coastal drainages (to Red Sea, Arabian Gulf, and Indian Ocean) and internal drainages to desert basins. One drainage on the whole peninsula, the Wadi Hajr in south Yemen, may have perennial flowing water to the sea.

Regarding the original and dispersal of freshwater fishes, the drainage pattern of the Peninsula can be divided to examine probable past dispersion routes and interconnection between or within structural basins.

Al Kahem and Behnke (1983) divided the Peninsula into six separate drainage basins based on the topography of the Peninsula (Fig. 3). It is assumed that during major Pluvial Periods, all drainages within any

Figure 3. Major basins and drainages of Arabia.


A Coastal Drainage Basin
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HAL 'UWEIRIDH
Jizil
Al Wejh
W. Al Hamd
Khaybar
Ar Rumah
Aneiza
Hamdh
Al Madina
Yenbo
'Aqiq
QATAR
GULF OF 'OMĀN
AL BATINA
HAJAR MTS.
Hanifah
Riyādh
Nisāh
Suleimiya
As Sahaba
Sakha
Sirra
Birq
RED SEA
Rābigh
'ARQ SUBAI'
Subai'
Qunsuliya
Khurma
Mecca
At Taif
Turabah
Turaba
Ranya
Kara
Al Lith
EL TUWEIQ
DAHANA
Dām
Suleiyil
JEBEL
W. Ad Dawsir
AR RUB' AL KHALI
Bisha
Tathlith
Shanna
Abhā
Salwa
Bishai Ibn Salim
Habauna
Marwan
Fara
Huseiniya
Najran
Jizan
Sa'da
Kharid
Jauf
Wadi Hadramawt
Tarim
Bat-ha
Buzūn
Henin
Shabwa
Marakhai
Qafana
Seihūt
Hodeida
Saham
Markha
'Amd
Duan
'Adim
Sena
Sidara
Ar Rima
Zabid
Hamra
Ahwar
Meifa'a
Hajr
Ta'izz
Bana
Tiban
GULF OF ADEN
SCALE IN KILOMETERS
0 100 200 300

one of the present internal basins would have been interconnected, allowing the opportunity for dispersal of fishes throughout a basin.

The Coastal Drainage Basin

This basin extends from the Gulf of Aqaba (North) to the Gulf of Oman, parallel to the sea coasts. This basin is a network of wadis. Wadi Hadramaut, Jizil, Aqiq and Al Hamd are the major wadis in this basin, but there are a great variety of wadis extending from the surrounding mountains toward the Red and Arabian Seas and the Gulf of Oman.

During the Eocene and Oligocene, a freshwater lakes system was widespread in the southern part of the Red Sea rift (Krupp 1983). The uplift of the mountain chain, along the east side of the Red Sea, influenced the drainage pattern (Krupp op. cit.). The lower courses of some larger wadis that formerly flowed to the south were captured by westward flowing drainages and diverted to the Red Sea (Krupp op. cit.). Krupp (1983) stated that geological processes in the Yemen mountains allowed a faunal exchange between the Wadi Hadramaut - Almasilah drainage system and the coastal drainages of the southern Red Sea and the Gulf of Aden until recent geological times. Thus a faunal exchange between the drainages of the southern and the drainages of the northern Red Sea probably occurred at the same period. Pluvial deposits in the beds of these wadis indicate these wadis were once large river systems. The four largest wadis with the contribution of their tributaries drain the Hadramaut Plateau and Al Hijaz mountains, respectively, to discharge their waters into the sands or the seas.

At present, the greater part of this basin is a land of valleys with river channels which are dry on the surface or contain only isolated pools during most of the year, but these numerous dry wadis may have sudden and violent torrents after rain storms. For example, Wadi Hadiyah, 25° 34' N 38° 41, contains several isolated pools during most of the year. These pools form a refuge for the fish during the summer season.

The springs (Aluyun) in the Al Hijaz region are numerous such as in the city of Khaybar (North Al Hijaz) there are over twenty springs in the area. These vary from small to large such as Ain (spring) Ali, Ain Albrikah, Ain Salaleam, Ain Albhair and Ain Mduwarah. These springs rise between the baslatic lava and the clays below. Though the soil of the wadi floors is saline, the water is not brackish. It was reported that there is one spring called Ain Waziriyah, 21° 27' N 39° 16' E, about 11-13 km east of Jeddah (Twitchell 1958). It is also reported that there are several springs in Wadi Fatimah near Mecca. About 15 km southeast of Mecca there is an ancient spring called Ain Zubaydah, 21° 20' N 40° 00' E. Qanats are found in a different part of this basin. These man-made water tunnels provide a refuge for fishes. Wadi Jizan dam has been constructed impounding the water in Wadi Jizan, 16° 54' N 42° 30' E, for irrigation and flood control (El Khatib 1974).

Ar Rub' Al Khali Drainage Basin

This basin slopes gently north from Bir Hadi 19° 26' N 51° 02' E, toward the Arabian Gulf. Mesozoic rocks show a trend toward shallow water sedimentation from the center of the basin north, west and southwest. The Ar Rub' Al Khali is the largest desert basin of Arabia with a surface of 600,000 km^2 (Krupp 1983). This basin was covered by a series of inland lakes during Pluvial phases of the Pleistocene (Krupp op. cit.). Holocene lake beds existed in the middle of the Wadi Ad Dawsir while the main wadi had ceased to flow by this time (Krupp op. cit.). Their depth and size is not yet known. Wadi Ad Dawsir is a large, old system, draining from the Asir escarpment ridge. Other wadis draining toward this basin are those collecting the water from the eastern side of Hadramaut Plateau in the south, Yemen highlands, and northeast of Oman Mountains. Mastodon, rhinoceros and crocodile remains from the dam formation in central Arabia indicate a formerly subtropical climate (Krupp op. cit.).

In the district of Al Aflaj, 22° 15' N 46° 50' E, the elevation of the largest pool, Ain Rass, is about 518 m and the water surface is some 8 m below the ground level. The depth of the water is unknown. There are four other pools in Al Aflaj: Ain Burj, Ain Heeb, Ain Al Both and Ain Shaghaib. The first three are connected. There is apparently no fish life in these pools. Perhaps the pools contain substances that are toxic to fish or the long isolation of these pools from surrounding drainages may have precluded fish invasion. Mandaville (1980) reported that at Ain Qannas, there is one spring at the Oasis of Jabrin. I am not aware of any fish in this spring, but future visits are necessary to determine the presence or absence of fish. There is a permanent river, 30 km long, 10 m wide, and 2 m deep, that flows from the west scarp of Asir and disappears into the sands of Wadi Bishah (Banister and Clark 1977). Wadi Al Mhaleh is a perennial stream located at about 9 km southeast of Abha city, 18° 13' N 42° 30' E. There are few springs which emanate from the granite and gneiss in At Ta'if City, 21° 16 N 40° 24' E, at an elevation of 1586 m. Abha dam has been constructed for irrigation and flood control (El Khatib 1974). The fish fauna of this drainage basin is discussed below.

Al Kharj Drainage Basin

This basin is south of Ar Rumah drainage basin. Wadi Hanifah, its tributaries and Wadi As Sahba are the major drainages in the basin. Wadi As Sahba, southeast of Harad, discharges its water into the Arabian Gulf south of Qatar Peninsula. Alluvium deposits and freshwater gastropod fossils are known from this basin. An ancient lake was reported by Powers (1966) in this basin. The present wadis are considered to be remnants of large rivers flowing during Pluvial Periods of the Pliocene and Pleistocene. Several deep pools, fed by spring seeps or ground water, occur in the Al Kharj area such as Ain Al Heet, a spring near the ancient Ain Khafs, and others. These springs are inhabited by fish, such as the cyprinodontid fish, *Aphanius dispar*, which indicates a direct connection to the sea in recent geological times (Al Kahem 1980). There are copious springs existing in eastern Arabia like those existing in Al Hasa Oasis, Saudi Arabia. These springs break out sometimes singly, sometimes in groups. Some of the largest springs are: Al Harrah (Hot), Barabeir, and Omm Sabaah. Such springs have *Aphanius dispar* (Al Kahem 1980, Al Kahem and Behnke 1983). This species dispersed from the Arabian Gulf through a perennial river, probably during the middle of the Holocene Period. Irrigation canals were constructed in Al Hasa oasis to improve the agricultural productivity of these areas (El Khatib 1974). There is no reference to fish protection in this area. Ground water pumping has already dried several springs. There should be general awareness of the danger of such action which might lead to the extinction of fish species in this oasis and other places throughout the Peninsula. Several dams have been constructed in this basin (Al Kahem 1980). Fishery surveys should be made in these reservoirs and their suitability for introductions of rare native fishes investigated.

Ar Rumah Drainage Basin

This basin is believed to have had a connection to the Tigris-Euphrates system several thousand years ago (Al Kahem 1980). It consists of Wadi Ar Rumah and Wadi Al Batin, which discharge their water into Shatt Alarab near Al Basrah in Iraq. Wadi Ar Rumah drains the eastern escarpment of Al Hijaz Mountains to discharge into the sands of central Arabia. Thousands of years ago it was connected with the Wadi Al Batin. Alluvium deposits were deposited in many areas in these Wadis. In Arabia, no fish collections have yet been made from this basin. Future visits will shed some light on the freshwater fishes of this drainage basin.

As Sirhan Drainage Basin

This basin includes the Wadi As Sirhan which is located in the northern part of the great Nafud sedimentary basin with its northern extremity adjacent to Jordan. It is over 300 km long and reaches widths of 50 km. There are numerous tributaries, which drain the surrounding plateaus. As Summan Plateau separates Mesopotamia from Wadi As Sirhan basin (Krupp 1983). Krupp (1983) states that there is no geological evidence of a former freshwater connection between Wadi As Sirhan and the Jordan system or the Euphrates. He considered the Azraq drainage basin and Wadi As Sirhan as one basin. This basin resulted from a growth of the Hail arch to the east during late Cretaceous and Eocene times (Powers et al. 1966). During the Pleistocene the Azraq area was covered by a large freshwater lake of 4000 km^2 (Krupp op. cit.). At present there are about 5 km^2 of perennial water bodies within the Azraq area. The water is mainly discharged from the Hauran-Jabal Druz mountains in the southern part of Syria (Krupp op. cit.). Krupp (1983) recorded the occurrence of a new species, Aphanius sirhani from the Azraq Oasis, Jordan, 32° 51' N 36° 49' E. In 1981, I visited Al Jawf area in the southern part of the Wadi As Sirhan, but no evidence of fish was found. Al Jawf city is located at 29° 50' N 39° 52 E.

Euphrates Drainage Basin

This basin takes its name from the past relationship with the Euphrates River. The drainage systems of this basin drain the surrounding plateaus excluding the Syrian desert plateau toward the Euphrates River. It is separated from As Sirhan drainage basin by the As Summan Plateau. The main drainage system which consists of a group of river beds is called Al Widyan. No visits have yet been made to this basin and nothing is known concerning the presence or absence of fish.

PREVIOUS HISTORY OF FRESHWATER FISHES OF ARABIA

The first report on freshwater fish from Arabia was by Playfair (1870) who communicated a record of Discognathus lamta from Aden. Based on a collection sent to British Museum Boulenger (1887) described a new species, Scaphiodon muscatensis, and recorded the occurrence of Aphanius dispar from Muscat. Berg (1949) synonymized Scaphiodon muscatensis with Cyprinion microphthalmum, a widespread species in Iran and Paksitan. Hora (1921) described a new species, Garra arabica, from Lahej, near Aden, South Yemen. Trewavas (1941) described three new species: Barbus arabicus, Garra tibanica, and Garra brittoni and recorded the occurrence of Aphanius dispar from Yemen, based on collections made by the British Museum of Natural History Expedition to southwest Arabia, 1937-38. Erdman (1950) reported killifishes and mullets from the eastern region of Saudi Arabia, without giving scientific names. Fowler and Steinitz (1956) described a new species, Garra barreimiae, from Oman. Menon (1964) synonymized Garra brittoni with Garra tibanica and pointed out that Garra arabica is actually Garra nasuta (an Indian species).

Balletto and Spano (1977) studied Garra tibanica from Yemen and described nine subspecies. Banister and Clarke (1977) described four new species: Barbus apoensis, Barbus exulatus, Cyprinion acinaces and Garra longipinnis, and one new subspecies: Garra barreimiae *shawkahensis*. Al Kahem (1980) mentioned the first record of the American mosquitofish, *Gambusia affinis*, from Saudi Arabia. Bianco and Banarescu (1982) recognized Oman *Cyprinion* as a subspecies of *Cyprinion watsoni*. Al Kahem and Behnke (1983) described a new species, *Cyprinion mhalensis* from Saudi Arabia and reported the first record of the genus *Acanthobrama* from the Arabian Peninsula. Coad, Al Kahem and Behnke (1983) described a new species *Acanthobrama hadiyahensis* from Saudi Arabia. Krupp (1983) described three new species: *Garra buettikeri*, *Garra mamshuqa*, *Garra sahilia*, and two new subspecies: *Cyprinion acinaces hijazi* and *Garra sahilia gharbia*. Krupp (op. cit.) recognized *Cyprinion microphthalmum muscatensis* as a distinct subspecies based on Banareseu's recommendation.

Van Couvering (1977) mentioned fossil cichlids (fam. Cichlidae) and *Barbus*-like material of unknown age from Ad Darb, Red Sea coast. Brown (1970) mentioned a Miocene fossil of *Barbus* in the Jizan basin, near Tihama north of the Yemen boundary.

Figures 4, 12, 22, 28 illustrate the known distribution of Arabian freshwater fishes based on previous literature and the results of my study.

METHODS AND MATERIALS

Fishes were collected by means of seines and hook and line. Fish specimens were immediately preserved in 10% formalin solution and later transferred to 40% isopropyl alcohol. Samples were collected in 1977 and 1981 from the Wadi Al Mhaleh, a permanent stream southeast of Abha City, from waters near Al Hufuf, Najran, Jizan, Al Kharj, Khaybar, and from the Wadi Hadiyah (west of Khayber City). Other drainages such as Al Jawf, Al Aflaj, Al Ula and Tabuk were visited but no evidence of fish was found. Spelling of geographical names follow the official standard names approved by the United States Board on Geographic Names, Publication No. 54, 1961. Names not included in the Gazetteer were standardized throughout the text. Measurements and counts on specimens were made according to the standard methods of Hubbs and Lagler (1958) with some particular modifications in accordance with Krupp (1983) and Banister and Clarke (1977).

The osteological terms used in this study follow those used by Howes (1982), Potthoff and Kelley (1982) and Hubbs, et al. (1974). To prepare the skeletons for study, techniques published by Vladykov (1962) were followed. Specimens are presently maintained in fish collections in the Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colorado, USA. Some specimens have been deposited in the National Museums of Natural Sciences, National Museums of Canada. The following abbreviations for counts and measurements are used:

A	Anal fin branched rays
AAP	Anterior ascending process
AFDL	Anal fin depressed length
AFL	Anal fin length
AF	Anterolateral foramen
Ar	Articular
BD	Body depth
BL	Barbel length (Posterior barbel)
C	Centrum
CPD	Caudal Peduncle least depth
CPL	Caudal Peduncl length
CP	Coronoid Process
D	Number of dorsal fin rays (Roman numeral for unbranched rays, Arabic numeral for branched rays)
DC	Dorsal crest
De	Dentary
DFBL	Dorsal fin basel length
DFDL	Dorsal fin depressed length
DO	Dorsal origin to snout-tip
DSL	Dorsal spine length (= longest unbranched spine)
F	Foramen
Fo	Fossa
HD	The horizontal distance from the tip of the snout to the pelvic fin origin
HL	Head length
HW	Head width
IOW	Interorbital width
L.L.	Scale count in lateral line
N	Notch
NA	Neural arch
NC	Neural complex
NPr	Neural Prezygopophysis
NS	Neural spine
OL	Orbit length
P	Pectoral fin rays
Pa	Parapophysis
PFL	Pectoral fin length
PP	Posterior process
Pty	Pterygiophore
Pz	Postzygopophysis
R	Rib
Ra	Retroarticular
S	Spine
S.D.	Standard deviation
SL	Standard length
Snl	Supraneurals (numbered)

Snt.L.	Snout length
TL	Total length
UJL	Upper jaw length, measured from barbel to snout-tip
UMMZ	University of Michigan Museum of Zoology
V	Ventral or Pelvic fin rays
VFL	Ventral fin length
$\overline{X}$	Mean

FRESHWATER FISHES OF ARABIA

FAMILY CYPRINIDAE

Cyprinids lack an adipose fin, and jaw teeth are also absent (Berra 1981). Body usually scaled. Pharyngeal teeth in one to three rows. About 275 genera in the freshwaters of the world except South American, Australia, and Madagascar (Nelson 1976).

Genus _Barbus_ Cuvier, 1817

Barbus Cuvier, 1817, Regne, anim. II, P. 192 (Type: _B._ _barbus_).

Scales of small, moderate or large size. Dorsal fin generally with the (third) longest simple ray ossified, enlarged and frequently serrated (Gunther 1868). Mouth arched, inferior; lips without horny covering. Typically with two pairs of barbels, seldom one or none. Pharyngeal teeth are 2.3.5 - 5.3.2 or 2.3.4 - 4.3.2. Peritoneum white or dark brown or black. Anal fin with 5 or 6 branched rays.

Taxonomic Outline

A most difficult and confusing problem of ichthyology is the classification of the African, Asiatic and European fish of the genus _Barbus_ (Myers 1960). _Barbus_ contain many phyletic lines of greater or lesser extent and the aggregate transcends the limit of what the majority of ichthyologists would consider a single genus (Myers op. cit.). Gunther suggested it was necessary to subdivide several sections of the genus purely on geographical ground before he could handle the classification expeditiously (Myers op. cit.). Boulenger divided Barbus into several sections, based on scale characters and it seems possible that these sections are of phylogenetic importance (Myers op. cit.).

Banister (1980) mentioned that the species of this genus are morphologically very variable which has led to the description of many nominal species. Banister (op. cit.) divided Mesopotamian Barbus into two stocks: the "European stock," with a cylindrical body, small scales and a serrated dorsal spine; and the "Afro-Indian" stock with a compressed body, large scales and a smooth dorsal spine.

Northeast African Barbus (large scale) and a group of large-scaled Near Eastern Barbus are the logical ancestor types of Arabian Barbus species.

Distribution

Barbus is widespread in temperate or tropical parts of Europe, Asia and Africa. The range of the genus in Arabia is the coastal drainages of the Red and Arabian seas and a new record from several collections is the occurrence of Barbus apoensis in the Wadi Al Mhaleh draining to the Ar Rub' Al Khali internal basin, Wadi Hadiyah and Ain Aljmyma, about 3 km northwest of Khaybar city center. Several Barbus species occur in the Tigris-Euphrates basin, and Barbus barbulus and Barbus luteus are known from the Mond river drainage of Iran (Saadati 1977). Barbus luteus also occurs in a drainage to the strait of Hormuz, near Bandar Abbas, Iran (Coad Pers. comm.). The number of Barbus species in Arabia is yet to be determined. Three species are currently recognized. Barbus apoensis is known from the Wadi Al Mhaleh southeast of Abha, the Wadi Turabah near At Ta'if, the Wadi Admah, 19° 53' N 41° 57' E, Wadi Shugub 20° 29' N 41° 13' E, Wadi Hadiyah and Ain (= spring) Aljmyma, Khaybar. Khaybar city is at 25° 42' N, 39° 31' E. Barbus arabicus is widespread in the southwestern part of Arabia. Barbus exulatus is known from several localities in the Wadi Hadramaut and Wadi Maran in East Yemen. Distinctive specimens from the Wadi Al Mhaleh, Wadi Hadiyah and Ain Aljmyma, indicate an undescribed species (Fig. 4).

Barbus apoensis

Barbus apoensis Banister, K. and M. A. Clarke - 1977. Jour. Oman Studies, Spec. Rep. (Sci. Results, Oman Flora and Fauna Survey): P. 113.

Material Examined

a. 12 fish, 90-205 mm SL, were collected June, 1981, from Wadi Hadiyah, 25° 34' N, 38° 41' E.

B. 19 fish, 60-136 mm SL, were caught July, 1981, from Ain (- spring) Al Jmyma, Khaybar. Khaybar city is at 25° 41' N, 39° 31' E.

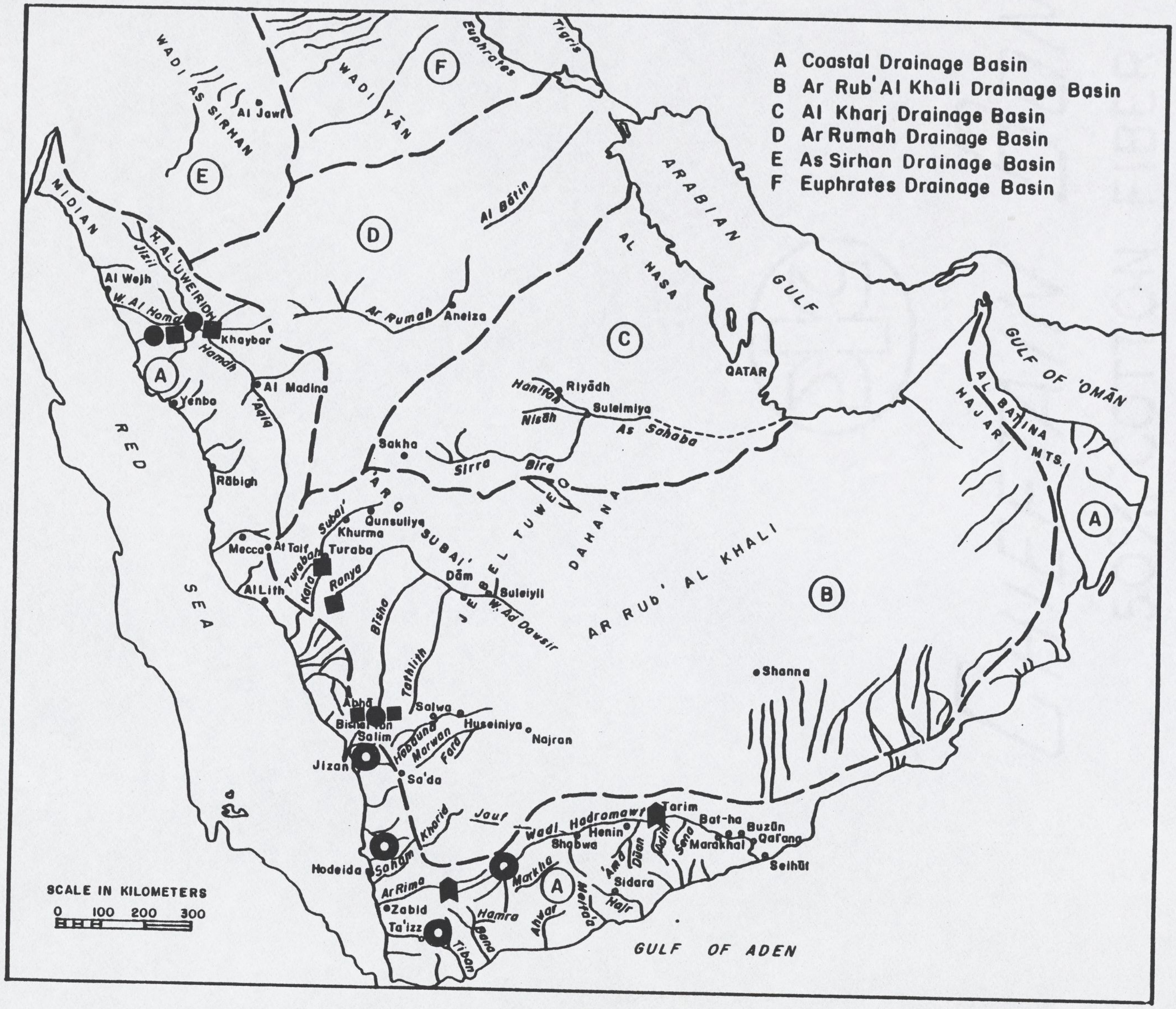
c. 1 fish, 274 mm SL, was caught July, 1977, from Wadi AlMhaleh, a permanent stream southeast of Abha city. Abha city is at 18° 13' N, 42° 30' E.

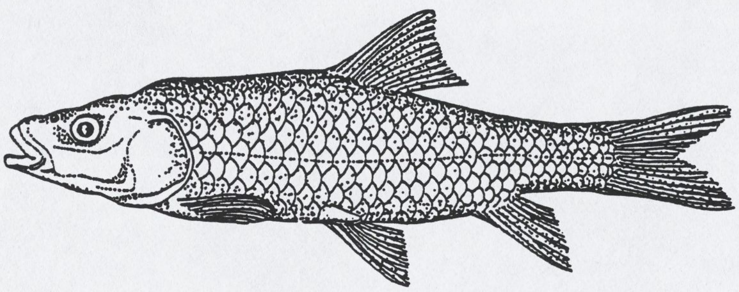
Description

Morphology

The shape of the body can be seen in Figure 5. This species was described by Banister and Clark (1977) from a permanent stream near Khamis Mushayt and other localities in Saudi Arabia. According to their description:

Figure 4. The distribution of *Barbus* spp.: *Barbus apoensis* (■), *Barbus exulatus* (☗), *Barbus arabicus* (◉), and unknown *Barbus* (●).


A Coastal Drainage Basin
B Ar Rub'Al Khali Drainage Basin
C Al Kharj Drainage Basin
D Ar Rumah Drainage Basin
E As Sirhan Drainage Basin
F Euphrates Drainage Basin
Euphrates
Tigris
WADI AS SIRHAN
WADI YĀN
Al Jawf
MIDIAN
Jizil
H. AL 'UWEIRIDH
Al Wejh
W. Al Hamd
Khaybar
Hamdh
Al Madina
Yenbo
'Aqiq
RED SEA
Rābigh
Al Bātin
Ar Rumah
Aneiza
AL HASA
ARABIAN GULF
QATAR
Riyādh
Hanifah
Suleimiya
Nisāh
As Sahaba
Sakha
Sirra
Birq
DAHANA
'ARQ SUBAI'
JEBEL TUWEIQ
Subai'
Qunsuliya
Khurma
Mecca
At Taif
Turaba
Al Lith
Ranya
Bisha
Dām
Suleiyil
W. Ad Dawsir
AR RUB' AL KHALI
Tathlith
Shanna
Abhā
Salwa
Huseiniya
Najran
Salim
Habauna
Marwan
Fara
Jizan
Sa'da
Khārid
Jauf
Wadi Hadramawt
Tarim
Henin
Shabwa
Bat-ha
Buzūn
Qafana
Marakhai
Seihūt
Hodeida
Saham
Ar Rima
Markha
Sidara
Hajr
Mefa'a
Ahwar
Hamra
Bana
Tibon
Zabid
Ta'izz
GULF OF ADEN
GULF OF 'OMĀN
AL BATINA
HAJAR MTS.
SCALE IN KILOMETERS
0 100 200 300



D IV 9-10, A III 6, V 9, L.L. 23-32.

Figure 5. Barbus apoensis, 176 mm SL.

> "The greatest depth of the body occurs about halfway between the origin of the pectoral fin and the origin of the dorsal fin. A pronounced nuchal hump is present and the dorsal profile of the head is concave. The mouth is terminal and has marked upwardly directed gape. The posterior barbels are small. The eyes are lateral and slightly protuberant. The lips are continuous. There are 4 unbranched rays in the dorsal fin. The last one is thickened into a smooth spine. The spine is not strongly ossified and is flexible in its distal third. There are 10 branched dorsal rays. The lateral line scales number 26-29. Twelve scales encircle the least circumference of the caudal peduncle.
>
> There are 2.3.5 - 5.3.2 pharyngeal teeth. The gill rakers are strong, curved and widely spaced. They decrease rapidly in size from the angle of the gill arch forwards. On the lower limb of the first gill arch there are 6-9 gillrakers."

The specimens discussed by AlKahem and Behnke (1983) show the characters described above except for some differences, such as 24-31 scales in the lateral line instead of 26-29 and 10-13 scales around the least circumference of the caudal peduncle. Krupp (1983) mentioned that in young specimens the dorsal profile of the head is convex, but it changes to concave in the adults.

The specimens examined show the following characters: There are 23-32 scales in the lateral line. 10-14 scales arund the caudal peduncle. The dorsal fin has 9(f2) or 10 (f30) branched rays. The anal fin has 5(f1) or 6 (f31) branched rays. There are 6-12 gill rakers on the anterior side of the first gill arch. On the posterior side of the first gill arch there are 12-17 gill rakers. The body depth is 29% of the standard length. The head length is 34% of the standard length. The caudal peduncle depth is 11% of the standard length. The caudal peduncle length is 16% of the standard length. Proportional measurements of Barbus apoensis expressed in thousandths of the standard length are presented in Table 1. Frequency distributions of meristic data for Barbus apoensis are presented in Table 2.

Table 1. Proportional measurements of Barbus apoensis expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CP L	BL	IOW	H D	PFL	VFL	DSL	HW
Wadi	1	195	155	342	348	071	109	561	194	226	194	109	187	065	129	561	219	194	161	226
Hadiyah	2	205	162	339	321	068	123	537	185	278	191	123	191	062	123	586	216	185	160	198
	3	185	147	288	340	075	109	571	184	238	224	109	170	068	122	585	211	184	170	190
	4	160	130	300	331	077	115	515	177	269	208	115	154	069	108	515	192	200	177	185
	5	169	134	276	351	059	097	529	186	284	187	112	149	067	111	537	224	201	194	223
	6	221	179	279	324	050	117	542	173	268	206	106	151	050	106	536	196	189	201	195
	7	255	205	278	302	054	107	537	176	273	215	107	122	043	112	561	205	176	185	180
	8	226	185	254	329	054	108	541	157	227	178	086	108	043	108	514	216	173	173	184
	9	172	14	264	314	071	100	514	178	235	207	100	143	057	114	514	207	228	200	235
	10	155	123	276	325	057	098	528	171	252	187	106	163	065	114	528	211	170	228	211
	11	124	98	276	296	082	112	531	194	255	153	102	122	071	102	489	204	214	244	204
	12	110	90	267	333	089	111	556	178	278	211	111	144	077	111	544	211	222	255	222
	Mean	181.4	145.7	287	326	067	109	539	179	257	197	107	150	061	113	539	209	195	196	204
	Min.	110	90	254	296	050	097	515	157	226	153	086	108	043	102	489	192	170	160	184
	Max.	255	205	342	351	089	123	571	194	284	224	123	191	077	129	586	224	228	255	235
Ain (= Spring)	13	158	129	310	341	076	093	535	178	256	209	116	186	062	132	605	225	209	155	202
Al J'myma	14	168	136	287	316	074	103	522	162	265	199	110	176	074	125	596	228	191	191	199
	15	158	128	336	336	078	094	555	211	289	203	117	172	070	133	586	234	211	172	195
	16	151	116	310	336	086	095	552	224	310	216	129	189	078	147	638	259	224	181	216
	17	161	127	307	386	087	118	591	173	268	205	118	157	063	126	622	236	197	157	181
	18	155	122	279	336	074	107	533	164	279	180	123	180	066	115	582	238	189	164	197
	19	129	105	267	390	076	086	533	171	286	190	105	143	067	105	619	229	190	171	190
	20	130	111	270	315	081	081	486	171	252	189	108	153	063	108	541	207	171	171	153
	21	131	100	260	350	090	100	540	190	270	200	120	170	070	120	560	230	180	170	180
	22	126	102	255	333	088	098	519	186	255	196	118	167	069	118	539	216	176	167	176
	23	129	102	294	353	088	098	539	186	265	206	108	176	069	127	569	225	206	196	186
	24	123	98	276	337	092	102	551	194	265	204	122	184	071	133	541	224	214	204	184
	25	117	86	291	360	093	093	547	186	279	221	128	174	069	116	547	233	198	186	186
	26	112	84	298	357	095	095	548	190	274	226	131	190	071	119	559	238	202	202	190
	27	108	83	289	361	084	096	542	181	277	253	133	181	072	120	566	241	193	217	193
	28	92	74	284	351	108	108	524	162	270	229	135	176	068	135	541	216	203	203	189
	29	82	62	290	371	081	097	516	161	306	241	113	141	064	113	581	210	226	210	194
	30	80	60	300	367	083	100	588	200	350	233	117	150	067	133	583	250	217	217	200
	31	81	61	279	377	098	098	590	180	328	229	131	164	066	115	574	230	230	213	197
	Mean	125.8	99.3	289	351	086	098	543	183	281	212	120	170	068	123	576	230	201	187	190
	Min.	80	60	255	315	074	081	486	161	252	180	105	141	062	105	539	207	171	155	153
	Max.	168	136	336	390	108	118	591	224	350	153	135	190	078	147	638	259	230	217	216

Table 1. Continued.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CP L	BL	IOW	H D	PFL	VFL	DSL	HW
Wadi	32	324	273	308	322	051	095	546	154	238	220	110	165	037	--	--	--	--	190	--
Al Mhaleh	Mean	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Min.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Max.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

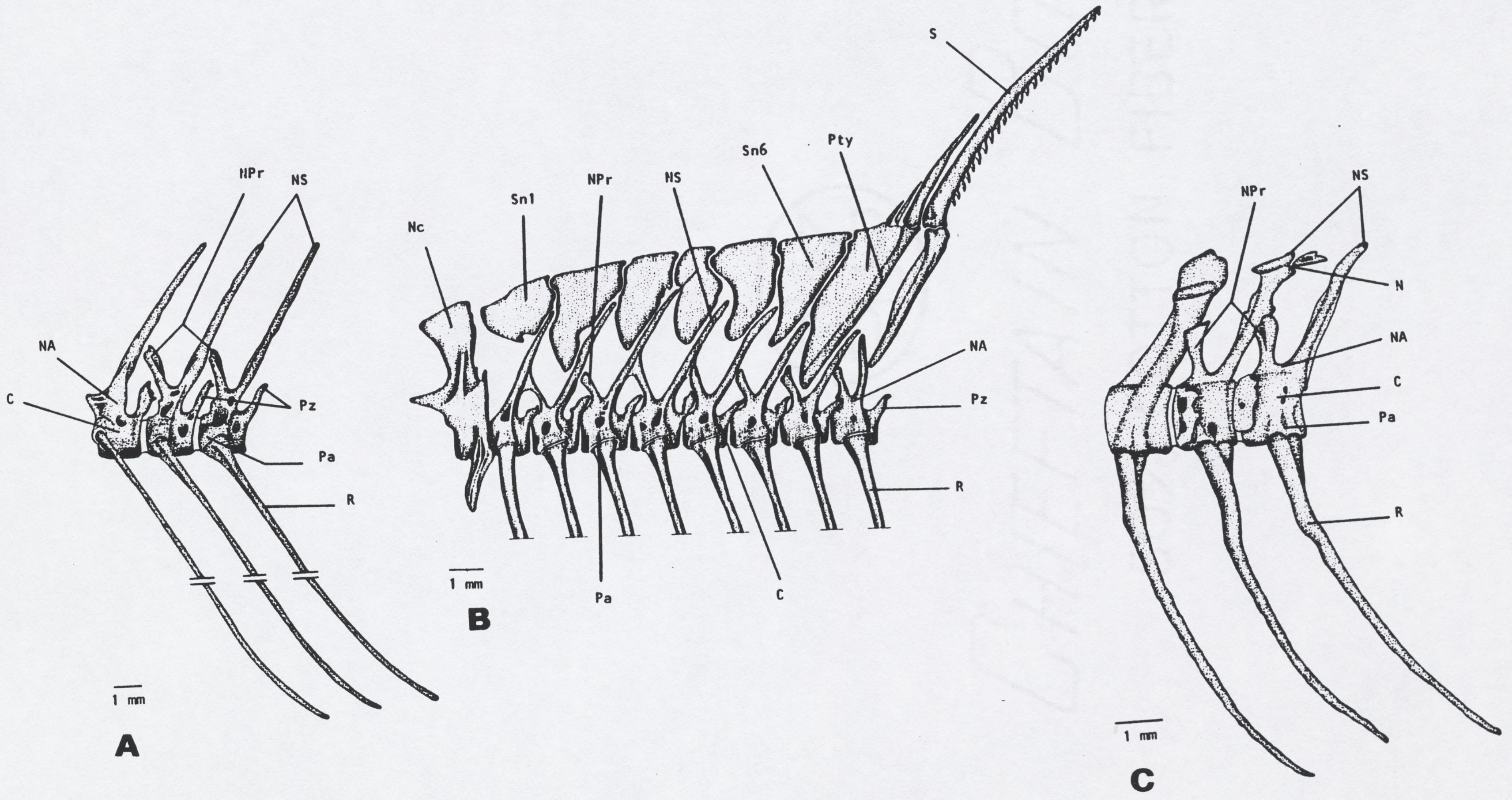
Table 2. Frequency distributions of meristic data for _Barbus apoensis_ (N = 32).

								$\overline{X}$	S.D.
Scales in lateral line	23	24	25	26	27	28	32	25.6	1.7
N. specimens	1	7	8	11	2	2	1		
Scales above lateral line		3	4	5				4.1	0.5
N. specimens		2	25	5					
Scales around caudal peduncle			10	11	12	13	14	12.3	0.9
N. specimens			1	3	19	5	4		
Scales between pelvic fin and lateral line						2	3	2.6	0.5
N. specimens						13	19		
Dorsal fin branched rays			9	10				9.9	0.2
N. specimens			2	30					
Anal fin branched rays			5	6				5.9	0.1
N. specimens			1	31					
Pectoral fin rays			14	15	16			15.1	0.7
N. specimens			6	18	8				
Pelvic fin rays			8	9				8.9	0.1
N. specimens			1	31					
Gill rakers on first arch;									
a) anterior side	6	7	8	9	10	11	12	8.7	1.3
N. specimens	1	4	11	6	8	1	1		
b) posterior side	12	13	14	15	16	17		15.6	1.2
N. specimens	1	1	3	7	13	7			

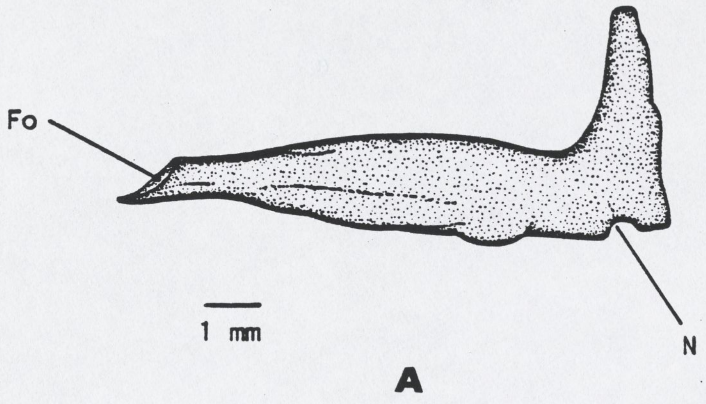
Skeletal Characters

The shape of the centrum can be seen in Figure 6. All centra exept the urostyle have neural prezygapophysis, postzygapophysis, neural arch and spine (Fig. 6). The first postweberian veretebra lacks a neural prezygapophysis. All precaudal vertebrae except the anteriomost

Figure 6. First, second and third postweberian vertebrae in lateral view of A. *Barbus apoensis*; B. *Cyprinion acinaces*; C. *Garra tibanica*.


S
Sn6
Pty
Sn1
NPr
NS
Nc
NA
C
Pz
Pa
R
N
1 mm
A
B
C

(i.e. Weberian apparatus) have Parapophysis. Neural prezygapophyses are thick, long, expanded and articulated with the neural spines. Their shapes are variable. The neural prezygapophysis structure may represent a new generic character for the genus Barbus. This peculiarity has not been mentioned in previous literature. Postzygapophyses are thin, narrow and short. Postzygapophyses are found in specimens of Barbus and Cyprinion but were not found in specimens of Garra. Thickened neural spines are not strongly ossified and are flexible in their distal third. The supraneurals of Barbus apoensis are thin, relatively large and each is separated from its respective neural spine. The last supraneural overlaps the anterior margin of the first pterygiophore. In three specimens examined there are 5 or 6 supraneurals, each separated from its neighbour. The first supraneural is separated from the "neural complex". The "neural complex" of the Weberian apparatus is upright and separated from the supraoccipital precess. The anterior border of the neural complex is concave, its posterior border is convex, giving a sickel-shaped appearance (anvil-shaped in unknown Barbus). The premaxilla (Fig. 7) is thin and shallow. The anteriordorsal part forms an ascending ramus which is directed toward the anterior end of the skull, where it contacts the rostral bone. The premaxilla tapers posteriorly. The anterior portion of the bone is notched (unnotched in unknown Barbus). On the posterior end of the bone there is relatively large fossa (no fossa in unknown Barbus). The greatest width of the premaxilla is 46% of its total length. The maxilla is thick and its dorsal border is convex (Fig. 8). There are two anterior ascending processes; one is thick with its tip compressed, the other is thin and



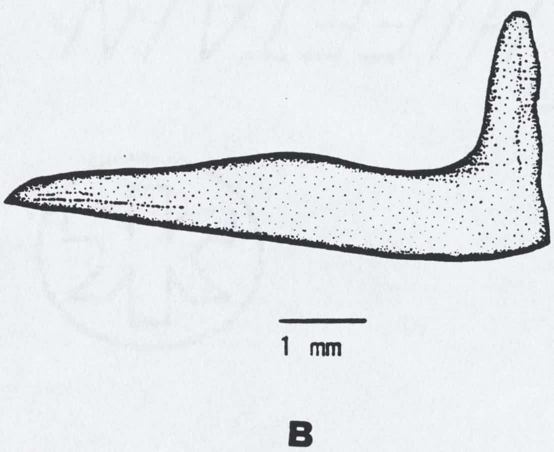


Figure 7. Dorsal view of right premaxilla of A. Barbus apoensis; B. unknown Barbus.

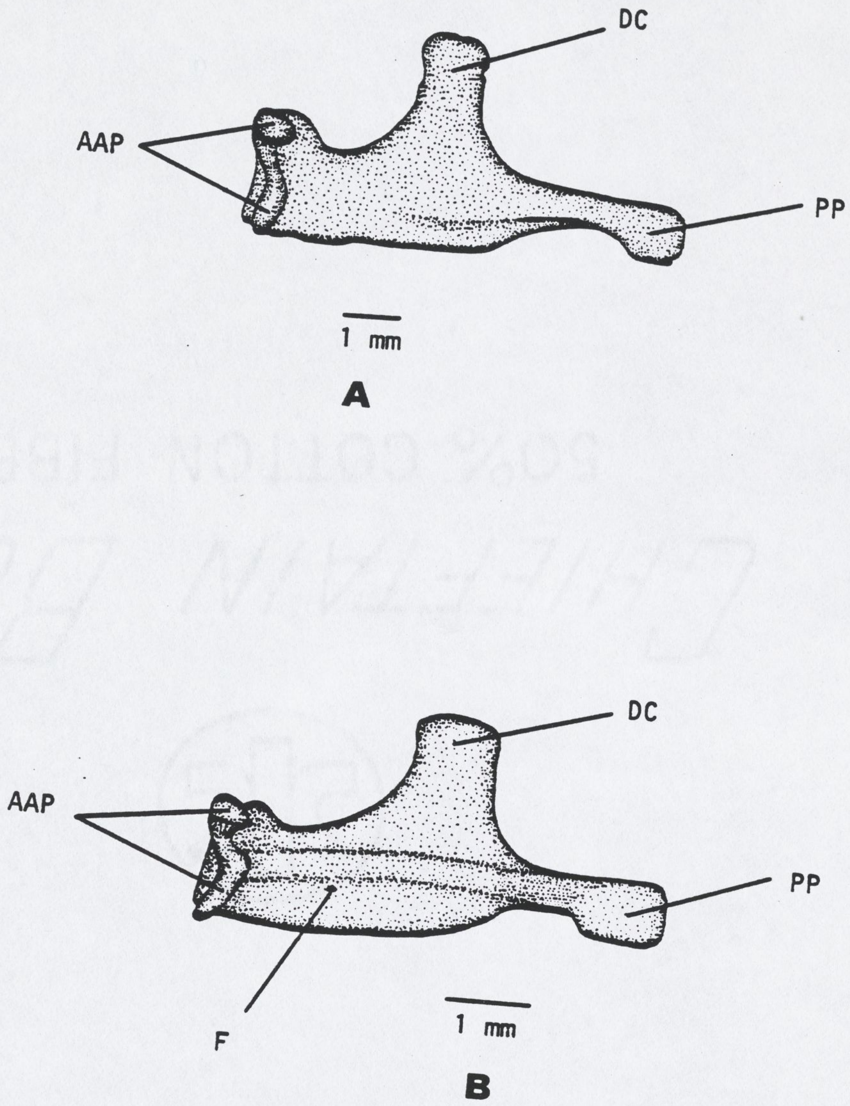


Figure 8. Inside view of right maxilla of A, Barbus apoensis; B. unknown Barbus.

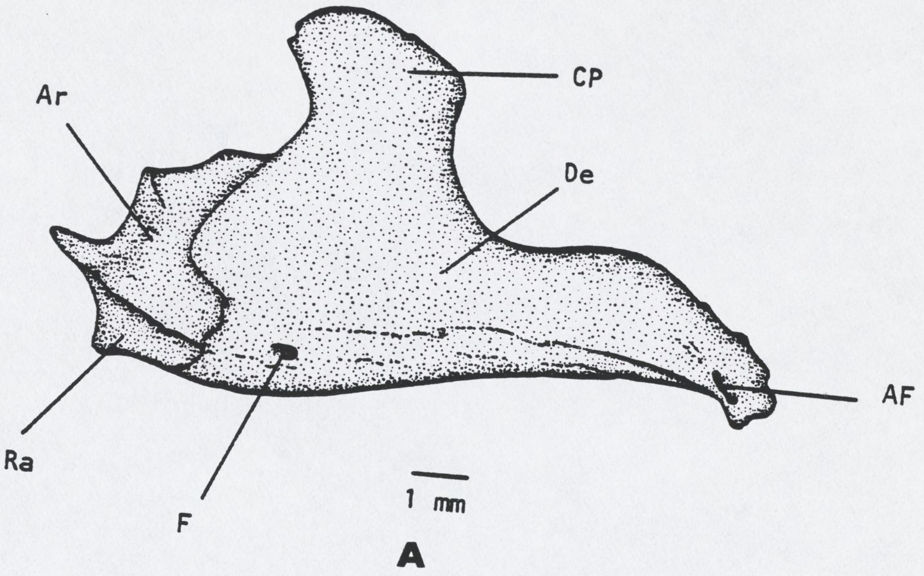
long. The maxilla lies dorsolateral to the premaxilla and is partly covered laterally by the anterior part of the lachrymal. At its posterior end the maxilla is expanded, giving it a plate-shaped appearance. The dorsal crest is thick and narrow. The dorsal crest lies midway in the length of the maxilla. The dentary (Fig. 9) curves at its anterior end to meet, at the midline, the anterior end of the opposite dentary. The dentary's wall is thick, its dorsal portion tapering to a thin edge and curving internally to form a sloped labial surface. The bone bears a large ascending coronoid process, which lies well back on the dentary. The coronoid process is broad. The posterior border of the coronoid process is strongly concave, while its anterior edge slightly convex. There are two foramen on the ventrolateral surface of the dentary. The articular is long and pointed. The postero-dorsal surface of the articular is notched to receive the articulating end of the quadrate. The retroarticular is a thick small bone lying below the ventral articular process.

Coloration

Living specimens have a brassy-golden coloration with olive fins. Preserved specimens are pale-yellow below and gray-brown above.

Habitat

Barbus apoensis occupies small to medium sized streams with moderate flow, typically with gravel and rubble substrate. These streams are usually composed of pools alternating with short stretches of riffles.



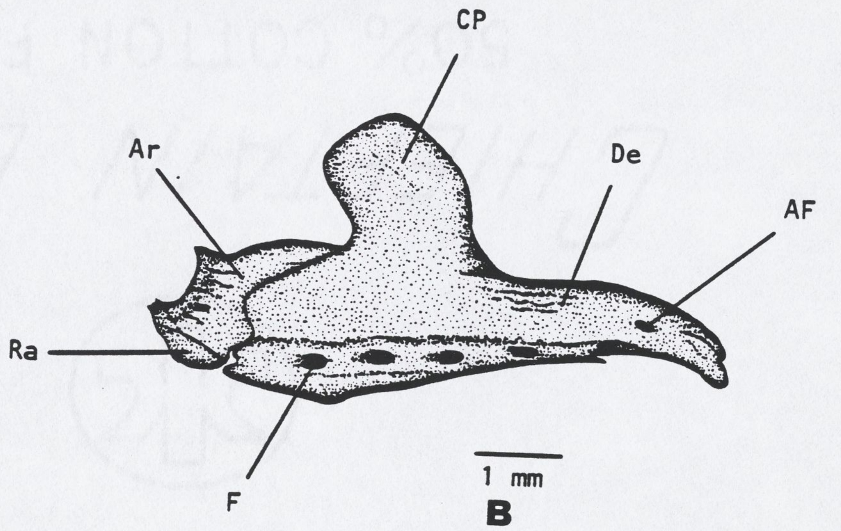


Figure 9. Lateral view of right lower jaw of A, Barbus apoensis; B. unkown Barbus.

Distribution

This species is known from Wadi Al Mhaleh, southeast of Abha, Ain AlJmyma, Wadi Turabah, Wadi Hadiyah and Wadi Shugub, Saudi Arabia (Fig. 4).

Relationships

A group of three related Near Eastern species of *Barbus*, *B. canis*, *B. chantrei* and *B. luteus*, suggests a common progenitor for them as well as for *B. apoensis*. The three Near Eastern species and *B. apoensis* share a set of characters differentiating them from othe Near Eastern *Barbus* --- 6 branched anal rays (vs. 5), few gillrakers, typically 10 branched dorsal rays (vs. typically 8) and low lateral line scale counts (23 to 34 vs. 40 or more). *B. canis* and *B. chantrei* have two pairs of barbels. *B. luteus* and *B. apoensis* have a single pair of barbels. All four species have an unserrated dorsal spine. *B. exulatus* and *B. arabicus* have two pairs of barbels and an unserrated dorsal spine. *B. exulatus* typically has 9 branched dorsal rays and *B. arabicus* 8. *B. canis* is endemic to the Jordan River basin, *B. chantrei* to the Orontes basin, and *B. luteus* is more widely distributed in the Tigris-Euphrates and Mond River basins.

Barbus exulatus

B. exulatus Banister, K. and M. A. Clarke. 1977. Jour. Oman Studies, Spec. Rep. (Sci. Results, Oman Flora and Fauna Survey): p. 116.

The description of this species was based on several localities associated with the Wadi Hadramaut and Wadi Maran, East Yemen (Fig. 4). According to the description, the body is slightly compressed and the dorsal profile is arched. Two pairs of barbels are present. There are

4 unbranched and 7-9 branched dorsal rays. There are 3 unbranched and 6 branched anal rays. The lateral line scale count ranges from 24-28. Gill rakers are short and widely spaced. Their count on the lower limb of the first gill arch ranges from 6-9.

Barbus exulatus resembles Barbus apoensis in general body shape and in the possession of 6 branched anal rays. It can be distinguished from the latter by the possession of two paris of barbels and sub-terminal mouth. Barbus arabicus differs from Barbus exulatus in the possession of 5 branched anal rays.

Barbus arabicus

Barbus arabicus Trewavas, 1941, British Museum (Natural History) expedition to South West Arabia 1937-8, 1(3):14.

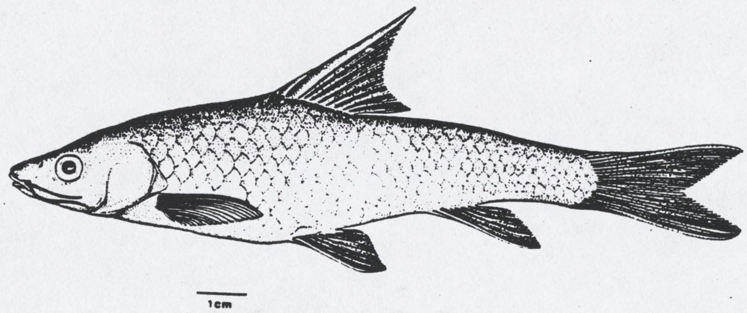
Tor arabicus: Karaman 1971, Mitt. Hamburg. Zool. Mus. Inst., 67:226.

Material Examined

One fish, 250 mm SL, from Wadi Jizan Dam, near Jizan City, 16° 54' N, 42° 29' E, collected by Dr. Naser Al Assgah, March, 1981, was examined.

Description

The body shape can be seen in Figure 10. The type locality of this species is unknown. The holotype was purchased at a market at Sana, North Yemen. In addition, Banister and Clarke (1977) recorded it from several localities of South and Southwestern Arabia. According to their description:



D IV 7-9, A III 5, V 9, L.L. 25-35

Figure 10. Barbus arabicus, 119 mm SL. (Adapted from Banister and Clarke 1977).

"The body is slim and graceful. The snout obtusely pointed in lateral view. The mouth is subterminal. There are two long pairs of barbels. The eyes are small and superolateral in positions. The dorsal fin has 4 unbranched rays (the last of which is ossified into a smooth straight spine) and 7-9 branched rays. The anal fin has three unbranched rays and five branched rays. There are 25 to 32 scales in the lateral line. There are 12 scales around the least circumference of the caudal peduncle. The gill rakers number 9-13 on the lower limb of the first gill arch."

Krupp (1983) mentioned that the dorsal surface of the head is convex in juveniles, but concave in mature specimens. He reported 30 to 35 scales in the lateral line. Pharyngeal teeth number 2.3.5 - 5.3.2.

The specimen examined from Wadi Jizan Dam shows: 8 branched dorsal rays, 5 branched anal rays, 13 pectoral fin rays, 9 pelvic fin rays and 13 gill rakers on the anterior side of the first gill arch. There are 19 gill rakers on the posterior side of the first gill arch. There are 13 scales around the least circumference of the caudal peduncle. Small protuberances on some gill rakers of the first gill arch were noted. The proportional measurements of Barbus arabicus expressed in thousandths of the standard length are presented in Table 3.

Coloration

Preserved speciments are grey-brown dorsally and pale-yellowish ventrally. Live specimens color reported by Banister and Clarke (1977) as "Ventral surface white. Laterally silver with a slight orange flush. All fins pale yellowish-orange, the dorsal fin with a dark pigment edging."

Habitat

Barbus arabicus inhabits medium-sized streams. Also, it was collected from Jizan dam reservoir with a maximum storage capacity of 71 MCM.

Table 3. Proportional measurements of <u>Barbus</u> <u>arabicus</u> expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CP L	B L	IOW	H D	PFL	VFL	DSL	HW
Wadi Jizan	1	300	250	288	256	036	068	480	136	152	152	136	172	088	108	520	172	148	152	192

Distribution

This species seems to be widespread in southwestern and southern coastal drainages (Fig. 4).

Relationships

Barbus arabicus can be distinguished from all other Arabian Barbus on the basis of five branched rays in the anal fin. Trewavas (1941) considered this species to be more closely related to some Indian species and to Barbus canis than to any of the African Barbus. However, Barbus canis has 6 branched rays in the anal fin, an important difference between Barbus arabicus and Barbus canis. Banister and Clarke (1977) and Banister (1973), aligned Barbus arabicus with the species of Barbus of northeastern Africa -- the Barbus intermedius complex for the following reasons: The morphological similarity between the species, i.e. the possession of the same type of scale striation, a caudal peduncle longer than deep, and a well ossified straight dorsal spine. The phenotypic variability of Barbus arabicus parallels Barbus intermedius (Banister 1973). The distribution of Barbus arabicus, i.e. in the sourthern part of Arabia just across the Red Sea from Barbus intermedius suggests an African origin (Banister and Clarke 1977). Perhaps the Barbus intermedius complex of northeast Africa represents an earlier branch of the phyletic line giving rise to the three Near Eastern Barbus species, discussed previously (lower number of dorsal and anal rays are probably primitive characters).

Barbus arabicus typically has 8 branched dorsal rays and the typical number of those rays in Barbus exulatus is 9. Barbus arabicus and Barbus exulatus both have two pairs of barbels.

Unknown *Barbus*

Material Examined

a) 6 specimens, 36-69 mm SL, were collected june, 1981, from Wadi Hadiyah, 25° 34' N, 38° 41', Saudi Arabia.

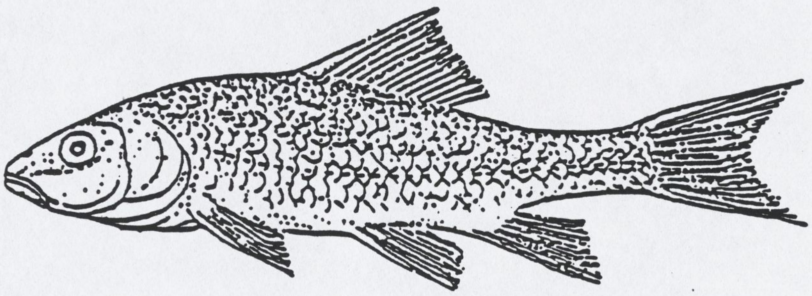
b) 2 specimens, 35-41 mm SL, were collected July, 1977, from Ain AlJmyma, Khaybar, Saudi Arabia. Khaybar City is at 25° 42' N, 39° 31' E.

c) 2 fish, 78-81 mm SL, were collected, July 1977, from Wadi Al Mhaleh southeast of Abha City, Saudi Arabia. Abha city is at 18° 13' N, 42° 30' E.

Description

Morphology

The body shape can be seen in Fig. 11. The head is short and obtuse. Mouth is terminal. Anterior edge of the lower jaw is curved, but without blade. There is one pair of small barbels. No tubercles observed. Peritoneum is dark-brown. Caudal peduncle short and narrow. The caudal fin is forked. The airbladder is bipartite, the posterior chamber is larger and slightly narrower than the anterior one. There are 4 unbranched rays and 10 branched rays in the dorsal fin. The last unbranched ray is ossified and has no serration. The dorsal fin origin is opposite the origin of the ventral fin. There are 3 unbranched rays and 6 branched rays in the anal fin. Pectoral fin rays range from 12 to 16. The lateral line is straight or curved to the middle of the caudal peduncle. There are 23-29 scales in the lateral line. Gill rakers are short, thin and slightly curved. Proportional measurements of unknown



D IV 10, A III 6, V 9, L.L. 23-29

Figure 11. Unknown Barbus, 81 mm SL.

Barbus are presented in Table 4. Frequency distributions of meristic data for unknown Barbus are presented in Table 5.

Skeletal Characters

All centra except Weberian apparatus and the urostyle have neural prezygopophysis, postzygapophysis, neural arch and neural spines. The first postweberian apparatus vertebra lacks neural prezygapophysis. All postweberian precaudal vertebrae have a parapophysis. The shapes and sizes of the centra, neural prezygapophysis, postzygapophysis, neural arch and spines are similar to those of Barbus apoensis.

The supraneurals are thin, shallow and each separated form its respective neural spine. The 'neural complex' of the Weberian apparatus is upright and dorsally separated from the posteriorly directed supraoccipital process. The anterior and posterior borders of the neural complex are concave, giving it an anvil-shaped appearance (sickle-shaped in apoensis). In the specimens examined there are 7 or 8 supraneurals, each is separated from its neighbour, the posterior element doesn't overlap the anterior margin of the first dorsal pterygiophore.

The premaxilla is thin and narrow (Fig. 7). The anterodorsal part of the bone is curved. No notch on the frontal surface of the anterior process of the bone (notched in apoensis). The posterior process is pointed and has no fossa (fossa present in apoensis). The premaxilla's greatest width is 35% of its length. The maxilla is thick with a broad dorsal crest (Fig. 8). The maxilla has 2 anterior ascending processes; one long and thin, the other is thick and short. The dorsal crest lies midway in the length of the maxilla. Its posterior and anterior borders

Table 4. Proportional measurements of unknown Barbus expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CP L	BL	IOW	H D	PFL	VFL	DSL	HW
Wadi Hadiyah	1	88	69	261	333	087	101	522	217	304	203	130	159	058	130	536	217	202	217	174
	2	44	36	276	417	111	167	583	194	389	333	250	222	083	139	556	277	278	222	222
	3	51	40	275	350	100	150	525	200	350	375	200	225	075	150	550	250	250	200	200
	4	81	61	262	328	098	066	508	197	279	229	098	148	066	197	525	213	213	197	164
	5	62	51	275	333	078	159	529	176	314	254	098	157	078	216	588	216	216	216	157
	6	60	45	244	311	089	069	511	200	289	266	111	166	067	222	489	222	222	222	178
	Mean	64.3	53.3	266	345	094	102	530	197	321	260	148	180	071	176	541	233	230	212	183
	Min.	44	36	244	311	078	059	508	176	279	203	098	148	058	130	489	213	202	197	157
	Max.	88	69	276	417	111	167	583	217	389	333	250	225	083	222	588	277	278	222	222
Ain Al Jmyma	7	41	35	229	343	114	085	514	200	314	171	114	170	057	257	543	200	171	171	171
	8	56	41	244	366	122	073	463	195	317	171	093	170	073	243	512	219	195	195	170
	Mean	48.5	38	237	355	118	079	489	198	316	171	104	170	065	250	528	210	183	183	171
	Min.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Max.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Wadi Al Mhaleh	9	104	78	269	333	077	103	526	218	321	155	128	167	051	179	--	--	--	--	--
	10	105	81	272	309	074	099	556	185	247	185	123	290	049	170	--	--	--	--	--
	Mean	104.5	79.5	271	321	076	101	541	202	284	170	126	188	050	170	--	--	--	--	--
	Min.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Max	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 5. Frequency distributions of meristic data for unknown Barbus

							$\overline{X}$	S.D.
Scales in lateral line	23	24	25	26	29		25.2	2.2
N. specimens	2	3	2	1	2			
Scales above lateral line		3	4	5			3.8	0.6
N. specimens		3	6	1				
Scales around caudal peduncle			10	11	12		11.0	0.9
N. specimens			4	2	4			
Scales between pelvic fin and lateral line					2	3	2.1	0.3
N. specimens					9	1		
Dorsal fin branched rays			10				10.0	0.0
N. specimens			10					
Anal fin branched rays			6				6.0	0.0
N. specimens			10					
Pectoral fin rays	12	14	15	16			14.1	0.9
N. specimens	1	7	1	1				
Gill rakers on first arch;								
a) anterior side	7	8	9	10			8.8	0.8
N. specimens	1	1	7	1				
b) posterior side	12	13	14	16			14.1	1.4
N. specimens	1	3	3	3				

are slightly concave. At its posterior process the maxilla is expanded, giving it plate-shaped appearance. A small foramen is present on the inner surface. The dentary is thick, its dorsal part tapering to a thin curved edge. The anterior tip of the dentary is almost pointed and bifurcated (unfurcated in apoensis). A small foramen is present on the anterior part of the dentary. On the ventrolateral part of the dentary there are a series of large foramen (Fig. 9). The coronoid process of the dentary is broad with a concaved posterior border. The articular is thin, long and pointed. There are no coronomeckelian bones on the surface of the angular of the specimens examined. The retroarticular bone is a small thin lying directly below the posterior end of the articular. Pharyngeal teeth are thin, relatively long, hooked and closely spaced. Their formula is 2.3.5 - 5.3.2 in all specimens examined.

Coloration

Alcohol preserved specimens are brownish dorsally and yellow-brown below the lateral line. No spots on the middle of the flank.

Habitat

This species occupies small to medium sized streams with substrate range from sand to gravel and rubble. These streams are usually composed of pools alternating with short stretches of riffle.

Distribution

This species was collected together with Barbus apoensis in the Wadi Al Mhaleh. Thus, the two occur in sympatry. The 1981 collections extended the range of the species to a spring (Ain Al Jmyma) north of Khaybar city and Wadi Hadiyah west of Khaybar, Saudi Arabia Fig. 4).

Relationships

A detailed comparison between specimens of this species and Barbus apoensis revealed similarities in most morphological and meristic characters. Non-overlapping values were found between these specimens and Barbus apoensis of comparable size in interorbital width (less in apoensis), width of gape (less in apoensis), head length (greater in apoensis), and depth of the caudal peduncle (deeper in apoensis). The pectoral fins in the distinctive specimens reach the origin of the pelvic fins; the pectoral fins don't reach the pelvic fin in typical apoensis specimens. In comparison, typical apoensis specimens have darker pigmentation, the body rises more abruptly back of the head, and scales are more stout in structure and more deeply embedded. The pre-maxilla is narrower than that of Barbus apoensis and has no notch and fossa. The maxillary dorsal crest is broader than that of apoensis. This species also can be distinguished from Barbus aponesis in general appearance of the neural complex (anvil-shaped vs. sickle-shaped), narrower coronoid process, more supraneurals (7-8 vs. 5-6), smaller articular, smaller retroarticular and the anterior part of the dentary is shallowly bifurcated. From Barbus arabicus this species can be distinguished by the possession of 6 branched anal rays (5 in arabicus) and one pair of barbels (2 in arabicus). From Barbus exulatus this species differs by having only one pair of barbels (2 in exulatus).

All of the four known Arabian species of Barbus appear to be part of a phyletic section of the genus characterized by low scale counts and few gill rakers, originating and speciating in the northeast Africa-Near East region. On the basis of the present states of knowledge, any attempt to delineate relationships and branching points, associating Arabian species to other species would be highly speculative. The number of branched anal and dorsal rays suggest Barbus apoensis, Barbus exulatus and the unknown Barbus originated from a Barbus canis-Barbus luteus type of ancestor invading from the north (Jordan River) or east (Tigris-Euphrates or Mond basins). Barbus arabicus, with fewer dorsal and anal rays is probably derived from the Barbus intermedius complex of north-east Africa.

Genus Cyprinion Heckel

Cyprinion Heckel, 1843, Russegger's Reisen, 1, P. 1015, 1065 (type: C. macrostomus).

Fishes of moderate size; scales of moderate size; dorsal fin with an osseous and serrated spine and numerous branched rays; mouth subterminal; pharyngeal teeth 2.3.4 — 4.3.2; one pair of barbels; peritoneum black; alimentary canal long and convoluted; air bladder bipartite; seven branched anal rays. A revised diagnosis of the genus was given by Howes (1982).

Distribution

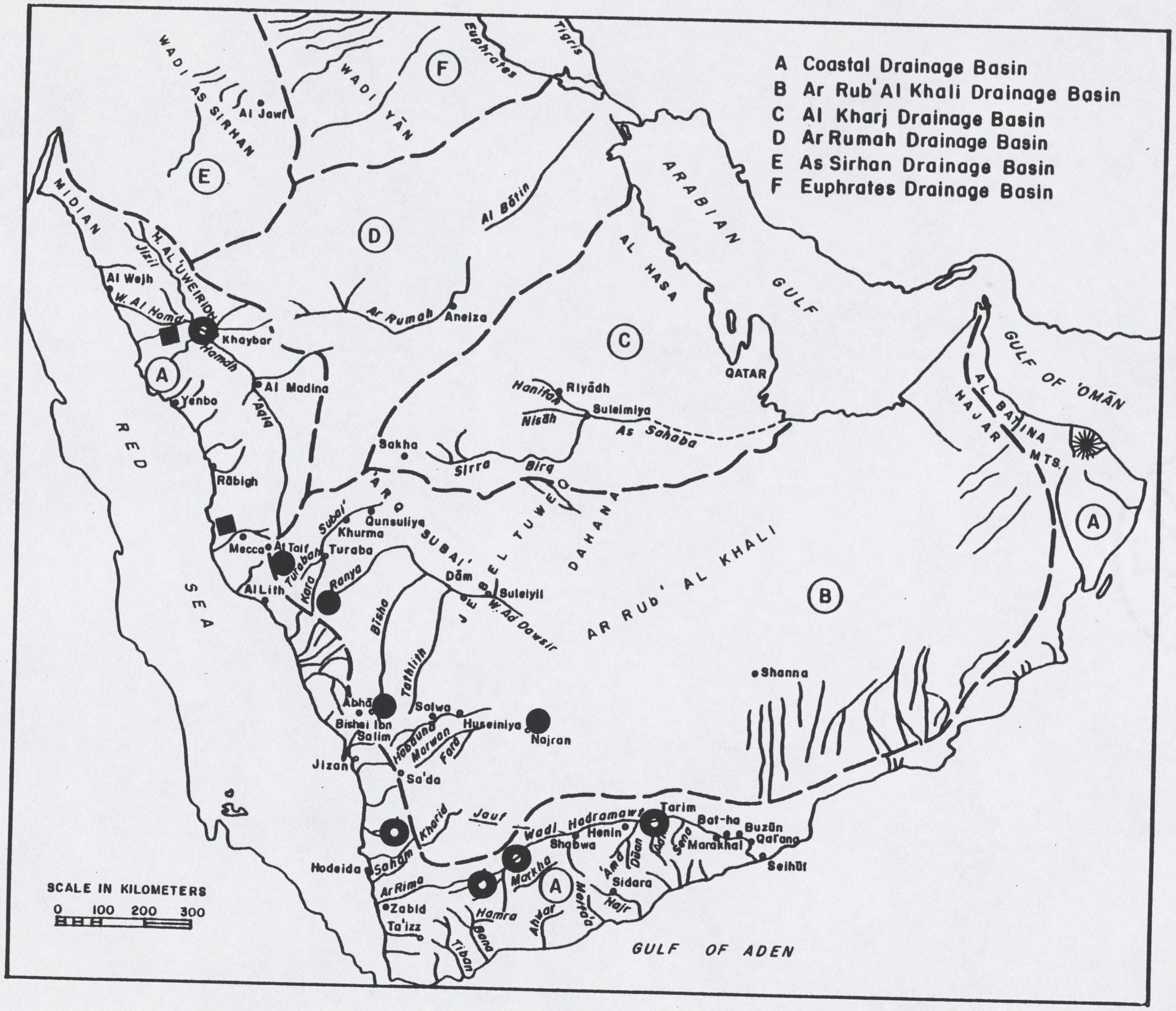
This genus is widespread in west Pakistan, Afghanistan, Arabia, Iran, Iraq and Syria. It occurs in all drainages to the Indian Ocean, and in tributaries to the Arabian Gulf.

In Arabia based on previous studies (Banister and Clarke 1977, Al Kahem and Behnke 1983, Krupp 1983), Cyprinion occurs in the coastal drainages and in Ar Rub' Al Khali Basin. In Saudi Arabia the genus occurs in Wadi Al Mhaleh of the Ar Rub' Al Khali Basin and in Red Sea drainages. Cyprinion acinaces was collected from Wadi Hadiyah and Khaybar springs. Cyprinion mhalensis was collected from Wadi Al Mhaleh in the Asir highlands. Cyprinion muscatensis was recorded from Muscat, Oman (Fig. 12).

Taxonomic Outline

Howes (1982) revised Cyprinion and recognized nine species including three Indian species formerly classified in the genus Semiplotus. According to Howes, the endemic Arabian species, Cyprinion

Figure 12. Distribution of _Cyprinion_ spp.: _Cyprinion acinaces acinaces_ (◉), _C. acinaces hijazi_ (■), _C. mhalensis_ (●), _Cyprinion muscatensis_ (✹).


A Coastal Drainage Basin
B Ar Rub' Al Khali Drainage Basin
C Al Kharj Drainage Basin
D Ar Rumah Drainage Basin
E As Sirhan Drainage Basin
F Euphrates Drainage Basin
SCALE IN KILOMETERS
0 100 200 300
WADI AS SIRHAN
Al Jawf
WADI YĀN
Euphrates
Tigris
MIDIAN
Jizil
H. AL 'UWEIRIDH
Al Wejh
W. Al Hamd
Khaybar
Hamdh
Al Madina
Yenbo
'Aqiq
Al Bātin
Ar Rumah
Aneiza
ARABIAN GULF
AL HASA
QATAR
GULF OF 'OMĀN
AL BATINA
HAJAR MTS.
Hanifah
Riyādh
Suleimiya
Nisāh
As Sahaba
Sakha
Sirra
Birq
DAHANA
ARQ SUBAI'
JEBEL TUWEIQ
RED SEA
Rābigh
Mecca
At Taif
Turaba
Subai'
Qunsuliye
Khurma
Turabah
Kara
Ranya
Al Lith
Dām
Suleiyil
W. Ad Dawsir
AR RUB' AL KHALI
Bisha
Tathlith
Shanna
Abhā
Salwa
Bishei Ibn Salim
Habauna
Marwan
Fara
Huseiniya
Najran
Jizan
Sa'da
Jauf
Kharid
Wadi Hadramawt
Tarim
Bat-ha
Buzūn
Qaf'ona
Henin
Shabwa
Marakhat
Seihūt
Hodeida
Saham
Markha
'Amd
Dū'an
Sidara
Hajr
Ar Rima
Zabid
Ta'izz
Hamra
Bana
Ahwar
Meifa'a
Tiban
GULF OF ADEN
A
B
C
D
E
F

acinaces retains the most primitive characters of all species in the genus.

Prior to Howes' publication, Berg (1949) recognized six species of Cyprinion: C. microphthalmum, C. macrostomum, C. irregulare, C. watsoni, C. milesi, and C. tenuiradius. Mirza (1969) synonymized C. irregulare with C. watsoni and claimed that C. microphthalmum could be distinguished by a three-chambered air bladder. However, on the basis of further study, Mirza (1971) concluded that the air bladder characteristic of two versus three chambers is not reliable for species recognition.

The latest revision by Howes (1982) recognizes nine species in the genus: C. acinaces (endemic to Arabia), C. macrostomum, C. kais (endemic to Tigris-Euphrates basin), C. milesi, C. watsoni, C. microphthalmum, C. semiplotum, C. modestum, and C. burmanica.

Prior to the publication of Banister and Clarke's work (1977), only Cyprinion muscatensis was known from Arabia. Banister and Clarke (1977) described Cyprinion acinaces as a new species from Arabia. Krupp (1983) recognized two subspecies of Cyprinion acinaces; Cyprinion acinaces acinaces and Cyprinion acinaces hijazi. Al Kahem and Behnke (1983) described Cyprinion mhalensis as a new species from Saudi Arabia. Bianco and Banarescu (1982) recognized Cyprinion watsoni muscatensis (in Oman; southeastern Arabia) as a subspecies of Cyprinion watsoni, but Krupp (1983) described the same taxon as a subspecies of Cyprinion microphthalmum. The validity of the nominal species muscatensis is far from settled and if muscatensis is regarded as subspecies,there is no valid basis to classify it as a subspecies of microphthalmum or watsoni.

In an attempt to establish the validity of C. microphthalmum and C. watsoni, Dr. Behnke and I critically examined Iranian Cyprinion utilized by Saadati (1977). Two samples collected near Bam (collections no. 34, 35, western Lut basin) stand out from all other non-Tigris, non-Mond drainages samples. I identify these Cyprinion from the western Lot basin as microphthalmum. They have a much smaller eye, a bulbous, overhanging snout, and a horizontal mouth with a very pronounced naked blade (smaller, more arch-shape mouth with cornified blade covered or partially covered with flesh in all other specimens). The Bam Cyprinion sharply stand apart from all other collections and conform to Mirza's (1969) illustration and description of microphthalmum fom near Quetta, Pakistan, the type locality. They also agree with the characteristics given by Day (1880) in the original description of micropthalmum.

Some element of doubt remains regarding the Lut basin Cyprinion as the same species Day (1880) described as Scaphiodon microphthalmus from two specimens (now lost) collected near Quetta. A lack of certainty will always exist without the type specimens. The original description emphasizes a small eye, a wide mouth with "horney covering" over the lips. Mirza's map of his collections denotes fish he identified as microphthalmum around Quetta. Howes (1982) distinguished C. microphthalmum by absence of the pelvic papillary flap (I find this character to be highly variable) and the loss of the supraneural - pterygiophore articulation (consistency and significance not demonstrated). Howes, however, used "microphthalmum" specimens at the British Museum from "Baluchistan" (drainage basin not given, but certainly not "topotyptes"). Howes distinguished C. watsoni mainly on the basis of a premaxillary notch. No locality data at all are given for the watsoni specimens he examined (type locality is "Sind Hills" given by Day (1872); most probably in the Indus River drainage). We can find no premaxillary notch in Gulf drainage Cyprinion. For C. milesi, Howes used specimens from "Afghanistan and Baluchistan" (no further locality given, but type locality is 32 km from Mekran coast of Indian Ocean). C. milesi was distinguished by Howes by a pelvic papillae (but, as mentioned this is variable in Cyprinion). Mirza (1969) distinguished watsoni by a more slender body and 33-36 scales and milesi with a deep body and 37-40 scales. Iranian specimens span the range of deep to more slender body and 33-40 scales so I provisionally include milesi as a synonym of watsoni pending further study. Unfortunately, Howes gave no meristic or morphological characters for specimens of Cyprinion he discussed. In comparison, Arabian Cyprinion show a predominance of the "watsoni" morphology, but especially in Oman specimens of muscatensis a more bulbous snout and straight cornified lower jaw is indicative of some microphthalmum influence, but with complete absence of serration on the dorsal spine. Dorsal spine serration is well developed in the Lut specimens I consider as microphthalmum. The evolutionary history of Cyprinion may have produced divergent lines represented by microphthalmum and watsoni but with incomplete reproductive isolation. Where they came together in Iran hybridization occurred and the original invaders on the Arabian Peninsula could have carried segments of both ancestral species. In any event, C. muscatensis of Oman cannot be clearly alligned with either microphthalmum or watsoni, as diagnosed from Iranian specimens, and should be recognized as a full species, at least until more definitive studies are made.

Cyprinion acinaces Banister and Clarke, 1977

This species is widely distributed along the coastal drainages of west and southwestern Arabia. This species is characterized by 11-12 dorsal fin branched rays; 7 anal fin branched rays, 11-17 gill rakers on the anterior side of the first gill arch, and 32-38 scale in the lateral line.

Cyprinion acinaces acinaces Banister and Clarke, 1977

Cyprinion acinaces Banister, K. and M. Clarke. 1977. Jour. Oman Studies, Spec. Rep. (Sci. Results Oman Flora and Fauna Survey): P. 123.

Cyprinion acinaces acinaces Krupp, F. 1983. Fauna of Saudi Arabia, 5:(In press).

Material Examined

a) 40 fish, 62-113 mm SL, collected July, 1981, from Ain (= spring) Salaleem, Khaybar, 25° 42' N, 39° 31' E, Saudi Arabia

b) 10 fish, 55-88 mm SL, collected July, 1981, from Ain AlJmyma, Khaybar, Saudi Arabia.

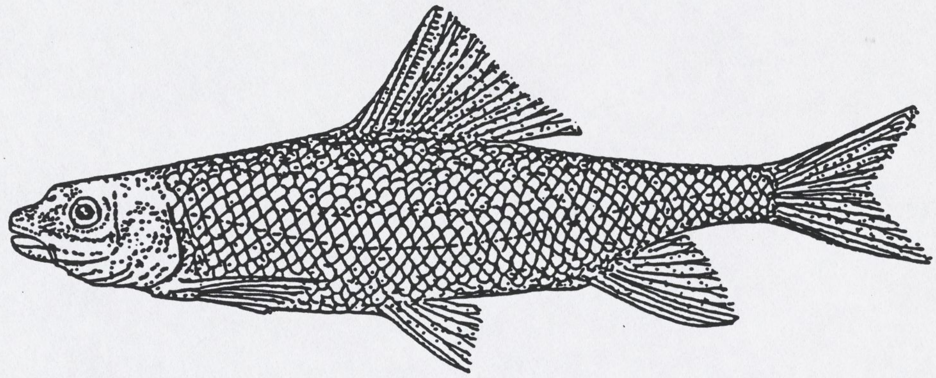
c) 9 fish, 70-127 mm SL, collected July, 1977, from Ain Ali, Khaybar, Saudi Arabia.

d) 20 fish, 57-117 mm SL, collected July 1977, from Ain AlBhair, Khaybar, Saudi Arabia.

Description

Morphology

The shape of the body can be seen in Figure 13. The mouth is subterminal. The lower jaw is gently curved and covered with a



D IV 11-12, A III 7 V 9, L.L. 32-28

Figure 13. _Cyprinion acinaces acinaces_, 110 mm SL.

sharp-edged horny sheath. Mouth is of variable shape, i.e. horse-shoe, transverse or oblique. In some specimens the cornified blade is weakly developed. Posterior barbels are present. These barbels are short. Tubercles are present on the snout and interorbital region of some specimens, while in other they cover the fin rays and the entire body. The head is elongate. The eyes are lateral and visible in ventral view. The peritoneum is sooty black. In some specimens, there is a well-developed, fatty, thickened papillose skin between the bases of the pelvic fin, but other specimens have a less developed structure. Specimens of this species possess the pronounced, scaleless bony ridge between the occiput and the origin of the dorsal fin similar to that seen in Cyprinion watsoni. The dorsal fin has 4 unbranched rays and 11 (f30) or 12 (f49) branched rays. The last unbranched ray is ossified into a long straight spine with a strongly serrated posterior face. There are 3 unbranched and 7 branched rays in the anal fin. There are 9 rays in the pelvic fin. The pectoral fin has 14 (f27), 15 (f29) or 16 (f23) fin rays. Pectoral fins do not reach pelvic fins.

Lateral line is straight in some specimens, curved in others. Total lateral line scale counts range from 32 to 38. Scale counts to the end of the vertebral column range from 30 to 35.

There are 3-4 scales between lateral line and the pelvic fin. There are 5-8 scales above the lateral line. The caudal peduncle is narrow and short. There are 12 (f5), 13 (f8), 14 (f12), 15 (f15), 16 (f36) or 17 (f3) scales around the least circumference of the caudal peduncle. The intestine length is from 2.4 to 3.8 times the standard length. The gas bladder has two chambers. Its posterior chamber is longer and slightly narrower than the anterior one. Gill rakers on the first gill arch are stout, short and curved, their count ranges from 11 to 17. There are 20-27 gill rakers on the posterior side of the first gill arch and 23-28 gill rakers on the anterior side of the second gill arch. Proportional measurements and frequency distributions of meristic data are presented in Table 6 and 7, respectively.

Skeletal Characters

All the vertebrae, with the exception of the four anteriomost and caudal vertebrae, have centra which are quite uniform in size and form (Fig. 6). Neural arch and spines are present on all vertebrae. Neural spines are long and thick. The neural prezygapophyses are relatively a long anteroprojections from the neural arch. Some neural prezygapophysis fused with respective neural spines, others are separated. The neural prezygapophysis are not developed on the first postweberian centrum. The postzygapophysis are posterodorsal spinelike projections on the upper parts of the centra. Postzygapophyses gradually diminish in size in the posterior half of the caudal region. The presence of postzygapophyses are found in specimens of _Barbus_ and _Cyprinion_ but were not found in specimens of _Garra_. The parapophyses are lacking on the first four vertebrae, but present on all precaudal vertebrae. The supraneurals of _Cyprinion_ _acinaces_ are large, thick and each is separated from its respective neural spine. There are 5 (f3) or 6 (f1) supraneurals, usually each articulating with its neighbour, posterior supraneural is articulating with the anterior margine of the first dorsal pterygiophore. The first supraneural is widely separated from the neural complex. The neural complex is upright and has almost

Table 6. Proportional measurements of Cyprinion acinaces acinaces expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CPL	Snt.L	PFL	DSL	IOW	BL
Ain	1	111	85	294	294	082	082	518	235	294	247	118	188	106	235	224	118	056
Salaleem	2	102	87	299	299	080	080	506	229	287	241	115	161	115	241	218	115	046
	3	116	94	245	277	085	074	524	213	306	234	106	138	096	202	202	106	043
	4	100	82	256	256	073	073	488	232	317	244	109	146	098	207	219	109	049
	5	100	81	247	247	074	074	494	235	309	247	111	148	099	209	209	111	049
	6	101	82	256	256	073	073	488	232	317	244	109	146	098	207	219	109	049
	7	92	71	295	309	084	098	535	254	252	225	099	169	099	225	211	127	042
	8	106	81	247	309	074	074	519	222	346	259	099	160	111	247	235	111	037
	9	104	81	247	247	074	074	494	234	309	247	111	148	099	209	209	111	049
	10	102	81	259	259	074	074	506	247	309	247	111	148	099	209	209	111	049
	11	89	65	338	323	092	092	538	261	308	235	092	169	108	215	231	123	046
	12	87	68	279	309	088	088	515	250	294	221	088	162	103	206	221	118	044
	13	91	71	295	309	085	085	535	268	225	225	099	169	099	225	211	127	042
	14	90	70	289	300	086	086	529	271	229	229	100	171	100	228	214	129	043
	15	86	67	299	299	075	075	537	254	299	254	104	179	104	224	224	119	045
	16	79	62	290	306	097	097	434	242	323	258	113	177	129	242	242	113	048
	17	128	102	245	284	078	078	509	245	343	235	088	127	098	206	216	098	049
	18	132	104	240	269	077	087	509	279	298	240	096	144	096	192	221	096	048
	19	135	107	271	280	075	084	514	243	289	234	084	159	093	205	187	093	037
	20	131	105	267	286	067	067	495	229	305	238	095	152	095	209	209	095	038
	21	130	105	276	276	067	086	533	248	343	238	095	114	095	209	209	095	038
	22	125	101	277	287	069	079	515	238	337	228	099	129	099	207	198	099	049
	23	115	89	269	292	067	067	528	281	315	236	112	135	112	225	213	112	045
	24	125	101	277	267	069	059	504	238	228	248	099	119	099	198	198	099	049
	25	118	91	231	253	077	066	505	219	308	242	109	132	109	198	242	099	043
	26	110	88	273	284	068	068	511	227	307	239	114	125	114	216	261	102	045
	27	106	85	259	271	071	071	518	235	306	235	106	129	118	224	259	106	047
	28	120	93	258	269	075	075	505	215	301	247	106	129	106	194	237	097	043
	29	125	97	258	278	072	072	526	216	278	247	103	124	103	196	216	103	041
	30	140	113	265	274	071	062	460	204	283	230	088	123	088	195	204	088	044
	31	113	85	259	282	082	071	518	247	329	256	118	141	118	212	224	118	047
	32	113	84	250	274	071	071	536	250	321	250	119	143	119	214	226	119	048
	33	103	87	264	276	069	069	529	229	333	253	103	138	092	195	207	103	046
	34	100	79	266	316	076	076	532	253	354	253	101	139	127	215	215	101	051
	35	110	83	253	289	072	072	518	217	337	250	108	132	096	217	229	096	048
	36	107	84	250	286	071	071	512	214	321	238	107	131	095	202	226	107	048
	37	106	76	263	289	079	079	553	237	355	238	118	145	105	224	263	105	053
	38	105	77	286	299	078	078	532	247	338	248	117	142	103	221	247	103	052
	39	92	70	286	314	086	086	543	271	300	257	114	157	114	214	243	114	057
	40	90	70	286	300	086	086	557	257	286	243	114	157	114	243	271	114	057

Table 6. Continued.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CPL	Snt.L	PFL	DSL	IOW	BL
Ain	Mean	108.4	85.1	269	285	078	077	516	240	306	242	105	146	104	214	223	108	047
Salaleem	Min.	79	62	231	247	067	059	434	204	225	221	084	114	092	192	187	088	037
	Max.	140	113	338	323	088	098	557	281	355	259	119	188	129	247	271	129	057
Ain	41	112	88	318	284	068	068	511	205	295	239	114	182	102	227	205	114	045
Al Jmyma	42	112	87	322	287	069	069	529	207	299	241	115	184	103	229	207	115	046
	43	105	85	294	282	059	059	506	212	306	247	118	176	094	224	200	118	047
	44	97	75	280	280	067	080	520	240	360	227	113	187	093	227	213	120	053
	45	78	62	290	290	096	097	516	226	323	226	113	177	113	226	26	097	048
	46	71	56	268	286	071	089	446	250	339	196	125	161	107	214	232	107	054
	47	72	55	291	304	091	109	473	255	364	236	127	182	109	218	236	109	055
	48	104	78	256	282	078	078	526	231	321	256	115	167	103	231	218	115	051
	49	102	85	235	247	059	071	471	212	318	224	118	200	082	212	188	106	047
	50	71	58	259	293	086	086	534	241	345	241	121	189	103	224	241	121	052
	Mean	92.4	72.9	280	284	074	081	503	228	327	233	118	181	101	223	217	112	050
	Min.	71	55	235	247	059	059	446	205	295	196	113	161	082	212	188	097	045
	Max.	112	88	322	304	091	109	534	255	364	256	127	200	113	231	241	121	055
Ain Ali	51	120	96	260	260	063	063	479	219	313	177	083	177	104	208	208	104	052
	52	73	60	283	267	083	083	500	233	300	167	100	167	116	267	233	117	050
	53	80	64	266	297	078	078	516	250	344	172	094	156	125	250	203	109	063
	54	85	61	279	295	082	082	557	246	328	180	098	180	115	262	230	115	066
	55	70	55	273	273	073	091	545	236	327	182	091	182	109	291	218	109	055
	56	75	58	276	276	086	086	517	224	310	190	103	172	103	241	207	103	069
	57	72	55	273	291	091	073	527	237	327	200	091	182	109	236	200	109	055
	58	127	102	304	284	078	056	500	245	324	176	088	167	098	196	186	098	029
	59	120	95	284	284	063	074	495	263	326	179	095	158	095	200	189	105	042
	Mean	91.3	71.8	278	281	077	076	515	239	322	180	094	171	108	239	203	108	053
	Min.	70	55	260	260	063	063	479	219	300	167	083	156	095	196	186	098	029
	Max.	127	102	304	297	091	091	557	263	344	200	103	182	125	291	233	117	069

Table 6. Continued.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CPL	BL	DSL
Ain Al Bhair	60	115	90	333	289	067	078	522	222	300	189	089	167	033	211
	61	120	96	333	281	063	073	510	219	313	188	104	167	031	188
	62	112	91	341	286	066	055	473	209	297	176	099	165	033	209
	63	132	107	336	280	065	065	505	243	308	196	121	178	037	187
	64	122	93	323	290	075	075	505	247	366	215	108	194	043	204
	65	130	100	330	279	060	060	520	220	310	190	140	190	030	190
	66	102	80	288	300	088	075	488	250	363	225	125	200	038	200
	67	89	68	279	294	088	074	500	221	309	176	103	191	059	221
	68	96	75	280	293	067	080	520	213	307	240	107	147	053	213
	69	78	61	279	279	082	082	492	246	328	164	098	164	066	230
	70	70	57	281	316	088	088	526	246	368	211	123	175	070	246
	71	85	65	277	308	077	077	538	215	308	200	123	169	062	200
	72	116	90	311	300	078	089	522	211	311	200	111	178	044	178
	73	136	117	256	256	051	068	419	205	274	179	103	145	034	171
	74	106	85	329	294	059	082	529	224	329	224	118	165	047	200
	75	120	94	287	287	064	074	511	213	309	191	106	149	043	202
	76	123	95	326	284	063	074	516	221	326	232	116	168	042	200
	77	110	90	278	267	067	078	511	222	300	222	122	167	044	222
	78	100	78	269	308	077	077	487	205	308	205	103	192	051	205
	79	109	80	300	300	075	075	513	213	288	188	113	188	050	225
	Mean	108.6	85.6	302	290	071	075	505	223	316	201	112	173	046	205
	Min.	70	57	256	256	051	055	419	205	274	164	089	145	030	171
	Max.	136	117	341	316	088	089	538	250	368	240	140	200	070	246

Table 7. Frequency distributions of meristic data for Cyprinion acinaces acinaces.

									$\overline{X}$	S.D.
Scales in lateral line	32	33	34	35	36	37	38		35.4	1.7
N. specimens	3	9	12	17	12	18	8			
Scales to the end of vertebral column	30	31	32	33	34	35			32.5	1.2
N. specimens	2	5	13	7	8	1				
Scales above lateral line		5	6	7	8				6.6	0.6
N. specimens		3	29	44	3					
Scales around caudal peduncle		12	13	14	15	16	17		14.6	1.3
N. specimens		5	8	12	15	36	3			
Scales between pelvic fin and lateral line					3	4			3.1	0.3
N. specimens					47	3				
Dorsal fin branched rays			11	12					11.6	0.5
N. specimens			30	49						
Anal fin branched rays			7						7.0	0.0
N. specimens			79							
Pectoral fin rays		14	15	16					14.9	0.8
N. specimens		27	29	23						
Gill rakers on first arch;										
a) anterior side	11	12	13	14	15	16	17		13.9	1.0
N. specimens	1	4	16	38	15	4	1			
b) posterior side	20	21	22	23	24	25	26	27	23.0	1.6
N. specimens	4	12	18	9	21	11	3	1		

convex posterior edge. The anterior border of the neural complex is concave, giving it an axe-shaped appearance. Dorsally it is separated from the posteriorly directed supraoccipital process. The premaxillary is thick and broad (Fig. 16). The posterior portion of the bone carries a small ascending process, and its tip pointed and shallowly bifurcated (unfuricated in <u>mhalensis</u>). The premaxillary greatest width is 43% of its length. The maxillary is thick, its dorsal surface convex (Fig. 17). On the anterior end of the maxillary there is only one ascending process (two in <u>mhalensis</u>). The anterior ascending process is long and thin. The dorsal crest is thick, narrow and lies midway in the length of the maxilla. At its posterior end the maxilla is expanded and form platelike structures. A relatively large foramen is present on the frontal rim of the maxillary (none in <u>mhalensis</u>).

The dentary is the largest bone in the lower jaw. It is curved anteriorly, to form a symphysis with its fellow of the opposite dentary. Coronoid process is a flat, broad ascending process lying well back on the dentary. The wall of the dentary is exceedingly thick, its dorsal part tapering to a thick edge and curving mesially to form a sloped labial surface. The articular is massive at its hind end. It has a dorsal notch for articulation with the quadrate, and opposite this, a ventral notch into which the dorsal edge of the retroarticular fits. The angular is long and pointed (Fig. 18).

The pharyngeal teeth number 2.3.4 — 5.3.2 in three specimens examined. The fifth tooth of the inner row of the right pharyngeal bone is very small, the rest are realtively thick and closely spaced. The pharyngeal teeth have spoon-shaped crowns. Their shapes do not vary significantly in all examined specimens.

Coloration

Fresh specimens are gray dorsally, silver laterally, and silver ventrally. Preserved specimens are gray-brown dorsally, silver-gray or white-gray laterally. Dark brown spots are present above the lateral line in young specimens. These spots become obscure in older specimens.

Habitat

This species inhabits shallow flowing springs with rock-bottomed channels. These springs usually occur with little or no aquatic vegetation.

Distribution

Previously this species was known only from Wadi Hadramaut, 15° 00' N, 50° 00' E. My collections extend the range to Khaybar drainages in Saudi Arabia (Fig. 12).

Relationships

Banister and Clarke (1977) were unsure of the affinities of *Cyprinion acinaces*. Howes (1982) concluded that *C. acinaces* retains more primitive characters than does any other species in the genus. *C. milesi* and *C. watsoni* also share several primitive characters with *C. acinaces*. According to Howes, *C. milesi* is the closest living relative (sister species) of *C. acinaces*. From *Cyprinion muscatensis* this species differs in the possession of a stout serrated dorsal spine. Differences between *acinaces* and *C. mhalensis* will be discussed below.

Cyprinion acinaces hijazi

Cyprinion acinaces hijazi Krupp, 1983. Fauna of Saudi Arabia, 5:(in press).

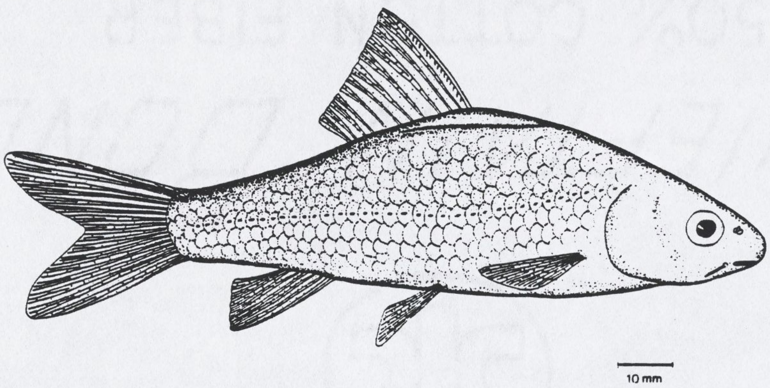
Material Examined

66 fish, 48-120 mm SL, collected July, 1981, from Wadi Hadiyah, 25° 34' N, 38° 41' E, Saudi Arabia.

Description

Morphology:

The shape of the body can be seen in Figure 14. The mouth is subterminal. The mouth shape is transverse. The anterior border of the lower jaw is curved, covered usually with a well developed horny sheath. The snout is blunt. The interobital space is flat. The eyes are lateral and visible in ventral view. The peritoneum is sooty black. there is a well developed bony ridge from the occiput to dorsal fin origin. No tubercles on the snout region of the specimens examined. There is no fatty-thickened papillose skin between the bases of the pelvic fin in all specimens examined. Dorsal fin has four unbranched rays and 11 (f12), 12 (f53) or 13 (f1) branched rays. There are III unbranched and 7 branched rays in the anal fin. Pectoral fins do not reach the pelvic fins. Pelvic fins do not reach the anal fin. Pectoral fin has 13 (f3), 14 (f20), 15 (f30), 15 (f11) or 17 (f2). Lateral line is curved and extends to the end of the vertebral column. There are 33-39 scales in the lateral line. Scale counts to the end of vertebral column range from 31 to 37. Between the lateral line and dorsal fin origin there are 5-8 and 2 to 4 scales between the lateral line and the



D IV 11-13, A III 7, V 8-9, L.L. 33-39

Figure 14. Cyprinion acinaces hijazi (Adapted from Krupp, 1983).

pelvic fin origin. There are 12 (f5), 13 (f7), 14 (f22), 15 (f15), 16 (f10), 18 (f6) or 19 (f1) scales around the least circumference of the caudal peduncle. Gill rakers are short, curved and relatively spaced. Small projections on gill rakers of the first gill arch were noted. There are 8-15 gill rakers on the anterior side of the first gill arch. On the posterior side of the first gill arch there are 20-27 gill rakers. Proportional measurements at frequency distributions are presented in Tables 8 and 9. The examined skeletal characters are similar to those of the nominated subspecies except this subspecies has narrow coronoid process (of the dentary), broad dorsal crest (of the maxilla), large pharyngeal teeth, short maxillary posterior process and the posterior border of the neural complex is concave (convex in *C. acinaces acinaces*). In one specimen the pharyngeal teeth number 2.3.5 — 5.3.2 otherwise their number is 2.3.4 — 5.3.2.

Coloration

Preserved specimens are gray-brown dorsally, silver-gray ventrally. Dark spots are present on the flanks of young specimens.

Habitat

This subspecies was collected from medium size streams usually composed of pools alternating with short stretches of riffles.

Relationships

With the nominate subspecies, this subspecies shares most morphological and osteological characters. *Cyprinion acinaces hijazi* can be distinguished from *Cyprinion acinaces acinaces* by a narrower coronoid process, broader dorsal crest (of the maxilla), relatively larger pharyngeal teeth, shorter maxillary posterior process, fewer

Table 8. Proportional measurements of <u>Cypinrion</u> <u>acinaces</u> <u>hijazi</u> expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CPL	Snt.L	PFL	DSL	IOW	BL
Wadi	1	132	102	265	216	059	069	519	206	225	225	078	137	078	206	206	100	049
Hadiyah	2	146	115	252	269	061	087	469	191	322	243	078	139	087	200	209	086	052
	3	125	101	257	248	069	079	505	228	307	238	069	119	089	198	188	090	049
	4	80	63	269	317	079	079	539	238	317	254	095	159	063	222	222	111	048
	5	86	68	235	279	088	074	515	221	309	250	088	162	074	221	235	118	044
	6	85	65	262	277	062	077	508	231	338	262	092	154	077	231	246	123	062
	7	85	64	297	297	078	078	531	234	344	234	094	141	078	234	234	109	063
	8	75	56	286	304	089	089	518	232	378	267	089	125	089	250	268	125	054
	9	115	95	284	263	063	063	495	221	295	232	095	137	084	179	189	095	042
	10	121	102	304	245	059	059	519	216	294	206	088	147	078	196	157	088	039
	11	105	82	280	268	061	073	537	207	305	256	109	159	096	207	219	098	049
	12	108	88	284	261	068	068	511	216	318	239	091	148	091	205	205	102	045
	13	89	73	274	274	068	082	493	233	342	192	109	123	096	192	205	096	055
	14	63	48	292	292	083	083	458	208	354	229	125	188	104	208	250	104	063
	15	66	54	259	271	074	074	537	222	296	204	111	167	111	204	222	111	056
	16	66	53	264	245	075	075	528	226	283	298	113	169	113	206	226	113	057
	17	115	91	264	274	066	066	549	219	341	253	088	165	077	186	231	109	044
	18	115	92	283	272	065	065	500	217	304	228	098	141	076	196	174	098	043
	19	120	97	247	268	062	052	495	247	351	227	082	153	072	206	206	093	041
	20	110	86	267	267	081	069	512	209	314	221	093	163	093	198	221	093	047
	21	91	75	240	280	080	080	507	213	320	227	093	160	080	187	187	093	053
	22	87	69	261	289	087	089	536	232	319	261	087	130	087	203	188	101	058
	23	81	65	246	277	092	077	538	215	308	246	092	138	092	200	215	092	058
	24	85	67	254	254	089	075	522	208	313	254	089	134	075	224	239	089	059
	25	100	80	263	250	075	063	550	213	300	225	086	163	100	188	200	088	050
	26	78	63	269	286	079	079	508	222	333	206	111	159	095	190	206	095	048
	27	68	54	296	278	074	074	537	222	241	278	111	167	093	241	203	104	056
	28	122	101	287	248	059	059	505	218	307	228	099	158	089	198	198	099	040
	29	121	95	284	253	063	063	526	221	316	232	105	168	095	211	211	095	042
	30	115	92	283	261	065	065	543	228	315	217	098	130	087	217	207	098	043
	31	95	72	278	278	069	069	528	222	347	222	083	167	097	222	222	097	056
	32	96	76	289	263	066	066	539	211	382	237	092	158	092	211	211	092	039
	33	126	100	250	270	070	070	530	240	260	260	090	160	100	220	200	100	040
	34	95	80	263	250	075	075	513	225	325	186	100	150	100	186	200	100	050
	35	71	60	233	267	083	083	500	233	333	267	100	167	100	217	250	100	050
	36	64	50	260	300	100	100	500	260	340	300	120	200	120	240	280	120	060
	37	120	99	273	263	071	071	535	222	273	212	091	182	081	202	192	101	040
	38	110	88	284	284	068	068	545	227	329	227	102	182	091	205	193	102	045
	39	110	87	291	291	068	068	563	229	322	229	103	184	103	218	195	103	046
	40	68	52	288	288	096	096	500	231	327	231	115	192	115	231	231	115	058

Table 8. Continued.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CFD	CFL	Snt.L	PFL	DSL	IOW	BL
Wadi	41	65	51	275	294	098	098	490	235	333	235	118	196	118	235	235	118	059
Hadiyah	42	67	51	294	294	098	098	509	235	333	235	118	216	118	235	235	118	059
	43	142	117	265	256	059	077	479	231	325	214	077	154	077	222	188	103	034
	44	110	86	291	267	081	081	500	221	302	244	081	163	081	209	233	105	047
	45	115	90	277	277	078	078	489	233	322	233	089	167	089	211	222	100	044
	46	86	70	257	271	086	086	486	214	343	243	086	171	071	186	200	086	043
	47	85	66	273	288	091	091	530	227	288	256	091	167	091	212	212	106	045
	48	140	113	230	274	062	071	504	239	345	248	079	133	079	186	204	097	035
	49	145	120	242	258	058	067	483	233	317	208	075	150	075	192	183	100	033
	50	130	105	267	248	057	067	514	229	305	229	086	152	086	100	200	095	038
	51	112	90	256	267	067	078	511	233	300	256	089	133	089	222	189	111	044
	52	90	70	271	286	086	086	571	214	300	257	086	157	086	214	214	086	057
	53	91	70	271	286	086	086	528	243	343	257	100	157	086	214	214	086	057
	54	83	65	246	277	077	077	492	231	323	215	077	154	077	215	231	092	046
	55	70	58	241	293	086	086	482	207	345	241	086	172	103	207	207	103	052
	56	112	89	281	269	067	067	506	225	281	241	101	146	101	225	179	101	045
	57	92	75	267	267	080	080	507	240	320	267	093	147	093	200	213	107	053
	58	95	75	293	280	080	080	560	227	307	267	093	147	093	213	213	107	053
	59	90	75	280	280	080	080	560	227	307	267	093	147	093	213	213	107	053
	60	95	75	267	280	080	080	560	227	293	253	093	147	093	213	213	107	053
	61	82	65	292	277	077	077	538	231	323	231	092	169	092	200	231	092	046
	62	89	71	282	282	070	070	493	211	282	254	099	155	085	211	211	099	042
	63	91	73	260	260	068	068	493	233	329	274	096	151	082	219	219	109	055
	64	82	65	277	277	076	076	524	231	232	231	092	169	092	200	169	108	062
	65	75	60	267	283	083	083	517	217	317	250	083	167	100	217	233	100	050
	66	75	60	267	283	083	083	517	217	317	250	083	167	100	217	233	100	050
	Mean	97.3	77.7	270	273	075	077	517	225	318	239	094	158	090	210	213	101	049
	Min.	63	48	230	216	057	052	458	191	225	186	069	123	063	179	157	086	032
	Max.	146	120	304	300	100	100	563	260	382	300	125	216	120	250	280	125	065

Table 9. Frequency distributions of meristic data for <u>Cyprinion acinaces hijazi</u> (N = 66).

									$\bar{X}$	S.D.
Scales in lateral line	33	34	35	36	37	38	39		37.3	1.5
N. specimens	1	3	3	13	14	15	17			
Scales to the end of vertebral column	31	32	33	34	35	36	37		34.8	1.6
N. specimens	3	4	4	11	19	17	8			
Scales above lateral line		5	6	7	8				6.1	0.6
N. specimens		8	42	15	1					
Scales around caudal peduncle	12	13	14	15	16	18	19		14.7	1.6
N. specimens	5	7	22	15	10	6	1			
Scales between pelvic fin and lateral line					2	3	4		2.9	0.4
N. specimens					6	56	4			
Dorsal fin branched rays				11	12	13			11.8	0.4
N. specimens				12	53	1				
Anal fin branched rays				7					7.0	0.0
N. specimens				66						
Pectoral fin rays	13	14	15	16	17				14.8	0.9
N. specimens	3	20	30	11	2					
Gill rakers on first arch;										
a) anterior side	8	9	10	11	12	13	14	15	12.5	1.3
N. specimens	1	1	2	8	16	27	9	2		
b) posterior side	20	21	22	23	24	25	26	27	23.6	1.6
N. specimens	1	6	9	11	23	8	6	2		

gill rakers on the anterior side of the first gill arch and concave posterior edge of the neural complex.

Cyprinion mhalensis

Cyprinion mhalensis Al Kahem and Behnke. Fauna of Saudi Arabia, 5:(in press).

Material Examined

a) 8 fish, 55-141 mm SL, were collected July, 1977, from Wadi Al Mhaleh, Southeast Abha city, Saudi Arabia. Abha city is 18° 13' N, 42° 30' E.

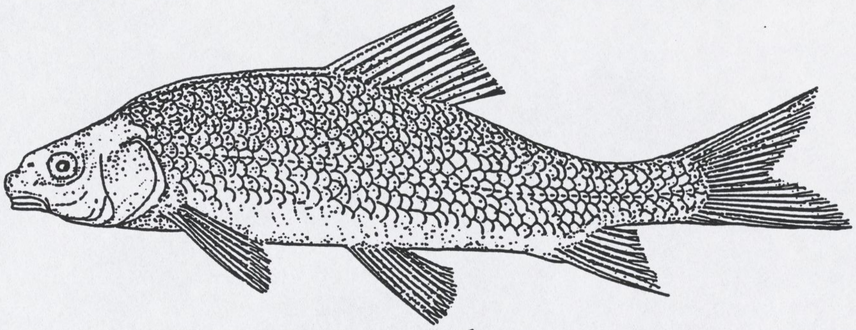
b) 2 fish, 72, 73 mm SL, were collected by Naser Al Assgah May, 1982, from Wadi Najran, 17° 30' N, 44° 07' E, Saudi Arabia.

Description

Morphology:

The shape of the body can be seen in Figure 15. Mouth is subterminal. The shape of the mouth is transverse or oblique. The anterior edge of the lower jaw is curved, often covered with a well developed blade. The blade in some specimens is not well developed, especially in small fish. The snout is short and blunt. The interorbital space is flat. There is one small pair of barbels. Tubercles are absent on the snout and interorbital region of the specimens examined. There is a well-developed bony ridge from the occiput to dorsal fin origin. The degree of the development of the bony ridge is more conspicuous in large specimens. Peritoneum is sooty black. No scales on ventral side. The eyes are lateral and visible in ventral view. The intestine is very long in one specimen; its length from the end of the stomach is 7 times the standard length, while in other

A



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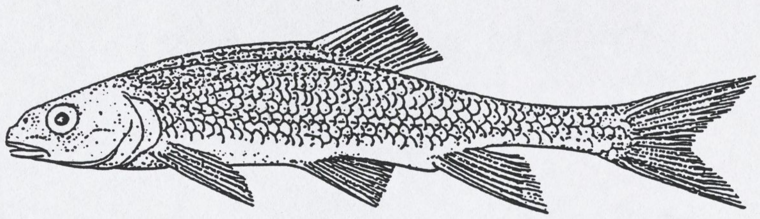

D III-IV 10, A III 7, V 9, L.L. 40-43

Figure 15. Cyprinion mhalensis, 141 mm SL (A). Cyprinion of uncertain identity, 124 mm SL (B).

specimens the intestine is about 4 to 6 times the standard length. The air bladder has two chambers; its posterior chamber is longer and slightly more narrow than the anterior one. There is one flap between the bases of the ventral fin or only a weak development of a papillae-like structure.

There are 3 or 4 unbranched rays and 10 branched rays in the dorsal fin (last two counted as one). The last unbranched ray is ossified almost to the tip and strongly serrated all along the ossified segment. The dorsal fin origin is slightly anterior to the origin of the ventral fin. There are 3 or 4 unbranched anal fin rays and 7 branched rays. The anal fin when laid flat does not reach the caudal fin. There are 40-43 pored scales in the lateral line. There are 36-41 scales to the end of the vertebral column. The lateral line is normally straight to the middle of the caudal peduncle, but in some specimens it is slightly curved. No scales on the bony dorsal ridge. There are 7-11 scales above the lateral line. Gill rakers are thin, short and slightly curved. On the anterior side of the first gill arch there are 10-16 gill rakers. On the posterior side of the first gill arch there are 21-32 gill rakers. On the anterior side of the second gill arch there are 22-31 (26) gill rakers. Proportional measurements and frequency distributions are given in Tables 10 and 11, respectively.

Skeletal Characters:

The shape of the centra are similar to those of Cyprinion acinaces. All centra except the first four (= Weberian apparatus) and the urostyle have postzygapophyses, neural arch and neural spines. Postzygapophyses gradually diminish in size on the caudal vertebrae. The first

Table 10. Proportional measurements of Cyprinion mhalensis expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CPL	Snt.L	PFL	DSL	IOW	BL
Wadi Al Mhaleh	1	180	141	262	241	049	064	518	191	262	248	099	163	092	199	177	099	035
	2	142	107	262	280	065	084	514	215	262	243	093	206	--	--	--	--	028
	3	133	107	262	271	065	065	523	206	243	224	093	187	093	178	178	094	037
	4	96	76	237	263	079	066	500	184	237	224	105	171	--	--	--	--	039
	5	85	66	258	273	091	076	545	212	273	227	106	182	--	--	--	--	030
	6	72	55	345	273	091	091	545	218	291	164	127	200	109	236	236	109	055
	7	93	71	239	268	070	070	521	183	239	169	099	169	099	225	225	099	042
	8	83	61	246	279	098	082	508	180	279	197	098	148	098	2298	229	098	049
	Mean	110.5	85.8	264	269	076	075	522	199	261	212	103	178	098	213	209	100	039
	Min.	72	55	237	241	049	064	500	180	237	164	093	148	092	178	177	094	028
	Max.	180	141	345	280	098	091	545	218	291	248	127	206	109	236	236	109	055
Wadi Najran	9	90	72	236	277	083	083	513	194	279	180	097	208	083	180	180	097	055
	10	82	73	246	273	082	082	520	178	273	191	095	191	095	178	178	095	055
	Mean	86	72.5	241	275	083	082.5	516	186	275	185	096	199	089	179	179	096	055

Table 11. Frequency distributions of meristic data for *Cyprinion mhalensis*.

								$\bar{X}$	S.D.
Scales in lateral line	40	41	42	43				41.3	1.3
N. specimens	4	1	3	2					
Scales to the end of vertebral column	36	38	39	41				38.4	1.8
N. specimens	1	2	1	1					
Scales above lateral line	7	8	11					7.8	1.2
N. specimens	5	4	1						
Scales around caudal peduncle	19	20						19.6	0.5
N. specimens	2	3							
Scales between pelvic fin and lateral line	3							3.0	0.0
N. specimens	10								
Dorsal fin branched rays	10							10.0	0.0
N. specimens	10								
Anal fin branched rays	7							7.0	0.0
N. specimens	10								
Pectoral fin rays	14	15	16	17				15.3	0.9
N. specimens	2	4	3	1					
Gill rakers on first arch;									
a) anterior side	10	12	13	14	16			12.9	1.5
N. specimens	1	2	5	1	1				
b) posterior side	21	22	23	24	25	26	32	24.2	3.1
N. specimens	1	2	2	2	1	1	1		

postweberian vertebra and the caudal vertebrae lack neural prezygapophysis. All precaudal vertebrae except the first four (= Weberian apparatus) have parapophysis. The supraneurals are large, thin and each except the first one is separated from its respective neural spine. The neural spines are relatively thick, long and stout. The posterior and anterior edges of the neural complex are concave, giving it an axe-shaped appearance. Dorsally the neural complex is separated from the dorsally directed supraoccipital process. There are 7 or 8 supraneurals, articulating with each other; the posterior supraneural overlaps the anterior rim of the first pterygiophore. The first supraneural is not in contact with the posterior border of the neural complex.

The premaxillary is thin and relatively narrow (Fig. 16). The bone curves mesiadlly anteriorly to meet at the midline, the anterior end of the opposite premaxilla. Posteriorly it tapers to form unbranched posterior process. The maxillary is thick, its dorsal surface is convex. There are two anterior ascending processes (one in <u>acinaces</u>). The upper portions of the ascending processes are fused together to form jointly compressed tip. The dorsal crest is broad and thick. The dorsal crest is situated anteriorly on the maxilla. The posterior process is short, its tip is expanded, giving it a triangular appearance (Figure 17). The dentary with a vertical, relatively long coronoid process, lying midway in the length of the dentary (Fig. 18). The anterior border of the coronoid process is slightly convex; its posterior edge is concave. Ventrolaterally the dentary bears several foramen. The articular is a thick trapezoid bone; its posterior end bears small foramen. The articular has a dorsal notch for articulation

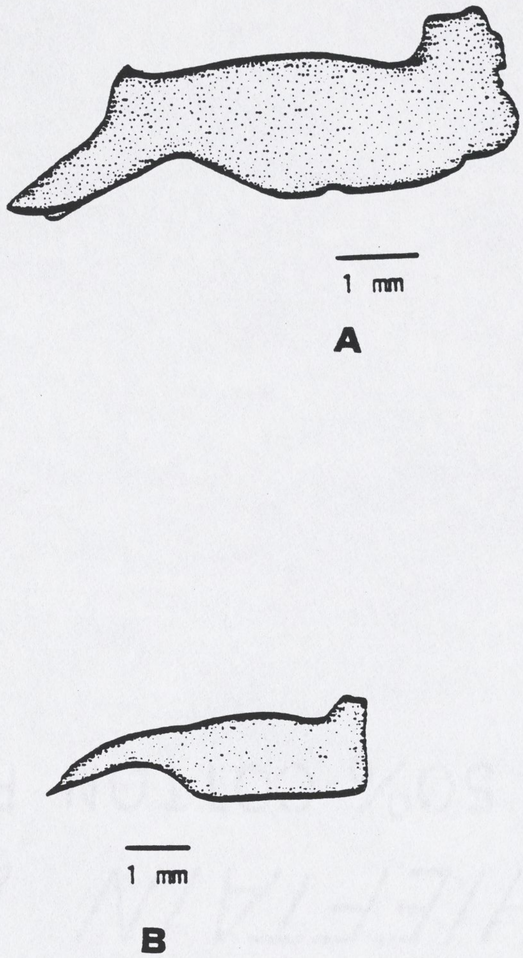

Figure 16. Dorsal view of right premaxilla of A. Cyprinion acinaces; B. Cyprinion mhalensis.

Figure 17. Inside view of maxilla of A. *Cyprinion acinaces* (right side); B. *Cyprinion mhalensis* (left side); C. *Cyprinion watsoni* (right side); D. *Cyprinion macrostomum* (left side).

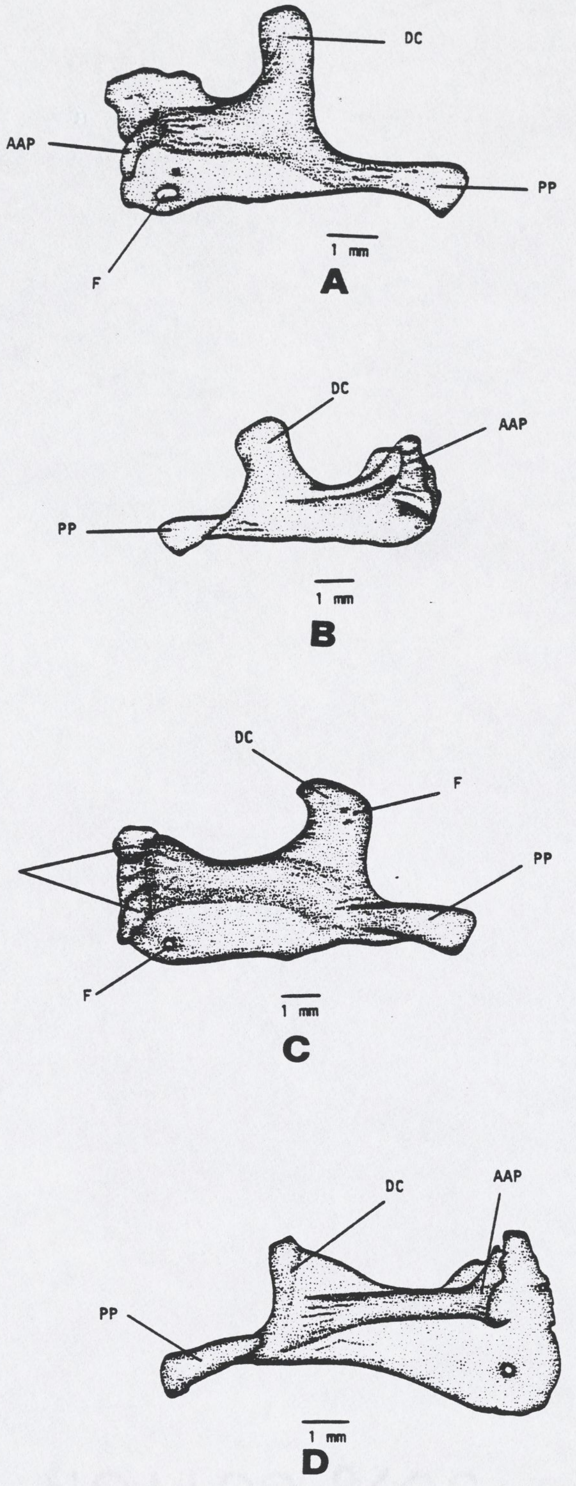
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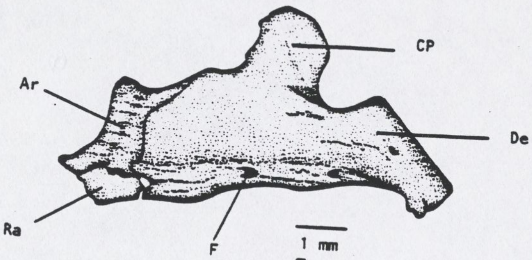
Figure 18. Lateral view of lower jaw of A. Cyprinion acinaces (right side); B. Cyprinion mhalensis (left side); C. Cyprinion macrostomum (left side); D. Cyprinion watsoni (right side).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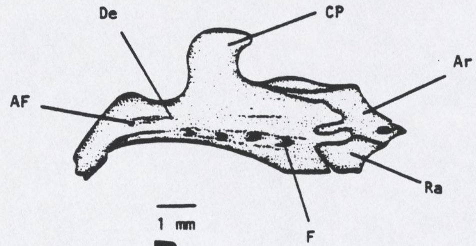
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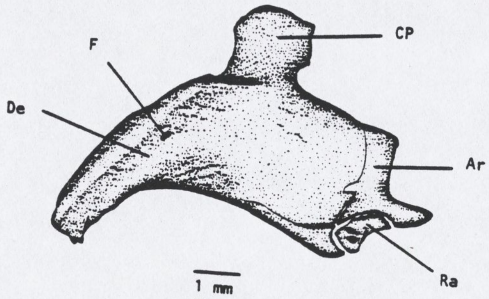
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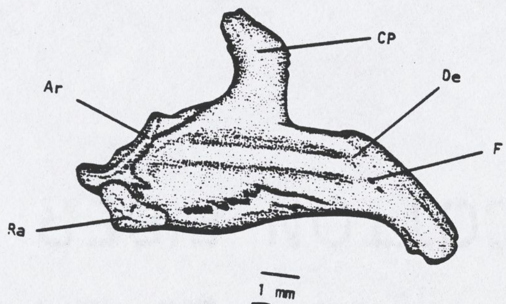
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with the quadrate, and opposite this, a ventral notch into which the dorsal edge of the retroarticular fits. A small foramen is present on the latter. Pharyngeal teeth are large, long and have spoon-shaped crowns (Fig. 19). Their formula is 2.3.5 — 5.3.2. The fifth tooth of inner row is relatively larger than of acinaces.

Coloration

Preserved specimens are gray-brown dorsally and silver-gray below the lateral line. Dark brown patches are present above the lateral line in some specimens expecially young fish. These patches disappear in mature fish.

Habitat

This species occupies small to medium sizes streams, usually composed of a series of small pools, alternating with short stretches of riffles. Streams with substrate range from sand to gravel and rubble.

Distribution

This species was collected from Wadi Najran and Wadi Al Mhaleh, tributary to the Wadi Bishah of the Ar Rub' Al Khali basin. Krupp (1983) recorded this species from Wadis Noaman, Shumrukh, Turabah, Afrak, Adama, Shuqub and Buwah, Saudi Arabia also of same basin (Fig. 12).

Relationships

Cyprinion mhalensis can be distinguished from Cyprinion acinaces in general appearance, fewer branched rays in the dorsal fin (10 vs. 12), more scales in the lateral line (40-43 vs. 32-38), more supraneurals

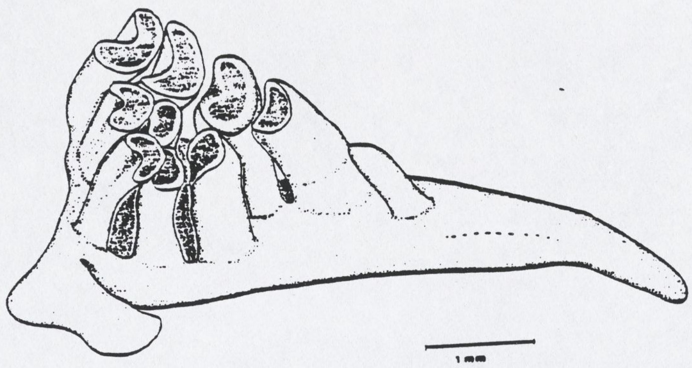


Figure 19. Right pharyngeal teeth of *Cyprinion mhalensis* (Adapted from Krupp 1983).

(7-8 vs. 5-6), and more scales around the least circumference of the caudal peduncle (19-20 vs. 12-17). Other distinctions separating *C. mhalensis* from *C. acinaces* are the possession of two anterior ascending processes of the maxilla in *mhalensis* (one in *acinaces*) and the posterior process's tip of the premaxillary is unfurcated. In comparison to specimens of *C. acinaces*, *C. mhalensis* has a greater relative length of the intestine, larger pharyngeal teeth and it lacks well developed skin flap between the pelvic fins. From *C. macrostomum* and *C. kais*, *C. mhalensis* can be distinguished by having fewer branched rays in the dorsal fin. Other distinctions between *mhalensis* and *macrostomum* include the shape of the lower jaw bones and the maxillae (Figs. 17 and 18). *C. microphthalmum* has shorter and weakly serrated dorsal spine. All Arabian *Cyprinion* are likely derived from an ancestor of *Cyprinion watsoni* and the scaleless bony ridge and general agreement in other characters indicate such affinities. The major distinctions separating *C. mhalensis* from *C. watsoni* are more scales in the lateral line (40-43 vs. 31-39) in *mhalensis* and the possession of two fused anterior ascending processes of the maxillary. *Cyprinion mhalensis* and *C. acinaces* are divergent from *C. watsoni* by having a stouter, more strongly serrated dorsal spine. *C. mhalensis* and *C. acinaces* are closely related and probably represent a divergence in Arabia after an ancestral species, probably close to *C. watsoni* or *C. milesi*, crossed the Arabian Gulf from Iran perhaps during the Pliocene or early Pleistocene.

Unknown Cyprinion

Material Examined

One specimen of Cyprinion was collected from unnamed spring in Khaybar city 1977. When this habitat was revisited in 1981 the spring was dry.

Description

The shape of the body can be seen in Figure 15. The mouth is subterminal. The mouth shape is transverse with a weakly developed blade. The snout is short and blunt. The interorbital space is flat. One pair of small barbels is present. There is a well developed bony ridge from occiput to the origin of the dorsal fin. The peritoneum is black. Ventral side is scaleless. The caudal peduncle is very narrow and long. The caudal fin is deeply forked. The intestine length is 2.1 times the total length. Air bladder has two chambers, its posterior chamber is longer and slightly narrower than the anterior one. The dorsal fin has 4 unbranched and 10 branched rays. The last unbranched ray is strongly ossified almost to the tip and serrated. The dorsal fin origin is opposite to the origin of the pelvic fin. There are 3 unbranched rays and 7 branche drays in the anal fin. The anal fin when laid flat does not reach the caudal fin. There are 40 scales in the lateral line. There are 7 scales above the lateral line. There are 13 scales around the least circumference of the caudal peduncle.

Gill rakers are short, thin and slightly curved. On the anterior side of the first gill arch there are 14 gill rakers. On the posterior side of the first gill arch there are 24 gill rakers. On the anterior side of the second gill arch there are 28 gill rakers. Proportional measurements are presented in Table 12.

Coloration

Preserved specimens are dark-brown dorsally and silver-gray below the lateral line. No dark spots on the middle of the flank.

Relationships

This specimen resembles *Cyprinion mhalensis* in the shape and the color of the body. It has the same number of dorsal and anal rays, the same number of scales, and in the possession of a strongly serrated spine in the dorsal fin. The major distinctions between this specimen and *C. mhalensis* is the greater relative length of the intestine in *C. mhalensis* (4.0-7.0 vs. 2.1) and the longer more narrow caudal peducle in this specimen. The scale count around the least circumference of the caudal peduncle is fewer in this specimen (13 vs. 19-20). This specimen might be an abberant *C. mhalensis* or subspecies of *mhalensis* or, perhaps, a new species. More specimens will be necessary to resolve these questions.

The significance of this specimen is that the meristic characters clearly indicate its affinities with *C. mhalensis* not *C. acinaces*, but Khaybar is in the Red Sea coastal drainage. All collections of *C. mhalensis* reported on here and by Krupp (1983) are from the Rub Al Khali basin. A collection of typical *C. acinaces acinaces* was made from Ain Ali in Khaybar only about 0.5 km from the site where the unknown *Cyprinion* was collected. Thus, it appears that a *Cyprinion* derived from or close to *C. mhalensis* occurs together with *C. acinaces* in the Red Sea

Table 12. Proportional measurements of unknown <u>Cyprinion</u> expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CPL	Snt.L	PFL	DSL	IOW	BL
	1	158	124	202	242	065	056	524	202	290	210	064	194	081	202	210	089	024

drainage of the Khaybar region. This area is drained by a network of interconnected wadis (Wadi Aqiq from near Taif to Madinah, Wadi Hamdh from Madina to Khaybar, and Wadi Jizl, draining from mountains north of Khaybar, Fig. 3). Future collections from these drainages should determine the taxonomic status of the unknown Cyprinion and if it occurs sympatrically with C. acinaces in some waters.

Cyprinion muscatensis Boulenger, 1887

20 fish, UMMZ 209947, collected, 1978, from Wadi Funja, about 60 km west of Muscat, Oman, by R. Haas. 5 fish, UMMZ 209941, collected, 1978, from Wadi Sumail about 100 km southwest of Muscat, Oman by R. Haas. The description is only based on 9 specimens. Other specimens are too small to enable accurate counts to be made.

The mouth is subterminal, the anterior edge of the lower jaw covered with a sharp-edged horny sheath. The mouth shape is transverse or horse-shoe in specimens examined. As with all Cyprinion, a posterior pair of barbels in present. Interorbital region is slightly convex and not tuberculated. Tubercles are present on the snout. The eyes are lateral and visible in ventral view. The pelvic fins have axillary scales. This flap corresponds to the flaps present in Cyprinion watsoni. There is a well-developed bony ridge from the occiput to dorsal fin origin. The scales on the ventral region are reduced in size. The dorsal fin has 4 unbranched rays, the last one of which forms a weak unserrated spine. There are 9 (f3), 10 (f5) or 11 (f1) branched rays. The origin of the dorsal fin is above the ventral fin origin. The anal fin has 3 unbranched and 7 branched rays. There are 35-40 scales in the lateral line. There are 12 (f2), 13 (f6) or 14 (f1) scales around the least circumference of the caudal peduncle. Gill rakers are short, thin and widely spaced. On the anterior side of the first gill arch there are 9 (f1), 10 (f3), 11 (f4) or 12 (f1) gill rakers. Preserved specimens are dark-grey above lateral line and silvery-grey below the lateral line. Two dark stripes are present above the lateral line in all examined specimens. The coloration of living specimens is unknown. Proportional measurements and frequency distributions are presented in Tables 13 and 14.

Comparative Remarks

A species of Cyprinion indigenous to Oman was the first freshwater fish formally described from Arabia. Boulenger (1887) named a new species, Scaphiodon muscatensis for the fish. The systematic status of Oman Cyprinion is still not well delineated. Without examining any Arabian specimens, Berg (1949) synonymized muscatensis with Cyprinion microphthalmum. Banister and Clark (1977) and Howes (1982) tentatively identified the Oman Cyprinion as C. microphthalmum. Bianco and Banarescu (1982) recognized muscatensis as a subspecies of Cyprinion watsoni, while Krupp (1983) recognized it as a subspecies of Cyprinion microphthalmum. A critical comparison between this species and all species in the genus Cyprinion revealed that this species is differentiated from all Cyprinion species by the possession of a weak unserrated spine in the dorsal fin. From Cyprinion acinaces, this species can be distinguished in body shape, fewer dorsal branched rays (9-11 vs. 11-12), shorter dorsal spine (16% SL vs. 21%), unserrated dorsal spine (serrated in all other Cyprinion), two stripes above the lateral line (none in acinaces), more scales in the lateral line (35-40 vs. 32-38) and fewer gill rakers on the anterior side of the first gill arch (9-12 vs. 11-17).

Table 13. Proportional measurements of *Cyprinion muscatensis* expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	AFDL	CPD	CPL	Snt.L	PFL	DSL	IOW	BL
Wadi	1	111	93	301	258	075	086	538	204	269	183	118	183	097	194	108	097	054
Fanja	2	84	70	271	271	086	100	529	200	300	200	114	171	114	214	157	100	057
	3	88	73	274	260	082	082	493	192	274	205	123	192	082	205	151	109	055
	4	80	63	254	270	095	079	539	190	333	238	127	175	111	238	175	111	063
	5	73	59	254	271	102	068	525	220	339	203	119	169	102	220	169	102	068
	6	70	55	236	273	109	090	509	186	309	218	127	182	109	218	164	109	073
	Mean	84.3	68.8	265	267	092	084	522	199	304	208	121	179	103	215	154	105	062
	Min.	70	55	236	258	075	068	493	186	269	183	114	169	082	14	108	097	054
	Max.	111	93	301	273	109	100	539	220	339	238	127	192	114	238	175	111	073
Wadi	7	91	76	303	276	079	079	526	184	316	171	132	184	092	197	184	105	053
Sumail	8	75	60	300	267	100	083	533	217	317	233	133	200	100	217	183	117	067
	9	102	85	235	235	071	071	482	165	259	224	106	176	082	200	141	094	059
	Mean	89.3	73.7	279	259	083	078	514	189	297	209	124	187	091	205	169	105	060
	Min.	75	60	235	235	071	071	482	165	259	171	106	176	082	197	141	094	053
	Max.	102	85	303	276	100	083	533	217	317	233	133	200	100	217	184	117	067

Table 14. Frequency distributions of meristic data for *Cyprinion muscatensis*.

						$\bar{X}$	S.D.
Scales in lateral line	35	36	38	39	40	38.0	1.6
N. specimens	1	1	4	1	2		
Scales above lateral line	4	5	6	7		5.8	0.9
N. specimens	1	2	4	2			
Scales between pelvic fin and lateral line	3	4				3.2	0.3
N. specimens	8	1					
Scales around caudal peduncle	12	13	14			12.9	0.6
N. specimens	2	6	1				
Dorsal fin branched rays	9	10	11			9.8	0.7
N. specimens	3	5	1				
Anal fin branched rays	7					7.0	0.0
N. specimens	7						
Pelvic fin rays	8	9				8.1	0.4
N. specimens	7	1					
Pectoral fin rays	14	15	16			15.0	0.9
N. specimens	3	3	3				
Gill rakers on first arch;							
a) anterior side	9	10	11	12		10.6	0.9
N. specimens	1	3	4	1			

From C. muscatensis, Cyprinion mhalensis differs in general body shape, more scales in lateral line (40-43 vs. 35-40), ossified serrated dorsal spine, longer dorsal spine (20% SL vs. 16%), shallower peduncle (10% SL vs. 12%), more gill rakers on the anterior side of the first gill arch (10-16 vs. 9-12), and more scales around the least circumference of the caudal peduncle (19-20 vs. 12-14). Although there are similarities between C. muscatensis and C. watsoni and C. microphthalmum, distinctive differences are found. C. watsoni can be distinguished by the shape of the body, fewer scales in lateral line (33-36 v. 35-40), a weakly serrated dorsal spine and the absence of the stripes above the lateral line.

C. microphthalmum can be distinguished by smaller eyes, feebly serrated dorsal spine, dorsal fin commences slightly in advance of the ventral, and the anal fin when laid flat reaches the caudal fin. Within Arabia, Cyprinion muscatensis most closely resembles Cyprinion mhalensis and both these species have similarities to C. watsoni and C. micropthalmum.

Thus, muscatensis appears to have its origin and closest relationships to the watsoni group. However the validity of nominal species (microphthalmum, watsoni, milesi) in the watsoni group is far from settled and if muscatensis is regarded as subspecies, there is no valid basis to classify it as a subspecies of microphthalmum or watsoni.

Until more critical studies are completed on the C. watsoni group and a more authoritative basis is established to determine the relationships of muscatensis to other species, C. muscatensis is recognized as a full species.

So far as known, all known Arabian Cyprinion are probably derived from the watsoni-microphthalmum group indigenous to the Indian Ocean and Arabian Gulf drainages of Iran and Pakistan.

Genus Garra Hamilton

Garra Hamilton, 1822, Fishes of the Ganges, Edinburg, P. 343, (type: Cyprinus lamta).

"Mouth transverse. Lips continuous covered with anterior and posterior labial folds. Jaws covered with horny sharp edge. Snout more or less rounded or slightly conical. Barbels generally four, sometimes two. Typically pharyngeal teeth number is 2.4.5 - 5.4.2. Scales of moderate size. Dorsal fin with 9 to 12 rays, 6 to 9 of which are branched originating in advance of pelvics. Anal fin short with 5 branched rays, pectoral fin with 19 rays. Lower lip modified into a suctorial disc with free anterior and posterior margin. Gill rakers widely set, short and few. Air bladder varies in form and extent" (Menon 1964).

Distribution

The genus is widescpread from South China and Borneo in the east, through Burma, India and Sri Lanka, Afghanistan, Iran, Syria and Arabia to Somaliland, Ethiopia, East Africa and then southward to Guinea through the Congo.

Taxonomic Outline

The genus Garra was described by Hamilton in 1822 based on Cyprinus lamta. Heckel (1842, 1844) described several species under a new genus, Discognathus from Syria, Iraq and Iran. Gunther (1868) listed D. lamta, D. microchir, D. variabilis, and D. nasutus in his "Catalogue of Fishes in the British Museum". Gunther, Playfair and Blanford referred to D. lamta specimens from Afghanistan, Arabia and Ethiopia respectively (Menon 1964). Berg (1949) revised this group and divided it into two genera, Garra (two pairs of barbels) and

Discognathichthys (= Discognathus) (one pair of barbels). Berg also pointed out that the sucking disc in Discognathus is fused at the anterior margin, whereas it is free in Garra. Berg (op. cit.) recognized two species of Discognathus: D. variabilis and D. rossica. Menon (op cit.) included Discognathus as a species group of Garra. Menon's arrangement of Garra is as follows:

a) The variabillis group (Discognathus). Garra variabilis and G. rossica are the only species in this group. Saadati (1977) found an undescribed species in Iran. Coad (1982) redescribed G. persica.

b) Gotyla group. G. gotyla, G. rhynchota and G. nasuta are the only species in this group.

c) Tibanica group. This group involved seven complexes and 28 species. According to Menon (op. cit.), the Garra species of Syria, Iraq, Iran and Arabia belong to the "rufa" complex of the "tibanica" group which consists of G. tibanica of Arabia, G. rufa obtusa from Iraq and Iran and G. barreimiae from Arabia. Menon (op. cit.) pointed out the Garra arabica, Hora 1921 is actually Garra nasuta (an Indian species).

Banister and Clarke (1977) recognized three species of Garra in Arabia:

1) Garra barreimiae Fowler and Steinitz, 1956.

2) Garra longipinnis Banister and Clarke, 1977.

3) Garra tibanica Trewavas, 1941.

They recognized two subspecies of G. barreimiae: Garra barreimiae barreimiae and Garra barreimiae shawkahensis. They agreed with Menon (1964) in aligning Garra barreimiae with Garra rufa, which is widely spread between the Mediterranean and the Tigris-Euphrates system. They related G. longipinnis with G. barreimiae.

Krupp (1982) described a new subspecies, Garra tibanica ghorensis (in southern Dead Sea Valley, Jordan).

Krupp (1983) described three new species: Garra buettikeri, Garra mamshuqa and Garra sahilia from the Arabian Peninsula. He recognized two subspecies of Garra sahilia, Garra sahilia sahilia and Garra sahilia gharbia.

Balleto and Spano (1977) described 9 subspecies of G. tibanica from South Yemen. Krupp (1983) synonmyized all of them with Garra tibanica tibanica.

My collections in 1977 from southwestern Saudi Arabia contain Garra tibanica tibanica from the Wadi Al Mheleh and from one spring in Khaybar city, Saudi Arabia. My collections in 1981 extended the range of the genus to Wadi Hadiyah, 25° 34' N, 38° 41' E, Wadi Najran, 17° 33' N, 45° 00' E and Al Wastah, a village southwest of Al Madinah city, Saudi Arabia. Al Madinah is at 24° 28' N, 39° 36' E (Fig. 22).

Garra tibanica Trewavas, 1941

Garra tibanica is characterized by 6-7 branched dorsal rays, 14-15 scales around the least circumference of the caudal peduncle, 30-37 scales in the lateral line and 8-14 gill rakers on the anterior side of the first gill arch.

Garra tibanica tibanica Trewavas, 1941

Discognathus lamta: Playfair, 1870, Proc. Zool. Soc., London: 85 (not Hamilton 1822)

Garra tibanica Trewavas, 1941, British Museum (Natural History) Expedition to southwest Arabia, 1937-8, I(3): 8.

Garra brittoni Trewavas, 1941, British Museum (Natural History) Expedition to southwest Arabia, 1937-8, I(3): 11.

Garra tibanica tibanica Balletto and Spano, 1977, Ann. Mus. Civ. Stor. Nat., 81:260.

Material Examined

a) 6 fish, 89-115 mm SL, were collected July, 1981, from Wadi Hadiyah, 25° 34' N, 38° 41' E, Saudi Arabia.

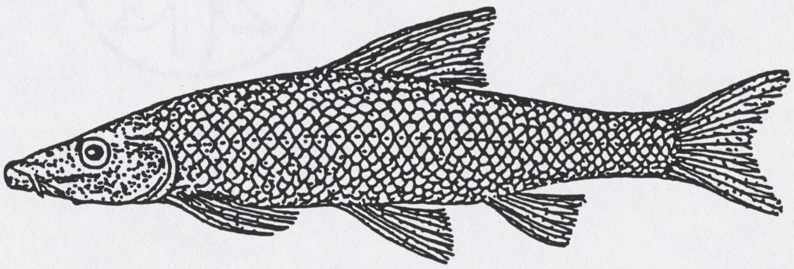
b) 7 fish, 38-71 mm SL, were collected July, 1977, and July, 1981, from Ain Al Jmyma, Khaybar, Saudi Arabia. Khaybar is at 25° 42' N, 39° 31' E.

c) 2 fish, 73-86 mm SL, were collected July, 1977, from Wadi Al Mhaleh, southeast of Abha City, Saudi Arabia. Abha is at 18° 13' N, 42° 30' E.

Description

Morphology:

The shape of the body can be seen in Figure 20. The snout is rounded and distinctly wedge-shaped in doral view, pointed in side view. Interorbital region is flat. Two pairs of barbels are present. The mental disc is well developed and papillose, but variable in shape. The mental disc is usually wider than it is long. In one specimen (75 mm SL) the mental disc width is 7 mm while its length is 6 mm. The anus is almost immediately in front of the anal fin. The air bladder is well developed. Most examined specimens possess tubercles on the side and top of the snout. The caudal peduncle is elongated.



D III-IV 7, A III5, V 8-10, L.L. 30-37

Figure 20. Garra tibanica, 78 mm SL.

The lateral line is almost straight to the end of the vertebral column. The dorsal fin has three or four unbranched rays; the last ray is not ossified. There are 6 (f3) or 7 (f12) branched rays. Brown spots present on the 3rd, 4th, 5th and 6th rays of the dorsal fin. The anal fin has three unbranched rays and five branched rays. The lateral line has 30-37 scales. There are 3-6 scales above the lateral line. Around the least circumference of the caudal peduncle there are 14 (f9) or 15 (f6) scales. The gill rakers are short and widely spaced. There are 8-14 gill rakers on the anterior side of the first gill arch. On the posterior side there are 17-21 gill rakers. Proportional measurements and frequency distributions of meristic data are presented in Table 15 and 16, respectively.

Skeletal Characters:

All the vertebrae, with the exception of the Weberian and caudal vertebrae, have centra which are uniform in form and size (Fig. 6). Neural arches and spines are present on all psotweberian vertebrae. Neural spines are long, thick and usually broad. The second postweberian vertebra's neural spine is notched at its dorsal tip. The neural prezygapophyses are long and broad. They gradually diminish in size in the caudal region. The first postweberian centrum lacks a neural prezygapophysis. All precaudal centra with the exception of the first four bear a very thin plate-like structure which cover the anterior portion of each centrum. In specimens examined of Arabian fishes, only _Garra_ was found to possess this bony covering of the precaudal vertebrae. This structure is absent in specimens of _Barbus_ and _Cyprinion_. All centra lacked postzygapophyses. The absence of postzygapophyses is an important distinction between the genus _Garra_

Table 15. Proportional measurements of <u>Garra tibanica tibanica</u> expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	BL*	CPD	CPL	PFL	H D	IOW	Snt.L,
Wadi	1	121	98	214	245	051	071	459	153	276	041	112	173	245	500	112	102
Hadiyah	2	114	89	224	243	056	101	483	135	269	044	112	146	213	483	124	101
	3	125	103	203	243	049	087	485	117	243	039	087	147	214	524	106	106
	4	142	115	217	252	035	078	487	122	261	044	104	157	200	504	104	104
	5	135	108	222	250	046	074	500	139	269	046	222	185	203	509	111	111
	6	121	98	214	255	051	071	500	153	276	041	112	184	214	489	112	102
	Mean	126.3	102	216	248	048	080	486	137	266	043	125	165	215	502	112	104
	Min.	114	89	203	243	035	071	459	117	243	039	087	146	200	483	104	101
	Max.	142	115	224	255	056	101	500	153	276	046	222	185	245	524	124	111
Ain	7	87	71	197	282	056	099	493	141	239	042	099	183	197	568	127	127
Al Jmyma	8	67	44	250	386	091	136	659	182	318	068	114	250	250	682	159	159
	9	56	42	238	333	071	119	500	143	238	071	119	190	238	571	143	143
	10	58	45	200	267	044	111	488	133	267	044	111	176	200	533	111	133
	11	51	40	25	300	050	125	500	125	250	050	100	200	200	550	100	125
	12	53	46	217	283	087	109	522	152	239	083	109	196	--	--	--	--
	13	46	38	211	289	079	105	526	132	237	079	105	211	--	--	--	--
	Mean	60.3	46.6	219	306	068	115	527	144	255	062	108	201	217	580	128	137
	Min.	46	38	197	267	044	099	488	125	250	042	099	099	197	533	100	125
	Max.	87	71	250	386	091	136	659	182	318	083	119	250	250	682	159	159
Wadi	14	94	73	221	279	058	093	476	151	209	035	105	151	200	581	129	120
Al Mhaleh	15	105	86	205	274	068	096	507	151	219	041	105	164	210	575	129	130
	Mean	99.5	79.5														
	Min.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Max.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

* Anterior barbel length

Table 16. Frequency distributions of meristic data for *Garra tibanica tibanica*.

								$\overline{X}$	S.D.
Scales in lateral line	30	31	32	33	34	35	37	33.0	2.1
N. specimens	2	2	1	6	1	1	2		
Scales above lateral line	3	4	5	6				4.5	0.9
N. specimens	1	9	2	3					
Scales around caudal peduncle	14	15						14.4	0.5
N. specimens	9	6							
Scales between pelvic fin and lateral line	2	3	4	5				3.3	0.8
N. specimens	2	8	4	1					
Dorsal fin branched rays	6	7						6.8	0.4
N. specimens	3	12							
Anal fin branched rays	5							5.0	0.0
N. specimens	15								
Pelvic fin rays	8	9	10					9.4	0.7
N. specimens	2	5	8						
Pectoral fin rays	12	13	14	15	16			14.7	1.1
N. specimens	1	1	3	7	3				
Gill rakers on first arch;									
a) anterior side	8	9	10	12	13	14		10.5	2.1
N. specimens	1	6	3	1	2	2			
b) posterior side	17	18	19	20	21			19.3	1.2
N. specimens	2	1	4	7	1				

and other Arabian cyprinid genera (Barbus and Cyprinion) (Fig. 6). All precaudal vertebrae excpet the Weberian vertebrae have parapophyses. The supraneurals are thin, narrow, short and feeble. They are widely separated from each other. Each supraneural is well separated from its respective neural spine. There are 5 or 6 supraneurals in the examined specimens. The posterior supraneural is separated from the anterior margin of the first dorsal pterygiophore. The neural complex of the Weberian apparatus is upright and has concave posterior and anterior edges, giving it an axe-shaped appearance. Dorsally the neural complex is separated from the posteriorly directed supraoccipital process. The first supraneural is widely separated from the neural complex. The premaxillary is thick and curved with only a slight anterior process. The tip of the posterior process is bifurcated. The two small processes of the posterior process are fused and twisted, giving it a braid-shaped appearance (Fig. 21A). The maxillary is thick and broad, its dorsal border is convex. There is one anterior ascending process (Fig. 21B). The posterior portion of the bone has two small notches on its posterior rim. One relatively large foramen is present in the upper part of the maxilla. The maxillary also lacks the dorsal crest and the well defined posterior process. The dentary curves mesially at its anterior end to meet at the midline its counterpart. The wall of the dentary is thick. The dorsal and ventral parts tapering to a thick edge and curving to form a sloped labial surface, giving it an L-shaped appearance (Fig. 21C). The dentary bears a small ascending coronoid process, which lies front on the bone. The articular is variable in shape, its posteriordorsal surface is notched to receive the articulating surface of the head of

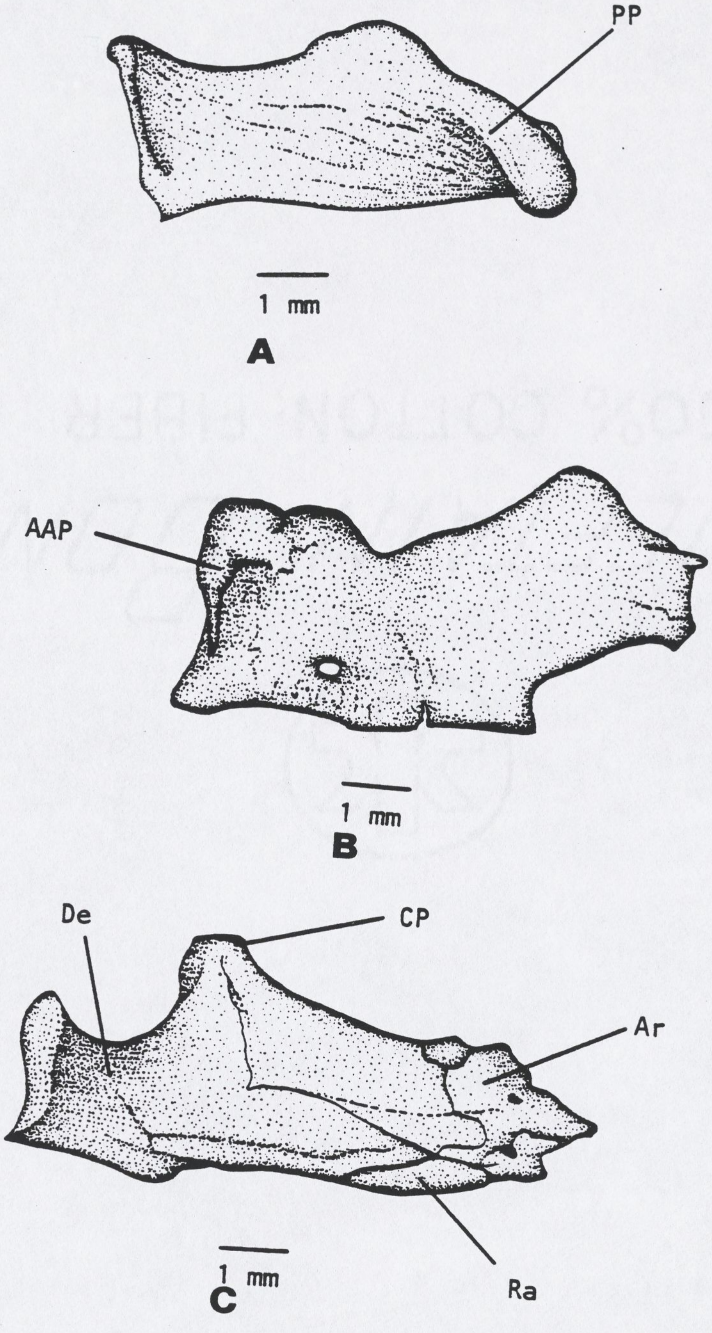


Figure 21. Garra tibanica jaw bones (right side). A, premaxilla in dorsal view; B, maxilla (inner side); C, dentary in dorsal view.

the quadrate. The retroarticular is a small variable-shaped bone attached posteroventral border of the articular.

Pharyngeal teeth number 2.4.5 - 5.4.2 in all the specimens examined. The teeth are short, relatively large and closely spaced. The crowns are spoon-shaped with slightly hooked tips.

Coloration

The color is dark-gray above, paler below. Dark spots at bases of the 3rd, 4th, 5th, 6th and 7th dorsal fin rays (branched) and a dark-brown spot behind the upper angle of the gill opening.

Habitat

Garra tibanica inhabits small to large streams with substrate ranging from sand, silt to gravel and rocks. It was collected from small pools alternating with short stretches of riffles.

Distribution

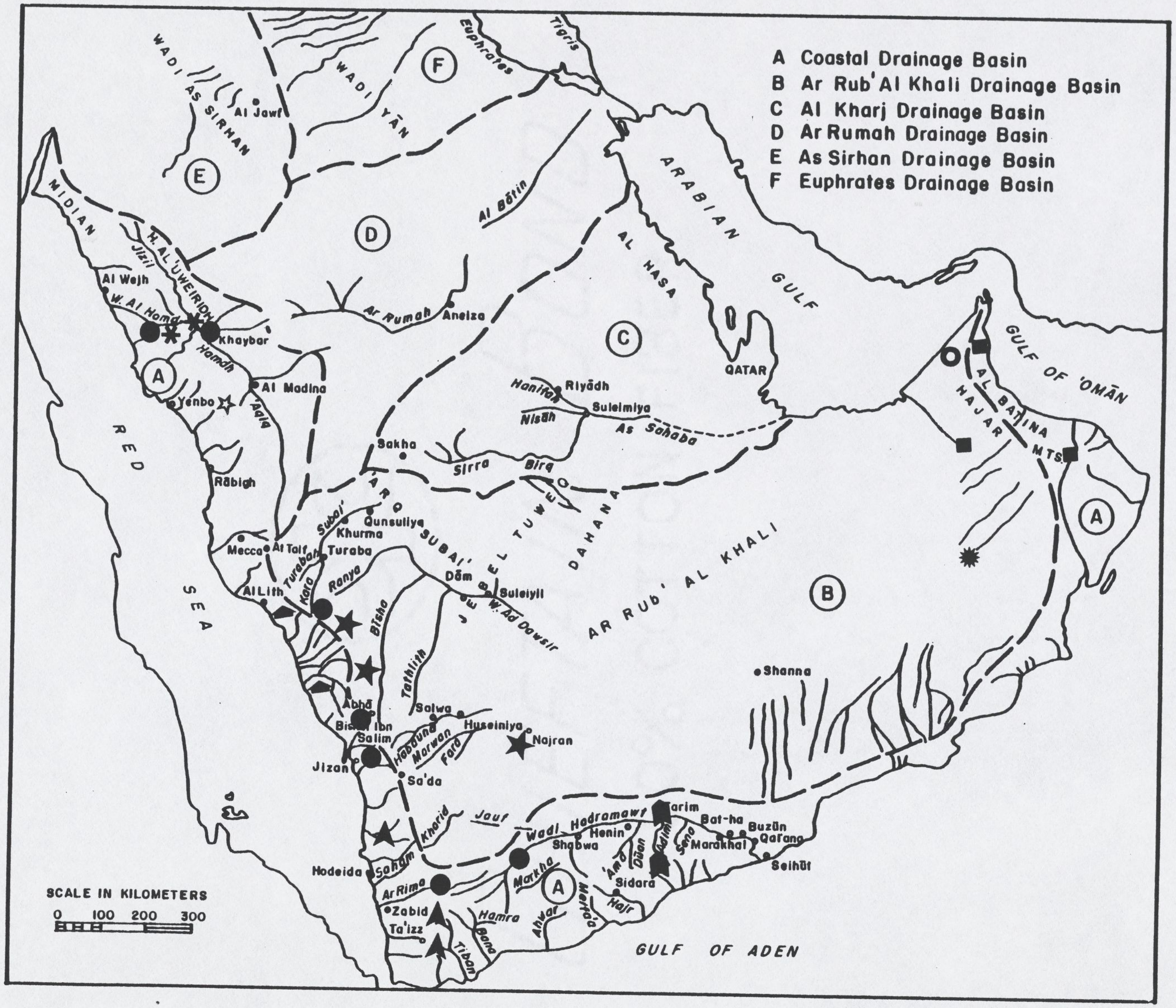
This species is widely distributed along the coastal drainages of west and southwestern Arabia (Fig. 22). Krupp (1982) recorded its occurrence in the southern Dead Sea Valley, Jordan.

Relationships

Garra tibanica shows considerable range in various meristic and morphometric features. For example, the gill rakers on the lower limb of the first gill arch range from 6 to 17, whereas Menon (1964) gave the range as 9-12.

Trewavas (1941) considered *tibanica* to be closely related to *Garra blanfordii*, a species of eastern Ethiopia. Menon (1964) concluded that

Figure 22. Distribution of *Garra* spp.: *Garra tibanica tibanica* (●), *G. barreimiae barreimiae* (■), *G. b. shawkahensis* (○), *G. longipinnis* (✹), *G. buettikeri* (✶), *G. mamshuqa* (▮), *G. sahilia sahilia* (▲), *G. s. gharbia* (▬), *Garra* sp. (☆), *Acanthobrama hadiyahensis* (✱).



A Coastal Drainage Basin
B Ar Rub' Al Khali Drainage Basin
C Al Kharj Drainage Basin
D Ar Rumah Drainage Basin
E As Sirhan Drainage Basin
F Euphrates Drainage Basin
WADI AS SIRHAN
Al Jawf
WADI YĀN
Euphrates
Tigris
Al Bātin
ARABIAN GULF
AL HASA
MIDIAN
H. AL 'UWEIRIDH
Jizil
Al Wejh
W. Al Hamd
Khaybar
Ar Rumah
Aneiza
Hamdh
Al Madina
'Aqiq
Yenbo
RED SEA
Rābigh
QATAR
Hanifah
Riyādh
Suleimiya
Nisāh
As Sahaba
Sakha
Sirra
Birq
GULF OF 'OMĀN
AL BATINA
HAJAR MTS
DAHANA
JEBEL TUWEIQ
ARO SUBAI'
Subai'
Qunsuliya
Khurma
Mecca
At Taif
Turabah
Turaba
Ranya
Al Lith
Kara
Bisha
Dām
Suleiyil
W. Ad Dawsir
AR RUB' AL KHALI
Tathlith
Abhā
Salwa
Bish Ibn Salim
Habauna
Marwan
Fara
Huseiniya
Najran
Jizan
Sa'da
Shanna
Jauf
Kharid
Wadi Hadramawt
Tarim
Bat-ha
Buzūn
Henin
Shabwa
Marakhai
Qarana
Seihūt
Hodeida
Saham
Markha
Sidara
Ar Rima
Zabid
Ta'izz
Hamra
Bana
Tiban
Ahwar
Hajr
GULF OF ADEN
SCALE IN KILOMETERS
0 100 200 300

G. tibanica is more closely allied to G. quadrimaculata of Ethiopia, but the latter differs in the more anterior position of the anus.

Banister and Clarke (1977) wrote:

> Within the tibanica complex, there are two species from northeast Africa that have some significant similarities with Garra tibanica. In Garra makiensis (Boulenger) and Garra ethelwynnae Menon, the vent is close to the anal fin and the body shape and color pattern the same as Garra tibanica.

According to Menon (1964) Garra rufa resembles Garra tibanica even though they are well separated. A comparison between G. tibanica and G. rufa (from the Tigris-Euphrates basin) revealed similarities in the shape and structure of pharyngeal teeth, lower and upper jaw bones. Overlapping values were found between these two species in the lateral line scales, dorsal fin branched rays and ventral fin rays. Garra rufa can be separated from G. tibanica on a variety of characters of which the difference of snout shape, color pattern and the number of the gill rakers on the anterior side of the first gill arch (20-21 vs. 8-14) are the most conspicuous. In G. rufa the anus is noticeable further away from the anal fin than it is in G. tibanica. Garra buettikeri can be distinguished from G. tibanica by a higher number of scales around the least circumference of the caudal peduncle (18-20 vs. 14-15). From G. sahilia, tibanica can be distinguished by fewer dorsal fin branched rays (7 vs. 8) and the color of the dorsal fin. G. tibanica differs from G. mamshuqa in the possession of more scales around the least circumference of the caudal peduncle (14-15 vs. 12-13) and lower branched dorsal fin rays (7 vs. 8). Garra longipinnis can easily be separated from G. tibanica by its thin body and very long paired fins, while G. barreimiae can be separated by its mottled pattern and the position of the anus.

Garra tibanica ghorensis

G. tibanica ghorensis is endemic to the southern Dead Sea rift valley. A detailed description was given by Krupp (1982). This subspecies can be distinguished from the nominal subspecies in having larger mental disc, longer barbels, and fewer scales around the caudal peduncle (12-16 vs. 14-18). It would be expected that this subspecies may occur in Dead Sea drainage (Jordan) of Saudi Arabia.

Garra buettikeri

Garra buettikeri Krupp, 1983. Fauna of Saudi Arabia, 5:(in press).

Material Examined

One fish, 58 mm SL, collected July, 1982, from Wadi Najran, 17° 33' N, 45° 00' E, Saudi Arabia.

Description

The body shape can be seen in Figure 23. The snout is blunt and wedge-shaped in dorsal view, pointed in side view. Small tubercles are present on the head. The mouth is subterminal. The mental disc is well developed, its center is covered by small papillae. Large papillae are present on the anterior and posterior sides. The mental disc is wider (6 mm) than long (5 mm) in single specimen. There are 3 unbranched and 7 branched rays in the dorsal fin. The anal fin has 3 unbranched and 5 branched rays. There are 38 scales in the lateral line. 7 scales above the lateral line. Between the lateral line and the pelvic fin origin there are 5 scales. In the specimen examined 19 scales encircle the least circumference of the caudal peduncle. Gill rakers are short, weak, hooked and widely spaced. There are 10 gill rakers on the anterior

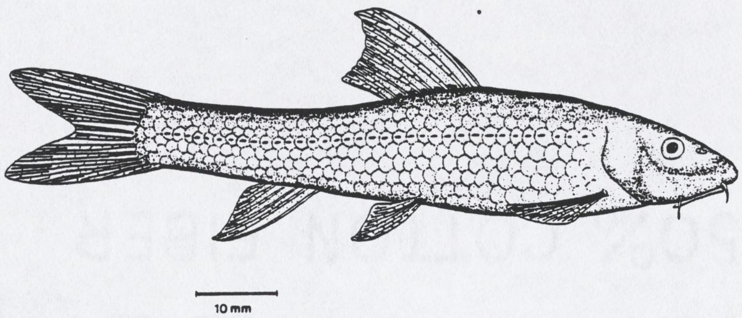


Figure 23. Garra buettikeri (Adapted from Krupp 1983).

side of the first gill arch. On the posterior side of the first gill arch there are 17 gill rakers. Proportional measurements are presented in Table 17.

Coloration

Preserved specimen is grey-brown dorsally, and light yellow-ochre ventrally.

Distribution

According to Krupp (1983) this species is widely distributed throughout the Ar Rub' Al Khali drainage basin (Fig. 22).

Relationship

Garra buettikeri differs from all other Arabian *Garra* in having more scales in the lateral line, above the lateral line, and around the least circumference of the caudal peduncle (Krupp 1983). Krupp considered *Garra buettikeri* to be closely related to *Garra tibanica* and *Garra sahilia* from southwestern Arabia. Krupp derived all of them from African *Garra*.

Garra barreimiae

Garra barreimiae Fowler and Steinitz. 1956. Bull. Res. Coun. Israel, 513(3-4):262-263.

G. barreimiae is known only from the drainages flowing from the Al Akhdar Mountains to the Arabian Gulf and to the Gulf of Oman. Based on the description of Banister and Clarke (1977), large specimens possess a wedge-shaped snout. The snout bears distinctive patches of horny tubercles. The mental disc is wider than it is long and more constant in form than in *G. tibanica*. The anus is further from the anal fin in

Table 17. Proportional measurements of <u>Garra</u> <u>buettikeri</u> expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	BL*	CPD	CPL	PFL	H D	IOW	Snt.L
Wadi Najran	1	70	58	207	241	068	052	500	121	240	052	103	172	241	552	121	121

* Anterior barbel length.

Garra barreimiae than in G. tibanica. There are 4 unbranched and 6 to 8 branched dorsal rays. The anal fin has 3 unbranched and 5 branched rays. The lateral line has about 33 scales. Banister and Clarke (1977) agreed with Menon (1964) in aligning G. barreimiae with Garra rufa, a widely distributed species between the Mediterranean and the Tigris-Euphrates basin. They described a new subspecies, Garra barreimiae shawkahensis. G. b. barreimiae is restricted to drainages flowing to the Gulf of Oman and the Oasis of Baraimi. G. b. barreimiae is restricted to drainages flowing to the Gulf of Oman and the Oasis of Baraimi. G. b. shawkahensis is confined to the Wadi Shawkah which drains the northwest slopes of Al Akhdar Mountains towards the Arabian Gulf. Krupp (1983) considered Garra persica to be closely related to Garra barreimiae and Garra longipinnis.

Garra longipinnis

Garra longipinnis Banister and Clarke. 1977. Oman. Jour. Studies, Spec. Rep. (Sci. Results - Oman Flora and Fauna Survey): P. 137.

This species was described by Banister and Clarke (1977) from the Village of Saiq, Oman. Based on their description, the body is thin and the paired fins are long. The mental disc is well developed. There are 4 unbranched and 6 to 7 branched dorsal rays. There are 3 unbranched and 5 branched anal rays. The lateral line has 29 to 31 scales. There are 13-14 gill rakers on the lower limb of the first gill arch. Gill rakers are short and widely spaced. The authors suggested the close relationship between this species, and Garra barreimiae based on the development of the mental disc, the rounded shape of the snout in the side view and a similar anus-anal fin distance (4-6% SL).

Garra mamshuqa

Garra mamshuqa Krupp. 1983. Fauna of Saudi Arabia, 5:(in press).

This species was described by Krupp (1983) from Wadi Hadramaut and its tributaries in Yemen. Based on his description, the body is very slender. The snout is more or less pointed in dorsal and in lateral view. The mental disc is very small. Only the anterior part is covered by papillae. Papillae are not found on either the center of the disc or its posterior part. There are 3 or 4 unbranched and 7 to 8 branched rays in the dorsal fin. The anal fin has 3 unbranched and 5 branched rays. There are 34-36 scalse in the lateral line. There are 4 or 5 scales above the lateral line. There are 12 or 13 scales around the least circumference of the caudal peduncle. The distance between the vent and the anal fin origin is longer than in any Arabian Garra. Based on anus-anal distance, Garra mamshuqa has been placed within the Garra rufa complex (Krupp 1983).

Garra sahilia

Garra sahilia Krupp, 1983. Fauna of Saudi Arabia, 5:(in press).

This species was described by Krupp (1983) from several localities in Yemen and southwestern drainages of Saudi Arabia. According to Krupp's description, the snout is blunt in side view and wedge-shaped in dorsal view. The menal disc is variable in shape. Papillae are present on all disc parts. The dorsal fin has 3 or 4 unbranched and 7 to 8 branched rays. There are 3 unbranched and 5 branched rays in the anal fin. There are 33-36 scales in the lateral line. 16-17 scales encircle the least circumference of the caudal peduncle. There are 10-16 gill rakers on the lower limb of the first gill arch. Krupp recognized two subspecies, G. s. sahilia and Garra sahilia gharbia. Garra sahilia

sahilia is restricted to drainages flowing to the Gulf of Aden and to the southern Red Sea. G. sahilia gharbia is restricted to the tributaries of the Red Sea north of Wadi Maur, 15° 45' N, 42° 42' E.

Unknown Garra

One specimen of a probable new form of the genus Garra was collected from a spring at Al Wastah, southwest of Al Madinah. The body shape can be seen in Figure 24. The body is deep. The snout is blunt. No tubercles on the sides and top of the snout. Two pairs of short barbels are present. The mental disc is wider than it is long (7 mm vs. 5 mm). There are small papillae on the fringe of the anterior part of the mental disc, but no papillae on the center of the disc nor on the posterior border (Fig. 25). The caudal fin is forked, other fins are short. The ventral fins do not reach the vent. The dorsal fin has 2 unbranched and 7 branched rays. The anal fin has 2 unbranched and 5 branched rays. There are 37 scales in the lateral line. Gill rakers are thin, short and widely spaced. On the anterior side of the first gill arch there are 13 gill rakers. On the posterior side of the first gill arch there are 18. The caudal peduncle is narrow and short. The pectoral fin has 11 rays. There are 7 rays in the pelvic fin. The distance between the anus and the anal fin origin is 4.3% SL. The morphology of the mental disc allies this specimen with Garra mamshuqa. Some slight differences are noted such as scales around the least circumference of the caudal peduncle (14 vs. 12 in mamshuqa). In G. mamshuqa the anus is further from the anal fin than it is in this speciment (4.9% SL vs. 4.3). More specimens must be examined from this locality to determine the status of this fish as a new species or

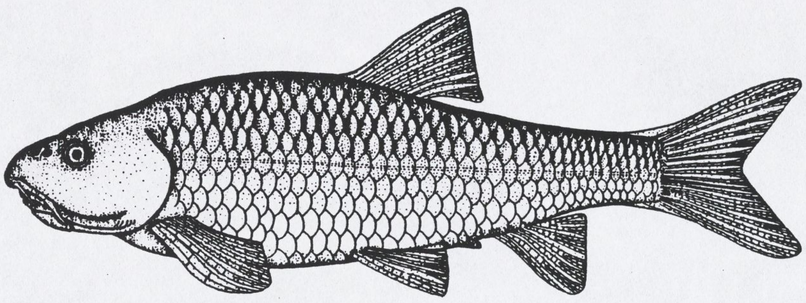
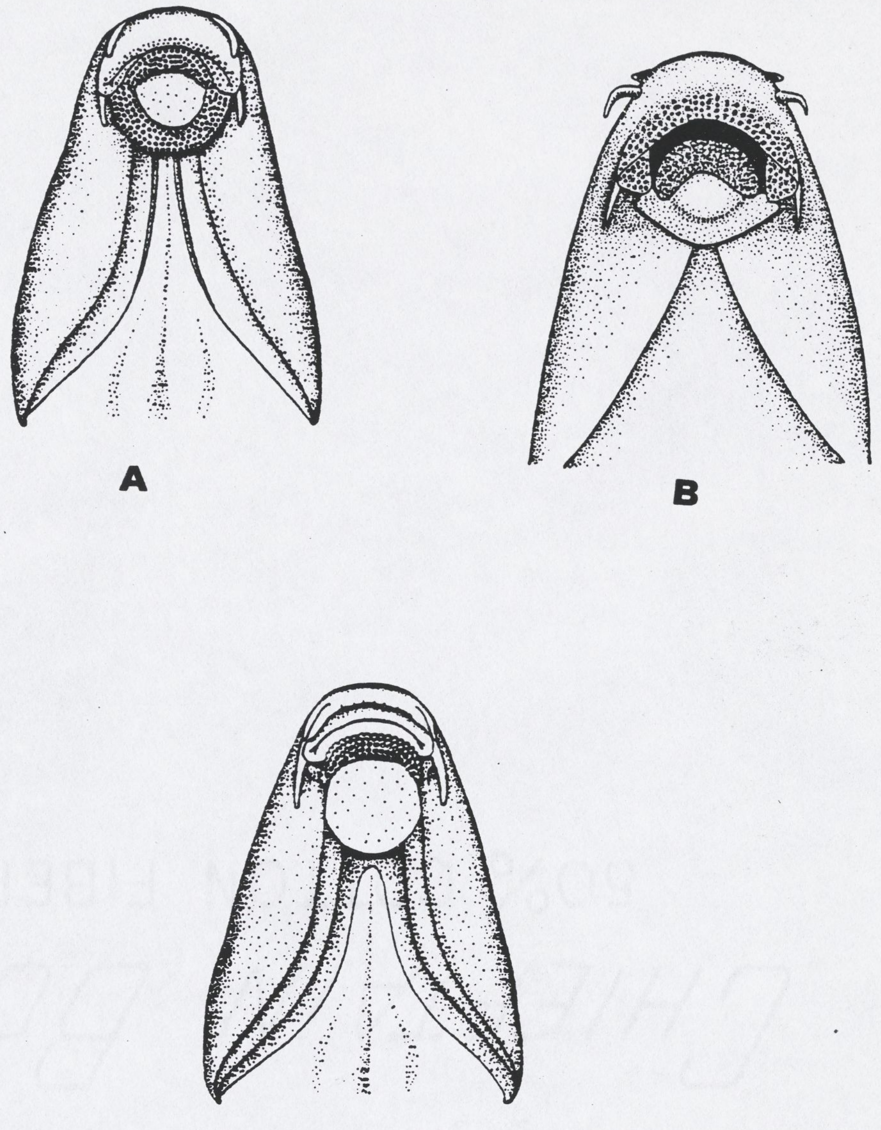


Figure 24. Unknown Garra, 46 mm SL.

Figure 25. Ventral view of the head of A. _Garra tibanica_; B. _Garra mamshuqa_; C. unknown _Garra_.


A
B
C

subspecies of Garra mamshuqa. Proportional measurements are presented in Table 18. The major significance of this specimen from the Red Sea drainage near Al Madinah is that it represents evidence of a G. mamshuqa ancestoral form moving from the Wadi Hadramaut area of the southern Arabian Peninsula along a route leading to distribution on the Red Sea coast. The locality where the specimen was collected is about 1500 km from the known distribution of G. mamshuqa in the Hadramaut drainage. A similar pattern of distribution is observed in Barbus arabicus, Cyprinion acinaces, Garra tibanica, and G. sahilia, indicating a generalized distribution track occurred in relatively recent geological time.

The Status of Garra arabica Hora, 1921

Garra arabica Hora, 1921 is a dubious species (Menon 1964, Al Kahem and Behnke 1983, Krupp 1983). In the nineteenth century, W. T. Blanford sent fish specimens from the Wadi Tiban drainage at the southern tip of the Arabian Peninsula to the Indian Museum. Hora (1921) named a new specis, Garra arabica, reputedly on the Arabian specimens. Trewavas (1941) mentioned that she examined a cotype specimen of G. arabica and found it closely resembled G. gotyla, an Indian species. Menon (1964) examined the types of Garra arabica and concluded that Garra arabica is actually Garra nasutus, an Indian species. Balleto and Spano (1977) examined 456 specimens from several localities of South Yemen. None of their specimens resemble the description of Garra arabica. Krupp (1983) and Al Kahem and Behnke (1983) agreed with Menon (op. cit.) in regarding G. arabica as G. nasuta. Thus, Garra arabica Hora, 1921, is not a valid species, and it can be assumed that the specimens on which the name G. arabica is based did not come from Arabia.

Table 18. Proportional measurements of unknown Garra expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	UJL	DO	DFBL	DFDL	BL*	CPD	CPL	PFL	H D	IOW	Snt.L
Wadi Al Wastah	1	57	46	261	283	087	065	522	174	239	065	108	196	196	543	109	109

* Anterior barbel length.

Genus Acanthobrama Heckel, 1843

Acanthobrama Heckel, 1843, in Russegger's Reisen, P. 1033 (Type: A. marmid).

The genus Acanthobrama Heckel is distinguished from other Arabian cyprinids by a keel on the belly between the pelvic fin and the anus. Pharyngeal teeth 5.5 or 5.4; 51-108 scales in the lateral line and scales without radii on the anterior field (Coad et al. 1983, Goren et al. 1973).

Taxonomic Outline

The genus Acanthobrama was described by Heckel in 1843 based on Acanthobrama marmid. Previously there were five known species in this genus, Acanthobrama centisquama, A. marmid, A. lissneri, A. telavivensis and A. terraesanctae. Goren et al. (1973) revised the genus to exclude A. terraesanctae which was made the type of a new genus, Mirogrex, distinguished principally by a more slender form and higher numbers of the gill rakers (mostly 20-28 compared to 12-15 in Acanthobrama). Howes (1981) synonymized Acanthobrama and Mirogrex with the genus Rutilus. Coad et al. (1983) regarded Mirogrex as a synonym of Acanthobrama, but retained the generic status of Acanthobrama. Coad et al. (1983) described Acanthobrama hadiyahensis as a new species from the area of Khaybar and Hadiyah, Saudi Arabia. This was actually the first record of the genus from the Arabian Peninsula.

Distribution

All known species of the genus except A. hadiyahensis are found in the Tigris-Euphrates and Levant drainages. Collections made in 1977 and 1981 extended the range of the genus to the northwestern part of Saudi Arabia (Fig. 22).

Acanthobrama hadiyahensis

Acanthobrama hadiyahensis Coad, Al Kahem and Behnke, 1983. Nat. Mus. Can., Pub. Nat. Sci., No. 2: P. 1.

Acanthobrama hadiyahensis was described by Coad et al. (1983) from the area of Khaybar and Wadi Hadiyah, Saudi Arabia. Based on their description, the dorsal fin origin lies posterior to the pelvic fin origin. The anal fin origin lies at, slightly in advance of, or slightly behind the dorsal fin insertion. The pectoral and pelvic fins extend beyond the pelvic and anal fin origin respectively, in members of both sexes, but not all individuals. The dorsal fin has 3 unbranched and 7 branched rays. The last unbranched dorsal fin ray tapers gradually from a smooth, rigid, thickened basal portion to a flexible, thin distal portion. The anal fin has 3 unbranched and 14 to 17 branched rays. The caudal fin is moderately forked and the dorsal and the anal fin margins are concave. Scales are evenly distributed over the body except on the belly between the pelvic fins base and the anus where there is a naked keel. This keel is formed by a fleshy protrusion of the belly in the absence of a median row of scales. There is no pelvic axillary scale. Radii are restricted to the posterior field. There are 54-58 scales in the lateral line. There are 20-22 scales around the least circumference of the caudal peduncle. A dark, mid-lateral band is developed posteriorly becoming diffuse near the head. The mid-line of the back is darker than the upper flanks but a clearly defined median line is not present. Fin pigmentation is concentrated on the rays. The fin membranes are clearer with the exception of the basal portions of the dorsal fin which have scattered pigments. Coad et al. (1983) considered *A. hadiyahensis* to be closely related to *A. telavivensis* (a Levant species) which has a similar range in lateral line scale number (51-60) and similar shape of pharyngeal teeth. Figure 26 illustrates *A. hadiyahensis*.

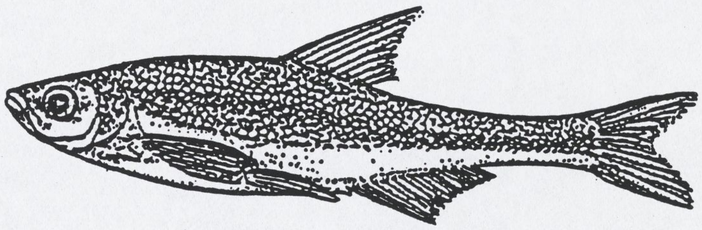


Figure 26. Acanthobrama hadiyahensis, 75 mm SL.

FAMILY CYPRINODONTIDAE

This very large family is commonly called "toothcarps." Fresh and brackish water, rarely coastal marine; southeastern Canada, South American North America, Africa, Madagascar, Southern Europe, and Southern Asia. Eggs layers, no gonopodium. Some are annual fishes, with eggs that can avoid desiccation, thus carrying the species over dry periods (Nelson 1976). About 50 genera with at least 300 species (Nelson op. cit.).

Genus _Aphanius_ Nardo, 1827

Aphanius Nardo, 1827, Adriat. Ichth., P. 438 (Type: _A. fasciatus_).

Typically small fish (100 m). Upper surface of the head is usually flattened. Mouth is superior specialized for feeding on surface. No barbels. No adipose fin. Fins spineless. No lateral line. Dorsal fin rather far back, usually arising in front of the anal fin.

Taxonomic Outline

Berg (1949) recognized three subspecies of _Aphanius dispar_; _Aphanius dispar dispar_, _A. d. richardsoni_ and _A. d. stoliczkanus_. Steinitz (1951) arranged _Aphanius_ species into the following groups:

1) The dispar group. _A. dispar_, _A. fasciatus_ and _A. iberus_ are the only species in this group.

2) The Cypris group. This group includes A. cypris and A. sophiae.

3) The chantrei group. A. chantrei and burduricus are the only two species in this group.

Sterba (1962) listed A. dispar, A. dispar richardoni, A. mento, A. fasciatus, A. iberus, A. chantrei and A. burduricus in his book "Freshwater Fishes of the World." He wrote "A definitive classification of the members of the genus Aphanius will not be possible until more intensive studies of geographical and environmental variation in these widely distributed fishes have been completed." Based on genetic interpretations, Villwock (1982) studied the speciation of members of the genus Aphanius and the genus Cyprinodon (New World cyprinodonts) and concluded that, Old World Cyprinodontids of the genus Aphanius and New World representatives of the genus Cyprinodon inhabit corresponding environments produced by arid climates. Villwock, Scholl and Krupp (1983) described Aphanius sirhani as a new species from Azraq Oasis, 32° 51' N, 36° 49' E, in Jordan. They expected that this species might inhabit the Wadi As Sirhan drainages in Saudi Arabia. Presently, Aphanius dispar is the only species of this genus known from Arabia (Al Kahem 1980, Al Kahem and Behnke 1983, Banister and Clarke 1977, Haas 1982, Krupp 1983, and Trewavas 1941). Aphanius dispar was found with American mosquitofish, Gambusia affinis, in one spring at Al Kharj, Saudi Arabia (Al Kahem 1980, Al Kahem and Behnke 1983). Saadati (1977) pointed out that Gambusia affinis had replaced Aphanius from much of its range in Iran. Al-Dahem et al. (1977) discussed interaction between Gambusia and three species of Aphanius in southern Iraq.

<u>Aphanius dispar</u> (Ruppell, 1828)

Widely distribued between Northeast Africa and Northwest India, living in freshwater, brackish to highly saline or marine water (Krupp 1983). D 8-11, A 8-10, V 6-7, L.L. 25-29.

<u>Aphanius dispar dispar</u> (Ruppell, 1828)

<u>Lebias dispar</u> Ruppell. 1828. Atlas zu der Reise im nordllichen Africa. fische des rothen Meeres: 66, Red Sea.

<u>Aphanius dispar dispar</u>: Berg. 1949. Trud. Zool. Ist. Akad. Nauk USSR, 8(4): 420.

<u>Material Examined</u>

a) 6 fish, 36-54 mm SL, collected June, 1977, from Ain Al Kharj, Saudi Arabia. Al karj city is at 24° 05' N, 47° 05' E.

b) 8 fish, 35-52 mm LS, collected June, 1977, from Ain Rasibe, Al Hufuf, Saudi Arabia. Al Hufuf city is at 25° 2' N, 49° 34' E.

c) 5 fish, 45-58 mm SL, collected June, 1977, from Ain Al Wame, Al Hufuf, Saudi Arabia.

d) 5 fish, 49-60 mm SL, collected June, 1977, from Ain Jabriah, Al Hufuf, Saudia Arabia.

e) 5 fish, 52-58 mm SL, collcted June, 1977, from Ain Al Bsatenat, Al Hufuf, Saudi Arabia.

f) 5 fish 49-55 mm SL, collected June, 1977, from Ain Al Jlajelah, Al Hufuf, Saudi Arabia.

g) 5 fish, 38-43 mm SL, collected June, 1977, from Ain Omm Sabaah, Al Hufuf, Saudi Arabia.

h) 4 fish, 30-45 mm SL, collected July, 1977, from Ain Modwarah, Khaybar, Saudi Arabia.

i) 5 fish, 44-49 mm SL, collected June, 1977, from Ain Al Khdud, Al Hufuf, Saudi Arabia.

j) 5 fish, 49-55 mm SL, collected June, 1977, from Ain Dalli, Al Hufuf, Saudi Arabia.

k) 5 fish, 36-47 mm SL, collected June, 1977, from Ain Omm Aleef, Al Hufuf, Saudi Arabia.

l) 5 fish, 32-37 mm SL, collected June, 1977, from Ain Al Harrah, Al Hufuf, Saudi Arabia.

m) 5 fish, 39-43 mm SL, collected June, 1977, from Ain Bohadi, Al Hufuf, Saudi Arabia.

n) 5 fish, 4-58 mm SL, caught June, 1977, from Ain Al Mshateiah, Al Hufuf, Saudi Arabia.

o) 5 fish, 44-54 mm SL, collected June, 1977, from Ain Barabir, Al Hufuf, Saudi Arabia.

p) 5 fish, 44-59 mm SL, collected June, 1977, from Ain Amarah, Al Hufuf, Saudi Arabia.

q) 5 fish, 41-59 mm SL, collected June, 1977, from Ain Talib, Al Hufuf, Saudi Arabia.

Description

The body shape can be seen in Figure 27. Eyes are lateral and visible in ventral view. The eyes are slightly protuberant. Scales cover the interorbital region. The dorsal profile is arched in both sexes. The dorsal fin origin lies posterior to the pelvic fin origin. The anal fin origin lies slightly in advance of the dorsal fin

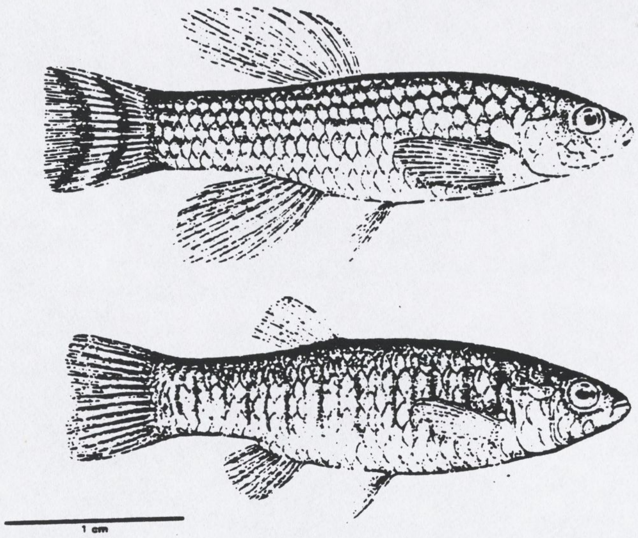


Figure 27. Aphanius dispar, male and female.

insertion. In adult males, the dorsal fin is twice as high as that of the adult female. In female fins are short and colorless. In adult male dorsal and anal fin reach the base of the caudal. There are 12-20 tricusped teeth per jaw. The anal fin is longer than in female. The dorsal fin has 6-9 branched rays. There are 6-9 branched rays in the anal fin. There are 25-29 scales in the lateral line. Gill rakers are relatively thick, long, curved and widely spaced. There are 11-16 on the anterior side of the first gill arch. On the posterior there are 16-24 gill rakers. Proportional measurements and frequency distribuions data are present in Table 19 and 20.

Coloration

Dark blue speckles occur on the dorsal and anal fins of the male. Males are brightly colored, brown to dark blue, with numerous irridescent, blue-silver blotches in rows on the flanks and weak brownish transverse bars above the caudal peduncle. Dorsal and anal fins with silvery blotches and dark spots. Pectoral and pelvic are yellow. Females are grey with a bluish silver sheen. Numerous transverse bars on the flank. Preserved specimens are blue-grey with dark grey bands.

Distribution

Aphanius dispar is able to tolerate wide variation in salinity accounts for its wide distribution. It occurs in the coastal drainages of the Arabian Peninsula, which probably had direct connection to the sea during the past several thousand years. The species occur in Ethiopia, Palestine, Iraq, near the Gulf drainages of Iran and in the

Table 19. Proportional measurements of <u>Aphanius dispar dispar</u> expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	DO	AFL	DFDL	CPD	CPL	PFL	VFL	DFBL
Ain Alkharj (Al Kharj)	1	63	53	283	245	094	604	151	151	170	189	189	113	151
	2	66	54	315	278	074	556	352	481	204	222	259	204	148
	3	66	53	340	283	075	566	358	472	208	226	245	189	132
	4	57	47	319	277	064	553	362	447	213	234	255	213	128
	5	51	43	326	302	093	674	186	209	209	209	209	140	162
	6	43	36	306	278	083	639	222	222	222	250	222	139	139
	Mean	57.7	47.7	315	277	081	599	272	330	204	222	230	166	143
	Min.	43	36	283	245	064	553	151	151	170	189	189	113	128
	Max.	66	54	340	302	094	674	362	481	222	150	259	213	162
Ain Rasibe (Al Hufuf)	7	58	47	340	298	085	596	340	426	213	298	213	170	149
	8	56	42	357	309	095	643	286	452	238	309	238	167	143
	9	65	52	327	288	077	558	231	423	192	269	231	19	154
	10	47	37	324	297	081	568	378	432	243	297	216	189	162
	11	46	35	343	343	086	571	400	429	286	286	257	171	171
	12	58	46	304	326	087	652	261	283	174	217	217	130	152
	13	61	50	300	300	100	640	220	220	180	200	200	100	160
	14	46	36	333	333	083	611	250	278	194	278	222	139	167
	Mean	54.6	43.1	329	312	087	594	296	368	215	269	224	157	157
	Min.	46	35	300	288	077	558	220	220	174	200	200	100	143
	Max.	65	52	357	343	100	652	400	452	286	309	257	192	171
Ain Alwami (Al Hufuf)	15	60	49	347	306	082	653	224	245	163	245	224	122	143
	16	56	45	333	333	089	622	311	356	178	267	267	156	200
	17	70	58	392	293	086	638	207	207	173	241	189	121	121
	18	61	50	320	300	080	660	220	240	160	200	200	120	140
	19	57	46	326	326	087	630	283	326	174	261	217	152	173
	Mean	60.8	49.6	324	312	085	641	249	275	170	243	219	134	155
	Min.	56	45	293	293	080	622	207	207	160	200	189	120	140
	Max.	70	58	347	333	089	660	311	356	178	267	267	156	200

Table 19. Continued.

Drainage	Specimen Number	TL	SL	BD	H L	O L	DO	AFL	DFDL	CPD	CPL	PFL	VFL	DFBL
Ain Jabriah	20	73	60	300	300	083	617	183	217	167	233	200	117	150
(Al Hufuf)	21	65	55	291	273	073	545	345	382	164	218	255	145	182
	22	68	57	333	281	088	596	281	351	175	228	228	140	175
	23	67	55	327	291	091	564	255	291	182	218	200	145	182
	24	59	49	306	327	102	633	224	245	163	204	204	163	163
	Mean	66.4	55.2	311	294	087	591	258	297	170	220	217	142	170
	Min.	59	49	290	273	073	454	183	217	163	204	200	117	150
	Max.	73	60	333	327	102	633	345	382	182	233	255	163	182
Ain AlBsatenat	25	65	55	327	309	091	618	200	218	182	200	200	127	127
(Al Hufuf)	26	65	53	358	321	094	660	206	226	189	226	226	132	132
	27	67	58	345	345	086	603	276	328	224	276	172	155	172
	28	68	56	393	357	089	625	375	446	214	268	268	196	179
	29	65	52	365	346	096	673	385	500	212	288	269	212	173
	Mean	66	54.8	358	336	091	636	288	344	204	252	227	164	157
	Min.	65	52	327	309	086	603	200	218	182	200	172	127	127
	Max.	68	58	393	357	096	673	385	500	224	288	269	212	179
Ain AlJlajelah	30	65	53	339	283	094	566	358	472	189	264	208	169	206
(Al Hufuf)	31	57	49	327	327	102	571	408	489	204	265	224	184	184
	32	66	55	273	327	091	636	200	218	145	218	182	127	127
	33	62	52	288	291	096	635	192	212	173	231	192	154	115
	34	65	53	283	302	094	660	189	208	151	208	189	151	113
	Mean	63	52.4	302	206	095	614	269	320	172	237	199	157	149
	Min.	57	49	273	283	091	516	189	208	145	208	182	127	113
	Max.	66	55	229	327	102	660	408	489	204	265	224	184	206
Ain Omm Sabaah	35	52	41	293	317	098	561	366	43	171	244	168	171	219
(Al Hufuf)	36	50	43	279	341	122	683	268	220	146	219	219	122	122
	37	52	43	279	341	116	628	233	209	139	186	209	116	139
	38	47	38	316	342	105	658	237	237	158	211	237	132	132
	39	52	41	293	317	098	585	366	463	171	244	244	171	219
	Mean	50.6	41.2	292	332	108	623	294	314	157	221	235	142	166
	Min.	47	38	279	317	098	561	233	209	139	186	209	116	122
	Max.	52	43	316	342	122	683	366	463	171	244	268	171	219

Table 19. Continued.

Drainage	Specimen Number	TL	SL	BD	H L	O L	DO	AFL	DFDL	CPD	CPL	PFL	VFL	DFBL
Ain Modwarah (Khaybar)	40	53	43	302	302	093	628	233	233	186	163	209	139	186
	41	52	45	333	267	089	556	333	378	200	222	289	222	178
	42	36	30	267	300	100	633	200	200	200	233	233	200	167
	43	38	31	258	355	097	645	258	194	161	258	225	194	161
	Mean	44.8	37.3	290	306	095	616	256	251	187	219	239	189	173
	Min.	36	30	258	267	089	556	200	194	161	163	209	139	161
	Max.	53	45	333	355	100	646	333	378	200	258	289	222	186
Ain Al Khdud (Al Hufuf)	44	58	47	362	340	106	638	383	447	234	255	255	191	213
	45	58	48	333	292	104	583	396	458	188	250	229	188	208
	46	59	49	306	306	102	633	224	224	184	224	204	122	184
	47	59	47	298	277	106	638	213	213	170	213	170	128	128
	48	55	44	295	295	091	614	227	227	182	205	227	136	136
	Mean	57.8	47	319	302	102	621	289	314	192	229	217	153	174
	Min.	55	44	295	277	091	583	213	213	170	205	170	122	128
	Max.	59	49	362	340	106	638	396	458	234	255	255	191	213
Ain Dalli (Al Hufuf)	49	54	43	302	279	116	628	209	209	163	186	209	116	116
	50	52	42	286	309	095	643	238	238	167	214	214	143	119
	51	51	42	235	235	095	619	214	214	143	167	214	119	119
	52	49	39	308	308	103	667	333	410	154	205	231	154	179
	53	55	53	245	245	075	491	245	302	151	189	208	132	113
	Mean	52.2	43.8	275	275	097	610	248	275	156	192	215	133	129
	Min.	49	39	235	235	075	491	209	209	143	167	208	116	113
	Max.	55	53	308	309	116	667	333	410	167	214	231	154	179
Ain Omm Aleef (Al Hufuf)	54	58	47	319	298	106	596	319	362	191	234	255	128	149
	55	54	42	309	333	119	643	357	405	190	238	238	167	167
	56	50	40	300	300	125	600	400	500	200	250	250	175	175
	57	50	39	333	333	128	641	333	436	179	231	231	154	179
	58	46	36	306	306	111	611	333	389	167	222	222	111	194
	Mean	51.6	40.8	313	314	118	618	348	418	185	235	239	147	173
	Min.	46	36	300	298	106	596	319	362	167	222	222	111	149
	Max.	58	47	333	333	128	643	400	500	200	250	255	175	194

Table 19. Continued.

Drainage	Specimen Number	TL	SL	BD	H L	O L	DO	AFL	DFDL	CPD	CPL	PFL	VFL	DFBL
Ain Al Harrah	59	46	36	333	333	111	667	333	417	167	222	250	167	194
(Al Hufuf)	60	42	34	294	265	118	647	353	412	147	265	206	118	176
	61	45	37	324	270	108	622	216	216	162	216	189	135	135
	62	42	32	375	344	125	688	250	219	188	219	188	125	188
	63	42	33	303	333	121	667	212	182	182	212	182	121	152
	Mean	43.4	34.4	326	309	117	658	273	289	169	227	203	133	169
	Min.	42	32	294	265	108	622	212	182	147	212	182	118	135
	Max.	46	37	375	344	125	688	353	417	188	265	250	167	194
Ain Bohadi	64	50	42	309	309	119	643	262	286	167	238	214	143	143
(Al Hufuf)	65	46	39	308	308	103	589	282	333	154	231	231	154	179
	66	56	43	349	372	116	674	163	163	163	186	233	116	139
	67	52	42	286	286	095	643	214	214	167	214	214	143	143
	68	41	41	293	317	098	609	195	219	146	171	195	146	171
	Mean	51	41.4	309	318	106	632	223	243	159	208	217	140	155
	Min.	46	39	286	286	095	589	163	163	146	171	195	116	139
	Max.	56	43	349	372	119	674	282	333	167	238	233	154	179
Ain Al	69	61	58	328	293	086	586	345	431	189	224	241	121	155
Mushateiah	70	59	48	333	292	104	563	333	417	167	208	229	146	208
(Al Hufuf)	71	61	49	306	327	102	57	245	306	163	204	204	122	163
	72	59	47	319	340	106	638	213	234	149	170	234	128	149
	73	52	41	317	317	122	659	244	219	146	171	219	122	146
	Mean	58.4	48.6	321	314	104	603	276	321	163	195	225	128	164
	Min.	52	41	306	292	086	563	213	219	146	170	204	121	146
	Max.	61	58	333	340	122	659	345	431	189	224	241	146	208
Ain Barabir	74	67	54	352	333	074	629	333	407	185	222	241	129	167
(Al Hufuf)	75	59	48	313	313	083	625	271	354	188	229	208	125	167
	76	51	44	273	295	091	591	341	386	205	227	205	114	159
	77	60	50	300	300	080	660	240	220	160	240	200	100	140
	78	53	45	289	311	089	600	222	200	156	244	222	089	133
	Mean	58	48.2	305	310	083	621	281	313	179	232	215	111	153
	Min.	51	44	273	295	074	591	222	200	156	222	200	089	133
	Max.	67	54	352	333	091	660	341	407	205	244	241	129	167

Table 19. Continued.

Drainage	Specimen Number	TL	SL	BD	HL	OL	DO	AFL	DFDL	CPD	CPL	PFL	VFL	DFBL
Ain Amarah	79	66	55	309	291	073	636	200	218	182	218	182	127	109
(Al Hufuf)	80	62	59	254	237	068	508	186	203	153	169	169	102	136
	81	54	44	295	295	091	659	182	227	205	273	205	114	114
	82	64	50	340	320	080	620	360	520	220	260	260	200	140
	83	63	49	347	327	082	633	388	469	204	245	245	204	182
	Mean	61.8	51.4	309	294	079	611	263	327	193	233	212	149	136
	Min.	54	44	254	237	068	508	182	203	153	169	169	102	109
	Max.	66	59	347	327	091	659	388	520	220	273	260	204	182
Ain Talib	84	69	59	322	322	085	610	322	221	203	254	220	136	169
(Al Hufuf)	85	53	42	381	286	119	619	238	238	190	238	238	095	143
	86	50	41	366	341	098	683	293	341	219	244	219	146	219
	87	55	45	311	289	111	622	222	200	200	222	200	111	133
	88	54	44	341	295	114	636	227	205	205	227	225	114	136
	Mean	56.2	46.2	344	307	105	634	260	241	203	237	220	120	160
	Min.	50	41	311	286	085	610	222	200	190	222	200	095	133
	Max.	69	59	381	341	119	683	322	341	219	254	238	146	219

Table 20. Frequency distributions of meristic data for <u>Aphanius dispar</u> (N = 88).

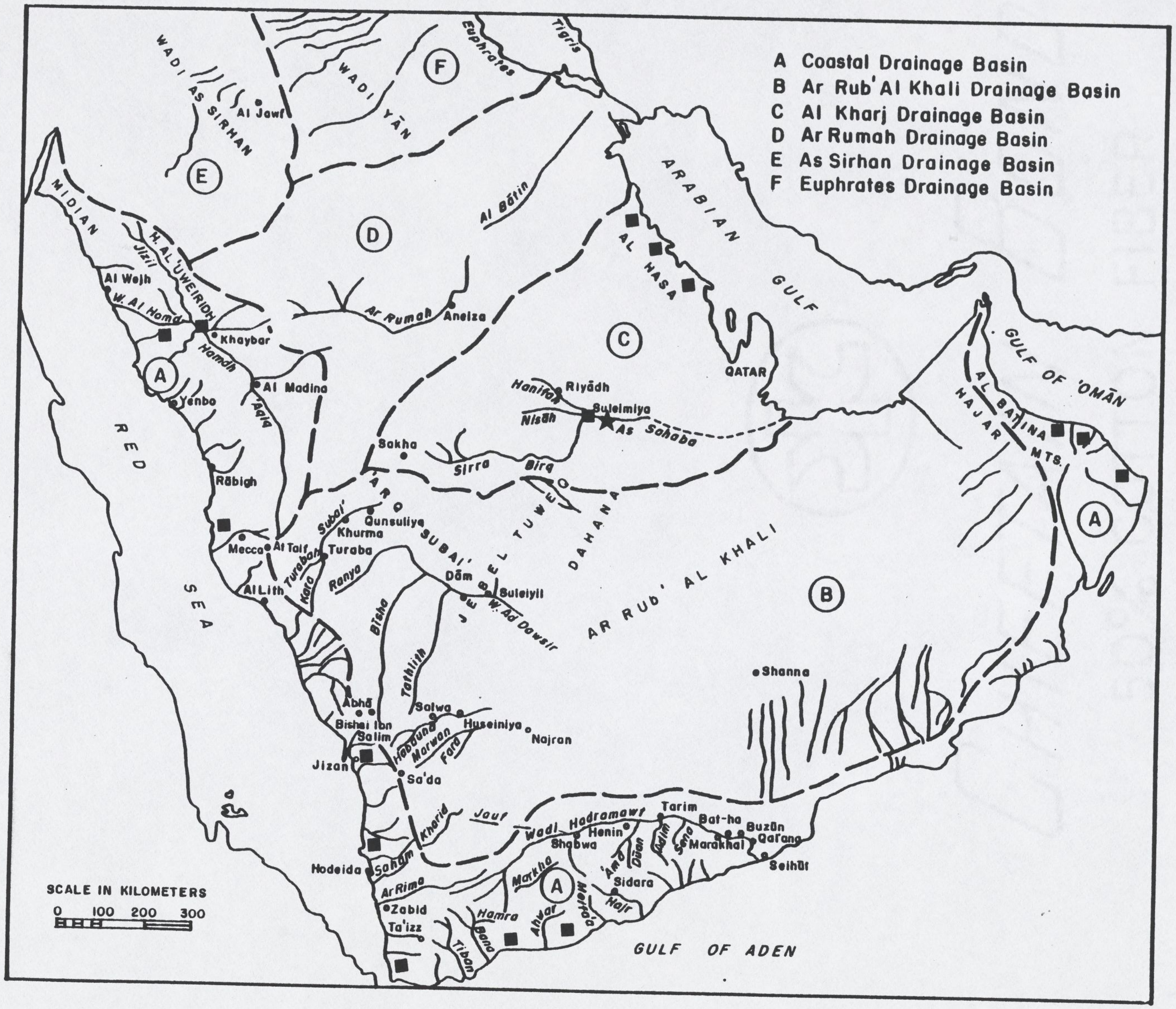
										$\overline{X}$	S.D.
Scales in lateral line	25	26	27	28	29					27.1	1.1
N. specimens	8	16	25	35	4						
Dorsal fin branched rays		6	7	8	9					7.5	0.6
N. specimens		4	35	46	3						
Anal fin branched rays		6	7	8	9					8.3	0.9
N. specimens		3	15	23	47						
Pectoral fin rays		13	14	15	16					13.9	0.6
N. specimens		19	58	10	1						
Pelvic fin rays		6	7							6.9	0.3
N. specimens		10	78								
Gill rakers on first arch;											
a) anterior side	11	13	14	15	16					14.0	0.9
N. specimens	1	26	40	11	10						
b) posterior side	16	17	18	19	20	21	22	23	24	20.7	1.2
N. specimens	1	1	1	4	34	25	17	4	1		

Dead Sea Valley. Collections made in 1977 extended the range of the species to the eastern region of Saudi Arabia, Al Kharj, and several springs of Khaybar city, where endemic Cyprinion occurs (Fig. 28).

Habitat and Ecology

Aphanius dispar is almost totally ubiquitous in all bodies of freshwater where it occupies a wide range of habitats differing in stream flow, water chemistry, temperature and substrate quality (Haas, 1982). It is also common in shallow stagnant or semi-stagnant waters. Aphanius dispar were present in temperatures ranging from 28.4 °C to 38.4 °C and pH 7.4-8.0 (Haas op. cit.). Haas (op. cit.) reported that this species occurs over sandy, rocky or soft detritus substrates. Aphanius dispar appears to prefer to spawn where there is some water flow and where there are vertical surfaces provided by plant material or algae-covered rocks, it breeds throughout the year with a probable peak in the months of April to June (Haas op.cit.). This species feeds almost constantly, especially in more quiet waters, by picking at rocks and other substrates. The gut of Aphanius dispar caught in their natural habitat contianed unicellular algae and filamentous algae (Al-Daham et al. 1977, Haas op. cit.). This suggets the possibility of using Aphanius dispar for biological control of filamentous algae which are so common in the irrigation channels of the Arabian Peninsula. Aphanius dispar also will take items at the surface, chase small fish and eat insect larvae. Ataur-Rahim (1981) found mosquito larvae in the stomach of A. dispar, which did not appear to eat algae until all the mosquito larvae have been consumed. Haas (1982) mention that, the eagerness with which mosquito larvae are eaten by Aphanius plus its

Figure 28. Distribution of _Aphanius dispar_ (■) and _Gambusia affinis_ (★).


A Coastal Drainage Basin
B Ar Rub' Al Khali Drainage Basin
C Al Kharj Drainage Basin
D Ar Rumah Drainage Basin
E As Sirhan Drainage Basin
F Euphrates Drainage Basin
WADI AS SIRHAN
Al Jawf
WADI YĀN
Euphrates
Tigris
Al Bōtin
ARABIAN GULF
AL HASA
MIDIAN
Jizil
W. AL 'UWEIRIDH
Al Wejh
W. Al Hamd
Khaybar
Ar Rumah
Aneiza
Hamdh
Al Madina
'Aqiq
Yenbo
RED SEA
Rābigh
Mecca
Al Taif
Al Lith
Turabah
Kara
Subai'
Qunsuliya
Khurma
Turaba
Ranya
Bisha
Tathlith
Sakha
ARQ SUBAI'
Sirra
Birq
JEBEL TUWEIQ
DAHANA
Hanifah
Riyādh
Nisāh
Suleimiya
As Sahaba
QATAR
GULF OF 'OMĀN
AL BATINA
HAJAR MTS.
AR RUB' AL KHALI
Dām
Suleiyil
W. Ad Dawsir
Shanna
Abhā
Bishai Ibn Salim
Solwa
Huseiniya
Najran
Habauna
Marwan
Fara
Jizan
Sa'da
Kharid
Jouf
Wadi Hadramawt
Tarim
Bat-ha
Buzūn
Qa'ana
Henin
Shabwa
Marakhai
Seihūt
Hodeida
Saham
Ar Rima
Markha
'Amd
Dōan
Adim
Sidara
Hajr
Zabid
Ta'izz
Hamra
Bana
Ahwar
Tiban
GULF OF ADEN
SCALE IN KILOMETERS
0 100 200 300

tolerance of a wide range of water quality conditions and ability to withstand considerable pollution make it an excellent candidate for use as a biological control agent against mosquito-borne human disease, in particular malaria. In Oman, Aphanius dispar has been introduced in open cisterns and wells to control mosquitos and they appear to be reproducing successfully even in wells (Haas, op. cit.). This suggests that it might be possible to use this species to control mosquitos in Saudi Arabia, in particular the southwestern region.

Relationships

Aphanius dispar is most unlikely to be confused with any other species on the Arabian Peninsula. The presence of teeth in the jaws, and the vertical bands on the flank and the caudal fin separate it from its sympatric species. Aphanius fasciatus (a circum-Mediterranean species) is superficially similar to A. dispar but can be distinguished by more rays (10-13 vs. 8-11) in the dorsal fin. Aphanius mento can be distinguished by the presence of fewer rays (5-6 vs. 6-7) in the pelvic fin. Krupp (1983) concluded that A. dispar, A. fasciatus and A. sirhani are closely related. Krupp (op. cit.) claimed that A. fasciatus and A. sirhani retain more primitive characters than does any other of the east Mediterranean species of the genus Aphanius. According to Krupp (1983), A. sirhani is the closest living relative of Aphanius dispar.

Aphanius dispar richardsoni (Boulenger, 1907)

Cyprinodon richardsoni Boulenger, 1907. Fishes of the Nile: 412.

Aphanius dispar richardsoni Berg, 1949, Trud. Zool. Ist. Akad. Nauk USSR, 8:848.

This species is restricted to the Dead Sea rift valley. Although there are few differences between A. d. richardsoni and the nominal subspecies, the former is mainly characterized by its isolated distribution (Krupp 1983).

FAMILY POECILIIDAE

Fresh- and brackish water; low elevations from eastern United States to northeastern Argentina. First three anal rays unbranched. Male with elongated anterior anal fin rays (gonopodium) usually with internal fertilization; bear young alive (Nelson 1976). Maximum size about 180 mm; most species are much smaller.

Genus Gambusia Poey, 1855

Gambusia Poey, Memorias, I, 1855, P. 382 (Type: *Gambusia punctata*).

Gunther (1880) described the genus as follows: Snout not produced, with the lower jaw more or less prominent. Both jaws with a band of teeth, those of the outer series being strongest and conical. Scales are large. Origin of the anal fin more or less in advance of that of the dorsal. Anal fin of the male modified into an intromittent organ and much advanced.

Distribution

Gambusia is a native to southern and eastern United States of America, Mexico and Cuba, where it occurs in small lakes, canals, and lagoons. Collections made in 1977 contained the first record of the genus in Arabia (Fig. 28).

Gambusia affinis

Heterandria affinis Baird et Girard, 1853. Proc. Acad. Nat. Sci. Phila. 6:390.

Two specimens SL 39 an 36 mm were collected from a spring in Al Kharj city, 24° 05' N, 47° 05' E. _Gambusia affinis_ is a small fish seldom exeeding 60 mm. The body shape can be seen in Figure 29. There are 12 or 14 gill rakers on the anterior side of the first gill arch. On the posterior side of the first gill arch there are 15 or 17 gill rakers. The dorsal fin has seven rays. The anal fin has 9 rays; the pectoral fin has 8 or 9 rays, and the pelvic fin has 5 or 6 rays. There are 28 or 30 scales in the lateral line. Proportional measurements are presented in Table 21.

Table 21. Proportional measurements of _Gambusia affinis_ expressed in thousandths of the standard length.

Drainage	Specimen Number	TL	SL	BD	H L	O L	DO	AFL	DFDL	CPD	CPL	PFL	DFBL
Ain Al Kharj	1	43	34	265	235	088	647	235	235	147	324	176	118
	2	45	36	306	250	083	639	222	194	139	306	194	111
	Mean	44	35	286	243	086	643	229	215	143	315	185	115

The genus _Gambusia_ has been introduced throughout the world to control the mosquito vector of malaria. Al Kahem and Behnke (1983) recorded the occurrence of _Gambusia affinis_ in Saudi Arabia. There should be a general awareness in Arabia concerning the potential danger that introductions of exotic species have for native species

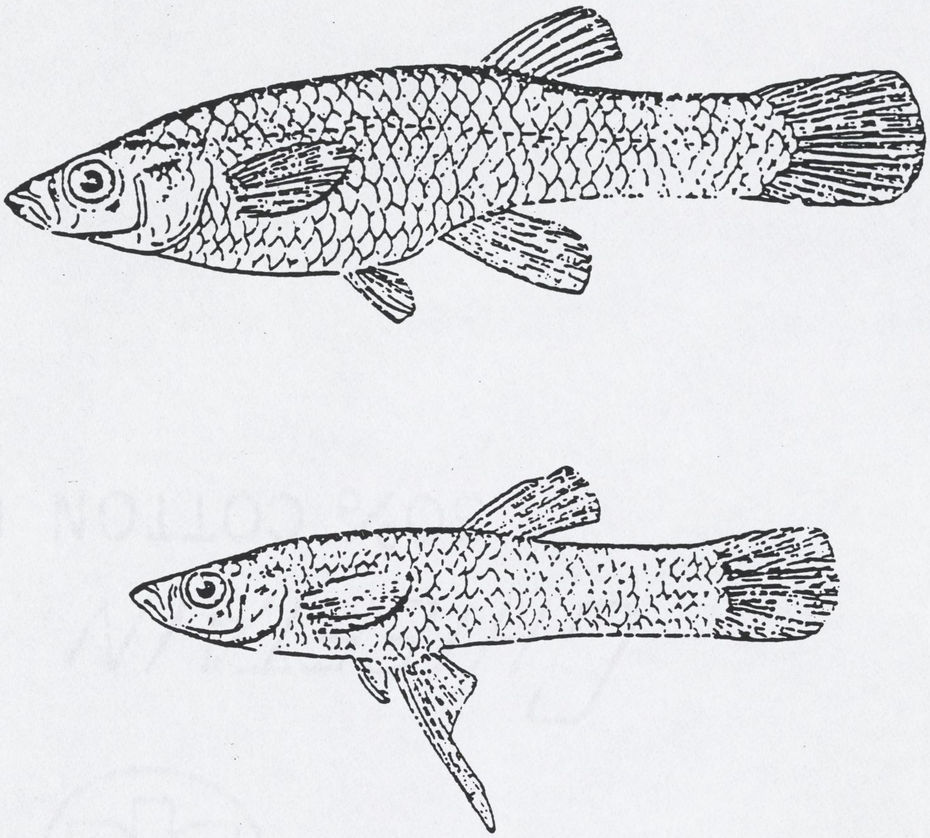


Figure 29. Gambusia affinis, female and male.

and for disruptions of ecosystems. Thus, it is important to complete a comprehensive survey of Arabian fishes to document the occurrence and status of all native species in order to better protect them from habitat destruction and non-native fish introductions. The native fish *Aphanius dispar* can act as an effective biological control for mosquitoes. Saadati (1977) pointed out that *Gambusia affinis* had replaced *Aphanius* from much of the range in Iran. Almost everywhere that *Gambusia* has been introduced, it has gradually wiped out most or all of the smaller native mosquito-destroying species (Myers 1965). In an artificial pools experiment, Huribert et al. (1972) found that *Gambusia affinis* greatly reduced rotifer, crustacean, and insect populations and thus permitted extraordinary development of phyto-plankton populations. Al-Dahem et al. (1977) discussed interaction between *Gambusia* and three species of *Aphanius* in southern Iraq. In the future, I strongly urge that native species should be given priority for introductions.

DISCUSSION

A total of 326 specimens were examined from different localities of eastern, southeastern, northwestern and southwestern Arabia. Collections made in 1977 and 1981, although restricted to Saudi Arabia, represent one of the most extensive sampling of freshwater fishes yet made from the Arabian Peninsula. The greatest concentration of freshwater fishes in Arabia occurs in the coastal drainage basin. The reason for this is that the range of mountains running parallel to the coast causes enough rainfall to maintain several permanent wadis (Banister and Clarke 1977). The freshwater fish fauna of Arabia is presumed to consist of isolated remnants of a once more extensive, heterogeneous fauna (Banister and Clarke op. cit.).

The following species and subspecies are recognized by the author: *Barbus apoensis*, *Barbus exulatus*, *Barbus arabicus*, *Cyprinion acinaces acinaces*, *Cyprinion acinaces hijazi*, *Cyprinion mhalensis*, *Garra tibanica tibanica*, *Garra tibanica ghorensis*, *Garra buettikeri*, *Garra mamshuqa*, *Garra sahilia sahilia*, *Garra sahilia gharbia*, *Garra barreimiae barreimiae*, *Garra Barreimiae shawkahensis*, *Garra longipinnis*, *Acanthobrama hadiyahensis*, *Aphanius dispar dispar*, *Aphanius dispar richardsoni* and *Gambusia affinis*. Undescribed species of *Barbus*, *Cyprinion* and *Garra* are recorded. The existence of *Cyprinion microphthalmum* and *Cyprinion watsoni* in Arabia is questionable. *Cyprinion muscatensis* is recognized as a full species.

Although no fish collections have yet been made in vast regions of Arabia and much is yet to be learned, some general conclusions can be made. It appears that the original African fish fauna existing up to the time of the initiation of the Red Sea rift in the Miocene were completely eliminated. All species of primary freshwater fishes known from Arabia are endemic species. This fact indicates long isolation.

The genus Cyprinion is of Asiatic origin and is represented by two, possibley three or four, (depending on validity of Cyprinion muscatensis and Khaybar species) endemic species. Howes (1982) synonomyized the genus Semiplotus with the genus Cyprinion. Furthermore, he concluded that C. acinaces is the closest living relative of C. milesi, and both are the sister-group of all other Cyprinion. However, Krupp (1983) doubted Howes' revision for several reasons. It is probable that C. acinaces and C. mhalensis are the result of divergence from a common ancestor in Arabia. The ancestral species is assumed to have moved across the Arabian Gulf from Iran during an early period of low ocean levels and a Gulf freshwater environment. Cyprinion muscatensis native to Oman appears to represent the most recent derived form from the ancestral species that moved across the Gulf during a later glacial epoch and did not have the opportunity to disperse eastward from Oman.

The genus Garra, also of Asiatic origin, crossed the Arabian Peninsula to become established in northeast Africa. Garra is represented by six, possibly seven, known endemic species. Menon's record of G. tibanica in Somalia is doubted (Al Kahem and Behnke 1983, Krupp 1983). It is probable that eastern and southeastern Arabian Garra are the result of divergence from a common ancestor in Arabia. The ancestoral species is assumed to have moved across the Arabian Gulf from Iran perhaps similar to C. muscatensis during a later glacial epoch and did not have the opportunity to disperse westward to southwestern and western Arabia. Western and southwestern Arabian Garra probably are derived from an ancestral stock dispersing from Africa to Arabia similar to B. arabicus origin. G. tibanica dispersed from the south to the southern Dead Sea Valley probably during Pleistocene times.

The genus Barbus is most abundant in its region of origin, the oriental region (Steinitz 1954). Banister (1980) divided Mesopotamian Barbus into two stocks: a. European stock with a cylindrical body, small scales and serrated dorsal spine, and an Afro-Indian stock with compressed body, large scales and smooth dorsal spine. Based on Banister's conclusion, all Arabian Barbus belong to the Afro-Indian stock. The three, probably four, endemic species of Arabian Barbus suggest two ancestral origins. B. apoensis and B. exulatus are most probably derived from an ancestor associated with the B. canis-B. luteus group invading from the north (Jordan R.) or from the east (Tigris-Euphrates or Mond R.). B. arabicus is most likely derived from an ancestral member of the Barbus intermedius complex, invading across the southern end of the Red Sea during a period of freshwater connections from northeast Africa.

Acanthobrama is a limited genus, both in area occupied and in number of species and is of Asiatic origin (Steinitz 1954). Acathobrama is represented only by one known endemic species in Arabia, Acanthobrama hadiyahensis. This species seems clearly derived from an ancestor which invaded the western Arabian Peninsula from the Jordan River basin, similar to the ancestral Barbus giving rise to Barbus apoensis and exulatus. Banarescu and Nalbant (1982) reviewed the noemacheiline loach (Cobitidae) species of the Jordan River drainage. It would be expected that cobitid fishes from the Jordan basin also had the opportunity to disperse to the Red Sea drainage of Saudi Arabia. Thus, 3 major invasion routes can be postulated to explain present distribution and speciation of primary freshwater species on Peninsula.

1. Across Arabian Gulf from Iran (G. barreimiae, G. longipinnis, all Cyprinion).
2. Northeast Africa (B. arabicus, G tibanica, G. buettikeri, G. mamshuqa, G. sahilia).
3. Jordan River (B. apoensis, B. exulatus, A. hadiyahensis).

Aphanius dispar, because of its ability to disperse through seawaters, does not represent ancient relict populations divergent from the parent species. The present distribution of Aphanius is assumed to be of late Pleistocene origin, when presently isolated internal basins had direct outlets to surrounding seas.

In Arabia, no fish collections have yet been made from Ar Rumah, As Sirhan and Euphrates basins. The other basins have not been extensively sampled. Much is yet to be learned on the freshwater fishes of the Peninsula.

Ichthyological studies can be of critical significance for interpretation of the climatic and hydrographic history of the country. Also, freshwater fish can become a more important part of the Arabian economy by increasing the supply of protein, by providing recreational and esthetic values and perhaps as biological control agents. However, introductions of non-native species without suitable planning and evaluation of all possible ramifications can cause ecological catastrophies. Utilization of native fishes to serve national interests should be given priority. My study on the freshwater fish fauna of Saudi Arabia emphasizes the need for a national awareness to preserve all native plants and animals and develop an environmental conscience to protect the nation's biological heritage. The rationale for the conservation of species will be elaborated in more detail in the following section on conservation.

SECTION TWO. CONSERVATION

THREATS TO CONTINUED EXISTENCE

Conservation and survival of endemic Arabian freshwater fishes depends on proper water management and the preservation of oasis environments. However, springs are the most endangered environments in Arabia and already I observed desiccation of springs. In Alula City, my home village (26° 37' N, 37° 52' E), there were 35 springs. When I visited the area in 1981, all of them were dry. The same situation occurred at Al Jawf and other cities in Saudi Arabia. Well drilling is responsible for such desiccations. Pumping water from springs at Al Hasa Oasis has restricted Aphanius dispar to very poor swampy habitats (person. obs.). One specimen of a probable undescribed species of Cyprinion was collected from an unnamed spring in Khaybar City in 1977. When this habitat was revisited in 1981, the spring was dry. Thus, Arabian endemic species are threatened due to many competing uses of water. The sparse natural waters of Arabia are under increasing impact from urban, agricultural and industrial demands. The third development plan of Saudi Arabia calls for national water development with consideration for water quality and quantity in relation to public health standards and for industry and agriculture, but water needs for any aspect of environmental conservation are ignored. To meet increasing demands, the development plan calls for more wells to be drilled. More large-scale irrigation projects and dams are planned for rapid implementation. Nomadic people have been responsible for the destruction of woodland and other types of plant cover, particularly in the Asir region, due to overgrazing, farming and charcoal burning (Landers 1981, Duba 1980). Observations in Iran have shown that devegetation severely affects the hydrological regime with consequent destruction of fish habitats (Coad, 1980). Thus watershed management is necessary to protect and restore water resources in Arabia. Six species of freshwater fishes have been introduced into Arabia (Al Kahem and Behnke 1983, Krupp 1983). During my visit to fish rearing ponds at Riyadh, Saudi Arabia, in 1981, a fishery consultant for the Saudi Arabian National Center for Science and Technology informed me that they are planning to introduce the common carp, Cyprinus carpio, and tilapia, Tilapia nilotica, into Wadi Jizan dam. There should be a general awareness in Saudi Arabia concerning the potential danger that introductions of exotic species have for native species or for disruptions of the ecosystem. Barbus arabicus is recorded in this reservoir. Thus, B. arabicus and other native fish species are the most appropriate since they have adapted to the environment for thousands of years. Exotic fishes from another continent or even from a different drainage basin may introduce disease or parasites to which nativefishes are ill-adapted, thus causing a drastic reduction in the population (Coad, 1980). Non-native species will probably prove to be serious predators or competitors of native fishes. Observations in other countries have shown that introduction of Gambusia is destructive not only to fish of similar and smaller sizes but also to larger fishes since Gambusia will eat their eggs and young (Myers 1965, Hurlbert et al. 1972, Coad 1980). Although pesticide poisoning of Arabian fishes has not been documented, the hazard is expected. Mishandling of pesticide applications are not uncommon in agricultural areas of Saudi Arabia (personal obs.).

RATIONALE FOR THE CONSERVATION OF SPECIES

Freshwater fishes of Arabia are restricted to the few remaining habitats suitable for their survival. All endemic species exist in the coastal drainage basin. Freshwater fishes of Arabia are facing threats of probable extinction because of encroachment on the habitat by man for economic gain. National awareness is urgent and necessary to preserve all native plants and animals and develop an environmental conscience to protect the Arabian biological heritage. Legal protection for threatened species is the goal to be attained. For this, a basic fact must be recognized. In Arabia, all laws must be based on the Qu'ran (The Glorious Book) and the Sunnah (Prophet's teachings). Any conservation law must have a basis in the Quran and the prophet's teaching. As we rapidly advance into the technological era, we probalbe are increasingly underestimating the finite nature of our resources and the extreme fragility of the natural environment upon which we depend so completely. A greater effort should be made to develop an environmental conscience. In order to do this the question must be asked: "Why should be conserve?" I examine several well-reasoned arguments for the preservation of species and habitats that address this broad question. I found a solid basis in Islamic teaching for conservation laws and a conservation ethic that gives due consideration to the preservation of all life and for a critical evaluation of short term gains vs. long term losses in regards to man's impact on the environment. The Islamic concept of the relationship of man to God and nature is based on the oneness of man and nature. Man's stewardship of the earth granted by God, basic rights granted by God to all living things, and man's duty to carry out God's will form the basic precepts for a conservation ethic.

Moral and Religious Beliefs

The presupposition with which Islam starts is that of God as the ultimate unity which stands behind and sustains the multiplicity apparent to our eyes (Dar 1979). A great example of this view is found in Abraham's faith. According to the story related in the glorious Qur'an, Abraham is a man who is steadfast in his faith in God despite all the tribulations and trials he has to undergo; he has submitted himself unconditionally before God, and does what God orders him to do unhesitatingly. The Qur'an refers to his total submission:

> "Behold! his Lord said to him: Bow thy will to Me. He said: I bow my will to the Lord and cherisher of the universe." (S.* Bagara, V*. 131).**

It was for this reason that the Qur'an describes him as the friend of God and the leader of humankind. Nothing is clearer than the following verse:

S means Sura = Chapter; V means verse.

**All verses used in this text are taken from the Glorious Qur'an translated (i.e. the meanings) in 1977 by A. Yusuf Ali and published by American Trust Publications, U.S.A.

> "And remember that Abraham was tried by his Lord with certain commands, which he fulfilled. He said: I will make thee an Imam to the nations. He pleaded: And also Imam to my offspring! He answered: But my promise is not within the reach of evil-doers" (S. Bagara, V. 124).

He gained knowledge of God through observation of the Kingdom of the heavens and earth: "So also did we show Abraham the power and the laws of the heavens and the earth, that he might with understanding have certitude" (S. An'am, V. 75). Abraham asserted: "For me, I have set my face, firmly and truly, toward Him who created the heavens and the earth, and never shall I give partners to God" (S. An'am, V. 74). According to the Qur'an, the God of Abraham has full control of the world and He determines the course of events in order to further His purpose and design in which man occupies a place of honor (Dar 1979). Abraham's God created the world with a purpose and has the welfare of mankind always before him (Dar 1979). This relationship is the peculiarity of Islam, which inherited the tradition of the Abrahamic presupposition. Ethics follows as a matter of course from this conception of God — it leaves behind all moral theories based on happiness or perfection, though what is true in these theories is contained in the ethics based on theistic presupposition (Dar op. cit.).

According to the Qur'an the believer in the unity of God (= Tawheed) can never be narrow-minded or shrivelled in outlook. He believes in a God who is the creator of the heavens and the earth, the master of the East and the West and the sustainer of the entire universe. He looks upon everything in the universe as belonging to the same Lord whom he himself belongs to. The believer knows that Allah (God) alone is the possessor of all power, and that besides him none can benefit or harm a person, or provide for his needs, or give and take away life, or wield authority or influence. A believer never becomes proud, haughty or arrogant. The boisterous pride of power, wealth and worth can have no room in his heart, because he knows that whatever he possesses has been given to him by God, and that God can take away just as He can give (Maududi 1977).

The belief in the unity of God creates in humans the consciousness that unless man lives rightly and acts justly he cannot succeed. The believer has firm faith in God who is the master of all the treasures of the earth and the heavens whose grace and bounty have no limit and whose power is infinite. The believer in Tawheed creates an attitude of peace and contentment, purges the mind of the subtle passions of jealousy, envy and greed, and keeps away the ideas of resorting to base and unfair means for achieving success. The most important effect of Tawheed is that it makes man obey and observe God's law. One who has belief in it is sure that God knows everything hidden or open and is nearer to him than his own jugular vein. We can hide from everyone, but we cannot hide anything from God; we can evade everyone, but it is impossible to evade God's grip. The firmer a man's belief in this respect, the more observant will he be of God's commands; he will shun what God has forbidden and he will carry out his behests even in solitude and in darkness, because he knows that God's police never leave him alone, and he dreads the court whose warrant he can never avoid (Maududi op. cit.). Thus the teachings of our Prophet Muhammad (God's blessings be upon him) firmly indicate that faith in one God is the most important and fundamental principle.

The glorious Qur'an is regarded by Muslims as the main source of their religion, laws and way of life (Tahir 1977). The Qur'an and the Sunnah are the sources for guidance to any problem to be solved. The glorious Qur'an contains fundamental principles for the regulation of human life. The Qur'an enumerates those basic laws in the light of which man may exercise his reasoning faculty, deciding what he must do as an obligation, what he may or may not do in his discretion and what he must forebear. The entire edifice of Islamic law, sociology and morals has been built by jurists, theologians and interpreters in the light of these basic principles of the Qur'an (Tahir 1977).

In Islam the inseparable link between mankind and nature, and also between the sciences of nature and religion, is to be found in the Qur'an itself, the Divine Book which is the word of God (Nasr 1968). As such the Qur'an is both the source of the revelation which is the basis of religion and that macrocosmic revelation which is the universe. Both mankind and nature are created by God. By refusing to separate man and nature completely, Islam has preserved an integral view of the universe and sees in the arteries of the cosmic and natural order the flow of divine grace (Nasr op. cit.). Man seeks the transcendent and the supranatural, but not against the background of a profane nature that is opposed to grace and the supranatural. From the bosom of nature man seeks to transcend nature and nature itself can be an aid in this process, provided man can learn to contemplate it, not as an independent domain of reality but as a mirror reflecting a higher reality, a vast panorama of symbols which speak to man and have meaning for him (Nasr op. cit.). Living and non-living beings are termed in the Qur'an as "signs of God":

"Behold! In the creation of the heavens and the earth; In the alternation of the night and the day; In the sailing of the ships through the ocean for the profit of mankind; In the rain which God sends down from the sky; and the life which he gives therewith, to an earth that is dead; in the beasts of all kinds that He scatters through the earth; In the change of the winds, and the clouds which they trail like their slaves between the sky and the earth; Here indeed are signs for a people that are wise" (S. Bagara, V. 164).

Ali (1977:64) in his comments on this verse wrote

"This magnificent nature passage stands out like a hill in a landscape, enhancing the beauty of our view, and preparing us for the every-day laws and ordinances which follow. Note its literary architecture. God is one; and among His wondrous signs is the unity of design in the widest diversity of nature. The signs are taken from the features of beauty, power, and utility to man himself, and lead up to an appeal to man's own intelligence and wisdom. We begin with the glory of the heavens and the earth, the wide spaces covered by man's imagination, remote and yet so near to his own life. The most striking every-day phenomenon resulting from the interrelations of the heavens and the earth is the alternation of day and night, regular and yet changing in duration with the seasons and the latitudes of our globe. The night for rest, and the day for work; and we can think of the work in terms of nature's beauty; the stately ships sailing through the ocean, for communications and merchandise between men. The seas thus serve us no less than the land, and the give-and-take between sea, sky, and land is further exemplified by the rain. The rain leads to the fertility of land, and here we are reminded of the contrast between the winter's death of nature and her revivification in the spring. Here we are reminded of agriculture and the use we make of cattle and all kinds of living creatures. The word translated 'beasts' has a wide meaning, including crawling creatures, insects, etc. — all contributing to the round of nature's operations. This leads us on to the wonderful winds, the region of the air, which man is just beginning to explore and navigate. The personified winds drive the clouds in the sky. Here is another aspect of clouds besides that of giving rain. The fleecy clouds are things of sunset beauty; at the mid-day they temper the glare of the sun; at all times the affect radiation and other processes going on in the sky. So we come back to the sky, rounding of the argument, and correlating our human life with the will and power of God, if we had the wisdom to see!"

The creation of man is termed in the Qur'an as the appointment of the Viceroy of God on earth:

> "Behold, thy Lord said to the angels: I will create a vicegerent on earth. Thy said: Wilt thou place therein one who will make mischief therein and shed blood? — whilst we do celebrate they praises and glorify thy holy name?" He said: "I know what ye know not." (S. Bagara, V. 30).

Man therefore occupies a particular position in this world. Thus according to the Islamic world view, God created the earth and heavens for the use of man. But man has to work in accordance with the code of ethics provided within the system, or else in the case of deviations, man earns God's wrath: "Then we made you heirs in the land after them, to see how ye would behave" (S. Yunis, V. 14). Thus Islam recognizes that man by virtue of his creation is a superior being, but at the same time he has been made responsible for any departure in his behavior from the ways laid down by God (Zaidi 1981). As discussed previously, man is the viceroy of God on earth, so he is the instrument of his Will. Grace and justice, are inherent factors manifested in his Will and intention (Zaidi 1981). God describes the Prophet Muhammad (Peace be upon him) as a person of great character, "Khulg": "And thou standest on an exalted standard of character" (S. Qalam, V. 4).

It is this Khulg of the Prophet (Peace be upon him) that sets the standard for the ethical excellence, which we must strive to achieve as well as possible, and it is this character that must govern the decision-action processes in all spheres of life including our interaction with the environment (Zaidi 1981). It is worth remembering that the basis of the Prophet's (Peace be upon him) character is justice; and justice has no meaning without piety ("Taqwa") and knowledge. Thus, justice, piety and knowledge are the core concepts on which Islamic administrative policies must be formulated, the policies which manifest obedience to God. As the Caliphate Ali puts it:

> "Islam means obedience to God; obedience to God means having sincere faith in Him; such a faith means to believe in His power; a belief in His power means recognizing and accepting His majesty; acceptance of His majesty means fulfilling the obligations laid down by Him; and fulfillment of obligation means action" (Zaidi op. cit.).

Thus, faith in Islam means action, action which must be administered within the framework of the character of the Prophet (Peace be upon him), whose obediance is in fact obedience to God, who orders obediance to Divine leadership as well (Zaidi op. cit.); and this is clearly stated in the following verse: "He who obeys the Apostle, obeys God; but if any turn away, we have not sent thee to watch over their evil deeds (S. Nisaa, V. 80).

Within such a matrix of decision-action processes, the main causes leading to the undesirable effects of man's interaction with the environment like greed, extravagance, ignorance, careless use of technology, and mismanagement of resources can be properly controlled (Zaidi op. cit.). Every Muslim is required to observe Piety in all kinds of decision and action (Zaidi op. cit.). Thus it is worth remembering the following verse:

> "O children of Adam! We have revealed unto you raiment to conceal your shame, and splendid vesture, but the raiment of restraint from evil [Taqwa], that is best. This is of the revelations of Allah; that they may remember" (S. A'raf, V. 26).

Worship in Islam is not restricted to the purely devotional practices (prayers, fasting) but extends over the whole of man's practical life as well (Asad 1979). Thus our actions must be performed as acts of worship. Every individual Muslim has to regard himself as personally responsible for all happenings around him and to strive for the establishment of right and the abolition of wrong at every time and in every direction (Asad op. cit.).

A sanction for this attitude is to be found in the verse of the Qur'an: "You are the best community that has been sent forth to mankind: You enjoining what is right, forbidding what is wrong, and believing in God" (S. Al-i-'imran, V. 110). Here moral knowledge automatically forces moral responsibility upon man (Asad op. cit.). In the quest of maximizing benefits from his environment, man has had an excellent record (Zaidi 1981). However, in the process, man has also created serious environmental disruptions. Freshwater and marine resources are of great importance, seen as potentially profitable. Man has always harvested the sea, but with his skill and modernized technology, populations of blue whale, tuna, sardine and anchovies have been depleted (Simmons 1981).

It is worth mentioning here the Islamic attitude toward natural resources (including fish) as seen by a well known Islamic scholar; Sayyid A bul A'la Maududi. Maududi (1977:112-115) wrote:

> "Man has been endowed with countless powers and faculties and providence has been very bountiful to him in this respect. He possesses intellect and wisdom, will and volition, faculties of sight, speech, taste, touch, and hearing, powers of hands and feet, passions of love, fear and anger and so on. His very life and success depend upon the proper use of these powers for the fulfilment of his needs and requirements. These God-given powers are meant for his

service and unless they are used in full measures life can't become worth living. God has also provided man with all those means and resources which were needed to put his natural faculties to function and to achieve to fulfilment of his need his environment and surroundings contain resources of every description; resources which he uses as means for the achievement of his ends. These powers and resources have been conferred upon you so that they may be used for the good of others. They have been created for your good and are not meant to harm and destroy you. Their function is to enrich life with good and virtue and not to throw it into jeopardy. Thus the proper use of these powers is that which makes them beneficial to you, and even if there be some harm, it must not exceed the unavoidable minimum. That alone would amount to the proper utilization of these powers. Every other use which results in waste or destruction would be wrong, unreasonable, and uncalled for. If your actions harm others and make you a nuisance to them, that would be a shear folly and an utter misuse of God-given powers. Or if you waste the resources, spoil them for nothing or destroy them, that too would be a gross mistake. Such activities would be flagrantly unreasonable, for it is the human reason which suggests that destruction and injury must be avoided and the path of gain or profit be pursued. And if any harm be counted, it must be only in such cases where it is just unavoidable. Any deviation from this would be evidently a wrong course. Those who knowingly misuse their powers and resources and through this misuse waste the resources, injure their own vital interests and cause harm to other people. Those who intentionally misuse their powers are wicked and evil-mongers and deserve the powerful club of law for their control and reform. Those who err because of ignorance need proper knowledge and guidance so that they see the right path and make the best of their powers and resources. And the code of behavior — the shariah — which God has revealed to man fulfils this very need. The Shariah stipulates the law of God and provides guidance for the regulation of life for the best interests of mankind. Its objective is to show the best way to man and provide him with the ways and means to fulfill human needs in the most successful and most beneficial way. Man should use them in such a way that he and his fellow human beings may reap handsome prizes from them and should never intentionally or unintentionally be of any harm to God's creation.

The fundamental principle of the law is that man has the right and in some cases it is his bounden duty, to fulfill all his genuine needs and desires and make every conceivable effort to promote his interests and achieve success and happiness, but (and it is an important but) he should do all this in such a way that not only the interests of other people are not jeopardized and no harm is caused to their strivings towards the fulfilment of their rights and duties, but there should be all possible social cohesion, mutual assistance, and cooperation among human beings in the achievement of their objectives. In respect of those things in which good and evil, gain and loss are inextricably mixed up, the tenet of this law is to choose little harm for the sake of greater benefit and sacrifice a little benefit for avoiding a greater harm. This is the basic approach of the Shariah.

Islam has strongly forbidden any action which causes harm to other people and becomes a source of menace to society. Islam does not want a man to become so selfish and self-centered that for the attainment of a few charms of the mind and body he unashamedly assails the right of others and violates all sanctions of morality."

Chapra (1979) emphasized that if the individual hurts the interests of others, then restrictions can and should be imposed on him. All jurists allow restrictions to be imposed if this prevents injury to other or safeguards public interest. Social welfare has a place of absolute importance in Islam. Individual freedom, though of primary significance, is not independent of its social implications (Chapra op. cit.). Thus the interest of society takes precedence over the interest of the individual. Individual freedom is therefore sacred only as long as it does not conflict with social interest, and only as long as the individual does not transgress the rights of others (Chapra op. cit.).

Chapra (op. cit.) added: "since all wealth is a trust of God, it would be a grave moral crime to destroy life." Destroying both life and property has been declared by the Qur'an to be equivalent to spreading mischief and corruption in the world: "When he turns his back, his aim everywhere is to spread mischief through the earth and destroy crops and cattle. But God loveth not mischief." (S. Baqara, V. 205).

Chapra (op. cit.) contended that it was this teaching of the Qur'an which promoted Abubakr, the first caliph, to instruct his generals going on a war assignment not to kill indiscriminately or to destroy vegetable or animal life even in enemy territory. He concluded that if this is not allowed in war, there is no question of its being allowed in peace.

All Muslims without exception are faced with special responsibilities. Every one has obligations to his own family and towards the society (Irving 1980). Thus man has the obligation to husband all species for his own interest and the interest of his fellow human and future generations.

The superior position given to man does not mean that God has given him unbridled liberty. Islam says that all the creation (including fish) has certain rights binding upon man (Maududi 1977). He should not waste them on fruitless ventures nor should he unnecessarily hurt them or harm them (Maududi op. cit.). The law of Islam allows us to slaughter animals for food but we are forbidden to kill merely for fun or sport and deprive them of their lives without necessity (Maududi op. cit.). Islam teaches the hunter that he should not hunt merely for sport, taking the life of animals without intending to eat them or otherwise benefit from them (Al-Qaradawi 1960). The Prophet (peace be on him) said: If some one kills a sparrow for sport, the sparrow will cry out on the day of Judgement, 'O Lord! that person killed me in vain! He did not kill for any useful purposes.' Again he said: whoever kills a sparrow or anything bigger than that without a just cause, Allah will hold him accountable on the day of judgment. The listeners asked, O Messenger of Allah, what is a just cause? He replied, that he kill to eat, not to simply chop off its head and then throw it away. As for water-game God has permitted all of it, but without any unnecessary cruelty as far as possible (Al-Qaradawi op. cit.). Reminding all Muslims God says; "Lawful to you is the pursuit of water-game and its use for food — for the benefit of yourselves and those who travel." (S. Maida, V. 99).

Maududi (1977) mentioned that Islam does not approve even the useless cutting of trees and bushes. Man can use their fruits and other produce, but he has no right to destroy them. Maududi (1977) added:

> "vegetables after all possess life, but Islam does not allow the waste of even lifeless things; so much so that it disapproves of the wasteful flow of too much water. Its avowed purpose is to avoid waste in every conceivable form and to make the best use of all resources — living and lifeless. Regarding the beasts of burden and animals used for riding and transport, Islam distinctly forbids man to keep them hungry, to take hard and intolerable work from them and to beat them cruelly."

Any Muslim who plants a tree or cultivates a field such that an animal or a human being eats from it, this act will be counted as an act of charity (Chapra 1979).

Thus justice in Islam is not only for humankind, but also extends to include all living things. The ancient nation of Thamud was warned that even a thirsty camel has its drinking rights. "For we will send the she-camel by way of trail for them, so watch them, (O salih), and possess thyself in patience" (S. Qamar, V. 27). "And tell them that the water is to be divided between them each one's right to drink being brought forward by suitable turns" (S. Qamar, V. 28). Thus animals must not be allowed to die of thirst. If senseless destruction is not allowed for terrestrial animals, there is no question of its being allowed to occur to fishes, which live in water and can't survive outside it. Another example of Islamic instruction to care about all living things can been seen from the following Hadith (= Prophet teaching): The Prophet of the world (peace be on him) urges us to be merciful and helpful to all of God's creatures.

Khan (1976) stated that Abu Huraira tells us that Allah's Apostle (peace be on him) said:

> "while a man was walking on a road, he became very thirsty. Then he came across a well, got down into it, drank of its water and then came out. Meanwhile, he saw a dog panting and licking mud because of excessive thirst. The man said to himself, this dog is suffering from the same state of thirst as I did. So he went down the well and filled his shoe and held it in his mouth and watered the dog. Allah thanked him for that deed and forgave him. The people asked: O, Allah's Apostle! Is there a reward for us in serving animals? He said: Yes, there is a reward for serving any living being." (Dr. Muhammad Khan is a translator of the meanings of Sahih Al-Bukhari and should not be confused with the original narrators such as Abu Haraira and others.).

Living beings include also those living in water (i.e. fishes, crustaceans, etc.), so anyone who protects their habitat to prevent their suffering will be rewarded.

Charity and sacrifice is not uncommon in an Arab land. Imam Al Maqdsi (1978:206) tells us the following story:

> "While Abdulah bin Jafar was going to his garden, he stopped by at a neighboring farm. He saw a black man preparing his lunch. The black man saw a hungry dog entering the farm. He fed the dog with all his lunch. Abdulah asked the man: Why did you prefer the dog over yourself, even though you are hungry? The man replied: It is not a land of dogs. The dog must come from long distance. The dog must be hungry. Then Abdulah asked, do you have more food? The man replied no, but I will eat in the next day. Abdulah said to himself, this man is more charitable than I. Abdulah bought the farm and the slave. He freed him and gave him the land."

It is not surprising to find that our daily newspapers urge people to be kind, merciful and helpful to all animals. For example in Al Madinah's newspaper (March 5, 1983), the editorial staff claimed the priority of Islam with regard to animal preservation. Furthermore, they claimed that a Muslim must properly feed, house, and look after all animals. They contended that the Prophet (peace be on him) is the prophet of the world, who sincerely urges his followers to be merciful and helpful to all animals. They added that the Prophet (peace be on him) saw a captive camel. He told the owner to free the camel. He asked him to observe God in every action. Even killing of small animals is not allowed (Al Jazerah, May 23, 1983). The following Hadiths (Prophet teachings) will shed some light on some of our responsibilities toward animals.

Ibn 'umar told that he heard God's messenger prohibit keeping an animal or anything else waiting to be killed (Bukhari and Muslim).* The prohibition is said to refer either to keeping such animals without food and drink or to imprisoning them and using them as targets.

Ibn 'Abbas reported the Prophet as saying "Do not take any living creature as a target.*"

Abu Huraira reported that God's messenger said that when a prophet was stung by an ant he ordered a colony of ants to be burned and God most high revealed to him, "Because an ant stung you, you have burned a community which glorifies me" (Bukhari and Muslim).* From what has been described previously, one strongly can conclude that species' protection has a basis in our religious and cultural heritage.

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*Taken from Miskat Al-Masabih (V. II). Translated by James Robson (1975: 872,879) and Published by S. H. Muhammad Ashraf, Kashmiri Bazar, Lahore (Pakistan).

Aesthetic Values

Aesthetically, species add to the diversity and texture of life's fabric on earth (Myers 1979). Every species is recognized as "a work of art" that can instill pleasure or satisfaciton or that merits preservation by virtue of its unique status (Bunnell and Williams 1980). Raising of fishes in aquaria in Saudi Arabia is a very common activity today. *Aphanius dispar* is commonly kept in aquaria (pers. obs.). According to Islam all the heavenly bodies and this earth and all rational beings, who have their existance in the midst of these, manifest God's beauty. And indeed there is nothing that does not manifest his beauty and his goodness (Sarwar 1938). Islam emphasized that all beautiful things should be the privilege of those with faith in God:

> "Say: Who hath forbidden the beautiful gifts of God, which he hath produced for his servants, and the things, clean and pure, which he hath provided for sustenance? Say: They are, in the life of this world, for those who believe, and purely for them on the day of judgment. Thus we do explain the signs in detail for those who understand" (S. A'raf, V. 32).

The beauty of plants and animals is described by several verses of the glorious Qur'an. Thus, it is worth remembering the following verses:

> "Seest thou not that God sends down rain from the sky? With it we then bring out produce of various colours. And in the mountains are tracts white and red, of various shades of colour, and black intense in hue" (S. Fatir, V. 27).

> "And so amongst men and crawling creatures and cattle, are they of various colours. Those truly fear God, among his servants, who have knowledge: For God is exalted in might, off-forgiving" (S. Fatir, V. 28). "And ye have a sense of pride and beauty in them as ye drive them home in the evening, and as yet lead them forth to pasture in the morning" (S. Nahl, V. 6).

In his commentaries on those verses, Ali (1977:1160, 1161, 657) wrote:

> "Man can see by his own experience what infinite shades and grades of colour there are in nature. Everyone can see how God's artistry produces from rain the wonderful variety of crops and fruits — golden, green, red, yellow and showing all the most beautiful tints we can think of. And each undergoes in nature the gradual shading of in its transformation from the row stage to the stage of maturity. The wonderful colours and shades of coloures are to be found not only in vegetation but in rocks and mineral products. In physical shapes of human and animal life, also, we see variations in shades and gradations of colours of all kinds. But these variations and gradations, marvellous though they be, are as nothing compared with the variations and differences in the inner or spiritual world. In outer nature we can, through colours, understand and appreciate the finest shades and gradations. But in the spiritual world that variation or gradation is even more subtle and more comprehensive. Who can truly understand it? Only God's servants, who know, i.e. who have the inner knowledge which comes through their acquaintance with the spiritual world, — it is such people who truly appreciate the inner world, and it is they who know that the fear of God is the beginning of wisdom. for such fear is akin to appreciation and love — appreciation of all the marvellous beauties of God's outer and inner ("God is exalted in might") and love because of his grace and kindness ("off-forgiving"). But God's forgiveness extends to many who do not truly understand Him. The good man is proud of his cattle and is good to them. As they go to and return from pasture, morning and evening, he has the sense of his power and wealth and their beauty and docility. Will not man turn from these material facts to the great spiritual truths and purpose behind them?"

Thus, in order to enjoy and contemplate animal beauty (including fishes) we must prevent their extinction due to man's intervention.

Animal Species Serve Man

Animal species' protection serves strictly utilitarian purposes of immediate value to society (Myers 1979). Myers (op. cit.) stated that present uses of genetic resources run into many thousands of forms, the main categories being modern agriculture, medicine and pharmaceuticals, and industrial processes. He added:

> "in view of the benefits derived from the small segment of species investigated thus far, the planetary spectrum of species can be considered among society's most valuable raw materials. He strongly emphasized that the erosion of genetic resources is not only a loss to future generations, but an impoverishment for present society."

According to Islam, God created animals to serve man. The following verses will increase our knowlege of such services: "And cattle he has created for you: from them ye derive warmth, and numerous benefits, and of their (meat) ye eat" (S. Nahl, V. 5). "Of the cattle are some for burden and some for meat, eat what God hath provided for you, and follow not the footsteps of Satan: for he is to an avowed enemy" (S. An'am, V. 142).

> "It is God who made your habitations; homes of rest and quiet for you; and made for you, out of the skins of animals, tents for dwellings, which you find so light when ye travel and when ye stop; and out of their wool, and their soft fibres, and their hair, rich stuff and articles of convenience for a time" (S. Nahl, V. 80).

Fishes are an important source of protein and are allowable for human consumption as is made clearer in the following hadith:

> "Ibn umar reported God's messenger as saying, Two types of animal which have died a natural death and two types of blood have been made allowable to us, the two which die a natural death being the fish and the locust, and the two types of blood being the liver and the spleen," (Taken from Mishkat

Al-Masabih, an English translation with explanatory notes by James Robson (1975:880).

Fish flesh is an important source of high grade animal protein (FAO, 1981). With growing world population and rising expectations for living standards, the pressures on fish both as a source of food and for its byproducts can only increase in the future (FAO op. cit.). Fisheries not only provide a significant portion of the protein available for human consumption, they are also an economically significant activity, providing jobs and investment opportunities, and, for many countries, a means of improving the balance of international trade (FAO, op. cit.). At the present time a considerable effort is being made to exploit the Red Sea and Arabian Gulf. Arabian freshwater can become a more important part of the Arabian economy by increasing the supply of protein. Some of the large cyprinid species may become important food fishes if stocked into reservoirs. Aphanius dispar feeds on filamentous algae and mosquito larvae (Al-Daham et al. 1977, Ataur-Rahim 1981, Haas 1982). Thus, it could be used for biological control. As a part of public education, I published a suggestion in the Al Jazerah newspaper (June 24, 1983) regarding the possibility of using A. dispar for biological control of filamentous algae and to control mosquitos in Saudi Arabia. Desert fishes are the first vertebrates to be affected by alternation and disruption of limited surface water (Soltz and Neiman 1978). Fishes indicate an ecosystem stability. The waters in which fish live are part of an ecosystem that may have considerable tangible values, such as providing water to a village dependent on it. Such values could be lost as a result of ground water pumping.

<u>Diversity and Stability of Ecosystem</u>

It is often argued that the more numerous an ecosystem's species, the greater is the ecosystem's stability (Myers 1979). Human beings like all other animals are societies of individuals, not individuals living by themselves and for themselves (Sarwar 1938). Fish, pigeons, reptiles, etc. — all are communities. Sarwar (op. cit.) emphasized that the existence of social life presupposes a social or communal law. Without this law no community can exist. It is the recognition of this law by instinct among animals, and by instinct and volition in man that the existence of community becomes possible and its life can continue to progress. In fish and other animals the whole law of the community is based on the instinct of making the community a permanent one (Sarwar op. cit.). These communities have become almost perfect in their adaptations to their surroundings. It is clear that all living things on this earth are communities and have their communal existence which necessarily implies communal law: "There is not an animal that lives on the earth, not a being that flies on its wings, but forms part of communities like you. Nothing have we omitted from the book, and they all shall be gathered to their Lord in the end." (S. An'am, V. 38). "Animals living on earth" include fishes, reptiles, insects, etc.

Sarwar (op. cit.) strongly contended that every thing that is injurious to communal life is a sin against the community. Sarwar (op. cit.) stated that the basis of animal morality is survival and success or continuity. And where we look into the record of primitive human societies we find the desire for permanence predominating over all desires and their behavior is governed by the search for means of a permanence. He insisted that the Prophet (peace be on him) sees that it is not right for his tribesmen to kill foreigners. The Prophet sees the oneness of mankind and the oneness of all animal life. It is the wisdom of God when He ordered Noah to take with him one pair of each species:

> "At length, behold! There came our command, and the fountains of the earth gushed forth! We said: Embark therein, of each kind two, male and female, and your family — except those against whom the word has already gone forth, and the believers. But only few believed with him." (S. Hud, V. 40).

Thus it is not the right of man to eliminate any of God's creatures from the planet earth.

Scientific Research Value

Many species that are otherwise economically negligible have some unique or special characteristic that makes them extremely valuable to research scientists (Ehrenfeld 1976). The desert pupfish of the United States, which is currently poised on the brink of extinction, could serve medicine through its remarkable tolerance to extremes of temperature and salinity, an evolved attribute that might assist research into human kidney diseases (Myers 1979). Old world cyprinodontids of the genus *Aphanius* and new world representative of the genus *Cyprinodon* inhabit corresponding remnants of similar environments produced by arid climates (Villwock 1982). *Aphanius dispar* can tolerate a wide range of temperature and salinity (Haas 1982). Thus *Aphanius* of Arabia could serve medicine through its remarkable tolerance of temperature and salinity. Endemic species evolving in Arabia are significant for the country's biological heritage.

Teaching Values

Endemic freshwater fishes and their environments provide excellent material for the training of future Saudi Arabian biologists in life history and ecological studies.

PRESERVATION STRATEGY

In 1981, the Saudi Meteorology and Environmental Protection Administration (MEPA) issued environmental standard document (1401-01). The purpose of these standards is to provide adequate basis for the evaluation and regulation of industrial and urban activities that currently exist in the Kingdom and to help in the planning, design, execution and operation of facilities that will be established over the next few years in a manner which shall not adversely affect the health, safety and welfare of the People and which shall help in promoting their overall economic and social well being. The emphasis of these standards is devoted to meteorology and pollution in relation to human health. This document contains no reference to fish and wildlife protection. Forest and Range law signed in 1978 is one of the first Kingdom-wide conservation policies, but its path is ill-defined and slow (Duba 1980). It also contains no reference to fish and wildlife preservation. In its development planning, the government of Saudi Arabia has established a policy to "create and maintain a system of parks and related services." The purpose of this endeavor is to assure that the significant scenic, natural, cultural, and recreational resources of the Kingdom will be identified and afforded protection for the benefit and enjoyment of present and future generations (Wirth 1983). One of the management objectives is to protect and manage the wildlife and (where feasible) reintroduce native species. Although the term wildlife could include fishes, the protection of freshwater fishes has not been clearly delineated. Legal protection for freshwater fishes of Arabia is the goal to be attained. In order to protect freshwater fishes I recommend the following:

1. Increase effort to survey and document fish species distributon and the status of their habitat.
2. Initiate life history studies.
3. Study the impact of man and domestic livestock on selected habitats within Asir National Park's boundaries.
4. Develop an environmental protection law requiring elucidation and consideration of the cost/benefit trade offs of the proposed actions.
5. Petition for conservation laws that may be effective to save species from extinction and protect their environments.
6. Establish a wildlife conservation agency authorized for biological management, research, and law enforcement. Such an agency would provide input during planning and development stages of water projects.
7. Initiate an environmental program to educate the Saudi people on the importance of their natural resources and its conservation. Publishing the results of this thesis will shed some light on the philosophical basis for natural resources conservation in Islamic societies.

These recommendations are wholly compatible and in complete accord with the basic tenets of Islam pertaining to man's relationship and duties to God, the oneness of man and nature and man's obligations inherent in his God granted stewardship of the earth.

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