THESIS

FRESHWATER FISHES OF SAUDI ARABIA

Submitted by

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY Hmoud Fares Alkahem ENTITLED Freshwater Fishes of Saudi Arabia BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF Master of Science.

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ABSTRACT OF THESIS

FRESHWATER FISHES OF SAUDI ARABIA

This work is the first comprehensive scientific collection and report on freshwater fishes from Saudi Arabia. About 600 specimens representing 8 species are discussed. Three new species of the genus Cyprinion were discovered.

The first record of a non-native fish (Gambusia affinis) from Saudi Arabia is given. Several new distributions are recorded.

Comprehensive appraisal of geological, geographical and climatic events correlated with zoogeographical evidence and interpretation of degree of divergence in living species are utilized to provide an interpretation of factors explaining the present distribution and taxonomy of freshwater fishes of Arabia.

Cultural and religious bases are presented as a rationale for preserving and protecting the native fishes of Saudi Arabia as a part of our biological heritage.

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The drawings of undescribed species of Cyprinion are the work of Mrs. Doris M. Rust, Colorado State University.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Arabian Peninsula consists of several nations. The largest is the Kingdom of Saudi Arabia, which occupies some four-fifths of the Arabian Peninsula (= Arabia). Other political subdivisions of the Peninsula are South Yemen, North Yemen, Oman, United Arab Emirates, and Qater.

Arabia is bounded by the Red Sea on the west, the Gulf of Aden and the Arabian Sea on the south, the Gulf of Oman and the Arabian Gulf (also called Persian Gulf) on the northeast (Plate 1). Geographically, the Peninsula and Syrian desert merge in the north without clear topographic demarcation, but the political boundaries of Saudi Arabia with Jordan and Iraq and Kuwait with Iraq are generally taken as marking the limit of Arabia.

During the early Cenozoic, Arabia was part of a continuous African-Asiatic land mass. From the middle to the end of this era an erosional process increased as a result of land movements causing an opening of the Arabian Gulf at the strait of Hormuz connecting the Gulf to the Indian Ocean (Abualula, 1975). During the Miocene the Red Sea was an arm of the Mediterranean Sea or the Tethys Sea. At that time the Red Sea was separated from the Indian Ocean, but in the beginning of the Pliocene, the land surface was raised, as a result of which the Red Sea separated from the Mediterranean-Tethys Sea and the Strait of Babalmandeb was formed connecting the Red Sea to the Indian Ocean.

The vertebrate fauna of Arabia are typical of the Ethiopian-Indian groups with a few Palearctic relicts. Among birds there are some Palearctic relict forms in Yemen, such as the Bullfinch and Gray shrike (Ripley, 1954). There are Palearctic relict reptiles and numerous insects, all presumably dating from a Pleistocene dispersal (Ripley, 1954). "Among mammals none can be ascribed to Palearctic origins with the possible exception of the hedgehog, the rest being derived either from Africa or the Orient" (Ripley, 1954).

Freshwater fishes are the best evidence of past land connection 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.

Virtually nothing is known of freshwater fishes of Arabia. 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 on 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. The most comprehensive work regarding freshwater fishes of the Arabian Peninsula with the first mention of freshwater fish from Saudi Arabia is the study of Banister and Clarke (1975). They recognized nine species of three genera of the "minnow" family Cyprinidae and one species of the "top minnow" family

Cyprinodontidae. All except one of the cyprinid species are considered endemic to Arabia, indicating the long isolation of most of Arabia from direct freshwater access routes of dispersal.

My collections made in 1977, although restricted to Saudi Arabia, represent the most extensive sampling of freshwater fishes yet made on the Arabian Peninsula. I found all of the species described by Banister and Clarke from Saudi Arabia plus three undescribed species of Cyprinion. The first record of the American mosquitofish, Gambusia affinis (Poecilidae), from Arabia was found in my collections.

It is important that further studies be initiated soon to increase the knowledge of the freshwater fish 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 fish species will likely be introduced. Unless the present fish fauna is studied and documented, species may become extinct before they were known to exist.

Plate 1 is a detailed map of Arabia and surrounding African and Asiatic regions to serve as a reference for the following discussion on the freshwater fishes of Arabia and the geological and hydrological factors determining their distribution and speciation. For most Arabic names there is no standard English spelling. For example, the Hadramut (an area and a wadi in South Yemen) may also be found in the literature as Hadramawt or Hadramaut.

GEOLOGICAL AND CLIMATIC HISTORY OF ARABIA

The Arabian Peninsula is a huge crustal plate composed of ancient sedimentary and volcanic rocks (Figure 1). In Pre-Cambrian time, long before the formation of the Red Sea, the peninsula was attached to Africa as a part of the African shield (Chapman, 1978). In late Precambrian, its surface was deeply eroded and peneplained. 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, 1978). Throughout Paleozoic, Mesozoic and early Cenozoic periods, many thousands of meters of sediments accumulated in the deep, slowly-sinking Tethys trough (Chapman, 1978). 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, 1978). The Mesozoic era was mainly a time of uplift and non-deposition (Brown, 1970).

During Miocene times the Red Sea was an arm of the Mediterranean but was separated from the Indian Ocean. From the middle to the end of the Cenozoic an erosional process increased as a result of land movements, causing an opening of the Arabian Gulf at the Strait of Hormuz, connecting the Gulf to the Indian Ocean (Abualula, 1975). During the Pliocene, the connection between the Red Sea and the Indian Ocean was established and the connection to the Mediterranean Sea was closed. Apparently, Arabia broke away from Africa by the opening of the Strait of Bab Almandab which allowed the Indian Ocean

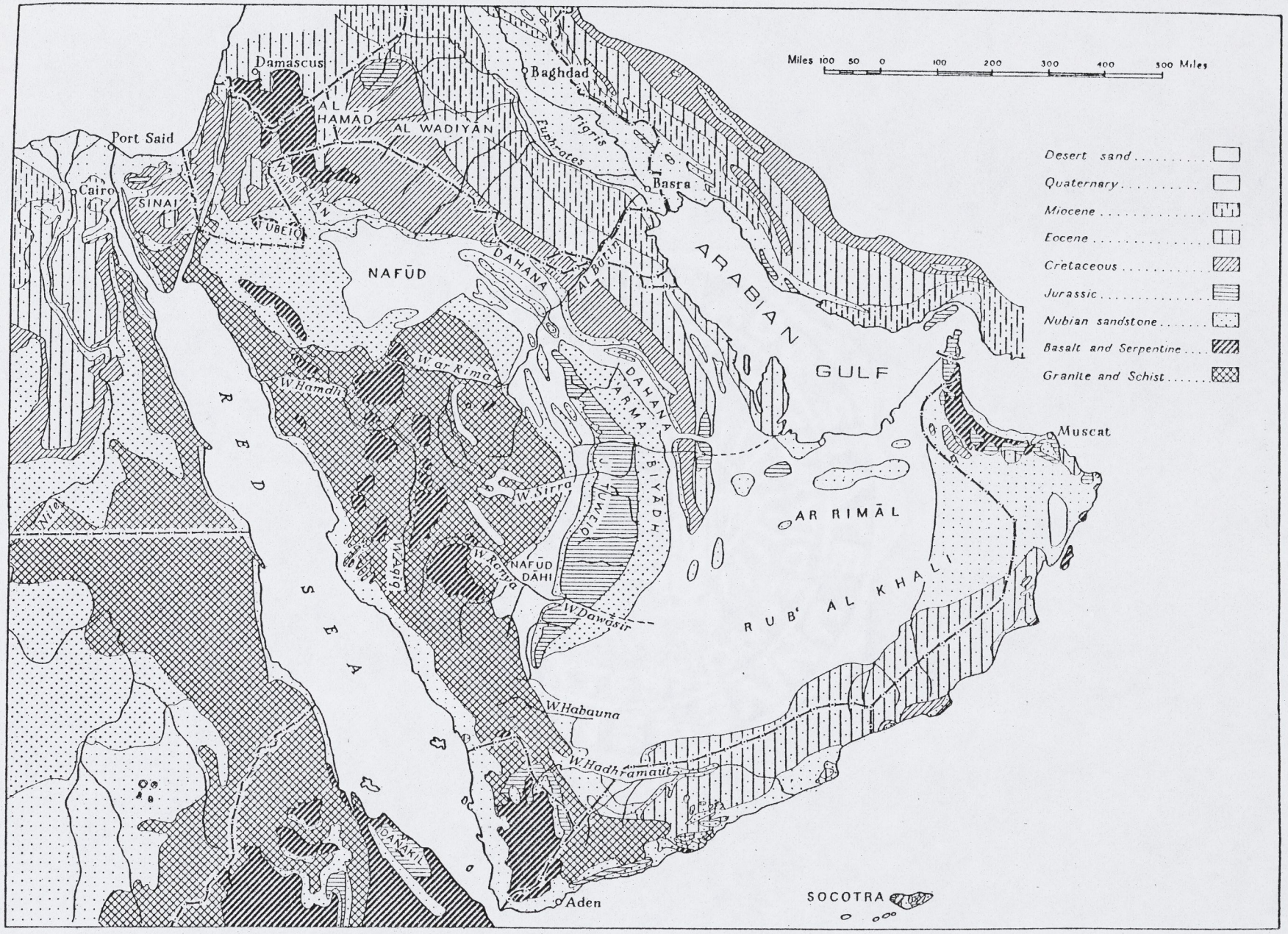

Figure 1. Geological map of Arabia (Adapted from Anon., 1946, Gr. Brit. Naval Intell. Div., Geographical Handbook Series, Western Arabia and the Red Sea).

waters to enter the Red Sea depression from the south (Coleman, 1973).

Miocene freshwater fish fossils are known from the Jizan Basin near Tihama north of Yemen. The fossil species recognized by Dunkel include two families of freshwater fish, Cichlidae and Cyprinidae (Brown, 1970). One of the Miocene fossils falls within the structural range of the recent genus Barbus. The other is close to the genus Tilapia (Brown, 1970). 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 climates 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 dispersal.

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 large rivers in the Arabian Peninsula (Fig. 2).

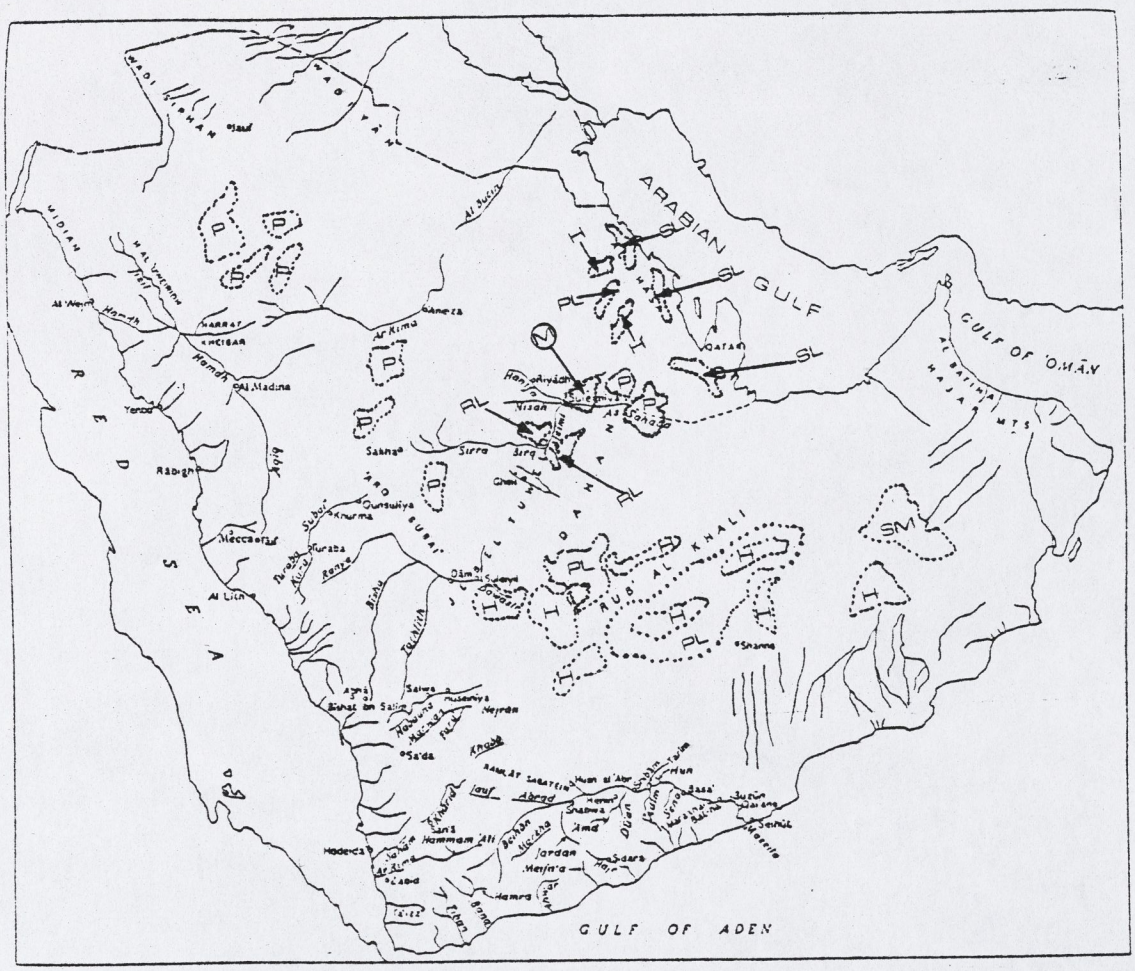

Figure 2. Assumed pluvial lake systems of Saudi Arabia: Miocene (M), Pliocene (P), Pleistocene (PL), Holocene (H), Recent Freshwater Lakes (RL), Salt Lakes (SL), and Salt Marshes (SM).

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 lakes and rivers were widespread throughout the coastal and central regions of Arabia. For example, Wadi Ar-Rumah and Al-Batin formed a large river draining the Harrat Khaybar mountains region and surrounding areas toward Shat Al-Arab (mouth of Euphrates and Tigres rivers). Freshwater fishes had opportunities to disperse into Arabia from the Tigres and Euphrates and the Gulf drainage systems.

Huzayyin (1941) recognized two major pluvial periods in Arabia. Ripley (1954) mentioned Paleoliths of a crude Levalloisian type from Hadramut indicating a degree of Paleolithic culture. Ripley (1954) mentioned a gravel spread on the north side of the Ar-Rub'alkhali and stone artifacts of Neolithic facies. This might be correlated with the Neolithic wet phase found at Fayoum in Egypt and the pluvial conditions in Palestine (Ripley, 1954). 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 Hadramut and Al-Masilah 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 and Ramirez, 1966). Lake terraces of presumed Pliocene Age are known only at the northwestern edge of Harrat Hutayam Mountain region (Powers and Ramirez, 1966); freshwater ostracod fossils

occur in the upper part of the rocks. Similar deposits of light-gray marl with gastropods and freshwater 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 and Ramirez, 1966). Freshwater fishes during that time might have dispersed to the Wadi As Sirhan and its tributaries to the north or to central Arabian 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 Tayma. 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 sandy limestone as in Al-Hufuf (Hötzl and others, 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-Hawta City in Saudi Arabia (Hötzl and others, 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 (Hötzl and others, 1978).

Fossil lake beds of the Ar-Rub'alkhali (Figure 2) serve as a framework on which to hang a time-stratigraphic column for the late Quaternary (McClure, 1978). 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, 1978). The latest of this series of Pleistocene Ar-Rub'alkhali lakes are still preserved and have radio carbon dates ranging from about 36,000 to about 17,000 years B.P. (Before Present) (McClure, 1978).

In the Pliocene periodically there was considerable moisture. Pliestocene climates probably fluctuated widely, relatively cool, moist interval 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 hyper-aridity 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. Displacement of the south-west monsoon in the Holocene resulted in a subpluvial phase in Ar-Rub'alkhali from about 9,000-6,000 years B.P.

Recently, the popular conception of Arabia 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 instance, during summer the average temperature is 31.7 C in Jiddah, while the

average temperature in Turyaf during winter is 4.5 C. The Peninsula is not nearly as rainless as is commonly supposed. It can probably be said that no part of Arabia escapes occasional showers, and heavy storms which fill the wadies with water occur every year. 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 3000 m has an annual average precipitation of 270.9 mm.

BASINS AND DRAINAGES OF ARABIA

The Arabian Peninsula is dominated by a plateau that rises 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-Medinah and increasing southward to over 3000 m. There are no permanent large rivers but wadies with river terraces are numerous.

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 Hajr River in South Yemen, has perennial flowing water to the sea.

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

Figure 4 illustrates six separate drainage basins based on the topography of the Peninsula. It is assumed that during major pluvial periods, all drainages within any one of the present internal basins would have been interconnected, allowing the opportunity for dispersal of fishes throughout a basin.

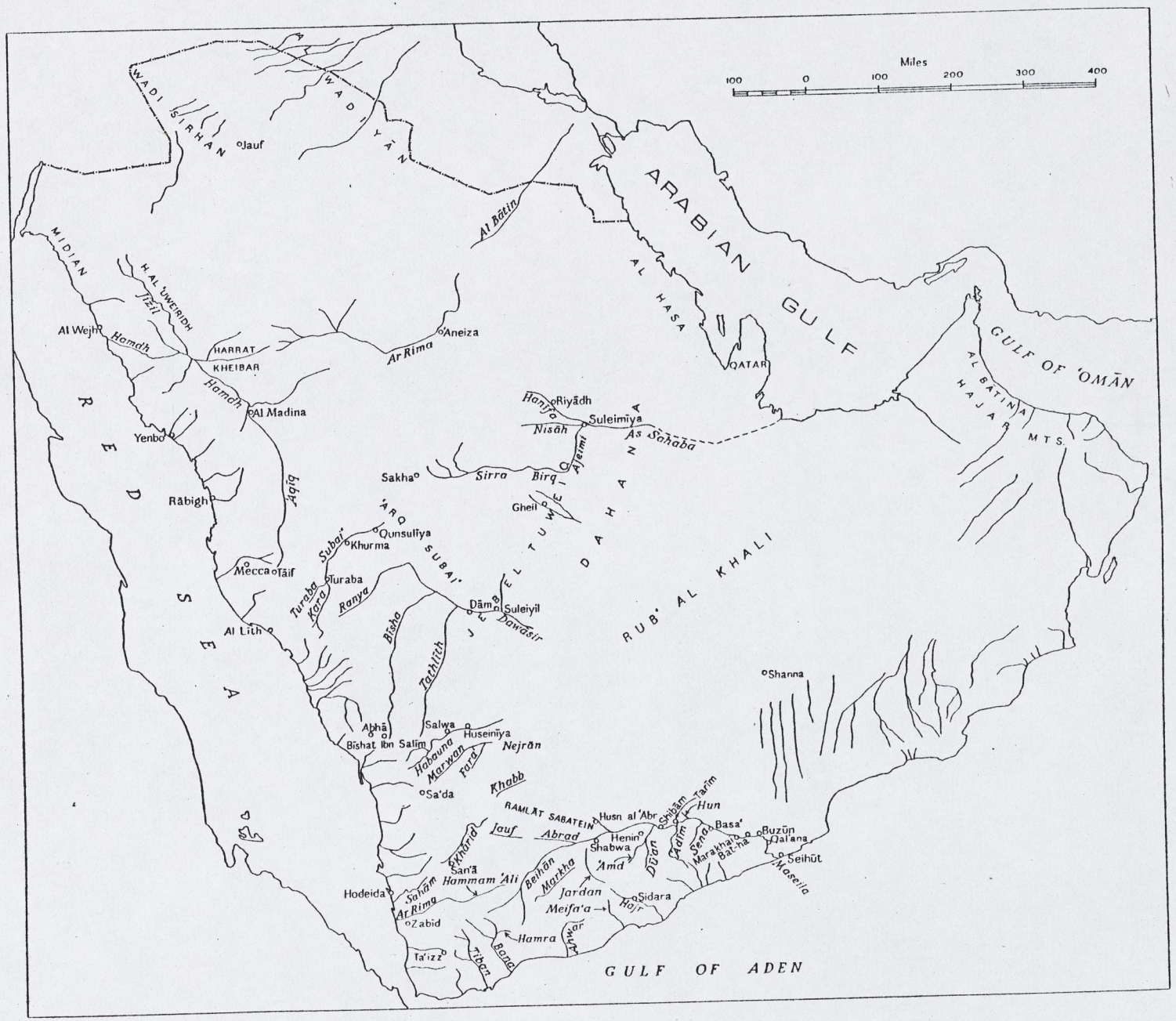

Figure 3. The drainages of Arabian Peninsula (Adapted from Anon., 1946, Gr. Brit. Naval Intell. Div., Geographical Handbook Series, Western Arabia and the Red Sea).

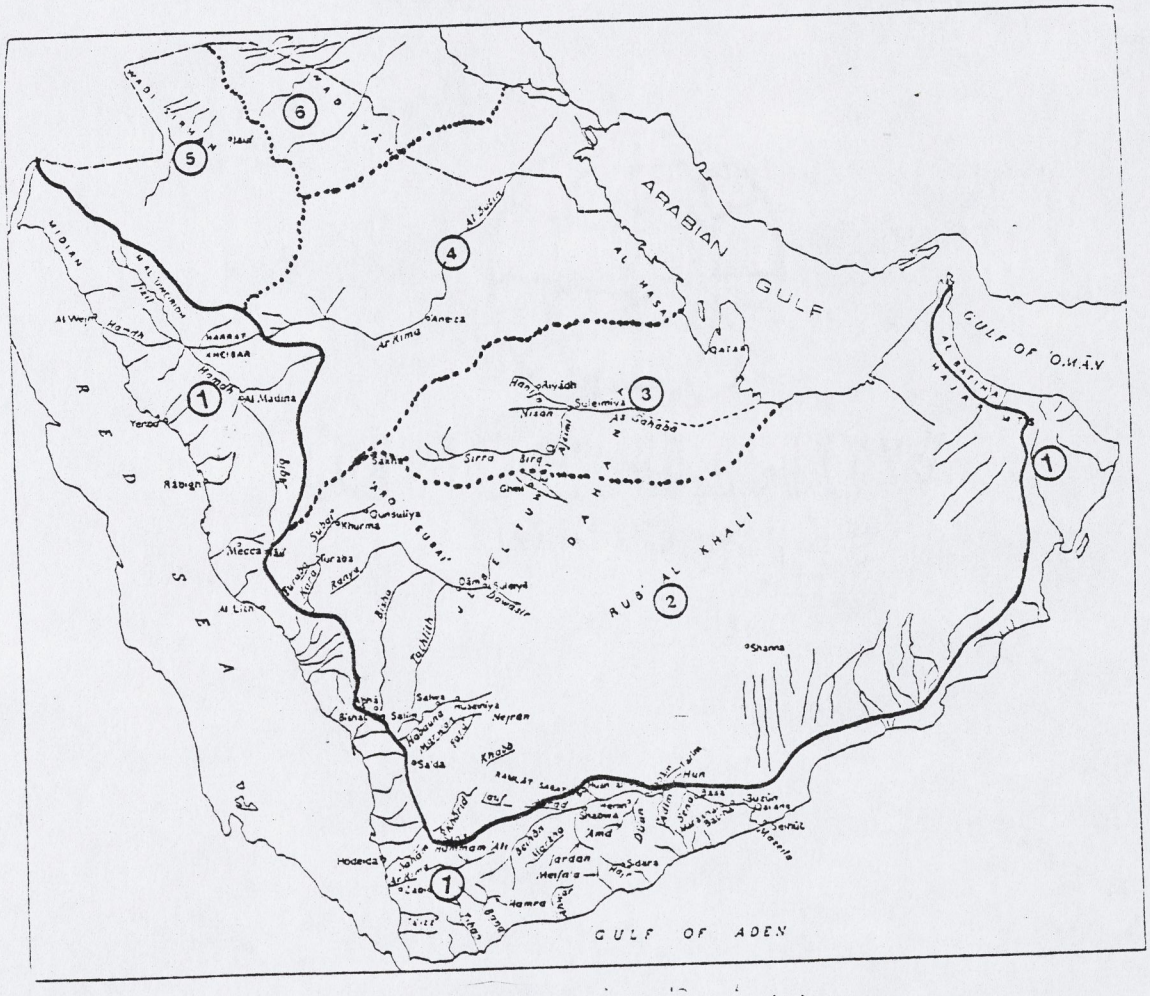

Figure 4. Major basins of Arabian Peninsula: (1) The coastal drainages, (2) Ar-Rubalkhali Basin, (3) Al-Kharj Basin, (4) Ar-Rumah - Al-Batin Basin, (5) As Sirhan Basin, and (6) Euphrates Basin.

The Coastal Drainages

This basin extends from the Gulf of Alaqaba (North) to the Gulf of Oman, parallel to the sea coasts. This basin is a network of wadies. Wadi Hadramut and Al-Hamdh are the major wadies in this basin, but there are a great variety of wadies extending from the surrounding mountains toward the Red and Arabian seas. Pluvial deposits in the beds of these wadies indicates these wadies were once large river systems.

The two largest wadies with the contribution of their tributaries drain the Hadramut Plateau and Al-Hijaz Mountains, respectively, to discharge their waters into the sand or the seas. Such wadies were affected by the uplift movement, resulting in a change in their direction.

Ar-Rub'alkhali 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. There is evidence of a Pleistocene and Holocene lake in the middle of Wadi ad Dawasir. The depth and size is not yet known. Wadi ad Dawasir is a large, old system, draining from the Asir escarpment ridge.

Other wadies draining toward this basin are those collecting the water from the eastern side of Hadramut Plateau in the south, Yemen highlands, and northeast of Oman Mountains.

Al-Kharj Basin

This basin is south of the Ar-Rumah - Al-Batin Basin. Wadi Hanifah, southwest of Ar-Riyad, its tributaries, and Wadi As Sahba are the major drainages in the basin. Wadi As Sahba, southeast of Haradh, 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 wadies are considered to be remnants of large rivers flowing during pluvial periods of the Pleistocene and Pliocene.

Ar-Rumah - Al-Batin Basin

This basin is believed to have had connection to the Tigres-Euphrates system several thousand years ago. 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 wadies. A lakes system was widespread in Al-Hasa Oasis and these lakes drain their water towards the Gulf, probably during the Pleistocene or Pliocene periods (McClure, 1978).

As Sirhan 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. This basin opens to the north and northeast into Jordan (Jordan R. basin). This basin resulted from a growth of the Hail Arch to the east during late Cretaceous and Eocene times (Powers and Rimirez, 1966).

Euphrates 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. The main drainage system which consists of a group of wadies is called Al-Widyah.

SPRINGS AND STREAMS

At present, the greater part of Arabia is a land of valleys with river channels which are dry on the surface or contain only isolated pools during most of the years, but these numerous dry wadies may have sudden and violent torrents after rain storms.

Perennial streams and rivers exist in several parts of the Peninsula, but with the single exception of the Hajr River in south-west Hadramut (S. Yemen), they are not continuous from the source to the mouth throughout the year. Some salt lakes occur as the sump of some basins; for example, Sabkhat Almora about 12 km long and 2.5 km wide is an extension of a lagoon which until recently separated Qatar from the mainland.

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 time.

The springs (Aluyun) in 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 Ali, Ain Al-Brikah, Ain Salaliem, Ain Al-Bhair, Ain Al-Ajlanah and Ain Mduwrah. 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. "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 Clarke, 1975). There is a perennial stream in Abha City called Wadi Almhaleh. There are a few springs which emanate from the granite and gneis in Ata'if City at an elevation of 1586 m. It was reported that there is one spring called Ain Waziria about 11-13 km east of Jeddah (Twitchell, 1958). It is reported that there are some springs in Wadi Fatima near Mecca. About 15 km woutheast of Mecca there is an ancient spring called Ain Zubaidah.

There are copious springs existing in eastern Arabia like those existing in Al-Hasa Oasis (Saudi Arabia). The total number is not known, but Vidal (1955) believed that there are about 50 or 60. These springs break out sometimes singly, sometimes in groups. Some of the largest springs are: Al-Harrah (Hot), Barabier and Umm Sabah. Such springs have Aphanius dispar. This species dispersed from the Arabian Gulf through a perennial river, probably during the middle of the Holocene Period.

In the district of Alaflaj, 264 km south of Al-Kharj, 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 Alaflaj: 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. The Qanats are found in different regions, as Alula, Al-Kharj, and Tabuk. These man-made water tunnels provide a refuge for fishes.

Many dams have been constructed impounding the water in wadies for irrigation or for flood control (Elkhatib, 1974). Some of these dams are very ancient. I am not aware of any fish introductions by man into artificial impoundments.

The major dams in Saudi Arabia are as follows: Wadi Jizan Dam, Abha Dam, Bathan Dam, Majma'ah Dam, Hreimlah Dam, Malham Dam, Ananyyah Dam, Al-Ainyyah Dam, and Diriyah Dams (Elkhatib, 1974). These dams impound up to several hundred hectares, but they exhibit great fluctuations in relation to the highly variable run-off patterns of the drainages. Their potential for fish has not been studied. Any future study should devote serious consideration to the dangers that non-native fish introductions may have on the native species. It is possible that some of the rare endemic fish species could flourish if stocked into reservoirs.

Wadi Jizan Dam

The maximum storage capacity is 71 million cubic meters (Elkhatib, 1974). The rainfall in the wadi plain and its basin varies greatly from year to year. This dam receives a magnitude of floods during each year. The dam serves two purposes (Elkhatib, 1974). The first is to regulate the flow of Wadi Jizan. The other is to enable further expansion of the agricultural area. No fishery is known in the impoundment.

Abha Dam

This dam was constructed to regulate the Wadi Abha. Its size is unknown. The catchment area of the dam is 58.5 km^2 (Elkhatib, 1974).

Bathan Dam

This dam is on the Wadi Bathan about six km from the city of Al-Medina. Its size is unknown (Elkhatib, 1974).

Majma'ah Dam

This dam is located at the junction of two wadis: Wadi Mashghar and Wadi Ougheik at about seven km southeast of Al-Majma'ah City. (Elkhatib, 1974). Its size is unknown.

Hreimlah Dam

This dam located on Wadi Abu Qathada west of Hreimlah Village. The catchment area is 350 km^2. The storage capacity is 1.5 million cubic meters (Elkhatib, 1974).

Malham Dam

This dam is located about 1 km west of the village of Malham. Storage capacity is 200,000 m^3.

Ananyyah Dam

This dam is located on the Wadi Ananyyah northwest of Hawtet Sudair in the Qasim region. It is an earthen dam, 180 m long and 8 m high with a top width of 15 m (Elkhatib, 1974). Its size is about 21,600 m^3.

Al-Ainyyah Dam

Located on Wadi Ainyyah, a tributary of Wadi Hanifah some 55 km west of Al-Riyadh-Salboakh Road. It is 400 m long and stores about one million cubic meters (Elkhatib, 1974).

Diriyah Dams

"These three small dams were constructed in 1968 on the tributaries of Wadi Hanifah crossing Diriyah, about 9 km west of Riyadh City" (Elkhatib, 1974). Their sizes are unknown.

Fishery surveys should be made in these reservoirs and their suitability for introductions of rare native fishes investigated.

PREVIOUS STUDIES OF FRESHWATER FISHES OF ARABIA

The first mention in the literature of freshwater fish from Arabia was by Boulenger (1887) who described a new species, Scaphiodon muscatensis, from Muscat. Berg (1949) synonymized Scaphiodon muscatensis with Cyprinion microphthalmum, a widespread species in Iran and Pakistan.

No additional reference to Arabian freshwater fishes was published until Trewavas (1941) described three new species: Barbus arabicus, Garra tibanica, and Garra brittoni and recorded the occurrence of Aphanius dispar (Cyprinodontidae) from Yemen, based on collections made by The British Museum of Natural History Expedition to southwest Arabia, 1937-38.

Fowler and Steinitz (1956) described a new species, Garra barreimiae, from Oman.

The most recent and comprehensive publication on the Arabian freshwater fishes is by Banister and Clarke (1975) in which collections from Saudi Arabia are mentioned for the first time.

They list nine species: eight Cyprinids and one cyprinodont: four of the cyprinids are described for the first time--Barbus apoensis, Barbus exulatus, Cyprinion acinaces and Garra longipinnis.

Van Convering (1977) mentioned fossil cichlids (family Cichlidae) and Barbus-like material of unknown age from Ad Darb, Red Sea coast. Brown (1970) mentioned the Miocene fossil of Barbus in Jizzan basin on Tihama north of the Yemen boundary.

Figures 8, 12, 20, and 23 illustrate the known distribution of the species mentioned above.

METHODS AND MATERIALS

Fishes were collected by means of nets, hook and line, and a small seine. Fish specimens were immediately preserved in 10% formalin solution and later transferred to 40% isopropyl alcohol.

Samples were collected in 1977 from several localities of eastern and northwestern Saudi Arabia, such as Alkharj (near Al-Riyadh), Almhaleh (between Abha and Khamis Mushyat), Khaybar (north Al-Hejaz) and Al Hufuf. Some other basins such as Tabuk, Alula and Al-Aflaj were visited but no evidence of fishes was found.

About 600 specimens of eight species were collected. The most common and ubiquitous species, Aphanius dispar, made up about two-thirds of the total number of specimens.

Measurements and counts on specimens were made according to the standard methods of Hubbs and Lagler (1947) with some particular modifications in accordance with Banister and Clarke (1975).

Counts were made and compared for the following characteristics: Total length (TL), standard length (SL), greatest body depth (BD), head length (HL), orbit length (OL), upper jaw length, measured from the barbel to tip snout (UJL), dorsal origin to snout-tip (DO), dorsal fin basal length (DFBL), dorsal fin depressed length (DFDL), barbel length (BL), caudal peduncle least depth (CPD), caudal peduncle length (CPL), number of gill rakers on anterior surface of first gill arch (GR), gill raker counts on the posterior

surface of first gill arch (GRP), number of dorsal fin rays (D) (Roman numeral for unbranched rays, arabic numeral for branched rays), anal fin rays (A), pectoral fin rays (P), ventral or pelvic fin rays (V), scales counts in lateral line (L.L.), scales counts above lateral line (SALL), lateral line series (L.S.), anal fin depressed length (ADL), intestine length (IL), posterior barbel length (P BL), interorbital width (IW), maximum length of the mental disc (DL), maximum width of the mental disc (DW), pectoral fin length (PFL), ventral fin length (VFL), and anal length (AL).

Morphological measurements were converted to percentage of standard length. Specimens are presently maintained in fish collection of Department of Fishery and Wildlife Biology, Colorado State University.

FAMILY CYPRINIDAE

Upper jaw margined, as a rule. Barbels if present not more than 2 pairs (4 pairs only in Gobiobotia (Berg, 1949)). Swimbladder usually free, not enclosed in a bony capsule. Body scaled. About 275 genera in the freshwaters of the world except South America, Australia and Madagascar (Nelson, 1976). More species than any family of vertebrates (about 2,000 species). The first 2, 3 or 4 rays in the dorsal and the anal fins unbranched. Most anterior unbranched rays often rudimentary. No adipose fin. Mouth toothless, head scaleless. Mostly Cyprinidae are small and some are very strikingly colored.

Genus Barbus Cuvier, 1817

Barbus Cuvier, 1817, Regne, anim. II, p. 192 (type: B. barbus).

Typically with two pairs of barbels, seldom one or none. Mouth inferior, lips well developed. Pharyngeal teeth are 2.3.5-5.3.2 or 2.3.4-4.3.2. Peritoneum white or dark brown. Anal fin with 5 or 6 branched rays.

Taxonomic Outline

A most difficult and confusing problem of Icthyology is the classification of the African, Asiatic and European fish of the genus Barbus (Myers, 1960). There are between 450-500 known species in this genus (Myers, 1960). Barbus contain many phyletic lines

of a greater or lesser extent and the aggregate transcends the limit of what the majority of ichthyologists would consider a single genus (Myers, 1960). Günther suggested it is necessary to subdivide several sections of the genus purely on geographical ground before he could handle the classification expeditiously (Myers, 1960).

Boulenger divided Barbus into several sections, based on scale characters and it seems possible that these sections are of phylogenetic importance (Myers, 1960).

The northeast African Barbus (large scale) and Barbus canis (Jordan River) are the logical ancestors to all known Arabian Barbus.

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. As far as known it is absent from the central drainages. There is no record of Barbus from Arabian Gulf drainages.

Several Barbus species occur in the Tigres-Euphrates basin, and B. barbulus is known from the Mond River drainage of Iran. No other gulf drainages were found to have Barbus (Saadati, 1977). The number of Barbus species in Arabia is yet to be determined. Three species have been described. Barbus apoensis is known from Wadi Almhaleh near Abha City, Wadi Turabah near Ataif and Wadi Adamah, 19° 53' N, 41° 57' E. Barbus exulatus is known from several localities in the Wadi Hadramut and Wadi Maran in East Yemen. Barbus arabicus is widespread in the southwestern part of Arabia.

Barbus apoensis Banister and Clarke, 1975

Barbus apoensis Banister, K. and M. A. Clarke. 1975. Jour. Oman Studies, Spec. Rep. (Sci. Results. Oman flora and fauna survey): p. 123.

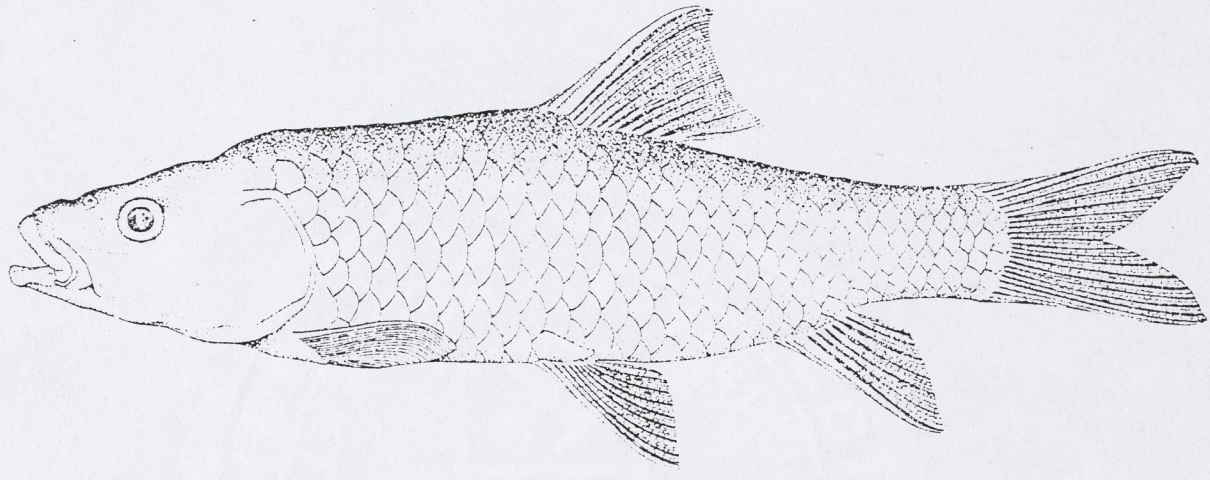

Figure 5. Barbus apoensis. 176 mm SL (from Banister and Clarke. Freshwater Fishes of Arabian Peninsula. 1975.)

D IV 10, A III 6, L. L. 31

Specimen Examined

One specimen, 273 mm SL, was caught July, 1977, from Wadi Almhaleh a permanent stream between Khamis Mushyat and Abha City.

Description

The shape of the body can be seen in Figure 5. This species was described by Banister and Clarke (1975) from a permanent stream near Khamis Mushyat and other localities in Saudi Arabia. They based their description on 12 specimens. According to their

description, "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 anterior barbels are absent and 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 an unserrated, smooth spine. The spine is not strongly ossified and is flexible in its distal third. There are 10 branched dorsal rays. The anal fin has 3 unbranched and 6 branched 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 gill rakers." The specimen examined from Wadi Almhaleh shows the characters described above except for some differences noted such as 31 scales in the lateral line instead of 26-29. Ten scales encircle the least circumference of the caudal peduncle. A well-developed bony ridge is present from the occiput to dorsal fin origin. Lateral line is straight. Other morphometric and meristic data is presented in Tables 1 and 2.

Table 1. Morphometric characters of Barbus apoensis from Wadi Almhaleh.

		% of standard length
TL	324 mm	-
SL	273 mm	-
BD	84 mm	0.31
HL	88 mm	0.32
OL	14 mm	0.05
UJL	26 mm	0.09
DO	149 mm	0.55
DFBL	42 mm	0.02
DFDL	65 mm	0.22
BL	10 mm	0.04
CPD	30 mm	0.11
CPL	45 mm	0.16
APL	60 mm	0.21

Table 2. Morphometric and Meristic data of a specimen of Barbus apoensis from Al-Mhaleh near Abha City.

TL	STL/BD	STL/HL	HL/OL	STL/DO	CPL/CPD	GR
324	3.3	3.1	6.3	1.8	1.5	10
GRP	**L.L.**	**SALL**	**D**	**A**	**P**	**V**
15	32	5	IV-10	III-6	15	9

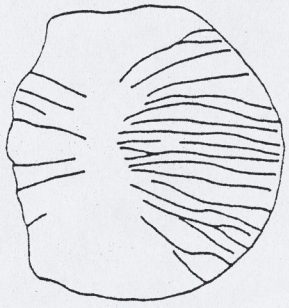

Fig. 6. Scale from Barbus apoensis, 141 mm SL. Scale of fifth row above the lateral line (from Banister and Clarke, Freshwater Fishes of Arabia, 1975).

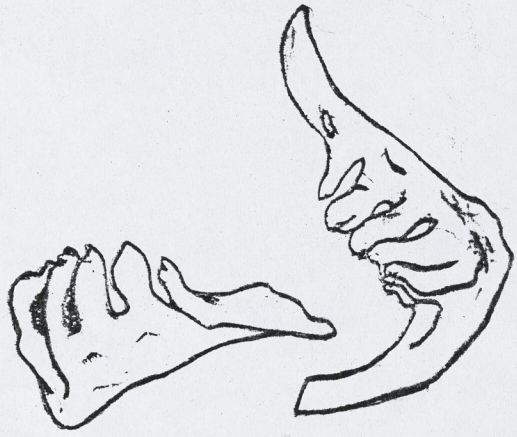

Fig. 7. Pharyngeal bone of Barbus apoensis 153 mm SL. (from Banister and Clarke, Freshwater Fishes of Arabia, 1975).

Coloration

Living specimen colors are golden with olive fins. Preserved specimen is pale-yellow below and gray-brown above.

Distribution

This species is known from Wadi Almhaleh between Khamis Mushyat and Abha. According to my knowledge of the area the type locality is the same as mentioned by Banister and Clarke (1975). Other than Wadi Almhaleh, the species is known from Wadi Turabah, near Ataif and Wadi Adamah, Saudi Arabia (Figure 8).

Relationships

The only other known species of Barbus typically with 6 branched anal fin rays are Barbus exulatus (endemic to Arabia) and Barbus canis

(endemic to Jordan River). Barbus exulatus resembles B. apoensis by having 6 branched anal fin rays, but it has two pairs of barbels, whereas B. apoensis has only one pair. The other known Arabian species, Barbus arabicus, and all large Barbus species of northeast Africa have 5 branched anal fin rays (Banister and Clarke, 1975).

"Barbus canis resembles B. apoensis in general appearance and more importantly in the possession of 6 branched rays in the anal fin" (Banister and Clarke, 1975). I am in agreement with Banister and Clarke that this character may serve to define a lineage within the Barbus species indigenous to Arabia and the Jordan River basin.

Barbus apoensis can be distinguished from Barbus canis by having fewer scales in the lateral line (26-30 vs. 30-40), one pair of barbels, and the dorsal profile of the head is more concave.

> Barbus exulatus is superficially like B. canis, but differs in several respects, such as: a sheath of enlarged scales at the base of the anal fin, subterminal mouth (terminal in B. canis), and a much longer, stronger dorsal spine (Banister and Clarke. 1975).

Banister and Clarke (1975) suggested that Barbus exulatus and Barbus apoensis are a sister group to Barbus canis.

Barbus arabicus

Barbus arabicus Trewavas, 1941, British Museum (Natural History) Expedition to southwest Arabia 1937-8, I (3):14.

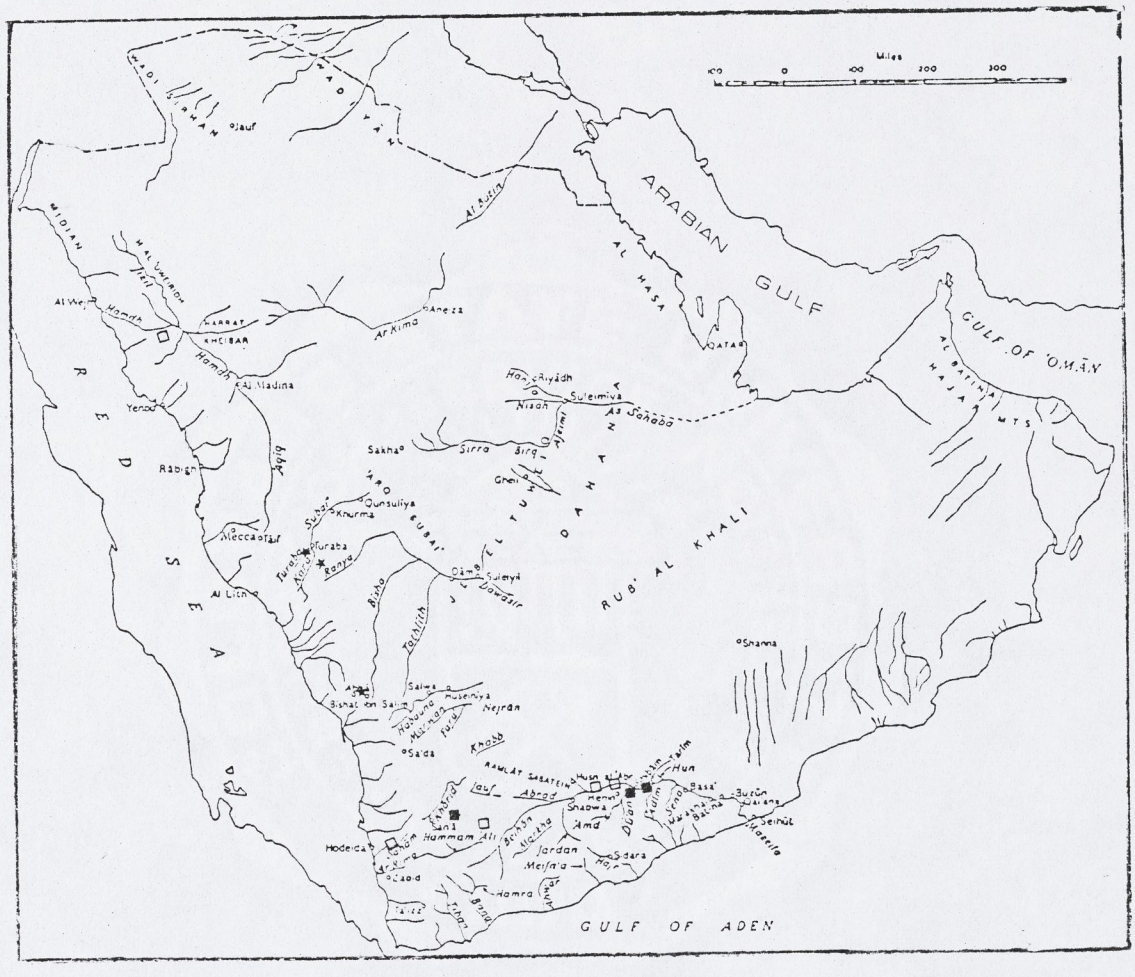

Figure 8. The distribution of Barbus spp.: Barbus apoensis (*) Barbus exulatus, (■), and Barbus arabicus (□).

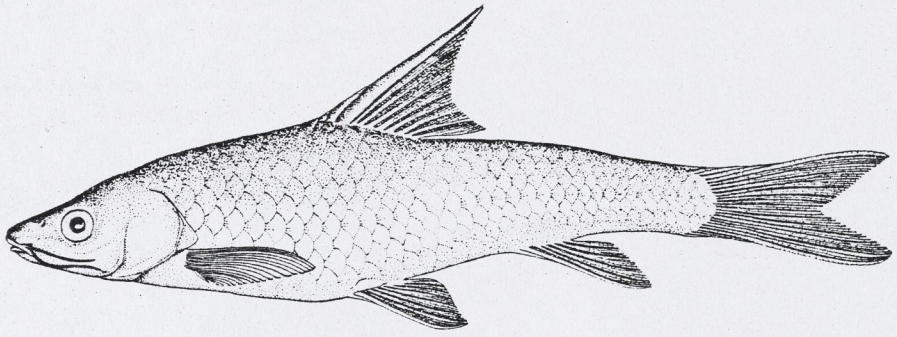

Figure 9. Barbus arabicus 119 mm SL. (from Banister and Clarke, Freshwater Fishes of Arabian Peninsula, 1975).

Description

There are no specimens in my collection, so only the briefest description will be given here (see Banister and Clarke, 1975, for more detail).

> The morphometric and meristic data for the holotype are: SL = 346 mm; DB = 20.0; HL = 131.2; CPL = 14.9; CPD = 8.4; L.L. 28; The horizontal eye diameter = 3.3; the least bony interorbital width = 9.6; the width of the widest part of the mouth = 9.0; the greatest length of the pectoral fin = 19.8; the number of scales around the least circumference of the caudal peduncle = 12; and the length of the anterior barbel = 7.2. In non-typical specimens (26-203 mm SL) the body is slim and graceful. The head is longer, the body is deep, the snout is acutely or obtusely pointed in lateral view. The mouth is subterminal. There are two pairs of long barbels. The eye is small and supero-lateral in position.
>
> The origin of the dorsal fin is in the posterior half of the body. There are four unbranched rays, the last of which is ossified into a smooth straight spine. Only a very small part of the tip

of the spine is flexible. There are 7-9 branched rays. The dorsal margin of the fin is concave when the fin is erect.

The anal fin has three unbranched rays and five branched rays.

There are 25 to 32 scales. All specimens show some degree of reduction in the number and size of scales on the breast and in some specimens the breast is apparently scaleless.

There are 12 scales around the least circumference of the caudal peduncle. The pharyngeal teeth are numbered 2.3.5-5.3.2. The gill rakers number 9-13 on the lower limb of the first gill arch. The gill rakers are moderately slender, short and curved towards the mid-line. (Banister and Clarke, 1975).

Distribution

This species seems to be widespread in the southwestern part of the Arabian Peninsula. It has been recorded from Wadi Maur, near Al-Zorah, northern Tihamah in Saudi Arabia (Fig. 8).

Figure 10. Barbus arabicus scale

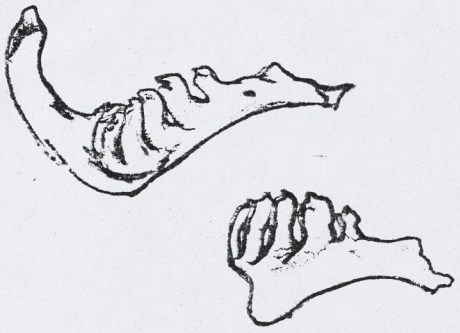

Figure 11. Barbus arabicus SL. left pharyngeal bone

Relationships

"Barbus arabicus can be easily distinguished from all other Arabian Barbus species because it has only five branched rays in the anal fin" (Banister and Clarke, 1975). 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 B. arabicus and B. canis. Banister and Clarke (1975) aligned Barbus arabicus with the species of Barbus in northeastern Africa--the Barbus intermedius complex because of the following reasons:

> The morphological similarity between these two species, i.e. the possession of the same type of scale striation (more or less parallel), a caudal peduncle longer than deep, and a well ossified straight dorsal spine (Banister and Clarke, 1975).
>
> The phenotypic variability of Barbus arabicus parallels Barbus intermedius (Banister, 1974).
>
> The distribution of Barbus arabicus, i.e. in the southern part of Arabia just across the Red Sea from Barbus intermedius, suggests an African origin (Banister and Clarke, 1975).

Genus Cyprinion Heckel

Cyprinion Heckel, 1843, Russger Reisen, 1, p. 1015 (Type: C. macrostomus).

Fishes of moderate size; scales of moderate size; Dorsal fin with an osseous and serrated spine and numerous branched rays; mouth inferior; pharyngeal 2.3.4-4.3.2; one pair of barbels; peritoneum

black; alimentary canal long and convoluted; air bladder bipartite or tripartite; seven branched anal rays.

A new generic character discovered by Saadati (1977) is a dorsal ridge derived from fused interneural bones.

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 Banister and Clarke's studies (1975) Cyprinion occurs in the coastal drainages and Ar-Rub'alkhali Basin (Fig. 12).

In Saudi Arabia, based on my collections, the genus occurs in the Wadi Almhaleh (Ar-Rub'alkhali Basin) and the Red Sea drainages. My collections consist of 57 specimens of Cyprinion from different springs and streams in Khaybar, N. Al-Hijaz and Wadi Almhaleh near Abha City. Cyprinion acinaces and one undescribed species were collected from Khaybar springs. Two undescribed species were collected from Wadi Almhaleh in the Asir highlands. The three new species are well differentiated from any described species by a long intestine (5.5 times the total body length), number of scales (29 or 42) and other morphological characters which are discussed below.

Taxonomic Outline

The systematic status of the species of Cyprinion is still not well delineated. The problem is that there appears to be no clear

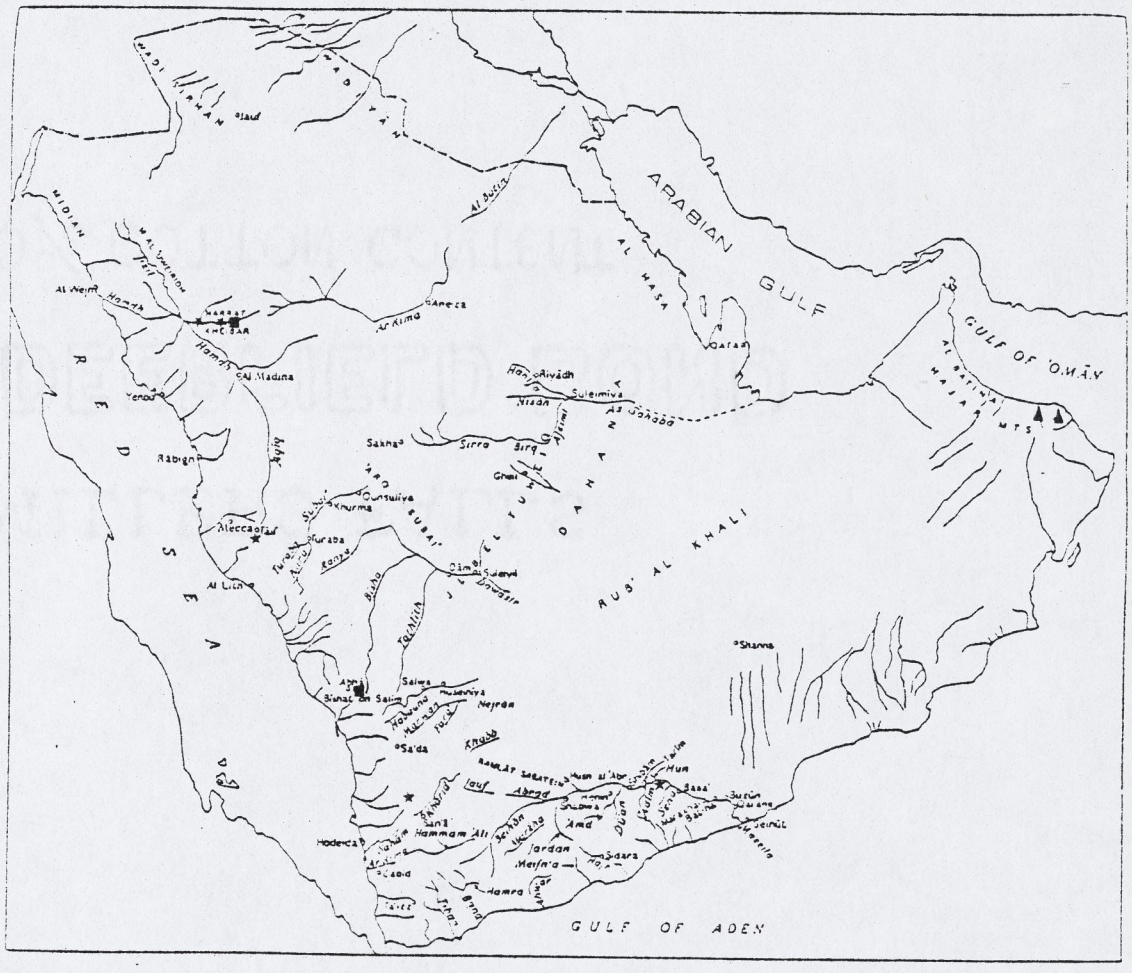

Figure 12. The distribution of Cyprinion spp. Cyprinion acinaces (*), Cyprinion microphthalmum (▲), and Cyprinion sp. nov. (■).

cut difference between species with 10 branched dorsal rays. Until 1949 about fifteen species of Cyprinion were commonly recognized (Saadati, 1977). Berg (1949) revised the genus and recognized only six species. The species recognized by Berg are: C. microphthalmum, C. macrostomum (Tigres-Euphrates Basin), C. irregulare, C. watsoni, C. milesi (Indian Ocean and Gulf drainages) and C. tenuiradius.

Mirza (1969) synonymized Cyprinion irregulare with Cyprinion watsoni. He recognized three species in Pakistan, C. watsoni distinguished by having an arched mouth, a conspicuous scaleless ridge on the back, bipartite air bladder, and the length of the alimentary canal about three times the total body length. C. milesi was distinguished by having a longer head and oblique mouth. C. microphthalmum was distinguished by having a transverse mouth, tripartite air bladder and the length of the alimentary canal more than 3.5 times the total body length.

Saadati (1977) indicated that the condition of the dorsal spine is highly variable in Iranian Cyprinion. Stout, weak and intermediate spines were found in a single sample.

Prior to the publication of Banister and Clarke (1975), only Cyprinion microphthalmum was known from Arabia. Banister and Clarke (1975) described Cyprinion acinaces as a new species from Arabia. My collections contain four species of Cyprinion. One of these, Cyprinion acinaces, was described by Banister and Clarke (1975). Three species are undescribed.

The occurrence of Cyprinion microphthalmum in Arabia is questionable. The species described in Oman as Scaphiodon muscatensis

by Boulenger (1887) and considered as C. microphthalmum by Berg (1949) is more likely Cyprinion watsoni, based on the condition of the air bladder and relative intestine length. All Arabian Cyprinion appear to represent divergences in the Cyprinion watsoni species group.

Cyprinion acinaces and the three new species most probably diverged from an ancestral species invading Arabia during the Pliocene.

Cyprinion acinaces Banister and Clarke, 1975

Cyprinion acinaces Banister, K. and M. Clarke. 1975. Jour. Oman Studies, Spec. Rep. (Sci. Results. Oman flora and fauna survey): p. 123.

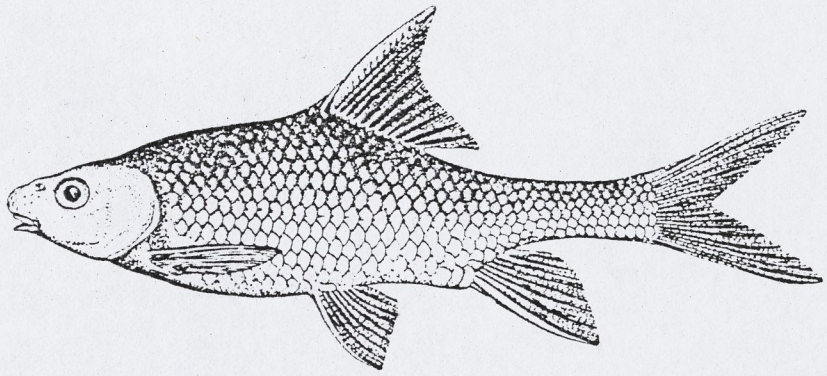

Figure 13. Cyprinion acinaces. 29-110 mm SL. (from Banister and Clarke, Freshwater Fishes of Arabian Peninsula, 1975).

D IV 12 (11), A III 7, V q, L.L. 32-38.

Material Examined

20 specimens were collected July, 1977, from Ain Al-Bhair, Khaybar, N. Al-Hijaz.

14 specimens were collected July, 1977, from Ain Slaliem, Khaybar, N. Al-Hijaz.

12 specimens were collected July, 1977, from Ain Ali (Abowashia), Khaybar, N. Al-Hijaz.

Description

The shape of the body can be seen in Figure 13. According to Banister and Clarke's (1975) description, "the mouth is ventral. The anterior edge of the lower jaw is gently curved and covered with a sharp-edged horny sheath. Barbels are short. Tubercles are present on the snout and interorbital region of some specimens. The eyes are lateral and visible in ventral view. The peritoneum is black. The skin between the pelvic fin base is fatty, thickened and papillose. The development of the thickened skin varies considerably. It is a heart-shaped patch of skin, although the papillae are continued onto the pelvic fin rays. At the other extreme there are three flaps: there is a median, posteriorly directed flap laying between the pelvic fin bases flanked on each side by a smaller flap which may cover the bases of the pelvic fins. The dorsal fin has four unbranched rays and 11-12 branched rays. The last unbranched ray is ossified into a long straight spine with a strongly serrated posterior face. The anal fin has three unbranched rays and seven branched rays.

In the lateral lines there are 34-39 scales. Pharyngeal teeth number 2.3.4-4.3.2 (Fig. 15). Gill rakers are widely spaced, short, thin and slightly curved. On the lower limb of the first gill arch there are 8-12 gill rakers." Specimens of this species possess well developed bony ridge without scales between the occiput and the origin of the dorsal fin similar to that seen in Cyprinion watsoni. The head is elongate. Mouth is of variable shape, i.e. ventral, transverse, oblique, terminal or subterminal. In other specimens the mouth contains a sharp curved blade in the lower jaw, while in yet others the cornified blade is weakly developed. Lateral line is straight in some specimens, curved in others. The lateral line scales count range from 32 to 38.

There are 2-4 scales between lateral line and the pelvic fin. There are 15-16 scales around the least circumference of the caudal peduncle. There are 5-8 scales above the lateral line. In some specimens there are no fatty-thickened papillose skin between the bases of the pelvic fin, but other specimens do have this structure. Brown spots above the lateral line present in young disappear in adults. There are tubercles in some male specimens. The stomach is well developed. The intestine length is from 2.1 to 3.6 times of the total length. The gas bladder has two chambers. Its posterior chamber is longer and slightly narrower than the anterior one. There are nine rays in the pelvic fin. The pectoral fin has 16 rays. Fins never reach each other. Gill rakers on the first gill arch are short, strong and curved, their count ranging from 12-15. There are 20-25 gill rakers on the posterior side of the first gill arch.

There are 23-28 gill rakers on the anterior side of the second gill arch. The caudal peduncle is narrow and short. The caudal fin is forked. The anus is immediately in front of the anal fin.

Morphometric and meristic data are presented in Tables 3 and 4.

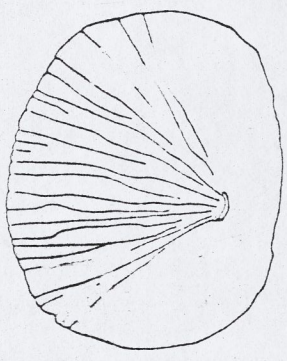

Figure 14. Cyprinion acinaces Scale of fifth row above the lateral line.

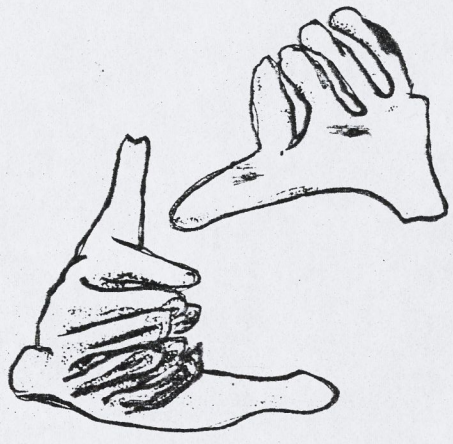

Figure 15. Right pharyngeal bone of Cyprinion acinaces.

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.

Table 3. The morphometric characters of Cyprinion acinaces.

	n	$\bar{x}$	Percent of Standard Length	S.D.	Range
TL	46	100.7	----	20.4	65 - 136 mm
SL	46	78.8	----	17.0	50 - 117 mm
BD	46	23.2	0.29	6.2	13 - 36 mm
HL	56	22.5	0.28	4.6	15 - 30 mm
OL	46	5.8	0.07	0.8	4 - 8 mm
UJL	46	5.9	0.07	1.1	4 - 8 mm
DO	46	40.3	0.51	717	30 - 55 mm
DFBL	46	18.1	0.23	3.9	12 - 27 mm
DFDL	46	25.1	0.32	5.4	16 - 36 mm
BL	44	3.7	0.05	0.8	3 - 5 mm
CPD	46	8.3	0.11	2.0	5 - 14 mm
CPL	46	13.4	0.17	2.9	8 - 19 mm
IL	11	254.3	3.20	59.6	170 - 350 mm
AFDL	46	15.2	0.19	3.7	10 - 26 mm

Table 4. Meristic and morphometric data of Cyprinion acinaces.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/UTL	SL/DO	SL/DFDL	SL/AFDL	CPL/CPD	CPL/SL	CPD/SL	GR	GRP	LL	SALL	D	A	P	V
Ain (spring) Salaleim (Khaybar, N. AlHijaz)	1	110	3.3	3.3	4.3	3.7	1.8	2.9	5.4	1.7	0.17	0.10	13	21	37	7	IV-12	III-7	14	9
	2	102	3.5	3.6	3.5	3.5	1.8	3.1	5.5	1.8	0.18	0.10	13	20	34	7	IV-12	III-7	15	9
	3	96	3.5	3.5	3.3	3.3	1.9	3.0	4.9	1.7	0.17	0.10	13	22	37	7	IV-12	III-7	16	9
	4	106	3.5	3.5	4.0	4.0	1.8	3.0	5.7	1.4	0.15	0.12	13	21	35	7	IV-12	III-7	16	9
	5	85	3.6	3.6	3.2	3.2	2.0	3.0	6.3	1.6	0.16	0.10	13	21	36	6	IV-12	III-7	16	9
	6	85	4.0	3.8	3.0	3.0	1.9	3.1	5.7	1.6	0.16	0.10	13	21	37	6	IV-12	III-7	16	9
	7	67	3.8	3.3	3.0	3.8	1.8	3.6	4.5	1.5	0.18	0.12	13	20	37	6	IV-12	III-7	15	9
	8	118	3.3	3.4	3.9	4.5	2.2	3.6	5.4	1.7	0.16	0.09	13	21	37	7	IV-11	III-7	16	9
	9	100	3.4	3.8	3.0	3.5	1.9	2.9	4.0	1.5	0.15	0.10	14	23	37	7	IV-12	III-7	16	9
	10	83	3.3	3.5	3.6	3.6	1.8	2.7	6.3	1.4	0.16	0.11	13	20	37	7	IV-12	III-7	16	9
	11	97	3.0	3.3	3.8	4.6	1.8	3.3	5.4	1.5	0.16	0.12	12	24	35	6	IV-12	III-7	16	9
	12	78	3.8	3.3	3.0	4.5	1.8	3.2	5.0	1.8	0.18	0.10	12	20	36	6	IV-11	III-7	16	9
	13	75	3.6	3.6	4.3	3.4	1.8	3.6	5.7	1.4	0.18	0.12	12	20	35	6	IV-12	III-7	16	9
	14	65	3.7	3.4	3.0	3.8	1.9	3.1	4.7	1.3	0.15	0.12	12	22	35	6	IV-12	III-7	16	9
	$\bar{x}$		3.5	3.5	3.5	3.7	1.9	3.2	5.3	1.6	0.17	0.11	12.8	21.1		6.5				
	min.		3.0	3.3	3.0	3.0	1.8	2.7	4.0	1.3	0.15	0.09	12	20	34	6				
	max.		4.0	3.8	4.3	4.6	2.2	3.6	6.3	1.8	0.18	0.12	14	24	37	7				

Table 4 (Continued). Meristic and Morphometric Data of Cyprinion acinaces.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/UTL	SL/DO	SL/DFDL	SL/AFDL	CPL/CPD	CPL/SL	CPD/SL	GR	GRP	LL	SALL	D	A	P	V
Ain Ali (Khaybar, N. AlHijaz)	15	120	3.8	3.8	4.2	4.2	2.1	3.2	5.6	2.1	0.17	0.08	13	23	38	6	IV-12	III-7	14	9
	16	73	3.5	3.8	3.2	3.2	2.0	3.3	6.0	1.7	0.17	0.10	14	24	37	5	IV-12	III-7	15	9
	17	80	3.8	3.4	3.8	3.8	1.9	2.9	5.8	1.7	0.16	0.09	13	21	37	7	IV-12	III-7	16	9
	18	85	3.6	3.5	3.6	3.6	1.8	3.1	5.5	1.7	0.18	0.08	13	21	36	-	IV-12	III-7	15	9
	19	70	3.7	3.7	3.8	3.0	1.8	3.1	5.5	2.0	0.18	0.09	12	20	36	6	IV-12	III-7	15	9
	20	75	3.6	3.6	3.2	3.2	1.9	3.2	5.3	1.7	0.17	0.10	13	21	35	-	IV-12	III-7	15	9
	21	71	3.6	3.4	3.2	4.0	1.9	3.1	5.0	2.0	0.18	0.09	14	23	36	-	IV-12	III-7	15	9
	22	127	3.3	3.5	3.6	4.8	2.0	3.1	5.7	1.9	0.17	0.09	13	24	37	7	IV-12	III-7	16	9
	23	135	3.2	4.1	5.8	3.6	1.9	3.0	5.9	1.7	0.16	0.09	13	25	37	7	IV-12	III-7	16	9
	24	120	3.6	3.6	4.5	3.9	2.0	3.1	5.9	1.7	0.16	0.09	14	24	37	7	IV-12	III-7	16	9
	25	119	3.6	3.6	4.2	3.8	1.9	3.3	4.8	1.8	0.18	0.09	14	25	38	7	IV-12	III-7	16	9
	26	110	3.4	3.9	4.0	3.4	1.9	3.0	5.1	1.9	0.17	0.09	13	24	38	8	IV-12	III-7	16	9
	$\bar{x}$		3.6	3.7	3.9	3.7	1.9	3.1	5.5	1.8	0.17	0.09	13.3	22.9	36.8	6.7				
	min.		3.2	3.4	3.2	3.0	1.8	2.9	4.8	1.7	0.16	0.08	12	20	35	5				
	max.		3.8	4.1	4.5	4.8	2.1	3.3	6.0	2.1	0.18	0.10	14	25	38	8				

Table 4 (Continued). Meristic and Morphometric Data of Cyprinion acinaces.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/UTL	SL/DO	SL/DFDL	SL/AFDL	CPL/CPD	CPL/SL	CPD/SL	GR	GRP	LL	SALL	D	A	P	V
Ain (spring) AlBheir (Khaybar, N. AlHijaz)	27	16	3.2	3.3	3.9	3.4	1.9	3.2	5.0	1.6	0.18	0.11	15	24	36	7	IV-12	III-7	15	9
	28	136	3.9	3.9	5.0	3.8	2.4	3.7	5.6	1.4	0.15	0.10	14	25	37	7	IV-12	III-7	16	9
	29	106	3.0	3.4	5.0	3.8	1.9	3.0	4.5	1.4	0.16	0.12	14	24	38	7	IV-12	III-7	16	9
	30	120	3.5	3.5	4.5	3.6	1.9	3.2	5.2	1.4	0.15	0.12	12	24	37	6	IV-12	III-7	16	9
	31	123	3.1	3.5	4.5	3.9	1.9	3.1	4.3	1.6	0.17	0.12	16	22	36	7	IV-12	III-7	16	9
	32	110	3.6	3.8	4.0	3.7	1.9	3.3	4.5	1.4	0.17	0.12	15	25	36	7	IV-12	III-7	16	9
	33	100	3.7	3.3	4.0	4.0	2.1	3.3	4.9	1.9	0.19	0.10	14	21	37	6	IV-12	III-7	16	9
	34	109	3.3	3.3	4.0	4.0	1.9	3.5	5.3	1.7	0.19	0.11	13	22	38	5	IV-12	III-7	16	9
	35	115	3.0	3.5	4.3	3.7	1.9	3.3	5.3	2.5	0.17	0.07	14	22	37	6	IV-12	III-7	16	8
	36	120	3.0	3.6	4.5	3.9	1.9	3.2	5.3	1.6	0.17	0.10	12	22	38	6	IV-12	III-7	16	9
	37	112	2.9	3.5	4.3	5.2	2.1	3.4	5.7	1.7	0.16	0.09	12	22	38	6	IV-12	III-7	16	9
	38	132	2.9	3.6	4.3	4.3	1.9	3.3	5.1	1.5	0.18	0.12	13	20	38	-	IV-12	III-7	16	9
	39	122	3.1	3.4	3.9	3.9	1.9	2.7	4.7	1.8	0.19	0.11	15	22	38	7	IV-12	III-7	16	8
	40	130	3.0	3.4	4.8	4.8	1.9	3.2	5.9	1.4	0.19	0.14	15	24	37	7	IV-12	III-7	16	9
	41	102	3.5	3.3	3.4	4.0	2.1	2.8	4.4	1.6	0.20	0.13	12	25	38	6	IV-12	III-7	16	9
	42	89	3.6	3.4	3.3	4.0	2.0	3.2	5.7	1.9	0.19	0.10	14	21	32	6	IV-12	III-7	16	9
	43	96	3.6	3.4	4.4	3.7	1.9	3.3	4.2	1.4	0.15	0.11	12	22	35	7	IV-12	III-7	16	9
	44	78	3.6	3.6	3.4	3.4	2.0	3.1	6.1	1.7	0.16	0.09	14	21	36	6	IV-12	III-7	15	9
	45	76	3.6	3.2	3.6	3.6	1.9	2.7	4.8	1.4	0.18	0.12	14	21	36	6	IV-12	III-7	16	9
	46	85	3.6	3.3	4.0	4.0	1.9	3.3	5.4	1.4	0.17	0.12	14	21	36	7	IV-12	III-7	16	9
	$\bar{x}$		3.3	3.5	4.2	3.9	1.96	3.2	5.1	1.6	0.17	0.11	13.7	22.5	36.7	6.4				
	min.		2.9	3.2	3.3	3.4	1.9	2.7	4.2	1.4	0.15	0.07	12	20	32	5.0				
	max.		3.9	3.9	5.0	5.2	2.4	3.7	6.1	2.5	0.20	0.13	16	25	38	7.0				

Distribution

Previously this species was known only from Wadi Hadramut and in a stream at (or near) Taif (Saudi Arabia). My collections extend the range to Khaybar Springs in Saudi Arabia (Fig. 12).

Relationships

The only Cyprinion with a strongly serrated dorsal spine is Cyprinion macrostomum but Cyprinion acinaces can be distinguished by having fewer branched rays in the dorsal fin (11-12 vs. 13-15, mostly 14), fewer branched rays in the anal fin (7 vs. 8), fewer scales (32-38 vs. 38-43). Banister and Clarke (1975) were unsure of the affinities of C. acinaces. In my opinion the presence of the conspicuous scaleless dorsal ridge and general agreement in other characters suggest the closest relationships of Cyprinion acinaces to Cyprinion watsoni.

UNDESCRIBED SPECIES OF CYPRINION

Three species collected from Saudi Arabia are previously undescribed. These species are quite distinct from each other and from other Arabian Cyprinion.

Undescribed Species No. 1

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

Material Examined

8 specimens, 55-141 SL, Wadi Almhaleh near Abha City (permanent stream) were caught July, 1977.

Description

The shape of the body can be seen in Fig. 16(A). The mouth is transverse, subterminal, oblique or ventral. The anterior edge of the lower jaw is curved, covered with a well developed plade. The blade in some specimens is not well developed, especially in small fish. The snout is blunt and short. 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. The degree of the development of the bony ridge is more conspicuous in large specimens than small specimens. Peritoneum is sooty black. No scales on ventral side. The eyes are lateral and visible in ventral view. The standard length is 3.8 times longer than the body depth. The head length is 3.7 times longer than the orbit.

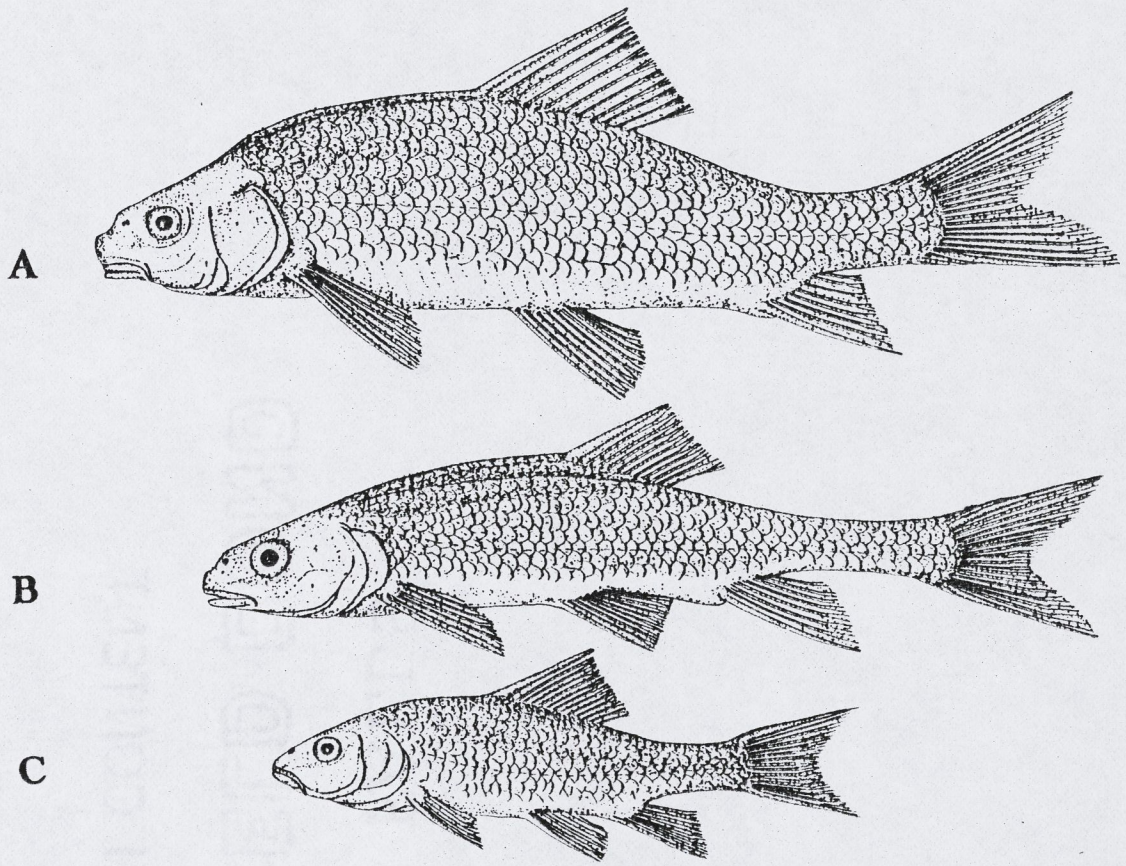

Figure 16. Three undescribed species of Cyprinion:
A. Undescribed species No. 1 (55-141 mm SL)
B. Undescribed species No. 3 (124 mm SL)
C. Undescribed species No. 2 (78-81 mm SL)

The standard length is 3.8 times longer than the head. The caudal peduncle is long and narrow; the caudal fin is forked. The caudal peduncle length is 18% of the standard length. The caudal peduncle depth is 10% of the standard length. The stomach is well developed and muscular. The intestine is very long in one specimen; its length from the end of the stomach is 5.5 times the total length, while in other specimens this length is about 4.0 times the total length. The air bladder is bipartite, its posterior chamber is longer and slightly more narrow than the anterior one.

There are 3 or 4 unbranched rays and 10 branched rays in the dorsal fin (last two counted as one). Last unbranched ray is ossified almost to the tip and strongly serrated all along ossified segments. The dorsal fin origin is opposite of the origin of ventral fin. The dorsal spine length is shorter than the body depth.

There are 3 or 4 unbranched anal fin rays and 7 branched rays. The anal fin when laid flat doesn't reach the caudal. Anus is immediately in front of the anal fin.

Squamation. There are 40-43 (41.4) scales in the lateral line. 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 ridge.

Gill rakers. Gill rakers are short, slightly curved and thin. On the anterior side of the first gill arch there are 11-16 (13.1) gill rakers. On the posterior side of the first gill arch there are 21-32 (24.4) gill rakers. On the anterior side of the second gill arch there are 22-31 (26) gill rakers. Morphometric and meristic data are given in Tables 5 and 6.

Table 5. Morphometric characters of undescribed Cyprinion species No. 1.

	n	$\bar{x}$	Percent of Standard Length	S.D.	Range
TL	8	110.5	----	37.3	72 - 180 mm
LS	8	85.5	----	29.8	55 - 141 mm
BD	8	22.4	0.26	7.7	15 - 37 mm
HL	8	22.8	0.27	7.1	15 - 34 mm
OL	8	6.1	0.07	0.8	5 - 7 mm
UJL	8	6.3	0.07	1.8	5 - 9 mm
DO	8	44.5	0.52	15.2	30 - 73 mm
DFBL	8	17.0	0.20	6.0	11 - 27 mm
DFDL	8	22.1	0.26	7.5	16 - 37 mm
BL	8	3.3	0.04	0.9	2 - 5 mm
CPD	8	8.6	0.10	2.6	6 - 14 mm
CPL	8	15.3	0.18	5.6	9 - 23 mm
IL	8	407.9	4.80	291.4	125 - 986 mm
AFDL	8	18.8	0.22	8.8	9 - 35 mm

Table 6. Morphometric and Meristic Data of Undescribed Species No. 1 from Almhaleh Stream (near Abha City).

No.	TL	SL/BD	SL/HL	HL/OL	HL/UTL	SL/DO	SL/DFDL	SL/AFDL	CPL/CPD	CPL/SL	CPD/SL	GR	GRP	LL	SALL	D	A	P	V
1	180	3.8	4.1	4.9	3.8	1.9	3.8	4.0	1.6	0.16	0.10	16	32	43	12	III-10	I-7	17	9
2	142	3.8	3.7	4.3	3.3	1.9	3.8	4.1	2.2	0.21	0.09	13	23	42	-	III-10	III-7	16	9
3	133	3.8	3.7	4.1	4.1	1.9	4.1	4.5	2.0	0.19	0.09	13	24	42	8	III-10	III-7	16	9
4	96	4.2	3.8	3.3	4.0	2.0	4.2	4.5	1.6	0.17	0.11	12	26	43	-	III-10	I-7	16	9
5	85	3.9	3.7	3.0	3.6	1.8	3.7	4.4	1.7	0.18	0.11	13	23	40	-	IV-10	III-7	15	9
6	72	2.9	3.7	3.0	3.0	1.8	3.4	3.7	1.6	0.20	0.13	11	22	40	-	IV-10	II-7	15	8
7	93	4.2	3.7	3.8	3.8	1.9	4.2	5.9	1.7	0.17	0.09	13	24	40	-	IV-10	III-7	14	8
8	83	4.1	3.6	2.8	3.4	1.9	3.6	5.1	1.6	0.15	0.09	14	21	41	-	IV-10	III-7	15	9
$\bar{x}$		3.8	3.8	3.7	3.6	1.9	3.9	4.5	1.8	0.18	0.10	13.1	24.4	41.4					
min.		2.9	3.6	2.8	3.0	1.8	3.4	3.7	1.6	0.15	0.09	11	21	40					
max.		4.2	4.1	4.9	4.1	2.0	4.2	5.9	2.2	0.21	0.13	16	32	43					

Coloration

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

Distribution

This species was collected only from Wadi Almhaleh, a permanent stream near Abha City (Fig. 12).

Relationships

This species doesn't resemble other Arabian Cyprinion species. It differs in certain characters such as long intestine (4-5.5 times the total length) and general morphology. This species can be distinguished from C. 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), and more gill rakers on the anterior side of the first gill arch (11-16 vs. 12-14). The affinities of this species are uncertain. Although all Arabian Cyprinion are most likely derived from an ancestor of Cyprinion watsoni and the scaleless bony ridge indicates such affinities, under the present state of knowledge of the genus it would be premature to state opinions with more authority.

Undescribed Species No. 2

D IV 10, A III 7, L. L. 29-30.

Material Examined

Two specimens, 78-81 mm SL, Wadi Almhaleh, a permanent stream near Abha City, were caught July, 1977.

Description

The shape of the body can be seen in Figure 16(C). The head is short and obtuse. Mouth is terminal. Anterior edge of the lower jaw is curved and is not covered with well developed blade. There is one small pair of barbels. The length of the barbel is less than the diameter of the eye (3-4 mm vs. 6-7 mm). No tubercles. There is a weakly developed bony ridge from the occiput to the dorsal fin origin. Peritoneum is sooty black. There are no scales on the ventral side of one specimen, but the other specimen does have ventral scales. The standard length is 3.7 times longer than the body depth. The standard length is 3.1 times longer than the head. The head length is 4.24 times longer than the orbit. The head length is 3.25 times longer than the upper jaw. Caudal peduncle is long and narrow. The caudal fin is forked. The caudal peduncle length is 19% of the standard length. The caudal peduncle depth is 12% of the standard length. The stomach is muscular. The intestine length is 3.0 times the total length. The air bladder is bipartite, the posterior chamber is longer 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 7 branched rays in the anal fin. The anus is immediately in front of the anal fin.

Squamation. The lateral line is straight or curved to the middle of the caudal peduncle. There are 29-30 (29.5) scales in the lateral line in the two specimens.

Gill rakers. Gill rakers are short, slightly curved and thin. There are 9-11 (10) gill rakers on the anterior side of the first gill arch. There are 14-16 (15) gill rakers on the posterior side of the first gill arch. On the anterior side of the second gill arch there are 14-16 gill rakers.

Morphometric and meristic characters are presented in Tables 7 and 8.

Coloration

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

Distribution

This species is collected from the same locality (Wadi Almhaleh) as Undescribed Species No. 1 (Fig. 12).

Relationships

Species #2 differs from all known Cyprinion species by unserrated dorsal spine. It differs by fewer scales (29-30) from all known Cyprinion species except an undescribed species mentioned by Saadati (1977) from Iran with 26-27 scales.

Table 7. Morphometric characters of undescribed Cyprinion species No. 2.

	n	$\bar{x}$	Percent of Standard Length	S.D.	Range
TL	2	104	----	---	-104 mm
SL	2	79.5	----	2.1	78-81 mm
BD	2	21.5	0.27	0.7	21-22 mm
HL	2	25.5	0.32	0.71	25-26 mm
OL	2	6.0	0.08	----	-6 mm
UJL	2	8.0	0.10	----	8 mm
DO	2	43.0	0.54	2.8	41-43 mm
DFBL	2	16.0	0.20	1.4	15-17 mm
DFDL	2	22.5	0.28	3.3	20-25 mm
BL	2	3.0	0.05	---	-4 mm
CPD	2	10.0	0.13	---	-10 mm
CPl	2	15.0	0.19	2.8	13-17 mm
IL	2	140.0	1.76	28.3	120-160 mm
AFDL	2	13.5	0.17	2.1	12-15 mm

Table 8. Meristic and Morphometric Data of Undescribed Species No.2 from Wadi Almhaleh Basin.

No.	TL	SL/BD	SL/HL	HL/OL	HL/UTL	SL/DO	SL/DFDL	SL/AFDL	CPL/CPD	CPL/SL	CPD/SL	GR	GRP	LL	SALL	D	A	P	V
1	104	3.7	3.2	4.2	3.2	1.8	4.1	5.4	1.7	0.20	0.12	9	14	29	-	IV-10	III-7	16	9
2	104	3.7	3.0	4.3	3.3	1.9	3.1	6.5	1.3	0.17	0.13	11	16	30	-	IV-10	III-7	15	9
$\bar{x}$	104	3.7	3.1	4.25	3.25	1.85	3.6	5.9	1.5	0.19	0.12	10	15	29.5					
min	-	-	3.0	4.2	3.2	1.8	3.1	5.4	1.3	0.17	0.12	9	14	29					
max	104	3.7	3.2	4.3	3.3	1.9	4.1	6.5	1.7	0.20	0.13	11	16	30					

From Species 1, Species 2 differs in general morphology, fewer scales (29-30 vs. 40-43) and fewer gill rakers (9-11 vs. 11-16) on the anterior side of the first gill arch.

From C. acinaces, Species 2 differs in general morphology, fewer branched rays in the dorsal fin (10 vs. 12), fewer scales in the lateral line (29-30 vs. 32-32) and fewer gill rakers on the anterior side of the first gill arch (9-11 vs. 12-16). The affinities of this species are uncertain. It likely represents a "sister" species of undescribed Species No. 1, diverging from a common ancestor in Arabia.

Undescribed Species No. 3

D IV 10, A III 7, L. L. 40.

Material Examined

One specimen, 124 mm SL, was collected July 1977 from Ain Ali (a spring), Khaybar City, N. Al-Hijaz.

Description

The shape of the body can be seen in Fig. 16(B). The snout is short and blunt. The mouth is transverse with a weakly developed blade. The interorbital space is flat. There is one small pair of barbels. The barbel length is smaller than the orbit length. No tubercles on the snout and the interorbital region of the specimen examined. There is a well developed bony ridge from occiput to the origin of the dorsal fin. The peritoneum is sooty black. No scales are on the ventral side. The standard length is 3.9 times longer than the body depth. The standard length is 3.8 times longer than the

orbit. The standard length is 4.1 times longer than the head. The caudal peduncle is very narrow and long. The caudal fin is deeply forked. The caudal peduncle length is 19% of the standard length. The caudal peduncle depth is 6% of the standard length. The stomach is well developed and muscular. The intestine length is 2.1 times of the total length. The air bladder is bipartite, its posterior chamber is longer 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 strongly ossified almost to the tip and serrated. Its length is shorter than the body depth (22 vs. 25). The dorsal fin origin is opposite to the origin of the ventral fin.

There are 3 unbranched rays and 7 branched rays in the anal fin. The anal fin when laid flat doesn't reach the caudal. The anus is directly in front of the anal fin.

Squamation. The lateral line is straight to the middle of the caudal peduncle. There are 40 scales in the lateral line. There are 6 scales above the lateral line.

Gill rakers. Gill rakers are curved, short and thin. On the anterior side of the first gill arch there are 14 gill rakers, and 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.

Measurements and meristic data is presented in Tables 9 and 10.

Table 9. Measurements in millimeters of Species No. 3.

		Percent of Standard Length
TL	158 mm	-
SL	124 mm	-
BD	25 mm	0.20
HL	30 mm	0.24
GL	8 mm	0.10
UJL	8 mm	0.10
DO	65 mm	0.52
DFBL	25 mm	0.20
DFDL	36 mm	0.29
BL	3 mm	0.02
CPD	8 mm	0.10
CPL	24 mm	0.19
IL	330 mm	2.60
AFDL	26 mm	0.21

Table 10. Morphometric and Meristic Data of Undescribed Species of Cyprinion No. 3 from Ain (spring) Ali, Khaybar, N. Alhijaz.

No.	TL	SL/BD	SL/HL	HL/OL	HL/UTL	SL/DO	SL/DFDL	SL/AFDL	CPL/CPD	CPL/SL	CPD/SL	GR	GRP	LL	SALL	D	A	P	V
1	158	3.9	4.1	3.8	3.8	1.9	3.4	4.7	3.0	0.19	0.06	14	24	40	6	IV-10	III-7	16	9

Coloration

Alcohol preserved specimen is dark-brown dorsally and silver-gray below the lateral line. No dark spots on the middle of the flank.

Distribution

This species was only collected from Ain Ali (Ali's spring), Khaybar City, N. Al-Hijaz (Fig. 12).

Relationships

This species doesn't resemble other Arabian Cyprinion species except some similarities with the species No. 1. This species can be distinguished from C. acinaces in general morphology, fewer branched rays in the dorsal fin (10 vs. 12) and more scales in the lateral line (40 vs. 32-38). Species 3 differs from Species 2 by the shape and the color of the body, more scales in the lateral line (40 vs. 29-30) and more importantly by having a strong serrated spine in the dorsal fin.

Undescribed species 3 probably is most closely related to Species 1 and 2, forming an endemic western Arabia species group of Cyprinion. The major distinction between Species 3 and Species 1 is the greater relative length of the intestine in Species 1 (4.0-5.5 vs. 2.1) and the longer, more narrow caudal peduncle in Species 3. The diagnosis of Species 3 is based on a single specimen and more specimens will be necessary to determine the range of variation in its diagnostic characters.

The comparison of characters between Cyprinion species is presented in Table 11.

Table 11. Comparison of Characters between *Cyprinion* species.

Basin	Species	SL/BD	SL/HL	HL/OL	HL/UJL	SL/DO	SL/DFDL	SL/AFDL	CPL/CPD	CPL/SL
Ain Salaleim	*C. acinaces*	3.0-4.0	3.3-3.8	3.0-4.3	3.0-4.6	1.8-2.2	2.7-3.6	4.0-6.3	1.3-1.8	0.15-0.18
	n = 14	(3.5)	(3.5)	(3.5)	(3.7)	(1.9)	(3.2)	(5.3)	(1.6)	(0.17)
Almhaleh Stream	*C.* sp. No. 1	2.9-4.2	3.6-4.1	2.8-4.1	3.0-4.1	1.8-2.0	3.4-4.2	3.7-5.9	1.6-2.2	0.15-0.21
	n = 8	(3.8)	(3.8)	(3.7)	(3.6)	(1.9)	(3.9)	(4.5)	(1.8)	(0.18)
Almhaleh Stream	*C.* sp. No. 2	3.7	3.0-3.2	4.2-4.3	3.2-3.3	1.8-1.9	3.1-4.1	5.4-6.5	1.3-1.7	0.17-0.20
	n = 2	(3.7)	(3.1)	(4.25)	(3.25)	(1.85)	(3.6)	(5.9)	(1.5)	(0.19)
Ain Ali	*C.* sp. No. 3	3.9	4.1	3.8	3.8	1.9	3.4	4.7	3.0	0.19
	n = 1									

Table 11 (Continued). Comparison of Characters between Cyprinion species.

Basin	Species	CPD/SL	GR	GRP	LL	SALL	D	A	P	V
Ain Salaleim	C. acinaces	0.09-0.12	12-14	20-24	34-37	6-7	IV-11-12	III-7	14-16	9
	n = 14	(0.11)	(12.8)	(21.1)	(36.1)	(6.5)				
Almhaleh Stream	C. sp. No. 1	0.09-0.13	11-16	22-32	40-43	-	(IV-III)-10	(I-II-7)	14-17	8-9
	n = 8	(0.10)	(13.1)	(24.4)	(41.4)	-				
Almhaleh Stream	C. sp. No. 2	0.12-0.13	9-11	14-16	29-30	-	IV-10	III-7	15-16	9
	n = 2	(0.12)	(10)	(15)	(29.5)	-				
Ain Ali	C. sp. No. 3	0.06	14	24	40	6	IV-10	III-7	16	9
	n = 1									

GENUS GARRA HAMILTON

Garra Hamilton, 1822, Fishes of the Ganges, Edinburg, pp. 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 or none. Pharyngeal teeth edentulous in three closely approximating rows: the inner 5 or 4, the middle 4 or 3, the outer 3 or 2. The typical number is 2.4.5-5.4.2. Scales of moderate size. Dorsal fin with 9 to 12 rays, 6 to 9 of which branched (II, 6 - III, 9) originating in advance of pelvics. Anal fin short with 6 to 8 rays (I, 5 - III, 5), Pectoral I - II, 17. Lower lip modified into a suctorial disk with free anterior and posterior margins. Gill rakers widely set, short and few. Air bladder varies in form and extent. (Menon, 1964).

Distribution

The genus Garra is widespread from South China and Borneo in the east, through Burma, India and Ceylon, Afghanistan, Iran, Syria and Arabia to Somaliland, Ethiopia, East Africa and then southward to Guinea through the Congo (Menon, 1964).

In Arabia species of this genus are recorded from Oman, United Arab Emirates (Gulf of Oman and Arabian Gulf drainages), Saudi Arabia and Yemen. I collected specimens of Garra from Wadi Almhaleh near Abha City and one spring at Khaybar City, North Al-Hijaz.

Taxonomic Outline

The genus Garra was described by Hamilton in 1822 based on Cyprinus lamta. Heckel described several species under a new genus Discognathus from Iraq, Syria, and Iran. Heckel described Discognathus fusiformes from Bombay and in 1846 recorded the occurrence of Discognathus in Ethiopia. Günther listed D. lamta, D. macrochir, D. variabilis and D. nasutus in his "Catalogue of Fishes in the British Museum" (Menon, 1964). Günther, Playfair and Blanford referred to D. lamta specimens from Afghanistan, Arabia, Ethiopia, respectively (Menon, 1964).

Berg (1949) revised this group and divided it into two genera, Garra (two pairs of barbels) and 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 recognized two species of Discognathus: D. variabilis and D. rossica. Menon (1964) included Discognathus as a species group of Garra. Menon's arrangement of Garra is as follows:

a) The variabilis group (= Discognathus)

   Garra variabilis (Heckel) and G. rossica (Nikolsky) are the only two species in this group. Saadati (1977) found an undescribed species in Iran.

b) Gotyla group.

c) Tibanica group. This group involved seven complexes and 28 species.

According to Menon (1964) the Garra species of Arabia, Iraq, Iran and Syria belong to the "rufa" complex of the tibanica group which consists of G. rufa rufa (Heckel) from Syria and Palestine, G. rufa obtusa (Heckel) from Iraq and Iran and G. barreimiae (Fowler and Steinitz) from Arabia (Saadati, 1977).

Banister and Clarke (1975) recognized three species of Garra in Arabia:

1) Garra barreimiae Fowler and Steinitz, 1956.

2) Garra longipinnis Banister and Clarke, 1975.

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 G. barreimiae with G. rufa, which is widely spread between the Mediterranean and the Tigres-Euphrates System. They related G. longipinnis with G. barreimiae.

My collections from western Saudi Arabia contain only Garra tibanica from Wadi Almhaleh, near Abha City, and from one spring in Khaybar City.

Garra tibanica Trewavas, 1941

Discognathus lamta: Playfair, 1870, proc. zool. soc.: 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.

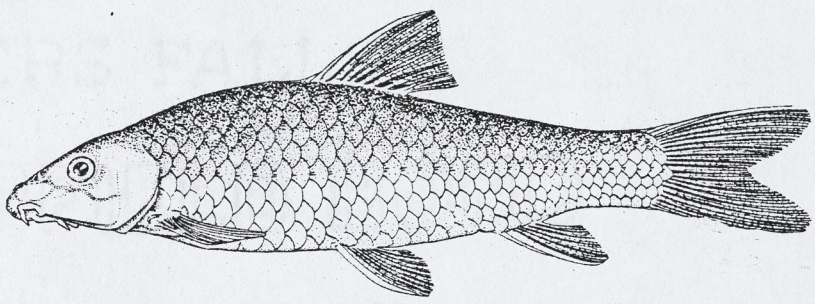

Figure 17. Garra tibanica. 78 mm SL (from Banister and Clarke, Fishes of Arabian Peninsula, 1975).

D III 7, A III 5, L. L. 30-36, P. 14-16, v. 8-9.

Materials Examined

a. Two specimens, 73-86 mm SL from Wadi Almhaleh (permanent stream) between Khamis Mushyat and Abha City, were caught in 1977.

b. Two fish, 38-46 mm SL from a spring in Khaybar, North Al-Hijaz.

In 1975 Banister and Clarke described this species from different localities in Arabia (Fig. 20). They based their description on 93 specimens, 46-110 mm SL. According to their description,

> The snout is blunt and distinctly wedge-shaped in dorsal views pointed inside view. Most specimens possess horny tubercles on the sides and top of the snout. The mental disc is variable in shape (Fig. 18). The anus is immediately in front of the anal fin. The dorsal fin has three or four unbranched rays; the last unbranched ray

> is not ossified. There are six, seven, or eight branched rays. The anal fin has three unbranched rays and five branched rays. The lateral line has 30-36 scales. Around the least circumference of the caudal peduncle there are 12 to 20 scales. The pharyngeal teeth number 2.4.5-5.4.2 in all specimens examined. The gill rakers are short and widely spaced. On the lower limb of the first gill arch there are 6-17 gill rakers.

The four specimens collected in 1977 are similar to the description given by Banister and Clarke. According to my specimens the lateral line is straight, the caudal peduncle is elongate. Brown spots present on the 3rd, 4th, 5th, and 6th rays of the dorsal fin. There are two pairs of barbels. In some specimens tubercles are absent. The disc width is 6 mm, the disc length is 5-6 mm, and posterior barbel length is short. The morphometric and meristic data are presented in Tables 12 and 13.

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).

Distribution

This species is widely distributed along the coastal drainages of west and southwestern Arabia. It occurs in Wadi Hadramut, Wadi Almhaleh between Khamis Mushyt and Abha and a spring in Khaybar City (Fig. 20).

Relationship

Garra tibanica shows considerable range in various meristic and morphometric features. For example, the gill rakers number on the

Table 12. Morphometric characters of Garra tibanica.

	n	$\bar{x}$	Percent of Standard Length	S.D.	Range
TL	4	74.5	----	29.4	46 - 105 mm
SL	4	60.8	----	22.5	38 - 86 mm
BD	4	13.0	0.21	4.9	8 - 19 mm
HL	4	17.0	0.28	6.1	11 - 24 mm
OL	4	4.3	0.07	0.9	3 - 5 mm
UJL	4	6.0	0.10	1.8	4 - 8 mm
DO	4	30.5	0.50	10.1	20 - 41 mm
BL	4	3.3	0.05	0.5	3 - 4 mm
AL	2	13.0	0.21	1.4	12 - 13 mm
DFDL	4	13.5	0.22	4.2	9 - 18 mm
DFBL	4	9.0	0.15	3.7	5 - 13 mm
CPD	4	6.5	0.11	2.3	4 - 9 mm
CPL	4	10.5	0.17	2.4	8 - 13 mm

Table 13. Meristical and Morphometric Data of Garra tibanica from Wadi Almhaleh Basin and a spring at Khaybar City.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/USL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Wadi Almhaleh Basin	1	105	4.5	3.6	4.8	3.0	2.1	-	-	1.4	14	17	36	6	III-7	III-5	16	9
	2	94	4.9	3.7	4.0	2.9	1.9	-	-	1.5	13	20	36	5	III-7	III-5	15	8
	$\bar{x}$		4.7	3.65	4.4	2.95	2.0	-	-	1.45	13.5	18.5	36	5.5				
	min.		4.5	3.6	4.0	2.9	1.9	-	-	1.4	13	17	36	5				
	max.		4.9	3.7	4.8	3.0	2.1	-	-	1.5	14	20	36	6				
Spring at Khaybar City	3	53	4.6	3.5	3.3	2.6	1.9	-	-	1.8	14	20	30	-	III-7	III-5	15	8
	5	46	4.8	3.5	3.7	2.8	1.9	-	-	2.0	13	19	31	-	III-7	III-5	14	9
	$\bar{x}$		4.7	3.5	3.5	2.7	1.9	-	-	1.9	13.5	19.5	30.5	-				
	min.		4.6	3.5	3.3	2.6	1.9	-	-	1.8	13	19	30					
	max.		4.8	3.5	3.7	2.8	1.9	-	-	2.0	14	20	31	-				

Notice: There are 21 or 22 gill rakers on the anterior side of the second gill arch.

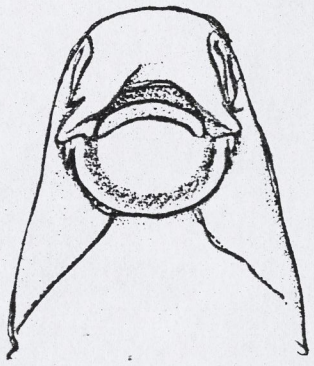

Figure 18. Ventral view of the head of Garra tibanica to show the mental disc.

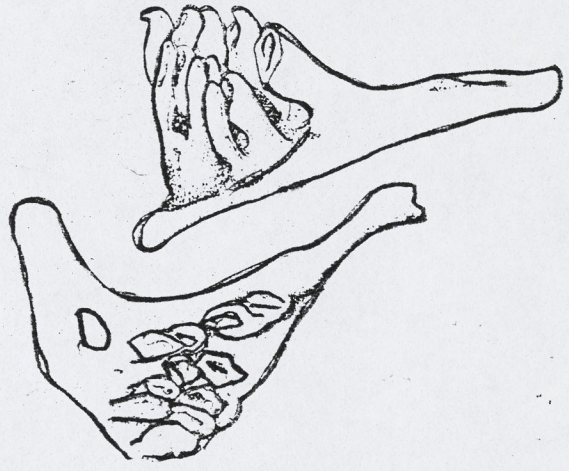

Figure 19. Garra tibanica left pharyngeal bone. 56 mm SL.

lower limb of the first gill arch range from 6 to 17 whereas Menon (1964) gave the range as 9-12 (Banister and Clarke, 1975).

Trewavas (1941) pointed out that this species is closely related to Garra blanfordii (Boulenger), a species of the eastern watershed of Ethiopia which resembles the Aden forms (and differs from other African species) in its proportions and scales counts and in the position of the anus, which is immediately anterior to the anal fin. Garra lamta resembles Garra tibanica in many features, but has larger eyes, the vent is more anteriorly palced and the caudal peduncle is shorter and deeper. Menon (1964) concluded that G. tibanica is most closely allied to G. quadrimculata, but the latter differs in the more anterior position of the anus.

"Within the tibanica complex there are two species from north-east Africa that have some significant similarities with Garra

tibanica"(Banister and Clarke, 1975). "In Garra makiensis (Boulenger) and Garra ethelwynnae (Menon) the anus is close to the anal fin and the body shape and the color pattern are the same as Garra tibanica" (Banister and Clarke, 1975). G. tibanica differs from G. makiensis in the presence of fewer scales in the lateral line (30-36 vs. 30-40). According to Menon (1964) Garra rufa rufa resembles the Garra tibanica complex even though they are well separated geographically. G. tibanica and G. rufa are probably both derived from a primitive Garra which occupied the area from south China as far west as Africa via Afghanistan, Iran, Syria and Arabia (Menon, 1964). "Garra tibanica doesn't closely resemble other Arabian species. 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 vent" (Banister and Clarke, 1975). Garra arabica, Hora is a dubious species. In the nineteenth century, W. T. Blanford sent fish specimens from Wadi Tiban drainage at the southern tip of the Arabian Peninsula to the Indian Museum. Hora named a new species, Garra arabica, in 1921, 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. Only G. tibanica has been found in several coastal drainages of Arabia. It is possible that the specimens on which the name G. arabica is based did not come from Arabia, but due to a mix-up of specimens at the Indian Museum "G. arabica" may actually be an Indian species. Future collections in the Wadi Tiban drainage would be necessary to shed more light on the validity of G. arabica.

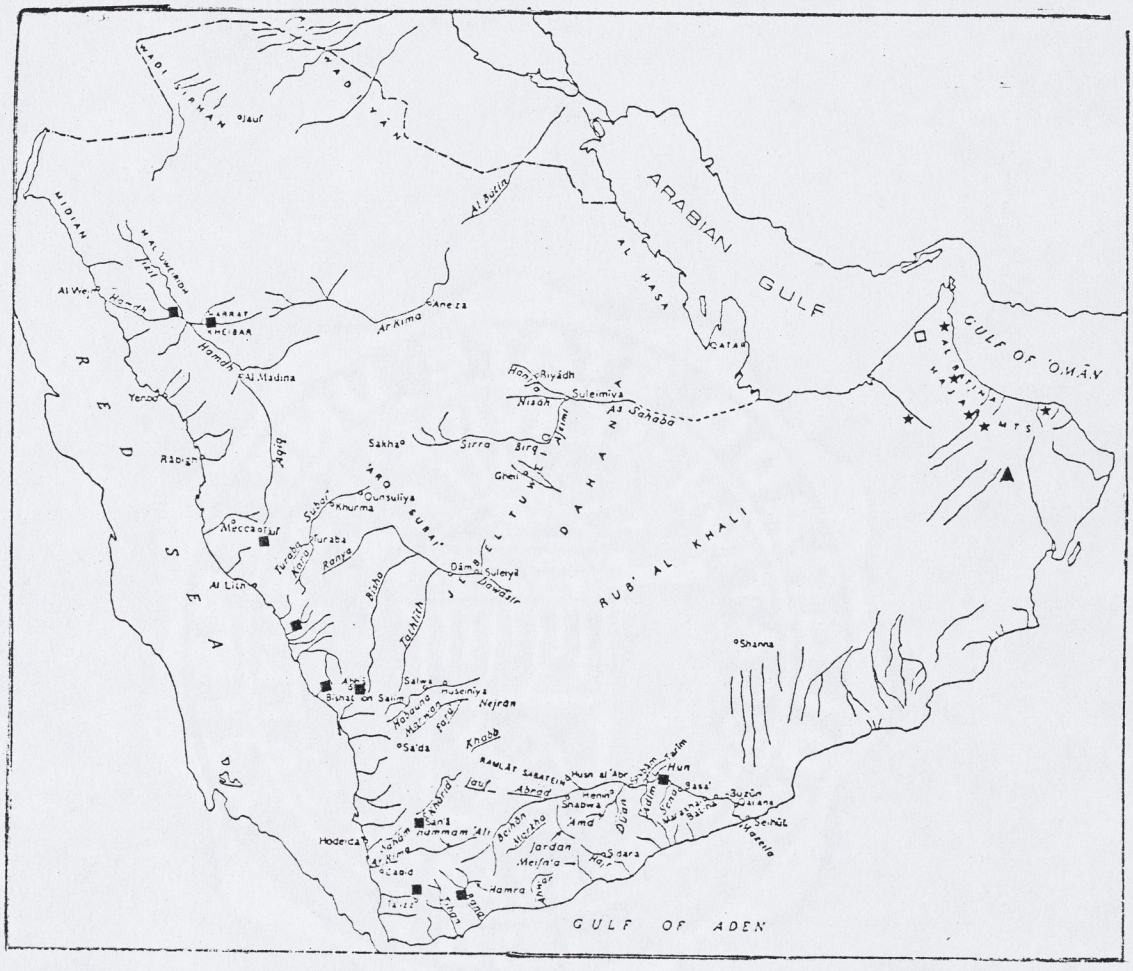

Figure 20. The distribution of Garra. Garra barreimiae (*), Garra barreimiae Shawkahensis (□), Garra longipinnis (▲), and Garra tibanica (■).

FAMILY CYPRINODONTIDAE (TOOTH-CARPS)

This is a very large family, commonly called "tooth carp." Typically small fish (< 100 mm). Upper surface of the head is usually flattened. Mouth is terminal, specialized for feeding on surface. No barbels. No adipose fin. Swim bladder without duct. Fins spineless.

Genus Aphanius Nardo, 1827

Aphanius Nardo, 1927, Adria. Icth. pp. 17-23, P. 438 (type, A. fasciatus).

Aphanius is the only genus of family Cyprinodontidae in Saudi Arabia. This genus is a relict of the ancient fauna of the Tethys Sea (Saadati, 1977). During the Alpine orogeny, these fish, having migrated inland, were trapped in a rising middle east plateau (Krinsly, 1970). There is no firm opinion of systematic status of the genus Aphanius in Saudi Arabia. Trewavas (1941) recorded Aphanius dispar from Yemen. Banister and Clarke (1975) recorded this species from Khaybar, Saudi Arabia. Aphanius were found among collections made from Al-Hufuf and Al-Kharj in Saudi Arabia. Aphanius were found with American mosquitofish, Gambusia affinis in one spring at Al-Kharj, Saudi Arabia.

Saadati (1977) pointed out that Gambusia affinis had replaced Aphanius from much of its range in Iran. Al-Daham and others (1977) discussed interaction between Gambusia and three species of Aphanius in southern Iraq.

Aphanius dispar (Rüppell, 1828)

Lebias dispar: Rüppell, 1828, Atlas Zu der Reise im nördlichen Afrika, 4. Fishche des Rothen Meers: 66.

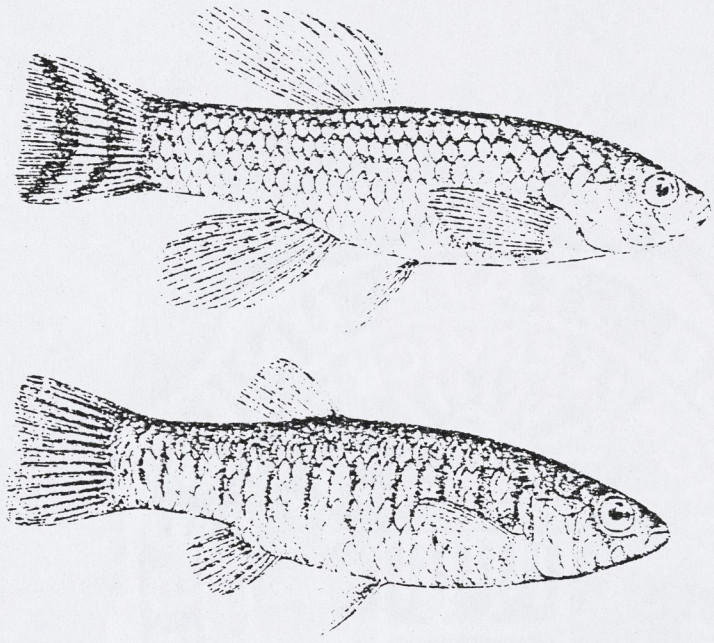

Fig. 21. *Aphanius dispar* male and female (Boulenger, Fishes of the Nile, 1907).

D I-7 or II-7, A I-8 or II-7, L. L. 26-28, P. 13-14.

Material Examined

93 specimens, SL. 30-60 mm. All specimens from Red Sea and Gulf drainages.

Description

This species appears to be the most widely distributed species in Arabia. This distribution is due to the salinity tolerance of Cyprinodont fishes which allow movement through the sea. Members of this species are sexually dimorphic. Specimens rarely reach 80 mm. In the adult male the dorsal fin is twice as high as that of the

adult female. Aphanius dispar exhibits considerable variation in the specimens examined. They have 13-16 gill rakers on the anterior side of the first arch and 15-23 gill rakers on the posterior side of the first arch. There are 26-28 scales in the lateral line. Dorsal fin has two unbranched rays and eight branched rays. Anal fin has eight rays. In the male the dorsal profile is arched. Pectoral fin overlaps pelvic fin, pelvic overlaps anal fin. Fins are long and pointed. Dark blue speckles occur on the dorsal and anal fins of the male. Male is brightly colored, brown to dark blue, with numerous iridescent, blue-silver blotches in rows on the flanks and weak brownish transverse bars above the caudal peduncle. Dorsal and anal fin with silvery blotches and dark spots. Pectoral and pelvic fins are yellow. Female gray with a bluish-silver sheen. Numerous transverse bars on the flank. Fins are small and rounded. In all specimens teeth are tricuspid. Pretonium black. The stomach is well developed.

Meristic and morphometric data are presented in Tables 14 and 15.

Distribution

Aphanius dispar is able to tolerate wide variation in salinity accounts for its wide distribution. It occurs in the coastal drainages of Arabia (Fig. 23), which probably had direct connection to the sea during the past several thousand years. This species occurs in Abyssinia, Palestine, Iraq, near the Gulf drainages of Iran, near the Dead Sea and the Asraq Oasis, Jordan. Banister and Clarke (1975) mentioned that this species occurs near the Red Sea drainages of Saudi Arabia. In 1977 I found this species to be widespread in

Table 14. Morphometric characters of Aphanius dispar from Al Hufuf, Khaybar and Al-Kharj springs.

	n	$\bar{x}$	Percent of Standard Length	S.D.	S.E.	Range
TL	93	56.4	----	7.9	0.8	36-73 mm
SL	93	46.1	----	7.1	0.7	30-60 mm
BD	93	14.5	0.31	2.6	0.3	8-22 mm
HL	93	14.1	0.30	2.2	0.2	8-20 mm
OL	93	4.4	0.10	0.6	0.06	3-5 mm
UJL	-	-	----	-	-	-
DO	93	28.6	0.62	4.1	0.4	19-37 mm
AL	93	12.4	0.27	3.8	0.4	6-20 mm
DFDL	93	14.1	0.30	5.5	0.6	5-26 mm
DFBL	75	7.3	0.16	1.6	0.2	5-11 mm
CPD	93	8.4	0.18	1.7	0.2	5-13 mm
CPL	93	10.6	0.23	2.2	0.2	7-16 mm

Table 15. Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/USL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Almdawrah (Khaybar City)	1	53	3.3	3.3	3.2	-	1.6	4.8	7.2	0.9	14	16	26	-	I-7	II-7	15	7
	2	52	3	3.8	3	-	1.8	3.5	4.5	1.1	15	17	26	-	I-7	II-7	14	6
	3	36	3.6	3.3	3	-	1.6	2.5	2.7	1.2	16	21	25	-	I-7	II-6	14	6
	4	38	3.9	2.8	2.8	-	1.6	4.4	5.2	1.6	16	20	26	-	I-6	I-8	13	-
$\bar{x}$	-	-	3.5	3.3	3	-	1.7	3.8	4.9	1.2	15.3	18.5	25.8	-				
min	-	-	3	2.8	2.8	-	1.6	2.5	2.7	0.9	14	16	25	-				
max	-	-	3.9	3.8	3.2	-	1.8	4.8	7.2	1.6	16	21	26	-				
Alkharj	5	63	3.5	4.1	2.6	-	1.7	5.3	8.8	1.1	18	23	25	-	I-7	II-6	13	7
	6	66	3.2	3.6	3.8	-	1.8	3.9	4.9	1.1	16	18	26	-	I-6	I-7	14	6
	7	66	2.9	3.5	3.8	-	1.8	4.1	5.3	1.1	16	19	25	-	I-6	I-7	14	6
	8	57	3.1	3.6	4.3	-	1.8	3.9	4.7	1.1	16	21	26	-	I-6	I-7	14	6
	9	51	3.1	3.3	3.3	-	1.5	4.8	7.2	1.0	16	23	25	-	I-7	I-8	13	7
	10	43	3.3	3.6	3.3	-	1.6	4.5	7.2	1.1	16	22	25	-	I-7	II-6	13	-
$\bar{x}$	-	-	3.2	3.6	3.5	-	1.7	4.4	6.4	1.1	16.3	21	25.3	-				
min	-	-	2.9	3.3	2.6	-	1.5	3.9	4.7	1.0	16	18	25	-				
max	-	-	3.5	4.1	4.3	-	1.8	5.3	8.8	1.1	18	23	26	-				

Table 15 (Continued). Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/USL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Rasibe spring (Al Hufuf)	11	51	2.9	3.6	3.5	-	17	4.7	5.9	1.4	11	19	27	-	II-7	II-7	16	7
	12	56	2.8	3.2	3.3	-	1.6	4.2	6.0	1.3	15	21	28	-	II-7	8	15	7
	13	65	3.1	3.4	3.8	-	1.8	4.3	5.2	1.4	14	21	27	-	I-7	II-7	14	7
	14	47	3.1	3.4	2.8	-	1.8	4.6	5.3	1.2	14	20	26	-	I-7	II-7	14	7
	15	46	2.9	3.2	4.0	-	1.8	3.9	5.0	1.0	15	21	25	-	I-7	II-7	14	7
	16	58	3.3	3.1	3.8	-	1.5	4.6	7.7	1.3	14	21	28	-	I-8	I-8	14	6
	17	61	3.3	3.3	3.0	-	1.7	5.0	10	1.1	14	21	26	-	I-8	I-8	14	7
	18	46	3.0	3.0	4.0	-	1.6	4.5	7.2	1.4	13	20	25	-	I-8	I-7	14	7
	$\bar{x}$		3.1	3.3	3.5	-	1.7	4.5	6.5	1.3	13.8	20.5	26.5					
	min.		2.8	3.0	2.8	-	1.5	3.9	5.0	1.0	11	19	25	-				
	max.		3.3	3.6	4.0	-	1.8	5.0	10	1.4	15	21	28	-				
Al Harrah (Al Hufuf)	19	46	3.0	3.0	3.0	-	1.5	4.0	6.0	1.3	13	21	26	-	I-8	I-8	14	7
	20	42	3.4	3.8	2.3	-	1.5	4.9	8.5	1.8	13	20	28	-	I-8	I-8	14	7
	21	45	3.1	3.7	2.5	-	1.6	5.3	7.4	1.3	13	20	28	-	I-8	I-8	13	7
	22	42	2.7	2.9	2.8	-	1.5	5.3	8.0	1.2	13	21	28	-	I-8	I-8	13	7
	23	42	3.3	3.0	2.8	-	1.5	5.5	8.3	1.2	13	20	27	-	I-8	I-8	13	7
	$\bar{x}$		3.1	3.3	2.7	-	1.5	5.0	7.6	1.4	13	20.4	27.4					
	min.		2.7	2.9	2.3	-	1.5	4.0	6.0	1.2	-	20	26	-				
	max.		3.4	3.8	3.0	-	1.6	5.5	8.5	1.8	-	21	28	-				

Table 15 (Continued). Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/USL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Unknown Spring (Al Hufuf)	24	60	3.6	3.8	3.3	-	1.6	5.0	8.3	1.2	15	24	28	-	I-8	I-9	13	7
	25	64	3.3	3.5	3.8	-	1.6	4.8	8.8	1.2	13	21	28	-	I-8	II-8	13	7
	26	58	3.4	3.4	3.5	-	1.5	5.9	7.8	1.3	13	21	28	-	I-7	I-9	13	7
	27	52	3.1	3.1	3.5	-	1.5	5.9	7.8	1.3	15	20	28	-	I-7	I-9	13	7
	28	52	3.1	3.1	3.5	-	1.5	4.2	7.0	1.3	13	21	28	-	I-7	I-9	13	7
$\bar{x}$			3.3	3.4	3.5	-	1.5	5.2	7.9	1.3	13.8	21.4	28	-				
min.			3.1	3.1	3.3	-	1.5	4.2	7.0	1.2	12	20	-	-				
max.			3.6	3.8	3.8	-	1.6	5.9	8.8	1.3	15	24	-					
Omm Aleef Spring (Al Hufuf)	29	58	3.1	3.4	3.5	-	1.8	3.9	7.8	1.2	14	20	28	-	I-7	I-9	14	7
	30	54	3.2	3.0	3.5	-	1.6	4.2	6.0	1.3	13	20	28	-	II-7	I-9	14	7
	31	50	3.3	3.3	2.4	-	1.7	4.0	5.7	1.3	14	20	28	-	II-7	I-9	14	7
	32	50	3.0	3.0	2.6	-	1.6	4.3	6.5	1.3	14	20	28	-	II-7	I-9	14	7
	33	46	3.3	3.3	2.8	-	1.3	4.5	9.0	1.3	13	19	27	-	I-7	I-9	13	7
$\bar{x}$			3.2	3.2	3.0	-	1.6	4.2	7.0	1.3	13.6	19.8	27.8					
min.			3.0	3.0	2.4	-	1.3	3.9	5.7	1.2	13	19	27					
max.			3.3	3.4	3.5	-	1.8	4.5	9.0	1.3	14	20	28					

Table 15. Meristic and Morphometric Data of Aphanius dispar (continued).

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/USL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Dalli Spring (Al Hufuf)	34	54	3.3	3.6	2.4	-	2.0	4.8	8.6	1.1	15	20	28	-	I-8	I-9	14	7
	35	52	3.5	3.2	3.3	-	1.6	4.7	7.0	1.3	14	20	27	-	I-8	I-9	14	7
	36	51	3.5	3.5	3.0	-	1.6	4.7	8.4	1.2	13	20	26	-	I-8	I-9	14	7
	37	49	3.3	3.3	3.0	-	1.3	3.3	6.5	1.3	14	22	28	-	II-7	I-8	14	7
	38	55	4.1	4.1	3.3	-	2.0	4.8	7.6	1.3	14	21	28	-	II-7	I-8	14	7
	$\bar{x}$		3.5	3.5	3.0	-	1.7	4.5	7.6	1.3	14	20.6	27.4					
	min.		3.3	3.2	2.4	-	1.3	3.3	6.5	1.1	13	20	26					
	max.		4.1	4.1	3.3	-	2.0	4.8	8.6	1.3	15	22	28					
Alkhdud Spring (Al Hafuf)	39	58	2.8	2.9	3.2	-	1.6	3.9	5.2	1.0	15	23	28	-	II-7	I-8	14	7
	40	58	3.0	3.4	2.8	-	1.7	4.4	5.3	1.3	14	22	28	-	II-9	I-8	14	7
	41	59	3.3	3.3	3.0	-	1.6	4.9	8.2	1.2	14	22	26	-	I-7	I-9	14	7
	42	59	3.4	3.6	2.6	-	1.7	5.9	7.8	1.3	13	21	27	-	I-7	I-9	14	7
	43	55	3.4	3.4	3.3	-	1.6	4.4	7.3	1.1	14	21	27	-	I-7	I-9	14	7
	$\bar{x}$		3.2	3.3	3.0	-	1.6	4.7	6.7	1.2	14	21.8	27.2					
	min.		2.8	2.9	2.6	-	1.6	3.9	5.2	1.0	13	21	26	-				
	max.		3.4	3.6	3.3	-	1.7	5.9	8.2	1.3	15	23	28	-				

Table 15 (Continued). Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/USL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Talibia Spring (Al Hufuf)	44	69	3.4	3.4	3.8	-	1.6	4.5	7.4	1.3	14	20	28	-	I-8	I-8	14	7
	45	53	2.6	3.5	2.4	-	1.6	4.2	10.4	1.3	14	20	27	-	I-8	I-8	14	7
	46	50	2.7	2.9	3.5	-	1.5	4.6	6.8	1.1	14	19	27	-	I-8	I-8	13	7
	47	55	3.2	3.5	2.6	-	2.0	5.0	9.0	1.1	13	20	27	-	I-7	I-9	14	7
	48	54	2.9	3.4	2.6	-	1.6	4.9	8.8	1.1	13	20	27	-	I-7	I-9	14	7
	$\bar{x}$		3.0	3.3	3.0	-	1.7	4.6	8.5	1.2	13.6	19.8	27.2					
	min.		2.6	2.9	2.4	-	1.5	4.2	6.8	1.1	13	19	27					
	max.		3.4	3.5	3.8	-	2.0	5.0	10.4	1.3	14	20	28					
Amarah Spring (Al Hufuf)	49	66	3.2	3.4	4.0	-	1.6	5.5	7.9	1.2	13	21	26	-	I-8	I-9	13	7
	50	62	3.9	4.2	3.5	-	2.0	5.9	9.8	1.1	13	20	26	-	I-8	I-9	14	7
	51	54	3.4	3.4	3.3	-	1.5	4.9	8.8	1.3	13	21	27	-	I-8	I-9	14	7
	52	64	3.0	3.1	4.0	-	1.6	3.8	5.0	1.2	14	20	28	-	II-7	I-9	14	7
	53	63	2.9	3.1	4.0	-	1.6	4.1	4.9	1.2	14	20	28	-	II-7	I-9	14	7
	$\bar{x}$		3.3	3.4	3.8	-	1.7	4.8	7.3	1.2	13.4	20.4	27					
	min.		2.9	3.1	3.3	-	1.5	3.8	4.9	1.1	13	20	26	-				
	max.		3.9	4.2	4.0	-	2.0	5.9	9.8	1.3	14	21	28					

Table 15 (Continued). Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/USL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Barabir Spring (Al Hufuf)	54	67	2.8	4.0	4.5	-	1.6	4.2	7.7	1.2	14	21	28	-	II-7	I-8	14	7
	55	59	3.2	3.2	3.8	-	1.6	4.8	8.0	1.2	13	20	28	-	I-8	I-9	14	7
	56	51	3.7	3.4	3.3	-	1.7	4.9	8.8	1.1	14	20	28	-	I-8	I-9	14	7
	57	60	3.3	3.3	3.8	-	1.5	5.0	10	1.5	14	20	26	-	I-8	I-9	13	7
	58	53	3.5	3.2	3.5	-	1.7	4.5	15	1.6	14	20	27	-	I-8	I-9	13	7
	$\bar{x}$		3.3	3.4	3.8	-	1.6	4.7	9.9	1.3	13.8	20.2	27.4					
	min.		2.8	3.2	3.3	-	1.5	4.2	7.7	1.1	13	20	26	-				
	max.		3.7	4.0	4.5	-	1.7	5.0	15	1.6	14	21	28	-				
Bo Hadi Spring (Al Hufuf)	59	50	3.2	3.2	2.6	-	1.6	7.0	4.7	1.4	13	20	26	-	I-8	I-9	14	7
	60	46	3.3	3.3	3.0	-	1.7	6.5	4.3	1.5	13	20	27	-	I-8	I-9	14	7
	61	56	2.9	2.7	3.2	-	1.5	8.6	4.3	1.1	14	22	27	-	I-8	I-9	14	7
	62	52	3.2	3.2	4.0	-	1.6	7.0	5.3	1.3	14	22	27	-	I-8	I-9	14	7
	63	41	3.4	3.2	3.5	1.6	6.8	5.1	1.2	13	21	28	-	I-8	I-9	14	7	
	$\bar{x}$		3.2	3.1	3.3	-	1.6	7.2	4.7	1.3	13.4	21	27					
	min.		2.9	2.7	2.6	-	1.5	6.5	4.3	1.1	13	20	26	-				
	max.		3.4	3.3	4.0	-	1.6	8.6	5.3	1.5	14	22	28	-				

Table 15 (Continued). Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/UJL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Almushateiah Spring (Al Hufuf)	64	71	3.1	3.4	3.4	-	1.7	4.1	9.7	1.2	14	21	27	-	I-8	I-7	15	7
	65	59	3.0	3.4	2.8	-	1.8	4.4	6.9	1.3	14	21	26	-	II-7	I-9	15	7
	66	61	3.3	3.2	3.2	-	1.8	4.9	8.2	1.3	14	20	27	-	II-7	I-9	15	7
	67	59	3.1	2.9	3.2	-	1.6	4.3	7.8	1.1	13	20	28	-	I-8	I-9	14	7
	68	52	3.2	3.2	2.6	-	1.5	4.6	8.2	1.2	13	20	28	-	I-8	I-9	13	7
	$\bar{x}$		3.1	3.2	3.0	-	1.7	4.5	8.2	1.2	13.6	20.4	27.2					
	min.		3.0	2.9	2.6	-	1.5	4.1	6.9	1.1	13	20	26					
	max.		3.3	3.4	3.4	-	1.8	4.9	9.7	1.3	14	21	28					
Omm Saba'ah Spring (Al Hafuf)	69	52	3.4	3.2	3.3	-	1.8	3.7	5.9	1.4	14	21	28	-	I-8	I-9	14	7
	70	50	3.6	3.1	2.8	-	1.5	4.8	8.6	1.5	14	23	27	-	I-7	I-9	13	7
	71	52	3.6	3.1	2.8	-	1.6	4.8	8.6	1.3	14	23	26	-	I-7	I-9	13	7
	72	47	3.2	2.9	3.3	-	1.5	4.2	7.6	1.3	13	22	27	-	I-7	I-9	13	7
	73	52	3.4	3.2	3.3	-	1.7	4.1	5.6	1.4	14	21	28	-	I-8	I-9	14	7
	$\bar{x}$		3.4	3.1	3.1	-	1.6	4.3	7.3	1.4	13.8	22	27.2					
	min.		3.2	2.9	2.8	-	1.5	3.7	5.6	1.3	13	21	26	-				
	max.		3.6	3.2	3.3	-	1.8	4.8	8.6	1.5	14	23	28	-				

Table 15 (Continued). Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/UJL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Aljalajenah Spring (Al Hufuf)	74	65	2.9	3.5	3.0	-	1.8	4.8	5.9	1.4	14	20	28	-	I-8	I-9	13	7
	75	57	3.1	3.1	3.2	-	1.8	4.5	5.4	1.3	14	20	28	-	II-7	I-9	14	7
	76	66	3.7	3.1	3.6	-	1.6	5.5	7.9	1.5	13	20	28	-	I=8	I-9	14	7
	77	62	3.5	3.3	3.2	-	1.6	5.2	6.5	1.3	14	20	28	-	I-8	I-9	14	7
	78	65	3.5	3.3	3.2	-	1.5	5.3	6.6	1.4	13	20	28	-	I-8	I-9	14	7
	$\bar{x}$		3.3	3.3	3.3	-	1.7	5.1	6.5	1.4	13.6	20	28					
	min.		2.9	3.1	3.0	-	1.5	4.5	5.4	1.3	13	-	-					
	max.		3.7	3.5	3.6	-	1.8	5.5	7.9	1.5	14							
AlBsatenat Spring (Al Hufuf)	79	65	3.1	3.2	3.4	-	1.6	5.0	7.9	1.1	14	21	28	-	I-8	I-9	13	6
	80	65	2.8	3.1	3.4	-	1.5	4.4	7.6	1.2	15	22	27	-	I-8	I-9	14	7
	81	67	2.9	2.9	4.0	-	1.7	5.8	6.4	1.2	13	21	28	-	I-7	I-7	15	7
	82	68	2.5	2.8	4.0	-	1.6	3.7	5.1	1.3	14	24	27	-	I-8	I-7	14	6
	83	65	2.7	2.7	3.8	-	1.5	3.7	4.7	1.4	13	22	27	-	I-8	I-7	14	7
	$\bar{x}$		2.8	2.9	3.7	-	1.6	4.5	6.3	1.2	13.8	22	27.4	-				
	min.		2.5	2.7	3.4	-	1.5	3.7	4.7	1.1	13	21	27	-				
	max.		3.1	3.2	4.0	-	1.7	5.8	7.9	1.4	15	24	28	-				

Table 15 (Continued). Meristic and Morphometric Data of Aphanius dispar.

Basin	No.	TL	SL/BD	SL/HL	HL/OL	HL/UJL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
Al Jabariyh Spring (Al Hafuf)	84	73	3.3	3.3	3.6	-	1.6	5.0	8.6	1.4	16	22	29	-	I-8	I-7	15	7
	85	65	3.4	3.7	3.8	-	1.8	3.9	6.9	1.3	15	21	29	-	I-8	I-8	14	7
	86	68	3.0	3.7	3.2	-	1.7	4.1	7.1	1.3	15	22	28	-	I-8	I-8	14	7
	87	67	3.1	3.4	3.2	-	1.8	5.0	6.9	1.2	14	21	28	-	I-8	I-8	14	7
	88	59	3.3	3.1	3.2	-	1.6	4.9	6.1	1.3	14	22	27	-	I-7	I-8	15	7
	$\bar{x}$		3.2	3.4	3.4	-	1.7	4.6	7.1	1.3	14.8	21.6	28.2					
	min.		3.0	3.1	3.2	-	1.6	3.9	6.1	1.2	14	21	27	-				
	max.		3.4	3.7	3.8	-	1.8	5.0	8.6	1.4	16	22	29	-				
Alowami Spring (Al Hafuf)	89	60	2.9	3.3	3.8	-	1.5	4.6	8.2	1.5	16	22	29	-	I-8	I-8	14	7
	90	56	3.0	3.0	3.8	-	1.6	3.8	6.4	1.5	15	22	25	-	I-8	I-9	14	7
	91	70	3.4	3.4	3.4	-	1.6	5.3	8.3	1.1	16	22	28	-	II-9	I-9	15	6
	92	61	3.1	3.3	3.8	-	1.5	5.0	8.3	1.3	15	22	29	-	II-9	I-9	15	6
	93	57	3.1	3.1	3.8	-	1.6	4.6	6.6	1.5	15	21	26	-	I-8	I-9	14	7
	$\bar{x}$		3.1	3.2	3.7	-	1.6	4.7	7.6	1.4	15.4	21.8	27.4	-				
	min.		2.9	3.0	3.4	-	1.5	3.8	6.4	1.1	15	21	25	-				
	max.		3.4	3.4	3.8	-	1.6	5.3	8.3	1.5	16	22	29	-				

the eastern regions of Saudi Arabia (Gulf drainages), Al-Kharj springs, and many springs of Khaybar City, where endemic Cyprinion occurs. The presence of this species in the eastern regions and Al-Kharj has not been mentioned before.

This species is not likely to be confused with any other species in Arabia. The presence of the vertical bands on the caudal fin of the male and the tricuspid teeth in the jaws distinguished it from other species.

FAMILY: POECILIDAE

Viviparous, more than 25 genera in North and South America. Anal fin of the male produced, its 3rd, 4th and 5th rays modified into a copulatory organ.

Genus Gambusia Poey

Gambusia Poey, Memorias, I, 1855, p. 382 (type: Gambusia punctata Poey from Cuba).

Teeth are conic or setiform. Jaws are elongate. Lower edge of the caudal peduncle is rounded or obtuse. Ventral fins are similar in both sexes (not enlarged in the males). Anal fins of the male are markedly produced forward.

Gambusia affinis (Baird et Girard)

Heterandria affinis Baird et Girard 1853.

Heterandria patruclis Baird et Girard 1853.

Gambusia affinis affinis Lindberg 1934, p. 357.

D 6 (last two rays taken as one), A 8-9, L. L. 28-30.

Specimens Examined

Two specimens SL 34 and 36 mm were collected from one spring in Al-Kharj City.

Description

This is a small fish, seldom exceeding 60 mm. The gill rakers number 12-14. The dorsal fin has six rays. The lateral line scales

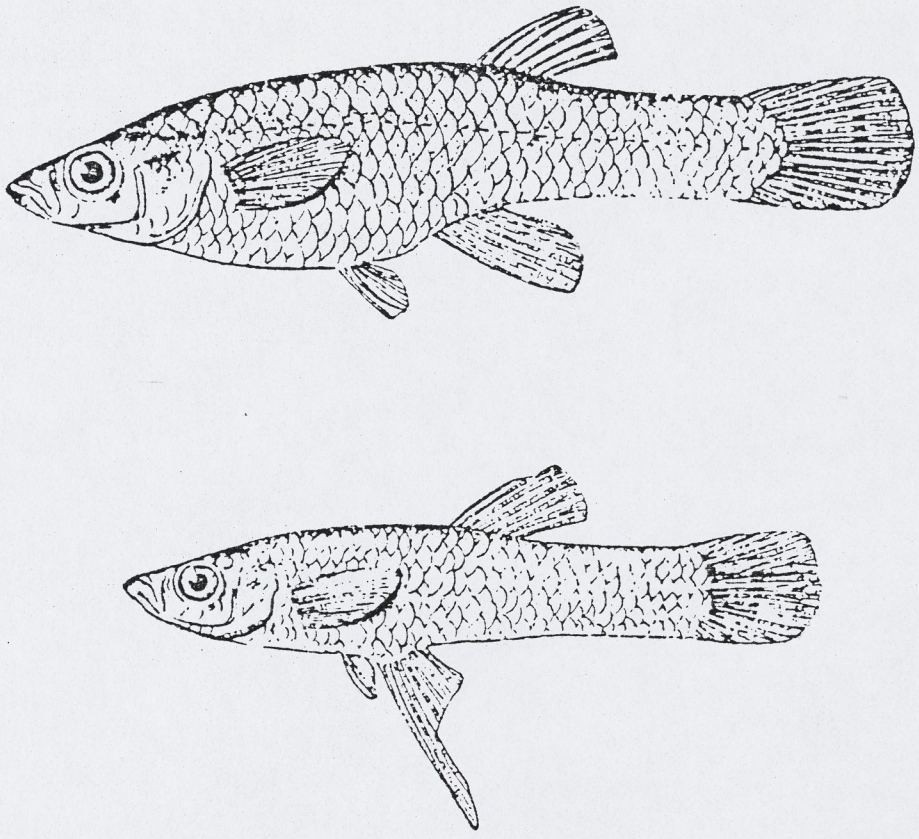

Figure 22. Gambusia affinis Female and male (Berg, L.S. Freshwater Fishes of USSR, 1949).

range from 28 to 30. The genus Gambusia has been artificially introduced throughout the world to control malaria. Among the collections I made in the summer, 1977, I found this genus in one spring in Al-Kharj City. This is the first time this species was discovered in Saudi Arabia. There should be general awareness in Saudi Arabia concerning the potential danger that introductions of exotic species have for native species or 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 introduction. The native "top minnow", Aphanius dispar, can probably act as an effective biological control for mosquitos. In the future, I urge that the native species should be used for such introduction.

Distribution

Gambusia is a native to southern and eastern USA, Mexico and Cuba, where it occurs in small lakes, canals, and lagoons. Gambusia affinis has been introduced and propagated all over the world for control of mosquitoes that are vectors for malaria. This is the first record of this species on the Arabian Peninsula (Fig. 23).

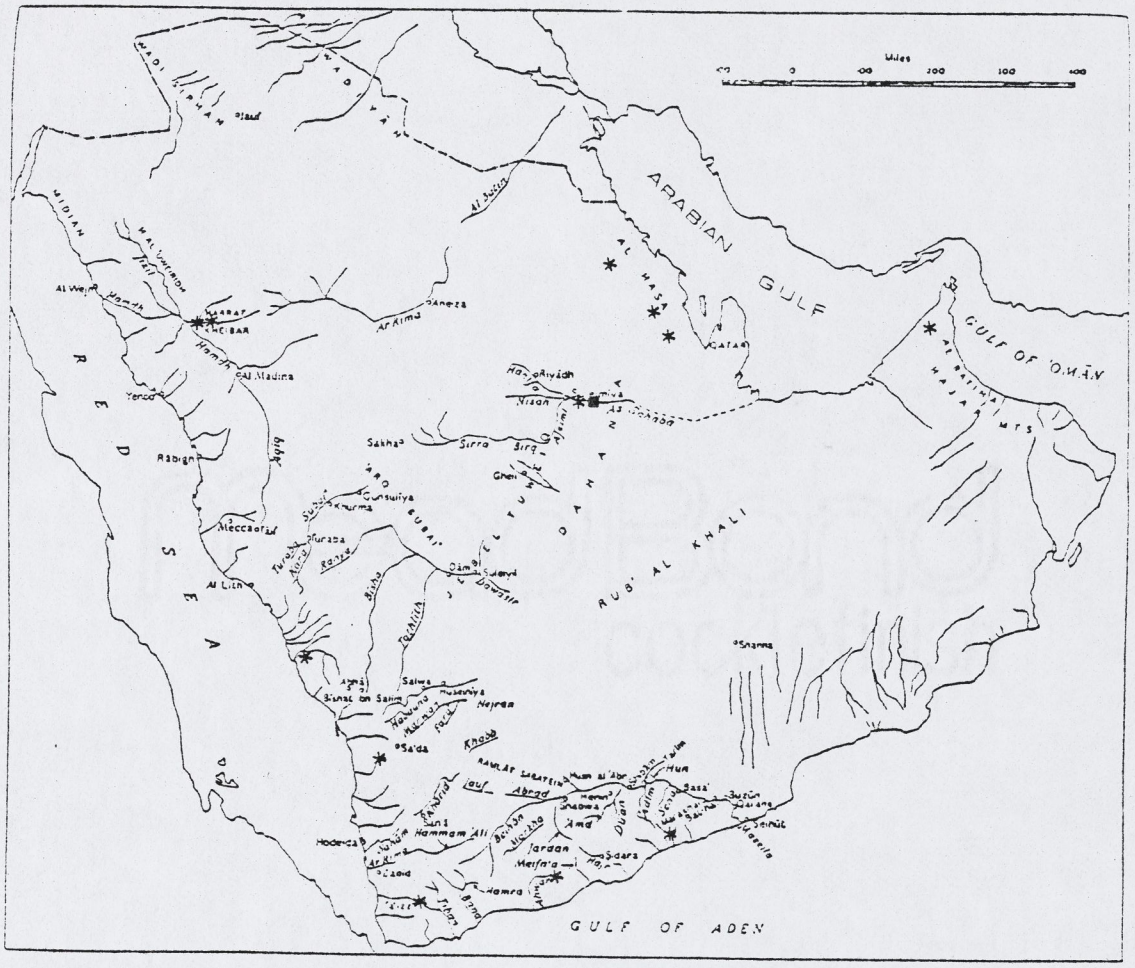

Figure 23. The distribution of Aphanius dispar (*) and Gambusia affinis (■).

Table 16. Morphometric and Meristic Data of Gambusia affinis (Baird and Girard) from a spring at Al-Kharj City.

No.	TL	SL/BD	SL/HL	HL/OL	HL/UJL	SL/DO	SL/PFL	SL/VFL	CPL/CPD	GR	GRP	LL	SALL	D	A	P	V
1	43	3.8	4.3	2.7	-	1.5	-	-	2.2	12	15	28	-	6	9	8	5
2	45	3.3	4.0	3.0	-	1.6	5.1	6.0	2.2	14	17	30	-	6	8	9	6
$\bar{x}$		3.6	4.2	2.9	-	1.55	-	-	2.2	13	16	29	-				
min.		3.3	4.0	2.7	-	1.5	-	-	2.2	12	15	28	-				
max.		3.8	4.3	3.0	-	1.6	-	-	2.2	14	17	30	-				

DISCUSSION

About 600 specimens representing eight species were collected in 1977 from 28 localities of eastern, northwestern and southwestern Saudi Arabia. The most common and ubiquitous species, Aphanius dispar, made up about two-thirds of the total number of specimens.

My collections made in 1977, although restricted to Saudi Arabia, represent the most extensive sampling of freshwater fishes yet made from the Arabian Peninsula. I found all of the species described by Banister and Clarke plus three undescribed species of the genus Cyprinion.

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. Virtually all species of primary freshwater fishes now known in Arabia are endemic species. This fact indicates long isolations.

The genus Cyprinion is of Asiatic origin and is represented by one non-endemic and four endemic species. The four endemic species appear to be more closely related to each other than to any other living species in the genus. The non endemic species (C. watsoni) of general Asiatic distribution is assumed to have crossed the Arabian Gulf from Iran in the late Pleistocene time when the Gulf was a freshwater lake due to a low sea level.

The genus Garra, also of Asiatic origin, crossed the Arabian Peninsula to become established in northeast Africa. Garra is represented by three, possibly four (depending on validity of G. arabica), endemic species. There is a question concerning Garra tibanica as an endemic Arabian species. Menon (1964) recorded G. tibanica from Somalia. There is such variability and diversity in Menon's "tibanica complex" that I consider the identification of Somalian specimens as G. tibanica, at best, doubtful.

The three endemic Arabian species of Barbus suggests two origins, Barbus apoensis and Barbus exulatus derived from a Jordan River Barbus canis-like ancestor, and Barbus arabicus derived from a large-scaled Barbus ancestor native to northeast Africa. Aphanius dispar, because of its ability to disperse through seawaters, doesn't represent ancient relict populations divergent from the parent species. The present distribution of Aphanius is assumed to be of late Pleistocene origin, when present isolated, internal basins had direct outlets to surrounding seas.

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

Ichthyological studies can be of critical significance for interpretation of climatic and hydrographic history of the country. Also, freshwater fish can become a more important part of the Saudi Arabian economy by increasing the supply of protein, by providing recreational and esthetic values and as a biological control agent for vegetation problems and disease vectors. 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. A continuation of the present study is necessary to complete the documentation of species, their distribution and habitats before extinction caused by water development projects occurs. 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 our biological heritage.

Our prophet صلى الله عليه وسلم urges us to be merciful and helpful to all of God's creatures. Thus, the development of an environmental conscience has a basis in our religious and cultural heritage. Abu Huraira رضي الله عنه tells us that Allah's Apostle صلى الله عليه وسلم 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 (again) and filled his shoe (with water) 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."

The original Arabic text is as follows:

حدثنا إسماعيل: حدثني مالك، عن
سمي مولى أبي بكر، عن صالح السمان،
عن أبي هريرة: أن رسول الله صلى الله عليه وسلم
قال: بينما رجل يمشي بطريق اشتد
عليه العطش، فوجد بئرًا فنزل فيها
فشرب، ثم خرج فإذا كلب يلهث
يأكل الثرى من العطش، فقال
الرجل: لقد بلغ هذا الكلب من
العطش مثل الذي كان قد بلغ بي
فنزل البئر فملأ خفه، ثم أمسكه
بفيه فسقى الكلب، فشكر الله
له فغفر له.
قالوا: يا رسول الله، وإن لنا في
البهائم أجرًا؟ فقال: في كل ذات
كبد رطبة أجر. *

*Sahih Al-Bukhari, 2nd edition, 1977, Vol. VIII, Hilah Yayinlari, P.O. Box 448, Ankara, Turkey.

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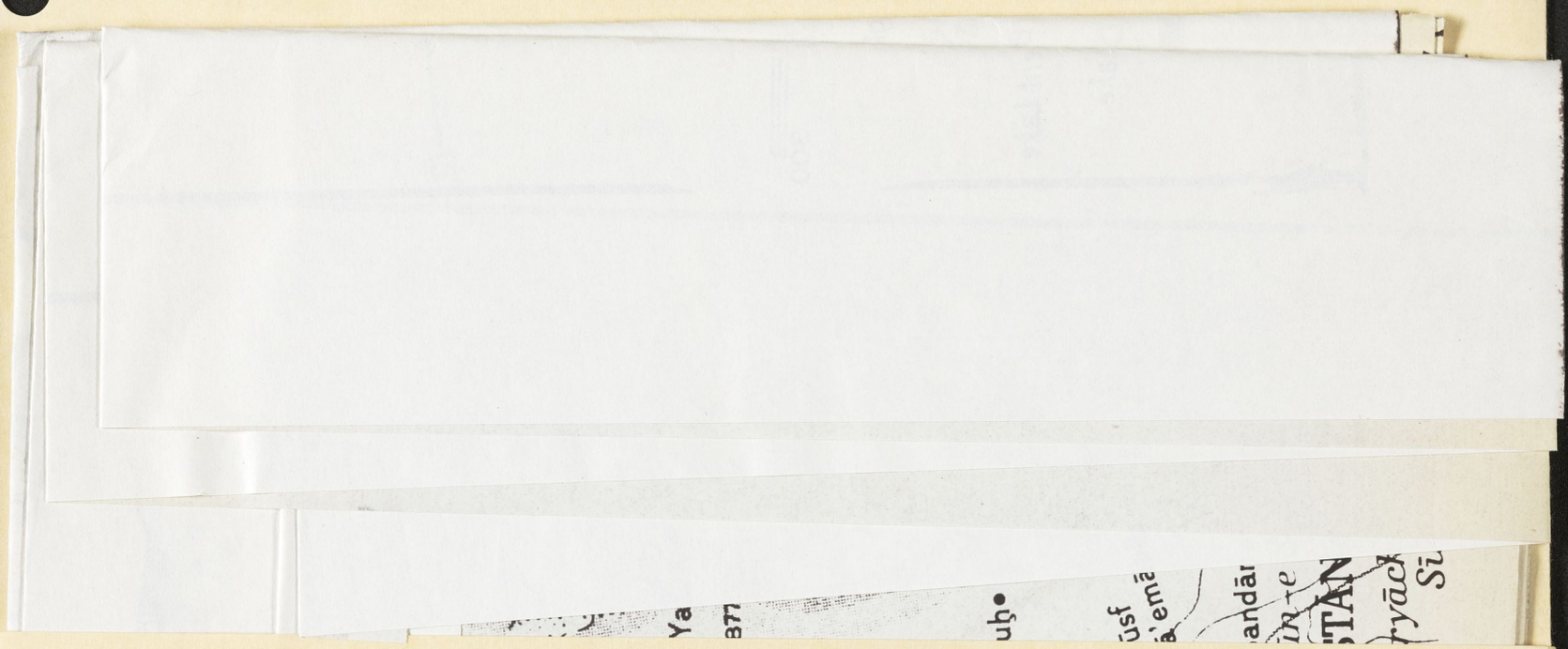

Plate 1. Map of Arabia and surrounding African and Asiatic regions.


MEDITERRANEAN
SEA
SYRIA
LEBANON
IRAQ
IRAN
KUWAIT
SAUDI
ARABIA
ARABIAN
GULF
BAHRAIN
QATAR
UNITED ARAB EMIRATES
GULF OF OMAN
TROPIC OF CANCER
OMAN
ARABIAN
SEA
YEMEN
DEMOCRATIC YEMEN
HADRAMAWT
GULF OF ADEN
DJIBOUTI
SOMALIA
ETHIOPIA
SINAI
RED SEA
Nubian Desert
An Nafūd
Ar Rab' al Khālī
(Empty Quarter)
Baghdād
Ar Riyāḍ
Makkah
Jiddah
Al Madīnah
Port Sudan
Khartoum
Aswān
Ṣan'ā'
Aden
Masqaṭ
Dubayy
Abū Ẓaby
Ad Dawḥah
Al Manāmah
Ad Dammām
Al Kuwayt
Eṣfahān
Shīrāz
Kermān
Yazd
SĪSTĀN
BALUCHISTAN
PAKISTAN
AFGHANISTAN
ERITREA
Suquṭrā
Kuria Muria Islands
KILOMETERS
STATUTE MILES
Roads
Airports
Railroads
Oil Pipe Lines
Canals
Passes
Craters
Oil Fields
Water Holes
Elevations in Meters
Intermittent Lake
Dry Salt Lake