Review

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Lobsters from Northern Arabian Sea (Pakistan Coast)

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Abstract. Pakistan is situated between latitude 24^0 and 37^0 North and longitude 62^0 and 75^0 East, on the eastern part of the Arabian Sea with a coastline of about 900 km. Lobsters are found both on its northwest (Balochistan) and southeast coasts (Sindh). Important fishing grounds of lobsters are located along Ormara, Pasni Gwader and Jiwani besides Karachi coast. Todate, 16 species of lobsters have been recorded from Pakistan. The only predominant commercial species is *Panulirus polyphagus*, which constitutes 83% of the catch. The paper provides an identification key for northern Arabian Sea lobsters and outlines the available information on the biology, fisheries and management of the lobster species from Pakistan. Most of the studies have been focused on *P. polyphagus*.

Keywords: Arabian Sea lobsters, *P. polyphagus*, Arabian Sea, lobsters

Introduction

Pakistan is situated between latitude 24^0 and 37^0 north and longitude 62^0 and 75^0 east on the eastern part of the Arabian Sea with a coastline of about 900 km. It is divided into two ecological zones: Balochistan coast on the northwest and Sindh coast on the southeast. The Balochistan coast is about 630 km long and the Sindh coast is about 270 km long. Along the Balochistan coast, the continental shelf is 10-20 km wide; the bottom is mostly rocky except at Sonmiani Bay. The Sindh coast is characterized by innumerable creeks; the continental shelf extends to about 30-100 km; the bottom of the shelf is muddy and muddy-cum-sandy. The river Indus discharges in this area and forms the Indus Delta, which is one of the largest deltas in the world. The Balochistan coast is endowed with stable hydrological conditions characterized by high temperature and salinity owing to little fresh water drainage.

Species diversity. A sound knowledge of biodiversity and biology of commercial species forms the basis for a sustainable management. To date, 16 species of lobsters have been recorded from Pakistan (Kazmi, 2004, 2003; Holthuis, 1991; Williams, 1986). These species belong to eight genera and two families. The family Palinuridae is represented by two genera *Panulirus* and *Puerulus*. Genus *Panulirus* has five species and two sub species recorded from Pakistan coast: *Panulirus versicolor, P. homarus megasculpta, P. homarus rubellus, P. ornatus, P. polyphagus* and *P. penicillatus*; *Puerulus* has two species: *Puerulus angulatus* and *P. sewelli*. The family Scyllaridae comprises of six genera and nine species *viz*. *Thenus orientalis, T. pariindicus, T. indicus, Scyllarides tridacnophaga, S. haani, Scammarctus batei, Eduarctus martensii, Acantharctus ornatus* and *Parribacus antarcticus.*

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History of Taxonomy of Pakistani Lobsters. The history of carcinological studies in Pakistan reveals that the lobster fauna of Pakistan reported in the beginning belonged to only one Palinurid genus *Panulirus* and its three species and one Scyllarid genus *Thenus*, till then monotypic (Ahsanullah, 1965; Tirmizi and Ahsanullah, 1965; Government of Pakistan, 1960; Hussain, 1958). Additions of several genera and species have been made through reports as World Lists (Burton and Davie, 2007; Holthuis, 2002, 1991, 1984; Williams, 1986) and new records made by local scientists (Kazmi, 2003, 1995; Moazzam *et al*., 2003; Fatima, 2000; Tirmizi and Kazmi, 1983).

In recent years several nomenclatural changes have also been made world wide. The scyllarine genus *Thenus* was represented only by *Thenus orientalis* until recently; now Burton and Davie (2007) have revised the taxonomy on the basis of DNA studies and recognized four species within the genus (Burton and Davie, 2007). They established three new species, one of these, *T. parindicus*, is also included in the material from Pakistan; another species *T. indicus* was separated from the old *T. orientalis* as non-type material from Karachi. The record of *T. orientalis* from Pakistan is given with some doubts by Burton and Davie (2007). Prof. Dr. L. B. Holthuis revised the Indo-Pacific species of the scyllarine genera in 2002 and separated several genera from the species formally placed in the genus *Scyllarus* Fabricius. Three such species which were reported from Pakistani waters were also transferred to the new genera created by Holthuis. The material examined for new genus *Acantharctus* included

material collected from Pakistan (then British India) in 1930. More works on taxonomic status also altered the species composition occurring in the northern Arabian Sea up to 10 °N. Some old records were found to be misidentified, for example *Jasus lalandi* reported by Prasad and Tampi (1968) is actually *Parribacus antarticus* (Holthuis, 1985). Pollock *et al.* (2000) have given the distribution of the species *Jasus lalandi* in the south east Atlantic region, so *J. lalandi* is no more included in the faunal list from Arabian Sea. Similarly the case of genus *Parribacus* (*P. antarticus*), reported by Williams (1986) from the northern Arabian Sea (including Pakistani waters), has to be treated with some reservation since it was not included by Holthuis (1991) in the world list of lobsters from Pakistan or either Arabian Sea. Another problematic genus is *Palinustus*. What is believed to be *P. waguensis* has been reported under the name of *P. mossambicus* from the Arabian Sea. The taxonomic status of *P. waguensis vis-á-vis P. mossambicus* is far from clear and closer study of the complex is still highly desirable (Holthuis, 1991).

The nominotypical form of *Panulirus homarus* (*P.h.homarus*) is found throughout the range of species but *P. h. megasclupta* is known only from the northern Arabian Sea and *P. h. rubellus* inhabits S. E. Africa and S. E. Madagascar (Holthuis, 1991). These subspecies were not distinguished in the study by Tirmizi and Ahsanullah (1965). Kazmi (1995) reported a specimen of *P. homarus* collected from Churna Island, Makran Coast (25°.5'E, 67°.5'N). Interestingly, this specimen appeared to be more similar to *P. h. rubellus* than to the local subspecies *P. h. megasculpta*. The colour pattern differed from all the known forms and some minor morphological differences were also noticed in the antennal peduncle, antennular plate, and the abdominal pleura. There is a prominent spine at the inner anterolateral angle of the basal antennal segment (Fig. 1a). The antennular plate has two unequal pairs of principal spines, two tufts of course plumose setae arranged in double row with three sharp spinules (Fig. 1b). The scallops of the abdominal grooves are deep, large and interrupted; the armature on the posterior margin of the abdominal pleurae is strongly developed (Fig. 1c). The live specimen (MRC Catalogue No. Rapt. 1) was dark brown with the anterior portion of the carapace brick red mid-dorsally and the abdomen was light orange. It is probable that two mentioned forms may have intermingled and a hybrid is emerging in our area since hybrids are common in areas where subspecies overlap (Pollock, 1993).

An earlier unpublished key prepared for the northern Arabian Sea up to 10° N, under the Pakistan Science Foundation Research Project (1988-89) titled "Guide to the Malacostraca of the Arabian Sea" by Tirmizi and Kazmi (1989) included fewer taxa. This key has been updated and included in this publication. To date two nephropine genera, *Nephropsis* and *Acanthocaris*, one polychelid genus *Polycheles*, one ibacine genus *Parribacus,* one arctidine genus *Scyllarides*, sole thenine genus *Thenus*, five scyllarine genera *Scammarctus,*

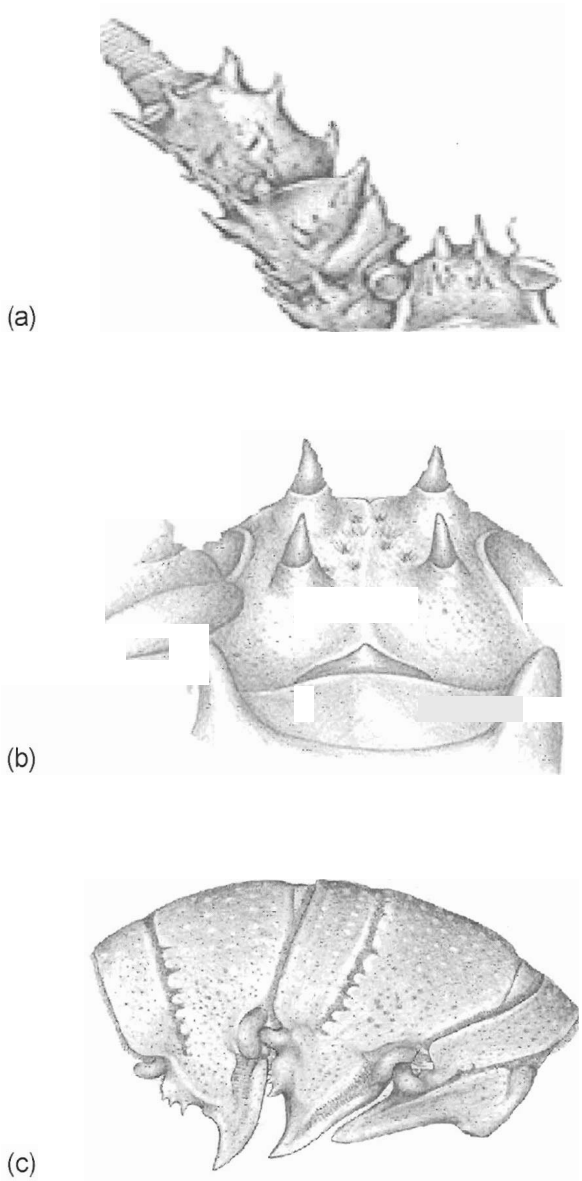

Fig. 1a-c. (a) The prominent spine at the inner anterolateral angle of the basal antennal segment. (b) The antennular plate showing two unequal pairs of principal spines, two tufts of plumose setae in double row with three sharp spinules. (c) The strong armature on the posterior margin of the abdominal pleurae.

Bathyarctus, Eduarctus, Acantharctus and *Biarctus* and two palinurid genera *Panulirus* and *Puerulus* are reported from the Arabian Sea. Out of these *Parribacus, Thenus, Scyllarides, Scammarctus, Eduarctus, Acantharctus, Panulirus* and *Puerulus* extend to north in the Arabia Sea (24-37 °N) in Pakistani coastal waters.

The key presented here has been fabricated using different sources mainly from Holthuis (1991). The first reports of the species from the area are referenced. For the higher taxa the key by Martin and Davis (2001) has been followed. Further Ahyong and O'Meally (2004) and Dixon *et al*. (2003) revised reptantian classification and changed the position of Scyllaridae and Palinuridae and put them in the infraorder Achelata.

Key to the northern Arabian Sea lobsters.

1a. First three pairs of pereiopods with true chelae, first pair the largest and most robust ---------- 2

1b. Third pereiopod never with a true chela, in most groups chelae also absent from first and second pereiopods --- 3

2a. Fourth pereiopod and usually also the fifth, without true chelae. Carapace cylindrical not flattened ----- Infraorder Astacidea, Superfamily Nephropoidea, Family Nephropidae - Deep sea true lobsters and lobsterettes ---------- 4

2b. All pereiopods, or at least the first four, with true chelae. Carapace flattened ---------- Infraorder Palinuridea, Superfamily Eryonoidea, Family Polychelidae ---------- A single genus and single species: *Polycheles andamanicus*

(Ramadan, 1938).

3a. Antennal flagellum reduced to a single broad and flat segment, similar to the other antennal segments ---------- Infraorder Palinuridea, Superfamily Palinuroidea, Family Scyllaridae ---- Slipper lobsters ---------- 9

3b. Antennal flagellum long, multi-articulate, flexible, whip-like or more rigid. Epistome short, far shorter than 1/3 of the carapace. Eyes not placed on an elevation of the cephalon. Carapace with numerous strong and less strong spines and two frontal horns over the eyes. Rostrum absent or reduced to a single spine. Legs 2 to 4 (usually also 1) without chelae or subchelae ---------- Infraorder Palinuridea, Superfamily Palinuroidea, Family Palinuridae- Spiny lobsters or Langoustes ---------- 19

4a. Rostrum laterally compressed for the larger part of its length, with dorsal and ventral, but no lateral teeth. Carapace with branchiostegal spine. Body entirely covered by numerous closely placed and sharply pointed spinules. Lateral margin of the telson with 6 to 12 spines ---------- Subfamily Neophoberinae ----------
A single genus and single species: Prickly deep- sea lobster ---------- *Acanthacaris tenuimana*

(Holthuis, 1984; Alcock and Anderson, 1894).

4b. Rostrum dorsoventrally depressed with lateral (and sometimes ventral) but without dorsal teeth; sometimes without any teeth. Carapace without a branchiostegal spine. Body never uniformly covered with spinules, although granules may be present all over or spinules may be placed on the carapace. The lateral margin of the telson with at the most three lateral spines, which if present, are usually small and irregular.
Scaphocerite absent. Carapace without postorbital spine. Abdominal sternites unarmed in both sexes. No podobranch on second maxilliped ---- Subfamily Thymopinae. Antennal scale absent. Pincers of first pair of legs with soft pubescence. Body not uniformly spinulose. Abdomen without a distinct median ridge --------- single genus: *Nephropsis* ---------- 5

5a. Rostrum without lateral teeth. A strong post-supraorbital spine present behind the supraorbital spine. Abdominal somites III to VI with a median dorsal carina. Anterior margin of pleura of abdominal somite II without spines. Telson without medio-dorsal spine - Gladiator lobsterette- ---------- *N. ensirostris*

(Macpherson, 1990).

5b. Rostrum with lateral teeth. Other characters mentioned under 5a present or absent ---------- 6

6a. Rostrum with one pair of lateral teeth (one tooth on either margin). Anterior margin of pleuron of second abdominal somite without a spine, although the pleuron itself may end in a sharp, spine-like tip ---------- 7

6b. Rostrum with two pairs of lateral teeth. Anterior margin of second abdominal somite with or without spine ------ 8

7a. Abdominal somites without any trace of a mid-dorsal carina. No post supraorbital spine on carapace. The distance between the supraorbital spines and the gastric tubercle is less than half the distance between the gastric tubercle and the cervical groove. Exopod of uropod with a diaeresis ------- Indian Ocean lobsterette ------ *N. stewarti*

(Macpherson, 1990).

7b. Median dorsal carinae on abdominal somites III to VI, but not second ---------- Ridge-back lobsterette ---------- ---------- *N. carpenteri*

(Holthuis, 1991).

8a. Abdomen with a dorsomedian carina on the somites II to VI. Exopod of uropod with a diaeresis. Rostrum with two pairs of lateral teeth in the basal part. The supraorbital spine is followed by a post supraorbital spine. Anterior

margin of pleura of abdominal somite II with one or two spines in the basal half. Telson without mediodorsal spine in the basal part.

Median groove of rostrum reaching distinctly beyond anterior pair of lateral rostral teeth. Distance between supraorbital spine and gastric tubercle is half the distance between gastric tubercle and postcervical groove ---------- Grooved lobsterette ---------- *N. sulcata* (Holthuis, 1991).

8b. Abdomen without mediodorsal carina. Exopod of uropod without diaeresis --------- Red and white lobsterette ---------- *N. suhmi.* (Macpherson,1990; Ramadan, 1938).

9a. Exopod of all maxillipeds with a multiarticulate flagellum. ---------- 10

9b. Exopod of third and first maxilliped without a flagellum; the flagellum of the second maxilliped transformed to a single laminate segment ---------- 11

10a. Carapace strongly depressed, with a deep cervical incision in the lateral margin. Mandible with a simple two-segmented palp -------- Sculptured mitten lobster ---------- Subfamily lbacinae

A single genus and single species: *Parribacus antarcticus* (Williams, 1986).

10b. Carapace rather highly vaulted, with a small, shallow cervical incision, which may be lacking altogether. Mandible with three-segmented palp ---------- Subfamily Arctidinae.

A single genus: *Scyllarides* ---------- 19

11a. Orbits on the anterolateral angle of the carapace. Body strongly depressed. Lateral margin of the carapace with only the cervical incision. No teeth on the lateral margin of the carapace, apart from the anterolateral and postcervical. Fifth leg of female without a chela ---------- Subfamily Theninae.

A sole genus *Thenus* and single species: Flat-head lobster ---------- 12

11b. Orbits on the anterior margin of the carapace, some distance from the anterolateral angle. Body not depressed, but rather high and vaulted. Lateral margin of the carapace with both cervical and postcervical incisions, neither of which is very deep. Lateral margin of the carapace with numerous teeth or squamiform tubercles. Fifth leg of female with a chela ------Subfamily Scyllarinae ---------- 14

12a. Spotting on pereiopods absent. Outer face of propodus of second leg having upper most longitudinal grooves with setae reduced to short thin line near base, or completly lacking. Merus of third maxilliped with out a small spine proximally on inner ventral margin; inner margin of ischium distally dentate, but smoother and slightly molariform proximally ---------- *T. parindicus.* (Burton and Davie, 2007).

12b. Spotting on pereiopods either present or absent. Outer face of propodus of second leg having upper most longitudinal grooves bearing obvious setae over at least proximal half. Merus of third maxilliped with a small spine proximally on inner ventral margin; inner margin of ischium prominently dentate along entire length ---------- 13

13a. Numerous small spots or blotches present on some or all segment of pereiopods ---------- *T. orientalis* (Ahsanullah, 1965).

13b. Small spotting on pereiopods absent, ventral face of some segments may be darkly blotched. Inner face of merus of one or more periopods lacking a large purple to black pigmented blotch ---------- *T. indicus* (Burton and Davie, 2007).

14a. Posterior half of the dorsal surface of abdominal somites II to IV with a rather wide transverse groove over the middle, sometimes with tubercles on either side, but without an arborescent pattern of narrow grooves. Abdominal somites with a distinct median longitudinal carina sharply set off from the rest of the dorsal surface ------ 15

14b. Posterior half of the dorsal surface of abdominal somites II to IV with an arborescent pattern of a narrow central transverse groove with side grooves, that often are branched ---------- 16

15a. Anterior part of thoracic sternum gutter-like sunken and directed down, its anterior margin tapering anteriorly and ending in a median point, which is placed lower than the anterolateral angles of the sternum. Fourth and fifth legs unusually long and slender, the fifth reaching the base of the antenna. Dactylus of third to fifth legs with a double dorsal fringe of setae. Fourth antennal segment without additional carina *Scammarctus*

A single species: Soft locust lobster ---------- *S. batei* (Holthuis,1991, as *Scyllarus batei*).

15b. Anterior margin of thoracic sternum V- or U- shapedly incised, truncate or convex, but in a horizontal plane, top not sunken. Fourth and fifth legs not remarkably slender and without a double dorsal fringe of setae on the dactylus.

Anterior margin of thoracic sternum truncate or convex, sometimes with a median tubercle but with median incision; this margin situated on about the same level as the anterolateral teeth of the rostrum. Propodii of first four

legs often with ventral setae ---------- *Bathyarctus* A single species: *B. rubens*

(Holthuis 1991; George, 1969, as *Scyllarus rubens*).

16a. Fourth segment of antenna with an additional carina or a row of tubercles outside the main oblique carina.
Abdominal somites II to IV with a median dorsal carina, that of somite III usually highest. Rostral tooth absent or small. Fourth antennal segment with an additional row of tubercles ---------- *Eduarctus* ---------- 17

16b. Fourth segment of antenna with a single oblique carina over its full length; no additional carina or rows of tubercles. Abdominal somites usually without a median carina ---------- 18

17a. The posterior margin of the smooth anterior half of abdominal somites II to IV crenulated -------- *E. aesopius*

(Holthuis, 1991 as *Scyllarus aesopius*).

17b. The posterior margin of the smooth anterior half of abdominal somites II to IV is straight, non crenulated ---------- Striated locust lobster ---------- *E. martensii*

(Holthuis, 1991, as *Scyllarus martensii*).

18a. Last segment of thoracic sternum with a sharp median thorn ----- *Acantharctus* ----- A single species: *A. ornatus*

(Ramadan, 1938, as *Scyllarus arctus* var. *paradoxus*).

18b. Last segment of thoracic sternum at most with a central tubercle.
Anterior margin of thoracic sternum deeply V - shapedly incised, without additional tubercles, pregastric tooth absent ------- *Biarctus* ------- A single species: *B. sordidus*
(Chhapgar and Deshmukh, 1964, as *Scyllarus sordidus*).

19a. Red spot on smooth part of somite 1 small and irregular; somites III-IV distinctly humped - Humpbacked locust lobster or Aeosop slipper lobster ---------- *S. haanii*

(Moazzam *et al*., 2003; Williams, 1986).

19b. Smooth part of somite1 without spot, or more often with 3 or more red or reddish spots of varying size and intensity ---------- 20

20a. Somite 1 with median spot diffuse, not surrounded by ring of yellow; pale red blotches on body surface, marbled with brown or grey; side plates of somite II toothed on margin ----- Locust lobster or Blunt slipper lobster ---------- *S. squammosus*

(Holthuis, 1991).

20b. Somite 1 with spots placed widely apart and nearly equal in size; yellowish brown - Clam - killer slipper lobster ---------- *S. tridacnophaga*

(Tirmizi and Kazmi, 1983).

21a. Flagella of antennules long, whip-like, longer than peduncle of antennules ---------- *Panulirus* ---------- 24

21b. Flagella of antennules short, shorter than last segment of antennular peduncle ---------- 22

22a. Frontal horns truncated with anterior margin crenulated; first segment of antennular peduncle reaching beyond antennal peduncle ---------- *Palinustus* ---------- A single species: *P. mossambicus*

(Kurian, 1967).

22b. Frontal horns tapering to a sharp point; first segment of antennular peduncle not over-reaching antennal peduncle. Antennular plate distinct, a stridulating organ present. Carapace with a median ridge behind the cervical groove, often with spines or tubercles, but without submedian rows ----------*Puerulus* ---------- 23

23a. Median keel of carapace with 8 small teeth (5 postcervical, 3 intestinal). Surface of carapace covered with scattered granules, large tubercles present on ridges, 2 spines behind supraorbital spines ------ Arabian whip lobster ---------- *P. sewelli*

(Ramadan, 1938).

23b. Median keel of carapace with 5 teeth (3 postcervical, 2 intestinal); body spines distinct and sharp; 3 spines behind supraorbital spines; fifth pereiopod of male not chelate -------- Banded whip lobster ---------- *P. angulatus*

(Moazzam *et al.*, 2003).

23c. Median keel of carapace with 5 to 7 teeth (3 postcervical, 2 to 4 intestinal); fifth leg of male chelate - Red whip lobster ---------- *P. carinatus*

(Moazzam *et al*., 2003).

24a. Abdominal somites with a distinct transverse groove which may be interrupted in the middle. Third maxilliped with or without exopod ---------- 25

24b. Abdominal somites smooth, without transverse groove. Third maxilliped without exopod ---------- 26

25a. Anterior margin of transverse groove of abdominal somites crenulated. Groove itself either complete or interrupted in the middle. Antennules plate with 4 equal large, well separated spines, arranged in a square with additional very small spinules scattered in between. Exopod of third maxilliped absent. Colour: body dark green or reddish brown, finely spotted with white. No distinct bands of light colour on the abdomen. A light anterior spot at the base of the abdomen pleura. Antennules banded. Legs rather uniform in colour, sometimes with faint, longitudinal streaks --------- Scalloped spiny lobster ---------- *P. homarus.*

(Tirmizi and Ahsanullah, 1965).

25b. Transverse groove of abdominal somites with straight margins, not crenulated.
Antennular plate with 4 strong spines, which are fused at their bases, forming a single bunch of 4 diverging points; the anterior pair shorter than the posterior. Exopod of third maxilliped present, with flagellum. Transverse grooves over the abdominal somites usually uninterrupted. Colour: body greenish or reddish, ranging from yellowish green through brown green to blue-black or dark reddish brown; speckled on carapace and abdomen with tiny whitish spots. No transverse colour bands on abdomen, but two rather large whitish spots on somite I. Antennules not banded. Legs with wider or narrower longitudinal yellowish lines or streaks on a dark (greenish or reddish) background -------- Pronghorn spiny lobster ---------- *P. penicillatus*
(Tirmizi and Ahsanullah, 1965).

26a. Abdominal somites 1 to 6 with a distinct uninterrupted white transverse band along the posterior margin ----- 27

26b. Abdomen without distinct transverse bands on all somites, sometimes there is a line of pale spots there, or a narrow line is present on somites I to III, but on somites IV and V, this is replaced by a row of spots. Antennular plate with 4 spines.
Abdominal somites smooth and naked. Colour of abdomen brownish or greenish grey with at most minute indistinct speckles. The usual large eyespot in the anterior half near the base of the pleura is accompanied by an oblique pale streak placed somewhat middle of the eyespot. The pleura have white tips, sometimes this white colour extends slightly up the anterior and posterior margins. Carapace with a peculiar and very characteristic marbling of pale lines near the bases of the frontal horns. Legs not streaked, but with very sharply defined irregular dark spots of a bluish or brownish colour, which often form incomplete rings around the various segments. Antennal flagella distinctly ringed --------- Ornate spiny lobster ---------- *P. ornatus*
(Fatima, 2000; Holthuis, 1991; Chhapgar and Deshmukh, 1964; Government of Pakistan, 1960).

27a. Antennular plate with 2 strong spines; surface of abdominal somites naked and smooth Colour: abdominal somites II to V with a white transverse band along the posterior margin which, however, is not set off by dark bands. Colour of body and abdomen usually greyish green without spots. Tailfan of a rather uniform colour. Legs irregularly spotted, not distinctly streaked ---------- Mud spiny lobster --------- *P. polyphagus*
(Tirmizi and Ahsanullah, 1965).

27b. Antennular plate with 4 strong spines arranged in a quadrangle. The whitish transverse bands along the posterior margin of the abdominal somites very distinct because they have a dark band in front and just behind them - Painted spiny lobster ---------- *P. versicolor*
(Tirmizi and Kazmi, 1983).

Lobster fisheries. The main fishing grounds for lobsters along the coast of Pakistan are shown in Fig. 2. Best lobsters in terms of size and weight are caught along Karachi coast though the quantity is low; other important fishing grounds are located along Balochistan coast (Ormara, Pasni, Gwader and Jiwani). The spiny lobsters, after being caught, are mostly kept alive in seawater cages in shallow submerged areas of the coast and at processing units till they are either locally marketed or exported to other countries. The average size of spiny lobsters is 106 mm carapace length (Tirmizi and Bashir, 1975). Out of 16 recorded species, *P. polyphagus* was the only species exploited commercially; 83% of the samples studied consisted of *P. polyphagus*, whereas 16% comprised of *P. homarus*, and 1% included *Thenus orientalis* and other species. The magnitude of lobster fisheries is low despite considerable species diversity. Total lobster catch during 1993 to 2005 is presented in Fig. 3 (Marine Fisheries Department, 2002) alongwith the total export and catch of lobsters separately from two maritime provinces *viz* Sindh and Balochistan. The lobster catch ranged between 615 to 1077 metric ton during 1993-2004; the maximum catch was observed in 1999. Lobster catches were high from Balochistan during 1993 to 1998 comprising of 62-73% of the total catch, whereas from 1999 onwards more than 50 percent (57-73%) of the total catch was obtained from Sindh coast; increase in lobster catch from Sindh coast was due to the intensification of catch effort along Sindh coast. Lobster fishing is conducted almost round the year but the best catches were observed by the end of August to end of September, whereas, minimum or almost nil catches were observed in June, July and early August due to the strong southwest monsoon which limits fishing activities. Export of lobsters ranged between 66 to 288 metric tones (Table 1) and the earnings ranged between Rs.6.3 to 75.8 million (1US$ = Rs.80).

Lobsters are exported in both the live and the frozen forms (whole, meat, tails) to USA, Japan, Saudi Arabia, Oman, Italy, The Netherlands, Hong Kong, Singapore, Belgium, France, Kuwait and Maldives (Marine Fisheries Department, 2002).

Biological studies. Present knowledge on lobster biology is based exclusively on a project report conducted by Marine

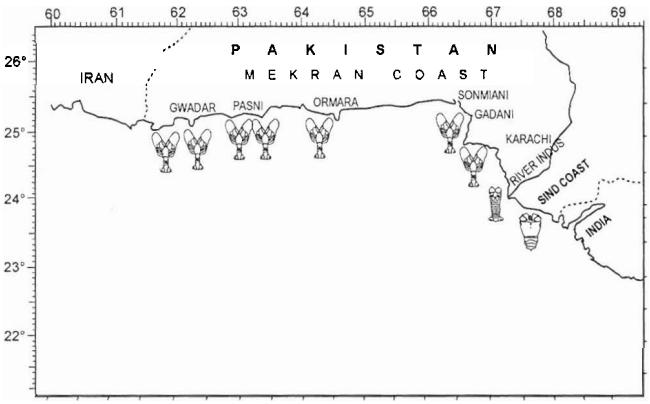

Fig. 2. The main fishing grounds for lobsters along Pakistan coast.

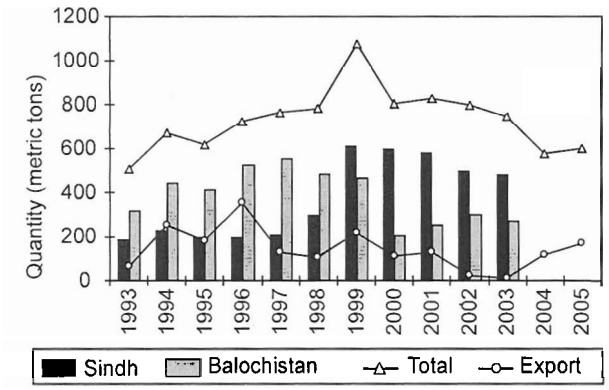

Fig. 3. Lobster catch during 1993 to 2004.

Table 1. Catch and export data of lobsters

Export					
Frozen meat, tail (met. tons)	Value (Rs. in million)	Live (met. tons)	Value (Rs. in million)	Total quantity (met. tons)	Total value (Rs. in million)
066	12.976	0	0	066	12.976
175	49.819	80	14573	255	64.392
152	37.331	33	5733	185	43.064
288	75.785	64	13534	352	89.319
129	48.583	03	121	132	48.704
079	29.624	25	8489	104	38.113
116	42.227	101	42.779	217	85.006
079	45.361	31	17.218	110	62.579
103	71.921	25	16.915	128	88.836
013	10.110	10	6.938	23	17.048
009	6.265	5	2607	14	8.872
013	5790	102	37317	115	86215
033	14522	136	47472	169	61994

Fisheries Department under a grant by Pakistan Agriculture Research Council (PARC, 1980). The study comprised of the information about the lobster species, habitat, fishing grounds, abundance, partial larval development, larval morphology, breeding season, fecundity and bionomics. The studies revealed that *P. polyphagus* (maximum total length: 37 cm) prefers muddy-cum-sandy bottom, close to the Indus River mouth at depths between 5-90 meters, generally at 40-50 meter depth, while *P. homarus* (maximum total length: 32 cm) normally inhabits rocky bottom, which are more common on northwest (Balochistan) coast. *P. ornatus* (maximum total length: 50 cm) was found in shallow coastal waters up to 10 meter depth mostly on muddy bottom including river Indus mouth, occasionally found in sandy areas. *P. versicolor* (maximum total length: 32 cm) is found between 1 to 15 meter depth, in clear waters on rocky substrates (Paradise point, Buleji), this species tends to hide in rock crevices and corals; juveniles are found in low salinity areas. *P. penicillatus* (maximum total length: 45 cm) inhabits clear water rocky substrates; it also hides under boulders and in crevices. *Puerulus swelli* is a rare species found in offshore deep waters (maximum total length: 5 cm). *Thenus orientalis* is found mostly from muddy areas along Indus deltaic areas (Fig. 2) in shallow waters of up to 100 meter depth; it is rarely found on Balochistan (Makran) coast (PARC, 1983).

Studies have been focused on *P. polyphagus* because of its abundance whereas little work has been carried on *P. homarus*. The size distribution of fished stock was between 6.5 cm to 24.5 cm tail length in *P. polyphagus*, whereas, for *P. homarus*, size range was 7.2-20 cm tail length. The sex ratio slightly varied both in *P. polyphagus* and *P. homarus* from typical 1:1 ratio and found to be 1.1:1 and 1.5:1, respectively, during the four year study period from 1976-1979. Phyllosama larvae of *Panulirus* were described from I-IX stage. Stomach contents of *P. polyphagus* revealed the presence of shell fragments of foraminiferans, bivalves, gastropods, juvenile crabs, crustacean remains (antennules, carapace, chelae, appendages, and gill rakers), fish eggs, fish scales, bones, vertebrae, sand grains and pebbles.

Hussain and Amjad (1980) worked on the breeding and fecundity of *P. polyphagus*. According to this study, berried females of *P. polyphagus* were found during the period October to May; the peak of breeding season was found during March-April. The eggs were oval in shape, average length of recently released eggs was 0.5023 mm, whereas, the breadth was 0.4255 mm. Fecundity was estimated as 83,960 to 790880 eggs (average = 306,700 ± 58,000) from 30 berried

females ranging in tail length from139 mm to 211 mm and weighing between 130 to 360 g tail weights (measured from anterior tip of the first abdominal terga to the tip of telson). Fecundity has a positive relationship with both tail length and tail weight of the lobster. Larval stages of lobsters collected from plankton from near shore and offshore samples were also studied and described by Ghory *et al*. (2005). Nutritional value and macro- and micro-nutrients of *Panulirus* sp. have been studied by Nisa *et al*. (1995).

Management. During the past decade, a number of international conventions included new obligations for management activities regulating ocean uses. The conventions (and codes) make explicit reference to protection of ecosystem features. The overarching convention in this respect is the Convention on Biological Diversity (CBD). Other international legal instruments include the UN Fish Stock Agreement and the FAO Code of Conduct. In response to these international agreements, national legislation and policies are required to incorporate ecosystem considerations more explicitly within national ocean management regimes. Pakistan is a signatory to the above cited conventions and has taken some important measures into consideration for the management of lobster fisheries in Pakistan:

1. *Minimum catchable size of lobsters*. Minimum legal size for catch is <15.0 cm, i.e. lobsters of less than 15.0 cm are not allowed to be caught and when captured should be immediately released back into the sea alive and shall not be landed or marketed.

2. *Protection of berried females*. No berried female should be caught and when captured should be released immediately into the sea alive

3. *Protection of soft shelled lobsters*. Protection of soft shelled or newly moulted lobster is considered necessary because moulting precedes mating (reproductive cycle).

Fisheries management in Pakistan is generally carried out through licensing, indicating exploitable stocks, designating the environmental friendly fishing gears and methods and by enforcing restrictions with regard to the closed season and closed areas. Pakistan also adopted guide lines to the code of conduct for responsible fisheries laid down by FAO. There are various regulations formulated within the country for management of fishing in Exclusive Fishing Zone (EEZ of the country (Regulation of Fishing Act, 1975, amended 1993; the Sindh Fisheries Ordinance, 1980; the Balochistan Sea Fisheries Act No. IX, 1971). Co-operation among fishermen, scientists, and government agencies is important for implementation, which at present, is lacking. There is a need for effective management programmes for sustainable utilization of lobster resources. Research on population dynamics, effects of dwindling habitats on various populations and stocks assessment are urgently needed. In addition, legal implementation of fishing regulations, creation of awareness among fishers on the negative impact of over-fishing and marketing of egg-bearing lobsters and juveniles are the most important aspects, which have not been given due consideration. There is a need of adopting less destructive methods like use of lobster traps and to educate the fishermen to release egg-bearing lobsters. Pakistan has no commercial fishing fleet to explore the deep sea resources; the rights for deep sea fishing have been given to various foreign countries through licensing. Deep sea fishing zone and catch, both are not inspected or documented by any agency. It may be inferred that deep sea forms of Pakistani waters are still unexploited.

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