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Status taxonomy and conservation issues of the cownose and butterfly rays of Pakistan (Northern Arabian Sea)

Abstract

In the present study, we documented rays from two families, Rhinopteridae and Gymnuridae, occurring in Pakistani waters. A total of 12 specimens were collected and examined between February 2017 and October 2021 from various localities along the Pakistani coastline. All specimens were preserved and housed in the Marine Biology Laboratory at the University of Karachi. Within Rhinopteridae, we identified *Rhinoptera javanica* and *Rhinoptera jayakari*, while Gymnuridae was represented by *Gymnura poecilura* and *Gymnura zonura*. These species are highly vulnerable due to their susceptibility to diverse fishing gears and their limited resilience to population depletion. Given the intense fishing pressure and inherent biological constraints, the adoption of urgent and effective conservation measures is imperative to avert further population reductions. All the species are briefly described and an identification key is provided for them which will support the overall systematic stability of butterfly and cownose rays in Pakistan and surrounding waters.

Keywords: gymnuridae, rhinopteridae, taxonomy, Pakistan, conservation, threats

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Introduction

The family Rhinopteridae, commonly referred to as cownose and bull rays, is represented by the single genus Rhinoptera, which encompasses forty nominal species distributed across four genera. These rays are found in warm tropical and temperate waters, typically exhibiting semi-pelagic behavior and often forming large schools. Study[1] recognized eight valid species within Rhinoptera and noted that Rhinoptera jayakari contains three unresolved subgroups in the western Indian Ocean. Members of Rhinopteridae are euryhaline, inhabiting a range of environments, including rivers, estuaries, and open ocean, with a particular preference for continental and inshore shelves. Their circumglobal distribution reflects a high degree of mobility.[2] Species identification within this family is based primarily on tooth-row morphology; however, interspecific variation remains inadequately resolved, underscoring the necessity for further taxonomic examination.[3,4] In contrast, members of the family Gymnuridae, commonly known as butterfly rays, are shallow-water inhabitants that dwell on muddy and sandy substrates in tropical and temperate seas. Traditionally, this family is classified under a single genus, Gymnura[5,6] which includes 11 recognized species. However, taxonomic uncertainties persist, with some studies suggesting that the genera Pteroplatea and Aetoplatea should also be included within Gymnuridae.[7] As a result, the systematics of batoid fishes within this family require re-evaluation.[8] Within the Indian Ocean, six species of Gymnuridae have been recorded, although only one species has been documented in Pakistani waters.[9]

Globally, both Rhinopteridae and Gymnuridae face significant fishing pressures, which are anticipated to intensify in the coming years.[10] In Pakistan, Cownose and butterfly rays are commonly found in fishery landings throughout the year, with peak occurrences between January and May. They are exploited both as a commercial food source and as bycatch in artisanal fisheries.[11] Their schooling behavior makes them particularly vulnerable to inshore fishing gears, such as beach seines, purse seines, gillnets, benthic longlines, and trawls. This magnitude of decline is not species-specific but provides valuable insights into broader patterns of population decline among batoids in the region. Although the species is frequently discarded and may exhibit high post-release survival in Pakistan, it remains exposed to substantial fishing pressure, with limited opportunities for refuge. Nevertheless, its continued frequent capture in certain areas may indicate some degree of resilience to fishing pressure, although this should be interpreted cautiously given the potential influence of spatial variation in fishing intensity and post-release survival. This magnitude of decline is not species-specific but provides valuable insights into broader patterns of population decline among batoids in the region. Although the species is frequently discarded and may exhibit high post-release survival in parts of the Arabian Sea, it remains exposed to substantial fishing pressure, with limited opportunities for refuge.[9,10] Nevertheless, its continued frequent capture in certain areas may indicate some degree of resilience to fishing pressure, although this should be interpreted cautiously given the potential influence of spatial variation in fishing intensity and post-release survival. Additionally, species of Rhinopteridae are frequently caught as bycatch across their range. In Southeast Asia, cownose rays are commonly captured in Indonesia, Thailand, the Philippines, and Taiwan,[12] areas characterized by high and often inadequately regulated fishing pressure. In South Africa, species of Rhinoptera accounted for approximately 9% of total batoid catches between 1981 and 2000,[13] with frequent capture as bycatch in shallow-water prawn trawl fisheries.[14] Therefore, the present study provides a detailed morphological characterization of Rhinopteridae and Gymnuridae species found in Pakistan, contributing to enhanced taxonomic clarity and supporting accurate species identification for regional fisheries management and conservation efforts.

Materials and methods

A total of 12 specimens were collected and examined between February 2017 and October 2021 from various localities along the Pakistani coastline. All specimens were preserved in the Marine Biology Laboratory, University of Karachi. Morphometric measurements of cownose rays were conducted following the protocols described by

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Pradeep et al.,[7] for the family Rhinopteridae and by Mukhta et al.,[7] for the family Gymnuridae. Morphological parameters were measured to the nearest centimeter using a measuring scale. Information on the current conservation status and global distribution of each species was obtained from the IUCN Red List website based on the most recent assessments. The following acronyms are used: CEMB (Centre of Excellence in Marine Biology, University of Karachi, Pakistan); WWFH (West Wharf Fish Harbor, Karachi). Conservation status categories follow the IUCN Red List of Threatened Species and include Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), and Data Deficient (DD) while scientific names were followed according to the WoRMS Editorial Boards (2026).

Results

Present study confirmed 2 species of family Rhinopteridae and 2 species of Gymnuridae from Pakistani waters (Table 1).

Table 1 Key to families rhinopteridae & gymnuridae of Pakistan

Couplets	Characters	Links
1a	Dorsal-fin small but noticeable at the tail base; upper surface of disc brown with many dark spots or lines interspersed with large round yellowish spots or irregular blotches, sometimes forming lines/ ocelli……	*Gymnura zonura*
1b	No dorsal-fin; upper surface of disc uniformly brown/yellowish-brown with scattered dark/light spots…….	2
2a	Length from cloaca-origin to tail tip nearly as long as snout-vent length; 9 black bands on tail……	*Gymnura poecilura*
2b 3a	Length from cloaca-origin to tail tip about half long of snout-vent length; 6 or less black bands on tail…… Small sting on tail base……	3
3b	No sting……	4
4a	Tail length half of the body with 3 black bands…..……	5
4b	Tail length half of the body with 6 black bands……	
5a.	Fleshy rostral flap with short posterior edge……	*Rhinoptera javanica*
5b.	Long rostral flap with long posterior edge……	*Rhinoptera jayakari*

Family gymnuridae

Medium to large-sized rays (disc width up to 4 meters), characterized by a disc that is broader than long and has a lozenge-shaped form. The snout is obtuse and only slightly produced, and the head does not extend beyond the disc. The tail, originating from the disc, is slender but significantly shorter than the disc length and features one or more serrated spines at its base. The nostrils, located near the mouth, are serrated, with their anterior margins notably raised and meeting at a narrow isthmus. The mouth is nearly straight to slightly arched, lacking papillae on the ventral surface. Spiracles are well-developed, either with or without tentacles (Figure 1).

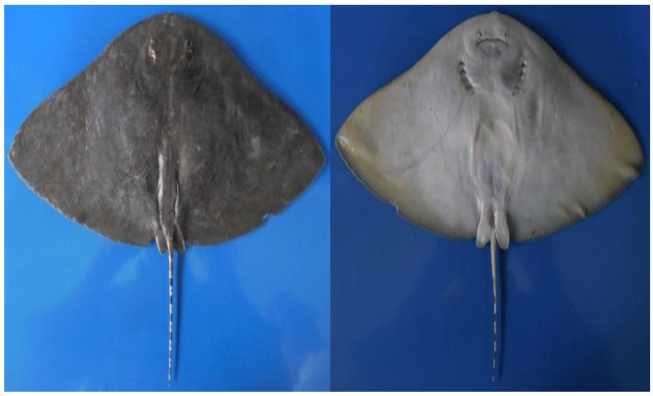


Figure 1 *Gymnura poecilura* (35.1 cm disc width) Center of Excellence in Marine Biology, University of Karachi, Pakistan.

Gymnura poecilura[7]

Common name: Long-tail butterfly ray

Local Name: Pappu (Sindhi); Pappu (Balochi).

IUCN Red list Status:VU.

Biology and ecology

Gymnura poecilura is a demersal species that inhabits sandy and muddy substrates in inshore waters, typically at depths ranging from the seafloor to 75 meters.[12] The maximum recorded size for this species is approximately 104 cm in disc width. Males reach sexual maturity at around 35 cm total length, while females mature at approximately 41 cm disc width.[12] This species exhibits aplacental viviparity, giving birth to 1 to 7 pups per litter, with the pups having a recorded birth size of approximately 22 to 26 cm total length.[12] The generation time for Gymnura poecilura can be inferred from other species within the family, such as Gymnura natalensis from South Africa, which matures at around 6 years of age and reaches a maximum age of approximately 24 years, resulting in a generation length of about 15 years.[13–15]

Fishing gears and crafts: Gill-nets and bottom trawls.

Material examined

Table 2 (CEMB, UOK, ELASM- 601); (Figure 1; Mature female; 35.1 cm Disc Width). Table 2 CEMB-UOK (Armature female; 30.4 cm DW); West Wharf Fish harbor, Karachi (24.8481 N, 66.9780 E): WWFH (Mature male; 63.8 cm DW): WWFH (Mature female; 46.4 cm DW).

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Table 2 Morphometric measurements of Family Gymnuridae of Pakistan. Measurements are given as % disc width±S.D (Measurements are provided in cm)

Parameters	*Gymnura poecilura*	*Gymnura zonura*
Disc width	100.0±7.1	100.0±7.1
Total length	40.4±3.0	40.4±3.0
Disc length	25.4±1.8	25.4±1.8
Body length	23.8±1.7	23.8±1.7
Head length	11.3±0.9	11.3±0.9
Pre-branchial length	7.1±0.5	7.1±0.5
Pre-branchial length to end of first gill slit	5.1±0.3	5.1±0.3
Pre-narial length	3.7±0.3	3.7±0.3
Pre-oral length	3.6±0.3	3.6±0.3
Snout to cloaca (anterior tip)	20.2±1.5	20.2±1.5
Snout to cloaca (Posterior tip)	20.3±1.5	20.3±1.5
Snout to mid cloaca	20.8±1.5	20.8±1.5
Trunk length (anterior tip)	10.6±0.8	10.6±0.8
Trunk length (Posterior tip)	20.3±1.5	20.3±1.5
Pre-clocal length	17.3±1.3	17.3±1.3
Tail length	27.6±2.0	27.6±2.0
Pectoral fin anterior margin	20.8±1.5	20.8±1.5
Pectoral fin base	24.2±1.8	24.2±1.8
Pectoral fin posterior margin	1.3±0.1	1.3±0.1
Pectoral fin inner margin	24.1±1.8	24.1±1.8
Pectoral fin height	1.9±0.2	1.9±0.2
Pelvic fin height	3.6±0.3	3.6±0.3
Pelvic fin anterior margin	3.7±0.3	3.7±0.3
Pelvic fin base	2.0±0.2	2.0±0.2
Pelvic fin posterior margin	0.6±0.1	0.6±0.1
Pelvic fin inner margin	3.6±0.3	3.6±0.3
Pelvic fin length	5.3±0.4	5.3±0.4
Total width of pelvic fin across the anterior most point of cloaca	4.3±0.3	4.3±0.3
Clasper length inner margin	1.9±0.2	1.9±0.2
Clasper length outer margin	1.1±0.1	1.1±0.1
clasper base width	0.5±0.1	0.5±0.1
Distance between 1st gill slit pair	8.1±0.6	8.1±0.6
Distance between 2nd gill slit pair	7.2±0.5	7.2±0.5
Distance between 3rd gill slit pair	6.3±0.5	6.3±0.5
Distance between 4th gill slit pair	5.3±0.4	5.3±0.4
Distance between 5th gill slit pair	5.2±0.4	5.2±0.4
First gill slit width	1.1±0.1	1.1±0.1
Second gill slit width	1.0±0.1	1.0±0.1
Third gill slit width	1.0±0.1	1.0±0.1
Fourth gill slit width	0.8±0.1	0.8±0.1
Fifth gill slit width	0.6±0.1	0.6±0.1
Pre-orbital snout width	15.4±1.1	15.4±1.1
Post-spircle snout width	23.5±1.7	23.5±1.7
Inter-narial width	2.9±0.3	2.9±0.3
Nostril width	0.6±0.1	0.6±0.1
Nostril length (NOL)	1.3±0.1	1.3±0.1
Nasal curtain length (NCL)	1.0±0.1	1.0±0.1
Nasal curtain width (NCW)	7.2±0.5	7.2±0.5
Mouth length (MOL)a	0.6±0.1	0.6±0.1
Mouth width (MOW)	2.9±0.3	2.9±0.3
Pre-orbital length (POB)a	4.1±0.3	4.1±0.3
Pre-spiracular snout length (PSP)	4.3±0.3	4.3±0.3
Post-orbital snout length (PoOB)	5.5±0.4	5.5±0.4
Post-spiracle snout length (PoSP)	5.8±0.5	5.8±0.5
Inter-orbital width anterior (INO1)	5.2±0.3	5.2±0.3
Inter-orbital width posterior (INO2)	5.4±0.4	5.4±0.4
Inter-orbital width at mid-eye level (INO3A)	5.3±0.3	5.3±0.3
Inter-orbital width centre of orbits (INO4A)	5.3±0.4	5.3±0.4
Eye length (EYL)	0.6±0.1	0.6±0.1
Eye height (EYH)	0.6±0.1	0.6±0.1
Inter-spiracular width anterior (INS1)	6.0±0.5	6.0±0.5
Inter-spiracular width posterior (INS2)	4.1±0.3	4.1±0.3
Inter-spiracular width mid-level (INS3)	4.1±0.3	4.1±0.3
Spiracle length (SPL)	1.1±0.1	1.1±0.1
Spiracle width (SPW)	1.0±0.1	1.0±0.1
Eye-spiracle space (ESL-EYE)	0.6±0.1	0.6±0.1
Tail width (TWB)	1.0±0.1	1.0±0.1
Tail width at half length of tail (TWS)	0.6±0.1	0.6±0.1
Tail depth (TDB)	0.5±0.1	0.5±0.1
Tail depth at half length of tail (TDS)	0.5±0.1	0.5±0.1
Tail insertion to spine origin (TBS)	1.9±0.2	1.9±0.2
Cloaca to origin of spine (CSL)	3.6±0.3	3.6±0.3
Spine length (SPL)	1.0±0.1	1.0±0.1

Diagnosis

Can be distinguished by having following combination of characteristics: the body of this species is compressed and slender, with an elongated, rhomboid-shaped pectoral fin, and the disc width is 1.9-2.0 times its length. The snout is short, with a weak apical lobe, and the preoral length accounts for 6.9-9.2% of the disc width. The pre-orbital snout length is 0.3-0.4 times the head length, forming a snout angle between 137° and 155°, and the pectoral angle ranges from 100° to 123°. The species has small orbits and lacks a tentacle behind the spiracle. The mouth is small, with a width 1.2-1.5 times the inter-nasal distance. The space between the first gill slits is 2.2-2.7 times the inter-nasal distance, while the fifth gill slits are 1.4-1.8 times the inter-nasal distance. The tail is slender, short, and less than the length of the disc, extending from the cloaca to the tip, nearly equivalent to the snout-to-vent length. The post-vent length is 31.7-45.5% of the disc width. There is no dorsal fin, and a faint dermal ridge may be present, either on the dorsal or ventral side. Tail spines may or may not be present, with juveniles typically lacking spines. The dorsal surface is smooth, devoid of thorns or denticles, and exhibits a uniform brown to olive-green coloration, occasionally with scattered pale or light yellow spots. Juveniles under 30 cm total length have a uniformly brown or gray dorsal surface covered in small dark brown spots. The ventral disc is uniformly whitish, and the tail features 9-12 alternating black and white bands, with juveniles showing prominent black saddles within the white bands.

Color

Disc plain brown above, white on posterior sides; no conspicuous markings.

Distinctive characters

The body is dorsoventrally compressed and laterally elongated, with the pectoral fins forming an accelerated, rhomboid-shaped disc. The disc width is approximately 1.9-2.0 times its length. The snout is short, with a weakly developed apical lobe. The pre-oral length accounts for 6.9-9.2% of the disc width, while the pre-orbital snout

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length is 0.3-0.4 times the head length. The snout angle ranges from 137° to 155°, and the pectoral fin angle ranges from 100° to 123°. The orbits are small, and there are no tentacles posterior to the spiracles. The mouth is relatively small, with a width 1.2-1.5 times smaller than the internasal distance. The space between the first gill slits is 2.2-2.7 times the internasal distance, while the space between the fifth gill slits is 1.4-1.8 times the internasal distance. The tail is narrow and shorter than the disc length, with the length from cloaca to tail tip nearly equal to the snout-to-vent length. The post-ventral tail length represents 31.7-45.5% of the disc width. The species lacks a dorsal fin, and a faint dermal ridge may or may not be present on both the dorsal and ventral surfaces. Tail spines may also be present or absent, with juveniles typically lacking spines. The dorsal surface is smooth, devoid of thorns or dermal denticles. In adults, the disc displays a uniform brown to olive-green color, occasionally marked with pale or light yellow spots. Juveniles (with a disc width <30 cm) typically exhibit a uniformly brown or gray dorsal surface densely covered with small dark brown spots. The ventral disc is uniformly whitish, and the tail displays 9-12 alternating black and white bands. In juveniles, distinct black saddles are present within the white bands.

Remarks

Gymnura poecilura was first described as Raja poecilura by Shaw, based on a drawing and brief descriptions provided by Russell. The original description was limited, offering only a basic account of its morphological features, and lacked supporting type material. Although G. poecilura is recognized as a widely distributed butterfly ray across the Indo-Pacific region, a thorough taxonomic analysis is lacking, and several of the characteristics currently used for its identification are ambiguous, potentially misleading, and unreliable. Existing evidence indicates that G. poecilura is present in fishery landings year-round, with peak abundance occurring between January and May. The predominant size range observed in fisheries is 35-70 cm in disc width (DW).[15] In several countries, including Thailand and Indonesia, the species is specifically targeted by artisanal fisheries for human consumption and is also commonly caught as bycatch. At present, no targeted conservation measures have been implemented for this species. Consequently, there is an urgent need for systematic documentation of both direct and incidental catches in artisanal and commercial fisheries throughout its entire range.

Distribution

Bahrain, Bangladesh, Cambodia, China, Egypt, Eritrea, India, Indonesia, Iran, Iraq, Israel, Japan, Kuwait, Malaysia, Myanmar, Oman, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, Somalia, Sri Lanka, Sudan, Taiwan, Thailand, Viet Nam, Yemen (Figure 2).[9]



Figure 2 *Gymnura zonura* (34.4 cm disc width) West Wharf Fish Harbor, Karachi, Pakistan.

Gymnura zonura

Common name: Zone-tail butterfly ray

Local names: Pappu (Sindhi); Pappu (Balochi).

IUCN Red list Status: EN.

Biology and ecology

Gymnura zonura is a benthic species found in inshore waters, typically on soft substrates at depths up to 40 meters.[12] The maximum reported size for this species is approximately 108 cm in disc width, with males reaching maturity at around 48 cm total length and females at about 78 cm disc width. Reproduction is viviparous, with litter sizes ranging from 2 to 4 pups per litter. The recorded birth size is approximately 20 to 21 cm in disc width. The generation time for Gymnura zonura can be inferred from Gymnura natalensis, which matures at approximately 6 years and has a maximum lifespan of around 24 years, resulting in a generation length of approximately 15 years.[15]

Fishing gears and crafts: Line gears; long-lines; set-beg nets.

Material examined

Table 2; CEMB-UOK, ELAMO-602 (Figure 2; Mature female; 34.4 cm DW): West Wharf fish harbor, Karachi (24.8481 N, 66.9780 E): WWFH (28.3 cm DW); WWFH (20.3 cm DW).

Diagnosis

A medium-sized butterfly ray characterized by the following combination of features: absence of tentacles on the inner posterior margin of the spiracles; a long tail (post-cloacal length 23-36% of disc width), adorned with 6-10 black bands; a small dorsal fin at the base of the tail, which is often present but may be absent; and the presence of caudal stings in most individuals. The disc is significantly wider than long, with a width approximately 1.8-2.1 times the length. The snout is short, with the pre-oral length measuring 2.8-4.5 times the post-cloacal length. The eyes are small, with orbital length constituting 15-30% of the inter-orbital width. Spiracles have a concave and curved anterior margin. The mouth is arched, with a slightly concave lower symphysis. The skin is completely smooth, with a poorly developed caudal sting, having a notably large base. The tail typically exhibits a groove when the sting is absent. The tail length is approximately 52-80% of the snout-to-cloacal length.

Color

Uniformly brown/ with numerous small round whitish spots; whitish to brownish ventral surface; tail banded, pale sections often with single dark spots between each black band.

Distinctive characters

The zonetail butterfly ray features a large, flattened body with a thin profile, typically distinguished by its broad pectoral fins that form an expansive disc, where the width exceeds the length. Its skin is smooth, with a uniformly brown dorsal surface adorned with numerous small, rounded white spots, while the ventral side is entirely white. This species has notably small snouts and eyes, with spiracles positioned slightly above the eyes. Unlike other members of Gymnuridae, it lacks tentacles on the inner posterior margin of the spiracles. The zonetail butterfly ray is further characterized by its long, slender, whip-like tail, which measures approximately two-thirds of the snout-to-vent length and displays 6-10 alternating black and white bands along its length. Additionally, a small dorsal fin is located at the base of the tail, and singular dark spots are occasionally found between

the black tail bands. The caudal sting is generally underdeveloped. The disc is large, with a lozenge shape, and the snout is short with a relatively projected tip. The spiracles lack the small tentacles on the inner posterior margin. The tail is long (post-cloacal length 23-36% of disc width), often featuring small dorsal fins. The tail exhibits 6-10 black bands, and spines may or may not be present. The dorsal surface of the disc is uniform brown, with numerous white spots, while the ventral disc is consistently white.

Similar species

Gymnura japonica (24.4) has a shorter tail (post cloacal length 45-60% of snout-cloacal length, 5-9 black bands), lacks a dorsal fin, and the pre-oral length of about 2.0-3.3 times post-cloacal length. *Gymnura poecilura* has a longer tail (post-cloacal length 31-54% DW; 8-14 black bands) and always lacks dorsal fins.

Remarks

The zonetail butterfly ray was initially described as Aetoplatea zonura, reflecting an earlier classification of the Gymnuridae family into two genera based on the presence or absence of dorsal fins.[16,17] However, a subsequent taxonomic review of Gymnura australis supported the consolidation of all species into a single genus, Gymnura.[18] As of 2020, the International Union for Conservation of Nature (IUCN) has listed the zonetail butterfly ray as Endangered, primarily due to overexploitation by industrial fisheries, particularly trawl fisheries, where it is harvested for raw material. Despite this, its relatively small body size, compared to other rays, results in lower economic value. The species is targeted for its meat, which is used for human consumption and as bait in longline fisheries. Additional anthropogenic pressures include targeted artisanal and recreational fishing, as well as incidental capture as bycatch. Interspecific competition with other butterfly ray species, especially the longtail butterfly ray, arising from overlapping distributions and similar feeding strategies, may further contribute to its low population abundance. Vulnerability is exacerbated by low fecundity, which limits the species' ability to recover its population. The species remains poorly studied, and the lack of targeted research and dedicated conservation initiatives likely hinders the development of effective management and conservation strategies.[17]

Distribution: Cambodia, China, India, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Viet Nam,[17] Pakistan (present study).

FAMILY: RHINOPTERIDAE]

Medium-large sized rays (DW 2.1m), lozenge-shaped disc, much wider than long, elevated head from disc, with eyes and spiracles on sides; tail distinct from disc (much longer than disc length); Mouth with no papillae; tessellate teeth fused into grinding plates (generally 7 or more rows); small dorsal-fin in front of spines; pectoral-fin reaching forward, forming a distinct lobe below the tip of snout; no caudal fin; upper surface naked or with thorn-lets.

Rhinoptera javanica

Common name: Javanese Cow-nose ray

Local name: Magole (Sin.); Dolunt (Balochi).

IUCN Red list Status: EN.

Biology and ecology: *Rhinoptera javanica* is a benthopelagic species found in tropical waters, typically at depths ranging from the surface to 50 meters.[19] This species can reach a maximum disc width of approximately 165 cm, with both males and females maturing at around 128 cm total length. R. javanica is aplacental viviparous, producing 1 to 2 pups per litter, with a recorded birth size of approximately 30 cm in disc width. There is currently no available data on the maximum age or age at maturity for this species. However, a generation time of approximately 14.5 years is inferred from Myliobatis californicus, which reaches a similar size upon full maturity.[20]



Figure 3 *Rhinoptera javanica* (50.1 cm disc width) center of excellence in marine biology, University of Karachi, Pakistan.

Fishing gears and crafts: Gillnets, set-beg nets, and bottom trawls.

Material examined: (Table 3) CEMB-UOK, ELASM-701 (Fig 3; mature female, 50.1 cm DW): West Wharf fish harbor, Karachi (24.8481 N, 66.9780 E): WWFH, Karachi (39.3 cm DW); WWFH (27.4 cm DW); WWFH (30.2 cm DW).

Table 3 Morphometric measurements of cownose rays of Pakistan (Measurements written as μ±S. D)

Measurements	*Rhinoptera jayakari* (n=4)	*Rhinoptera japonica* (n=3)
Disc Width	20.6±3.7	36.8±10.2
Total length	18.2±1.6	39.5±11.5
Tail lenagth	11.1±2.1	18.2±4.2
Disc length	7.0±1.5	21.5±7.6
Disc thickness	0.9±0.2	3.8±1.3
Disc, anterior margin of spiracle to pectoral fin insertion	7.9±1.9	20.0±5.8
Disc, snout to maximum Width	5.7±0.9	14.0±3.6
Head length	6.0±1.0	10.7±2.9
Snout, Pre-orbital	0.7±0.2	3.6±1.2
Snout, Pr-oral	1.2±0.3	4.1±1.3
Snout, Pre-nasal	0.9±0.2	3.8±1.3
Lower flap length	1.0±0.2	4.1±1.4
Eye diameter	0.3±0.2	0.8±0.2
Inter-eye width	1.2±0.2	5.8±2.1
Orbit and spiracle length	0.6±0.1	3.1±1.1
Spiracle length	0.6±0.1	1.5±0.4
Inter spiracular width, anteriorly	1.7±0.4	5.5±1.7
Inter spiracular width, posteriorly	1.9±0.5	6.6±2.1
mouth width, between the edges of teeths	1.0±0.2	3.1±0.9
Mouth width, between the folders	1.3±0.2	4.5±1.5
Nostril length	0.2±0.1	0.5±0.1
Nasal curtain width	0.3±0.1	4.8±2.0
Nasal curtain Length	0.1±0.1	1.6±0.6
Inter nasal width anteriorly (between bases of nasal curtain)	0.9±0.2	3.3±1.1

Table 3 Continued...

Inter nasal width posteriorly (between posterior out ends of nostrils)	1.3±0.3	4.1±1.3
Width between first gill slit	0.2±0.1	1.0±0.3
Width between fifth gill slit	0.2±0.1	0.7±0.2
Distance between 1st gill slit	1.7±0.3	6.3±2.1
Distance between 5th gill slit	1.2±0.2	4.3±1.5
Pelvic fin length	0.8±0.3	4.5±1.6
Pelvic fin base width	0.9±0.3	2.4±0.6
Tail width, axil of pelvic fin	0.5±0.1	1.3±0.3
Tail width, base of sting	0.3±0.1	0.7±0.2
Tail height, base of sting Spine length	0.3±0.1	0.8±0.2
Snout to origin of cloaca	5.7±0.9	19.8±6.5
Cloaca origin to sting	4.3±0.7	5.3±1.4
Cloaca origin to tail tip	13.0±2.9	20.8±5.3
Cloaca length	1.8±0.2	2.1±0.6
Clasper, post cloacal length (from posterior edge of cloaca to tip of clasper)	0.2±0.1	4.2±1.7
Clasper, length from pelvic axil (from insertion of pelvic fin to tip of clasper)	0.5±0.2	4.1±1.6
Dorsal fin base length	0.8±0.3	2.3±0.7
Dorsal fin height	0.5±0.1	1.8±0.6
Teeth rows on upper jaws	1.0±0.2	0.9±0.3

Diagnosis: can be distinguish from other members of families by the following combination of characteristics: The species features an extensive disc with a distinctly shaped head. The rostral fins are separate from the pectoral fins, forming loose, flexible lobes in front of each orbit, but not extending forward to the center of the head. The snout width is nearly equal to the inter-orbital distance, with a shallow median notch. The eyes are rounded, and the papillae are erect. The spiracles are large and positioned just behind the eyes. Each jaw contains seven rows of teeth, with the median row being more than three times as wide as it is long. The outermost row of teeth is the smallest, being roughly as wide as it is long. The gill slits are of moderate size, evenly spaced, with the last gill slit being the smallest. There is a single dorsal fin, originating above the ends of the ventral fin bases, with serrated spines located immediately behind the dorsal fin. The pelvic fins are relatively narrow and long, culminating in an obtuse anterior lobe. The tail is long, cylindrical, and whip-like.

Color: Dorsal surface plain-brown, posterior sides white without conspicuous markings.

Distinctive characters: *Rhinoptera javanica* is a very large cownose ray characterized by alozenge-shaped pectoral disc that is broader than long, with disc width (DW) measuring 55-58% of the total disc proportions as reported, and an anterior margin notched posterior to the eyes. In adults, the head is relatively small, with a ventral length of 22-24% DW. The width across the middle of the eyes is 13.6-15% DW, while the width across the middle of the spiracles is 14.7-15.9% DW. Internarial width ranges from 7.4 to 8.0% DW. The snout tip is moderately notched, and the cephalic lobe is short, with its posterior edge barely reaching the mouth; it is partially depressible into a shallow groove. The spiracles are larger than the eyes and are situated slightly posterior to the pectoral-fin origins. The mouth is approximately equal in length to the preoral region. The teeth are plate-like, with approximately seven rows in each jaw. The three central rows are considerably broader than the lateral rows, and the middle row is 1.4-1.8 times wider than the adjacent rows. Teeth in the middle row of the upper jaw are particularly short, with a width-to-length ratio of 10-13:1. The pectoral-fin tips are narrowly angular. The tail is typically 2.4-3.4 times the disc length. The dorsal fin is prominent, with its origin located well posterior to the pelvic-fin insertion and its posterior margin predominantly deeply concave. The caudal sting is short, approximately equal to or slightly shorter than the dorsal-fin base, and originates well posterior to the free posterior tip of the dorsal fin. Strongly notched snout medially to form 2 lobes; relatively narrow head; spiracles width ranges at spiracles to 15-16% of DW; Outer edges fleshy on rostral-flap not reaching to mouth; tail long; origin of dorsal-fin distinctly behind the pectoral-fin insertion; outer margin of dorsal-fin strongly concave white stings behind the free rear-tip of dorsal-fin.

Remarks: Rhinoptera is a taxonomically complex genus that requires extensive research to resolve species boundaries and accurately determine species distribution. The zonetail butterfly ray (Aetoplatea zonura) was first reported from Pakistan by Qureshi. This species is primarily distributed across the eastern Indian Ocean and the western central Pacific, with a range extending from India to Indonesia, including Singapore and Thailand. Its presence in Myanmar was later documented.[19] The current study confirms the occurrence of A. zonura in the Arabian Sea along the Pakistani coast. However, according to studies,[19,20] the species had previously only been recorded from India eastward and had not been documented in the Arabian Sea.

Morphometric and taxonomic analyses of Pakistani specimens reveal several diagnostic features, including numerous small, round, whitish spots on the dorsal surface and a banded tail pattern, where light interspaces often contain a single dark spot between successive black bands. Similar dorsal coloration and tail patterning have been reported in specimens from Myanmar by study[17] and later by research.[8] The Javanese cownose ray (Rhinoptera javanica) has experienced significant population declines throughout its range, with estimated reductions of 50-79% over the last three generation lengths (approximately 44 years). These declines reflect intense exploitation pressures, exacerbated by broader declines in elasmobranch, ray, and whipray populations. Overfishing, particularly in Chinese and Vietnamese waters, poses a major threat to the species' survival and raises serious conservation concerns.[13] At present, no specific regulations exist to protect this species. Increased monitoring and regulation of fisheries across its range would significantly contribute to its conservation, as well as the protection of other elasmobranch species.

Furthermore, fisheries-independent research is urgently needed to estimate population abundance and biomass, which would inform effective management strategies.

Distribution: Bangladesh, Cambodia, China, India, Indonesia, Iran, Japan, Malaysia, Myanmar, Oman, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, United Arab Emirates, Viet Nam (Figure 4).[21]

Rhinoptera jayakari

Common name: Omani Cow-nose ray

Local name: Gaim, Magole (Sindhi); Dolunt (Balochi).

IUCN Red list Status: EN.

Biology and ecology: This species is benthopelagic, inhabiting the continental shelf and primarily found in inshore waters at depths from the surface to 50 meters.[19] It reaches a maximum size of approximately 90 cm in disc width, with males maturing at around

78 cm disc width. However, there is no available data on the size at maturity for females. Reproduction is viviparous, with a single pup per litter. No information is currently available regarding the age at maturity for this species. However, the generation length can be inferred from the similar species Rhinoptera bonasus, which has an estimated generation length of 10 years.[22]



Figure 4 *Rhinoptera jayakari* (21.3 cm disc width) center of excellence in marine biology, University of Karachi, Pakistan.

Fisheries: Gillnets; bottom trawls.

Material examined: Table 3 CEMB-UOK, ELASM- 702 (Fig 4; immature female; 21.3 cm DW). West wharf fish harbor, Karachi (24.8481 N: 66.9780 E); WWFH (17.4 cm DW); WWFH (23.1 cm DW).

Diagnosis: can be distinguish by following combination of characters: The disc length of this species is 1.5 times its disc width, with the anterior margin being nearly straight and the outer margin concave. Most of the disc has smooth apices. The trunk is broad and thick, and the head is relatively wide, with the distance between the outer margins of the spiracles measuring 5.3 times the disc width. The snout is bi-lobed on the dorsal surface, separated at the level of the mouth by a lower, forward-projecting continuous groove around the front of the head. The eyes are moderately large, located laterally on the head just medial to the spiracles, and the eye length is 1.8 times the length of the spiracles. The mouth is straight, narrow, and transverse, with the pre-oral distance measuring 8.4 times the disc width. The anterior nasal flap is long and expanded medially, fusing into a broad, elongated, and fringed nasal curtain that overlaps the mouth. The nostrils are positioned somewhat anterior to the mouth, connected by broad nasal grooves to the mouth. The tail is short, measuring 1.4 times the disc length, and its base is relatively high. A rounded dorsal fin originates over the pelvic fin insertions, with the outer margin nearly straight. A serrated spine is located behind the dorsal fin on the tail, with its base positioned beneath the anterior margin of the dorsal fin. The teeth are flat and pavement-like, with 9 series in the upper jaw. There are three central rows of broad teeth, and 3-5 narrower, diamond-shaped teeth on each side.

Color: Olive dorsally, white ventrally with a black tail.

Distinctive characters: *Rhinoptera jayakari* is a very large, robust cownose ray characterized by a broad, elongated pectoral disc, with disc length equivalent to 58-64% of disc width (DW). The anterior margin of the disc is notched posterior to the eyes. The head is relatively large, with a ventral length of 24-26% DW. The width across the middle of the eyes ranges from 14.5 to 17.4% DW, while the width across the posterior margins of the spiracles is 16.5-17.5% DW. Internarial width measures 8.3-9.1% DW. The snout tip is deeply notched, and the cephalic lobe is elongated, with its posterior margin typically extending beyond the mouth and approaching the first gill slit. The cephalic lobe is partially depressible into a shallow groove. The spiracles are considerably larger than the exposed eyes and are positioned slightly posterior to the pectoral-fin origins. The mouth is slightly wider than the preoral region is long. The teeth are plate-like, arranged in 9-11 rows in each jaw, with the three central rows substantially broader than the lateral rows. The middle row is 1.6-2.4 times wider than the adjacent rows, while the teeth in the middle row of the upper jaw are 5-8 times wider than their length. Dermal denticles form a weak band along the midline of the disc. The pectoral-fin tips are narrowly angular. The tail is typically 1.4-1.8 times the disc length. The dorsal fin is prominent, with its origin positioned over or slightly anterior to the pelvic-fin insertions and its posterior margin ranging from straight to slightly convex. The caudal sting is short, generally slightly longer than the dorsal-fin base, and originates beneath the inner margin of the dorsal fin. The disc of this species is wing-like, with a length measuring 1.5-1.6 times its width.

The anterior margin is nearly straight, while the posterior margin is concave, with acutely pointed apices. The disc is mostly smooth, except for small stellate-based prickles located on the dorsal snout, interorbital space, and a triangular patch on the posterior third of the trunk, which extends to the dorsal-fin origin. The trunk is broad and thickened, and the head is relatively wide, with the width between the posterior margins of the spiracles measuring 5.0-5.5 times the disc width. The upper snout is bilobed, separated from the lower, forward-projecting bilobed portion by a deep, continuous groove around the front of the head. The moderately large eyes are positioned laterally on the head, just anteromedial to the spiracles, with the eye length measuring 1.8 times the length of the spiracles. The mouth is transverse, straight, and narrow, with the width between the folds measuring 1.3 times the head width. The preoral distance is 8.7-9.2 times the disc width. The anterior nasal flaps are elongated, medially expanded, and fused into a broad, fringed nasal curtain that overlaps the mouth. The nostrils are slightly anterior to the mouth and are connected to it by broad nasoral grooves. The tail is short, measuring 1.4-1.7 times the disc length, with a relatively high, rounded dorsal fin at its base, positioned at the level of the pelvic-fin insertions. The dorsal fin has an almost upright posterior margin, and a serrated spine is located behind it, with its base positioned beneath the inner margin of the dorsal fin. This spine measures 5.1-6.2 times the tail length. The teeth are flat and pavement-like, arranged in 9 or 12 series in the upper jaw. There are three central rows of broad teeth and 3-5 rows of narrower, diamond-shaped teeth on each side. The middle teeth of the lower jaw are 1.5 times broader than the adjacent teeth. The dorsal surface of the disc is dark olivaceous, while the ventral surface is white. The tail darkens distally and becomes black.

Remarks: The systematics of the Rhinopteridae family remain unresolved, with approximately 8 species currently recognized, three of which occur in the Indo-West Pacific: Rhinoptera javanica, R. jayakari, and R. neglecta. The species Rhinoptera adspersa was once distinguished from R. javanica based on a lower number of upper-jaw tooth rows (seven versus nine). However, since tooth-row counts are now understood to be variable, R. adspersa has been synonymized with R. javanica.[16] An examination of three specimens in the present study further confirms this variability, with one specimen exhibiting nine tooth rows and two showing twelve, reinforcing the conclusion that tooth-row count is not a reliable diagnostic characteristic for distinguishing R. jayakari from R. javanica. Rhinoptera neglecta, which is restricted to Australia, is easily distinguished from both R. javanica and R. jayakari by its smooth, prickle-free disc, a dorsal-fin origin anterior to the pelvic-fin insertions, and a tail length approximately equal to the disc length. Rhinoptera jayakari has often been misidentified as R. javanica, but it can be separated by its broader head (16.5-19% of disc width compared with 14.5-16% in R. javanica), shorter tail (1.4-1.8 times the disc length versus 0.5-0.8 times), and a dorsal-fin origin aligned with the pelvic-fin insertions,

while in R. javanica, the dorsal fin originates posterior to the pelvic fins.

The report of R. javanica from the Gulf of Aden by Bonfil and Abdallah[23] was based on a misidentification of R. jayakari, as the illustrated specimen exhibited the short tail characteristic of the latter species. Reports of R. javanica from the northwestern Indian Ocean include records from Iran, Pakistan,[9] and Oman (P. R. Last, pers. obs.). Sommer, Schneider, and Poutiers also reported R. javanica from Somalia, although this record lacks voucher specimens or photographic documentation. Rhinoptera sewelli, originally described from the Arabian Sea, has been synonymized with R. jayakari.[15] Both R. javanica and R. jayakari are sympatric in the western Pacific, but the distribution of R. jayakari remains poorly described due to frequent misidentifications. For example, Rhinoptera sp. 1 reported from eastern Indonesia was later reidentified as R. jayakari.[9] Rhinoptera jayakari inhabits shallow coastal waters, typically at depths of less than 30 meters, where fishing pressure is often intense, particularly in Southeast Asian waters. The strong swimming ability of cownose rays makes them especially vulnerable to capture in inshore fisheries, notably gillnet fisheries, which are widespread in regions like Indonesia. Recent reductions in shark-net deployments in South Africa are expected to help reduce incidental catches of these rays in the area.[13] Accurate estimates of both fishing and natural mortality are crucial for effective evaluation and management of Rhinopterid fisheries.

Distribution: Baharain, Bangladesh, Cambodia, China, Djibouti, Egypt, Eritrea, India, Indonesia, Iran, Iraq, Japan, Kenya, Kuwait, Malaysia, Maldives, Mozambique, Myanmar, Oman, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, Somalia, Sri Lanka, Sudan, Taiwan, Tanzania, Thailand, United Arab Emirates, Viet Nam, Yemen.[24]

Discussion

The present study confirms the presence of two species from each the families Rhinopteridae and Gymnuridae, including the first documented record of Gymnura zonura in Pakistani waters. Within the Rhinopteridae, Rhinoptera jayakari has been previously reported from the Gulf of Oman and the Red Sea.[23] Although research[1] identified several morphological features of R. jayakari, these alone are insufficient for definitive species confirmation. Additional observations have been made from India[25] and the Gulf of Mannar.[26] Another species reported from Pakistan, R. javanica, remains poorly studied throughout its distribution range. Rhinopterid species primarily inhabit coastal waters at depths of less than 30 meters, making them vulnerable to high fishing pressures, particularly in South Asian regions. Despite their strong swimming abilities, these rays are especially susceptible to inshore fisheries, such as gillnets. In countries like Indonesia,[10] the Philippines,[11] Malaysia,[27] and Pakistan, Rhinopterids are frequently landed in areas characterized by high, largely unregulated fishing pressures. Their accessibility in nearshore environments contributes to extensive exploitation throughout their range.[16] In Pakistani waters, approximately 2,000 trawlers operate across the continental shelf, targeting shrimp in shallow waters and finfish in deeper shelf areas. In Iran, fishing pressure has increased over time, as reflected by a rise in the number of fishers from 70,729 in 1993 to 109,601 in 2002.[10,11]

Similarly, in the Red Sea, the number of traditional Saudi Arabian fishing vessels increased from approximately 3,100 in 1988 to 10,000 in 2006. In Eritrea, fisheries catch and effort data indicated that both total fishing effort and annual catches increased by more than twofold between 1996 and 2002. Butterfly rays are generally discarded in the Red Sea and the Gulf because their meat is considered undesirable, whereas they are commonly retained in Indian fisheries. The post-release survival of butterfly rays caught by hook-and-line gear is likely to be higher than that of individuals captured by trawling, as trawl capture may cause substantial injury and subsequent mortality, even when individuals are released.[10]

The family Gymnuridae (butterfly rays) has a complicated taxonomic history, due to insufficient species descriptions and limited documented intraspecific variation,[7] which complicates the resolution of their systematics. Continued research is required to clarify Gymnurid systematics in the Indian Ocean. Butterfly rays are captured in significant numbers as bycatch in benthic trawl fisheries, making them highly vulnerable.[17] These species exhibit low fecundity, with females producing only four embryos per reproductive cycle, and are landed year-round, with peak catches occurring between January and May.[14] Gymnurids are targeted for human consumption by artisanal fisheries, particularly in Thailand and Indonesia, and are also incidentally captured in commercial fisheries throughout their range.[16] Both Rhinopteridae and Gymnuridae face severe threats from various fishing practices.[13] Their inherent life-history traits limit their resilience to population declines, highlighting the need to monitor both direct and incidental captures in artisanal and recreational fisheries across their distributions.[13]

The implementation of conservation frameworks, such as the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks), is crucial for the sustainable management of elasmobranch populations. Species-specific research is essential, including studies on age and growth, movement patterns, habitat use, nursery areas, and reproductive biology, to inform effective conservation strategies for batoid fishes. Fisheries assessments focusing on species-specific landings and discard rates can help elucidate socio-economic drivers influencing exploitation trends. The current lack of region-specific data on the biology and ecology of local elasmobranch populations underscores the urgent need for targeted research efforts. Methods such as tagging, tracking, and genetic analyses are crucial for assessing population structure and distribution patterns. Finally, a broader, global approach to elasmobranch fisheries management, supported by advanced methodologies such as electronic tagging and population dynamics modeling, is necessary. Given the ecological significance of Pakistani waters, continued research is essential to conserve batoid species, especially in light of climate-driven shifts in species distributions.

Conclusion

The current study confirms the presence of two species from each of the families Rhinopteridae and Gymnuridae in Pakistani waters. Despite their strong swimming capabilities, these rays are particularly vulnerable to inshore fisheries, including gillnets, due to their habitat in coastal environments. Effective, global management of elasmobranch fisheries is essential, and this should be supported by advanced techniques such as electronic tagging and population dynamics modeling. Given the ecological importance of Pakistani waters, ongoing research is crucial for the conservation of batoid species, particularly in the context of climate-driven shifts in species distributions.

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Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

All applicable national, international, and institutional guidelines for the care and use of animals were followed.

Data availability

The dataset generated or analyzed during the present study is available from the corresponding author Amir Javed on reasonable request.

Author contribution

PJAS conceived and designed research. AJ conducted the fieldwork. AJ and SS analyzed data. All the authors contributed to writing the manuscript. PJAS read and approved the manuscript for submission.

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