



Extraction of People's Perception Toward Horseshoe Crab Existence in Northeast Coast of India

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Understanding local community attitudes toward wildlife and their environment is critical for making sensitive conservation planning and management decisions particularly for conservation-neglected species like *Tachypleus gigas*. A questionnaire-based interview was carried out on 388 local households from 12 different villages in Balasore, Odisha, between September 2018 and February 2019, which uses a theoretical mapping on attitudes toward horseshoe crabs. We found that 53% of interviewees accepted the presence of horseshoe crabs in their area, 27% have oppressive attitudes, and the remaining 20% were having mixed feelings. Most respondents (>60%) considered horseshoe crabs to bring tangible benefits such as esthetic, monetary, and cultural significance. However, a handful of respondents expressed oppressive attitudes because horseshoe crabs damage their fishing nets (<20%). Both principal component and stepwise analyses revealed that age, gender, and education were demographic components that closely relate local community perceptions toward the conservation-neglected horseshoe crabs that remain threatened by by-catch. We encourage socioeconomic monitoring particularly during rapid economic and infrastructure development to minimize knowledge erosion and to appreciate local ecological knowledge for better conservation management in India.

Keywords: community, threats, estuary, relationship, fisheries, management

INTRODUCTION

Expansions of human populations in coastal areas result in exploitation (Brash, 1987; Newmark et al., 1993; Walters, 2004) and the reduction of species (Gregory, 2005; Ndenecho, 2009) as precursors to the sixth extinction era (Ceballos et al., 2015; Corlett, 2015). Humans have overlooked the context of biological diversity. Biotic assemblages are present to serve a certain function in the ecosystem (Manfredo, 2008; Rands et al., 2010; Nelson et al., 2018, 2020; Jaffar et al., 2019). Yet humans portray themselves as stakeholders with commensalism attitudes toward resources and their interaction with wildlife in their area (Nepal, 2002; Braga and Schiavetti, 2013;

Fakhrul-Hatta et al., 2018; Khalib et al., 2018; Liao et al., 2019). While planning for development, authorities often proposed actions based on top-down decision that may disregard wildlife and communities who inhabit a certain area of interest (Sutherland et al., 2004; Segan et al., 2011). We propose an “otherwise” approach where the community governs and manage their habitat. In this sense, opinions of *Odia* community were bottom-up suggestions that call for transparent management decisions, particularly for resource exploitation and human-wildlife co-habitations.

India is a South Asian country with large land plains, and 68% of its boundaries are surrounded by seas that support some 1.38 billion humans that unleash anthropic stress to wildlife and surrounding environments, particularly the water bodies (Schipper et al., 2008; Sodhi et al., 2010). We perceived the local communities are engaging themselves in experiential learning from the environment because their livelihood and well-being relate with resource governance in the area. Hence, the gathering of opinions related to non-keystone species produces genuine opinions from the community particularly, when they are sharing resources with this animal. Therefore, we introduce conservation-neglected horseshoe crabs like *Tachypleus gigas* and *Carcinoscorpius rotundicauda* as our tool because they are available in India and also throughout Southeast Asia (John et al., 2018; Nong et al., 2020).

Horseshoe crab species currently under conservation purview are *Limulus polyphemus* and *Tachypleus tridentatus* because their respective statuses in the wild were recently changed from “data deficient” to “vulnerable” and “endangered” in International Union for Conservation of Nature (IUCN) Red List (Smith et al., 2018; Laurie et al., 2019). This means that *T. gigas* and *C. rotundicauda* statuses in the wild are “data deficient” and yet to receive recommendations for updating. Separately, horseshoe crabs spend their entire life cycle (spawning grounds, embryogenesis, nursery grounds, and feeding grounds) interacting with humans (Smith et al., 2009). Therefore, India has placed horseshoe crabs under Wildlife Protection Act 1972 and Fisheries Act 1897 protection. Further, fishery pressure is relieved during the peak spawning season of horseshoe crabs (between May and September), which falls on no-fishing season (April–July) in India (Pati et al., 2015; Pati, 2017; John et al., 2018). Moreover, the Association for Biodiversity Conservation and Research, a non-governmental organization, has implemented projects related to beach cleaning (Mohanty, 2017b; Kundu, 2018), culture and tradition (Mohanty, 2017a), awareness (Pati and Dash, 2016; Pati et al., 2017; Reuters, 2020), horseshoe crab rescue (Senapati, 2018; Pati, 2019a,b; ENS, 2020), celebrations (Mohanty, 2020), and art (Patsani, 2018).

However, all efforts are inadequate if knowledge raised from community engagements is not documented and made available to the public. Hence, with an objective to document community perceptions toward horseshoe crabs after a series of conservation-leadership programs, we design our instrument (questionnaire) using layman's terms so that community members can freely express their opinions without a scientific stigma. The *Odia* community opinions and views are respected by maintaining a non-disclosure approach while welcoming

rural folks into horseshoe crab conservation-based programs in Balasore (Odisha), northeast India. Overall, this community perception survey enables us to understand community values and their attitudes toward horseshoe crabs in India.

METHODOLOGY

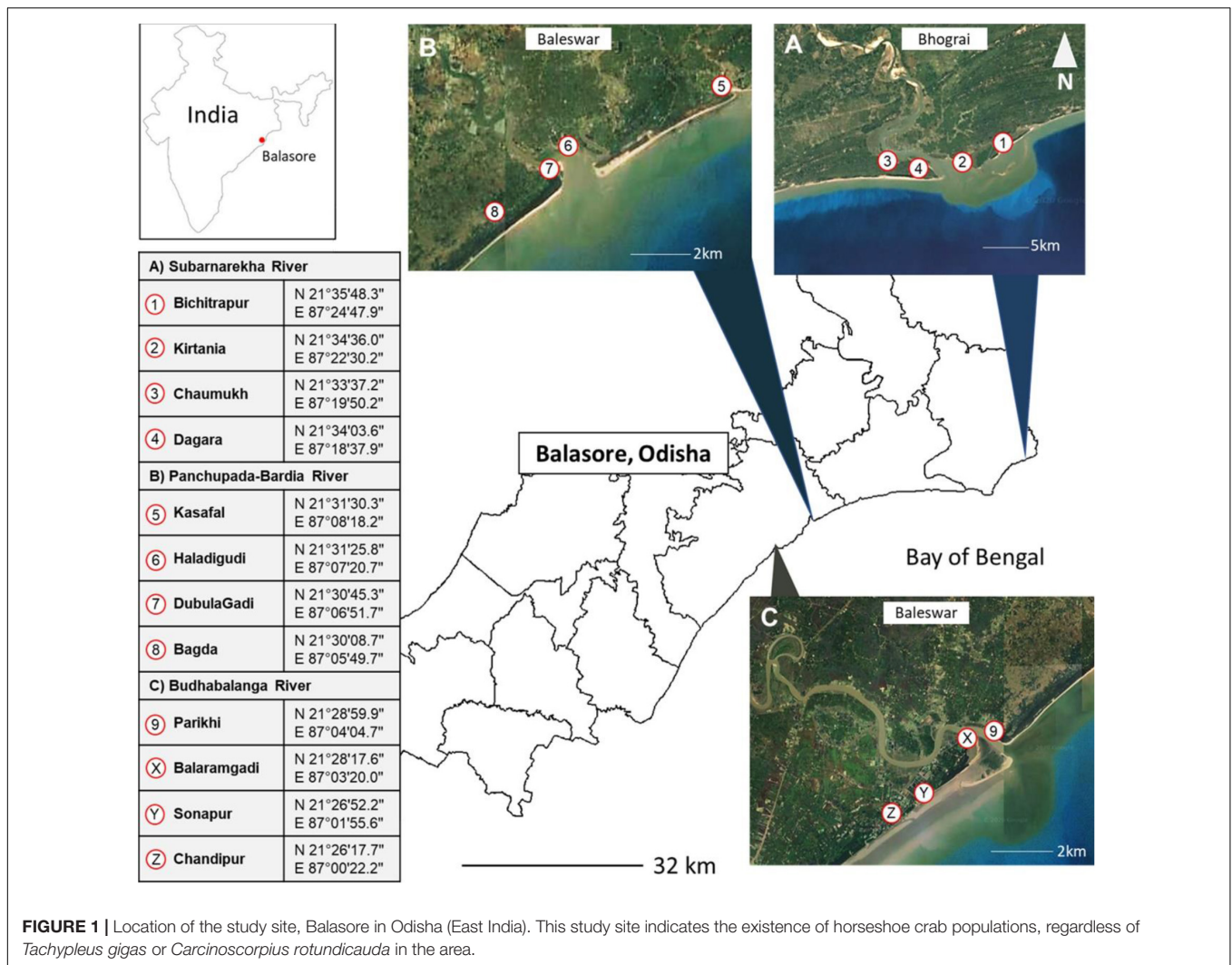
Experimental Design

The present study involved the participation of coastal communities in Balasore (Odisha, India) within an 88-km² (N 21°30'; E 86°56') intersection of the Subarnarekha, Panchupada-Bardia, and Budhabalanga estuaries (**Figure 1**). Since both rivers extend into northeast Bay of Bengal (the most productive waters in northeast India), capture fisheries and horseshoe crab (*Tachypleus gigas*) by-catch are human-wildlife interactions of the *Odia* community. While coastal communities in Baleswar and Bhograi areas (Balasore, **Figure 1**) are risking their capture fishery efforts with unpredictable weather and stormy waters of the Indian Ocean, we also learned that horseshoe crabs cause fisher net damage and income loss. This is challenging because *T. gigas* is placed in Schedule IV of Wildlife Protection Act 1972, and deleterious acts toward the listed wildlife (in either schedules) are punishable with fines (between USD 16 and USD 254) that are unaffordable by these communities. However, out of the six schedules, Schedules I and II provide absolute protection, and offenses under these are prescribed with the highest penalties. The horseshoe crab *T. gigas* is listed in Schedule IV of Wildlife Protection Act 1972, but penalties for violations are minimal (from USD 16 to USD 50). For effective conservation to stabilize horseshoe crab population structure in the wild, absolute protection is needed, and it is imperative that the current Wildlife Protection Act be updated.

Here, we partake discussions with the community before designing our questionnaire. All questions are tested using 50 randomly selected members from the public before every set of questionnaires is validated using Cronbach α test (SPSS v.16, IBM, United States). We adopted the procedures of Creswell and Tashakkori (2007) to amend the questionnaire until Cronbach α test score >0.70 was achieved. A pre-interview (during 16 December 2018) is carried out on another 50 random members from the public to finalize the contents of our questionnaire (Cronbach α = 0.87). With this, our questionnaire covers sociodemographic information, local beliefs on the animal, local knowledge of horseshoe crab, and also their perceptions, attitudes, and opinions toward the horseshoe crab.

Data Collection

We identified a total of 500 households from the Subarnarekha (Bichitrapur, Kirtania, Dagra, and Chaumukha), Panchupada-Bardia (Kasafal, Haladigudi, Dubulagadi, and Bagda), and Budhabalanga (Parikhi, Balaramgadi, Sonapur, and Chandipur) river estuaries using random respondent selection and also “snowball sampling” for their interaction with aquatic species (cf. Newing et al., 2011; **Figure 1**). We further limited the respondents by their age (between ages 18 and 65), and only one representative is allowed per household (assures responses are independent).



Thus, our final sample size is 388 respondents who fulfilled all the desired criteria while also answering most of the questions (>80%). Every respondent needed approximately 1 h both for the face-to-face interview session (verbal consent, identity non-disclosure, and eligibility) in *Odia* language and to complete the questionnaire with Likert scale (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree) and open-ended questions. Our data collection was supported by two volunteers from the Association of Biodiversity Conservation and Research because our intension is to understand coastal community perception on wildlife (marine animal) threats, actions to conserve them, and the willingness to participate in conservation programs (horseshoe crab volunteerism in annual *Raksha Bandhan*, art contests, participatory horseshoe crab research, beach cleanups, and horseshoe crab tourism) that were held annually in Balasore (Odisha, India).

Data Analysis

We registered all data into both SPSS v.16 (IBM, United States) and also Microsoft Excel as platforms for descriptive and

statistical analyses. We develop principal components to analyze the community perceptions using key-word strings. The stepwise analysis that amalgamates Bray–Curtis similarity index and Spearman's correlation is used to organize data into statistical associations that give the highest value for the best relationship. Both the principal component and stepwise analyses were developed in Primer v.6.1 using protocols of Gorley and Clarke (2006).

RESULTS

Data on Local Knowledge

To explore opinions from 388 respondents, we classify them into age groups of 18–24 (Group 1), 25–34 (Group 2), 35–44 (Group 3), 45–54 (Group 4), and 55–64 (Group 5). The second-line arrangement involved education through the separation of respondents into upper primary (UP), middle elementary (ME), and high school/college (HC) groups (**Table 1**). However, we only considered opinions of 350 individuals (90.2% of men and

women) who possess ME (45.1%) or higher (32.0%) education because they correctly identified the shape and form of horseshoe crab (*Tachypleus gigas*) from a series of aquatic life pictures (ghost crab, freshwater and marine rays, horseshoe crab in mating pairs, porcelain crab, and hermit crab) presented to them. Only 252 (69.4%, $P = 0.921$, eigenvalue 5.7, cumulative variation 88.8%) respondents from whom a majority (167 persons) are between 35 and 54 years old (**Figure 2A**) and possess ME education (**Figure 2B**) knew about “*Nilarakta Kankda*” (*T. gigas*) as mentioned in folk stories from their culture. Comparatively, a majority of 173 individuals aged between 35 and 54 years from the 277 (75.4%, $P = 0.927$) respondents who knew *T. gigas* shape and form (particularly women; **Figure 2C**) associated this arthropod with aphrodisiac tonic, traditional medicine, and alchemy preparations. Only a handful ranging from 12 to 39 female respondents with a majority of them aging 25–54 years were uncertain about *T. gigas* relevance to their culture ($P = 0.898$) and tradition ($P = 0.726$; **Table 1**), although this arthropod coexist with other fishery resources in their area.

With 173 male and 92 female respondents acknowledging the year-long availability of *T. gigas* ($P = 0.924$), we learned that horseshoe crab emergence into shallow waters was not influenced by season (rain, summer, or winter, $P = 0.456$, eigenvalue 8.71; cumulative variation 79.9%; **Figure 3**) in this northeast territory unless the fishermen were fishing exclusively for horseshoe crabs. A total of 29 respondents suggest that environmental conditions *vis-à-vis* *T. gigas* populations are recovering ($P = 0.454$), whereas five male and four female respondents claimed that coastal conditions and horseshoe crab populations remained similar to their first contact with this arthropod ($P = 0.457$). A vast collection of 321 (91.7%, $P = 0.920$, **Figure 3A**) respondents expressed either uncertain or negative views on *T. gigas* population recovery because their opinions closely relate with wild capture fisheries as resource (**Table 1**). On the other hand, although 148 individuals (with ME and HC education; **Figure 3B**) were uncertain about *T. gigas* role in the environment, 77 (32.9%) male and 38 (32.8%) female respondents expressed views on “biological control” for bivalve and small crab populations after highlighting presence of empty bivalve shells and crab remnants after day-time net casting in the lowest tide (1–1.2 m) waters during the summer months (**Figure 3C**). These 115 respondents knew about their environment and were able to express their opinions with scientific logic, although these 35 (UP), 47 (ME), and 33 (HC) individuals were deprived of advanced education.

***Tachypleus gigas* and the Odia Community**

We learned that 184 individuals aging between 25 and 54 years (from the total of 350 respondents) who correctly identified horseshoe crabs closely associate their livelihood to *T. gigas* ($P = 0.883$, eigenvalue 5.63; cumulative variation 84.0%; **Figure 4A**; **Table 1**). In their perception, although horseshoe crabs are not fished as alternative protein or exotic food, occasionally, there are middlemen who purchase both male (small) and female (large) *T. gigas*. However, these

middlemen would only pick healthy-looking crabs (absence of encrusting/fouling organisms on the carapace or absence of morphological abnormalities), as these men inform (some respondents) of lucrative demands in the north and west territories of India. While some respondents routinely fish from the estuary, they would not purposely collect *T. gigas* and sell (USD 0.50 to USD 0.72) these arthropods to middlemen simply because arrival of middlemen are uncertain. The fishermen do not want to be seen with a large number of horseshoe crabs in their possession and fear heavy fines. Moreover, the crabs are often seen in inundated areas for amplexus, but artisanal fishermen make contact with horseshoe crabs during net casting. These individuals either sell or consume all resources (finfish and shellfish including horseshoe crabs) gathered from their routine activity. With this, a total of 212 respondents ($P = 0.794$) comprising 137 male and 75 female individuals from all age groups (and having UP or ME education; **Figure 4B**) referred to horseshoe crabs as by-catch. On the contrary, 155 male and 72 female respondents ($P = 0.879$) expressed dissatisfaction because entangled horseshoe crabs either damage or make their nets unusable (**Figure 4C** and **Table 1**). Although fishermen do not immediately discard their nets into the sea when horseshoe crab entangling is common, there are incidences where horseshoe crabs are forcefully removed, but only when *T. gigas*' limbs and tail cease to move (inactive or presume dead).

Capture fisheries are carried out by 226 respondents from age groups 3 and 4 (35–54 years old; 62.9–69.9%, $P = 0.941$, eigenvalue 8.49; cumulative variation 88.2%; **Figure 5A**) for their survival, livelihood, and income (**Table 1**). Therefore, horseshoe crabs are indirectly exploited (by-catch) because all respondents (regardless of their education; **Figure 5B**) stressed on nets becoming entangled by individual crabs rather than by *T. gigas* in pairs. The community fears that reduced horseshoe crab capture in pairs relates to reduced finfish and shellfish availability. In their perception, resource depletion may force their community into starvation. On the contrary, 223 respondents ($P = 0.958$) aging between 35 and 54 were a majority of the 388 respondents who collectively agreed (94.3–100% across all age groups; **Figure 5C**) that horseshoe crabs and capture fisheries are threatened by degraded habitat. Though not associated, but collectively, 228 men and 111 women made 75 observations of crows, and 188 witnessed accounts of dogs and 56 counts of pig predation on *T. gigas* ($P = 0.735$), which suggests that horseshoe crabs are at risk of terrestrial animal predation after becoming stranded or when discarded on the beach (**Table 1**).

DISCUSSION

The present study reached out to 117 respondents from Subarnarekha, 119 respondents from Panchupada-Bardia, and 152 respondents from Budhabalanga river estuaries in northeast India where 65% and 35% of the respondents were, respectively, men and women. A vast majority of respondents received ME education (175 persons; 45%) compared with HC (124 persons; 32%) and UP (89 persons; 23%), which means that education was reformed in India to include science, mathematics,

TABLE 1 | Processed data from the instrument (questionnaire) after receiving responses from Odia folks in Balasore.

Criteria	G1	G2	G3	G4	G5	M	F	UP	ME	HC
Demography										
Education	19	75	118	136	40	254	134	89	175	124
+ ID	18	68	106	123	35	234	116	80	155	115
−ID	1	7	12	13	5	20	18	9	20	9
Beliefs										
Cultural significance (yes)	(15) 14	(42) 36	(75) 73	(92) 92	(28) 28	(157) 156	(95) 87	(57) 55	(111) 106	(84) 82
Traditional significance (yes)	(11) 11	(56) 56	(91) 81	(97) 92	(22) 21	(178) 182	(99) 82	(64) 59	(124) 112	(93) 89
Tradition (not sure)	2	1	4	5	2	0	12	3	6	3
Local ecological knowledge										
Availability (throughout the year)	14	55	76	99	27	173	92	67	105	93
Hsc. recovering (yes)	2	6	6	11	4	19	10	10	7	12
HSc. recovering (same)	0	3	5	1	0	5	4	4	1	4
Ecological role (yes)	9	22	37	33	14	77	38	35	47	33
Ecological role (not sure)	7	28	42	57	14	102	46	29	64	55
Relationship										
Economic importance (yes)	6	42	58	84	22	137	75	43	98	71
Causes net damage (yes)	12	41	69	80	25	155	72	57	103	67
Threats										
Hsc. habitat degraded (yes)	18	65	101	122	33	228	111	76	153	110
Predation (crow)	2	16	20	28	9	54	21	19	31	25
Predation (dog)	12	27	58	72	19	121	67	40	81	67
Predation (pig)	2	14	18	16	6	38	18	15	26	15
Hsc. as by-catch (yes)	9	46	63	86	22	147	79	50	98	78

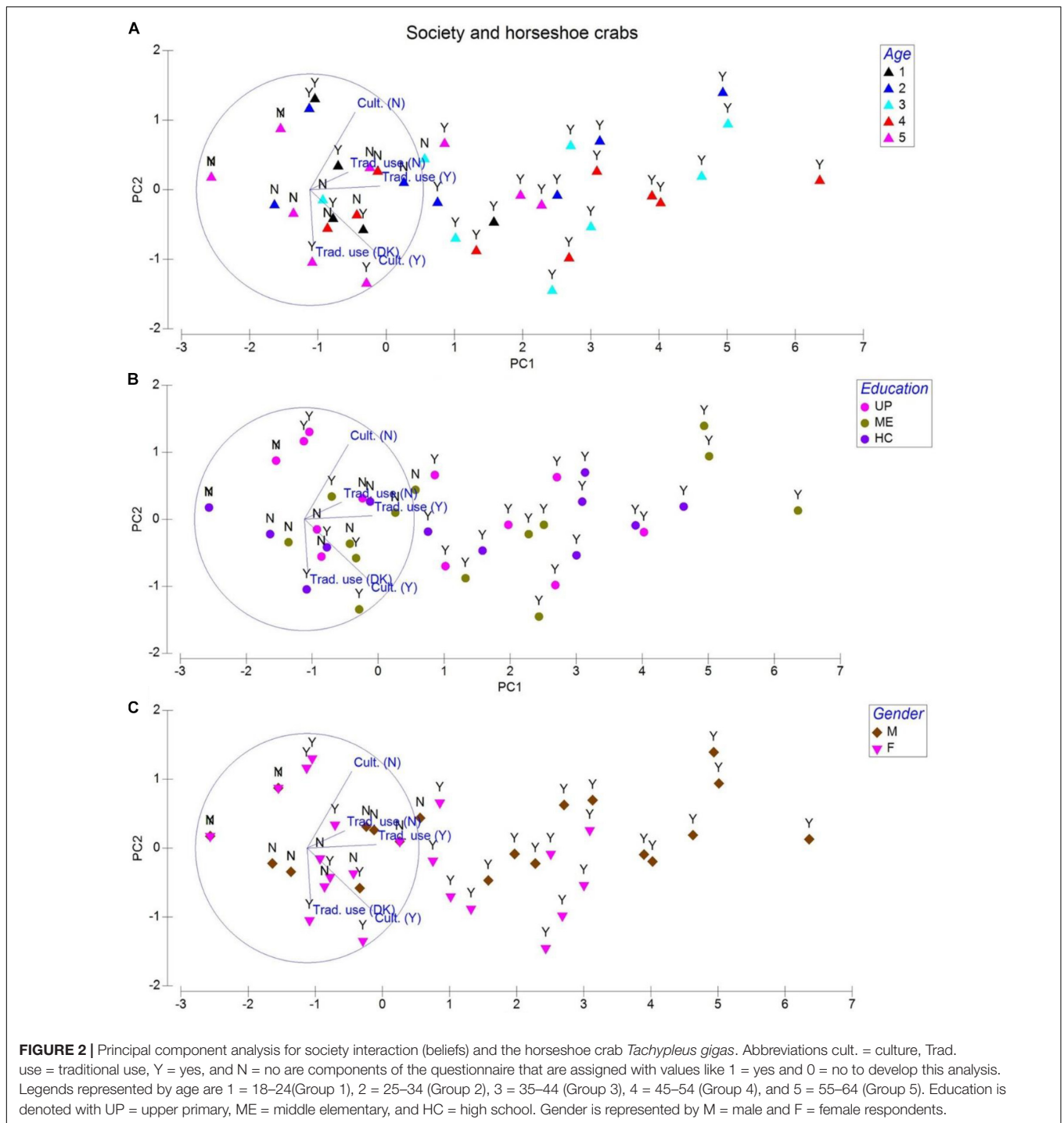
Table headings are abbreviated as G = group, M = male, F = female, UP = upper primary, ME = middle elementary, and HC = high school/college. Abbreviated components listed in criteria include + ID = number of respondents who successfully identified horseshoe crabs, −ID = number of respondents who were not able to identify horseshoe crabs, and Hsc. = horseshoe crab(s). Values in (brackets) for "beliefs" section refer to total number of respondents. Values in other sections refer to number of respondents who successfully identified horseshoe crab from pictures presented to them.

and geography (Suchkov, 1959). Education is relevant to their scientific logic when reasoning on biology–ecology opinions (Gafour and Narayan, 2012). For instance, respondents from Subarnarekha, Panchupada-Bardia, and Budhabalanga estuaries used the term “biological control” for horseshoe crabs against bivalves and small crabs. It shows that these folks understand prey–predator interactions from their basic science education, and also experience working with predators provides them with local ecological knowledge.

We also learned that horseshoe crabs compete with fisher folk for shellfish, but we did not expect that the Odia community ignores the crab's presence even though this arthropod threatens their livelihood. Instead, the by-catch (horseshoe crab) is removed from nets with caution and returned back to the sea. But when opportunity arises, they are sold to the middlemen for extra income. In addition, most of the respondents were within ages 35–54 (254; 65%), which means that these rural folks may possess traditional and cultural knowledge that was passed from one to the next generation. Perhaps, this passed knowledge allowed them to correctly identify mating horseshoe crab pairs (amplexus), size disparity between male (small) and female (large) crabs, and also their species (“*Ram Lakhan*,” rounded tail, *Carcinoscorpius rotundicauda*; and “*Nilarakta Kankda*,” triangular tail, *Tachyplesus gigas*). Rural communities are known to possess traditional knowledge of forest and aquatic resources (Demunshi and Chugh, 2010), and they pioneer on resource

bioprospecting as well as shared-benefit practices (Moran, 2000; Torri, 2011; Pati et al., 2020a). We have learned the benefits of horseshoe crab blood lysate for endotoxin recovery through research, but it was commercialization that lures communities into horseshoe crab exploitation (Bolden et al., 2016). Also, confidence in biomedical bioprospecting concerning blood proteins (tachyplesin-*a*, *b*, *1*, and *2*) gained urban community support for horseshoe crab-derived antibiotics (Dash et al., 2017; Mans, 2017), the use of embryonic peri-vitelline fluid to trigger stem cell differentiation into cardiomyocyte (Ghaskadbi et al., 2008; Alam et al., 2015b) and dendritic cells (Chinnari et al., 2015), and horseshoe crab chitosan use for food preserves and wound healing (Alam et al., 2015a; Pati et al., 2018, 2020b).

We learned about perceived (38 persons) and acquired knowledge (350 persons) through this study because relationships concerning *T. gigas* and community (culture), its use for traditional applications (tradition), and local ecological knowledge (role, availability, and recovery of *T. gigas*) were unexplored prior to this study. Tribal traditional knowledge considers arthropods as a dietary and medicinal resource (Jayashankar et al., 2016), whereas coastal communities in India are experts on culture and capture fisheries (Nair et al., 1990; Kumari and Singh, 2020). Unfortunately, past and present research did not focus on *T. gigas* and *C. rotundicauda*. Local ecological knowledge that entails sociology and indigenous practices remain top-down and targeted toward community



development in India (Davis and Wagner, 2003; Aswani et al., 2018). This means that biodiversity well-being continues to remain neglected. In our approach, community opinions (local economy support and impacts to the community) vis-à-vis expressions on existing threats (resource pool reductions from habitat loss) are relevant with livelihood and ecosystem interactions (cf. Joa et al., 2018) such as social-shared perceptions, values, norms, and also local experiences.

We translate the questionnaire into a conservative mindset for resource pool governance, which also means that there is concern for resource reduction and that the community is attentive toward yield of wildlife. Therefore, our action to replace keystone species like mangroves (*Avicennia* sp. and *Sonneratia* sp.) and mud crab (*Scylla* sp.) with a neglected species like *T. gigas* allowed us to harness the *Odia* community's knowledge about their environment as well as the biology of different

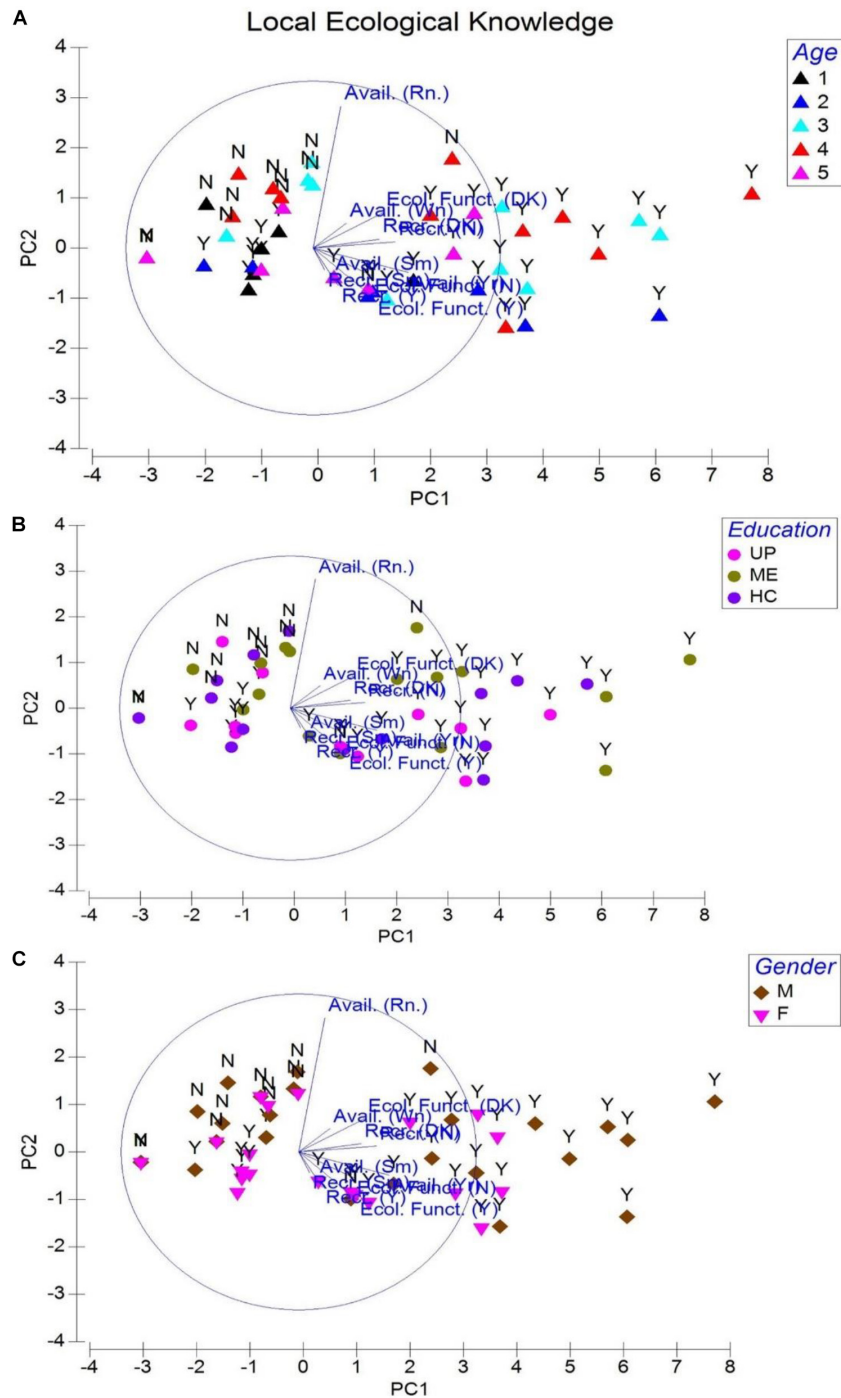
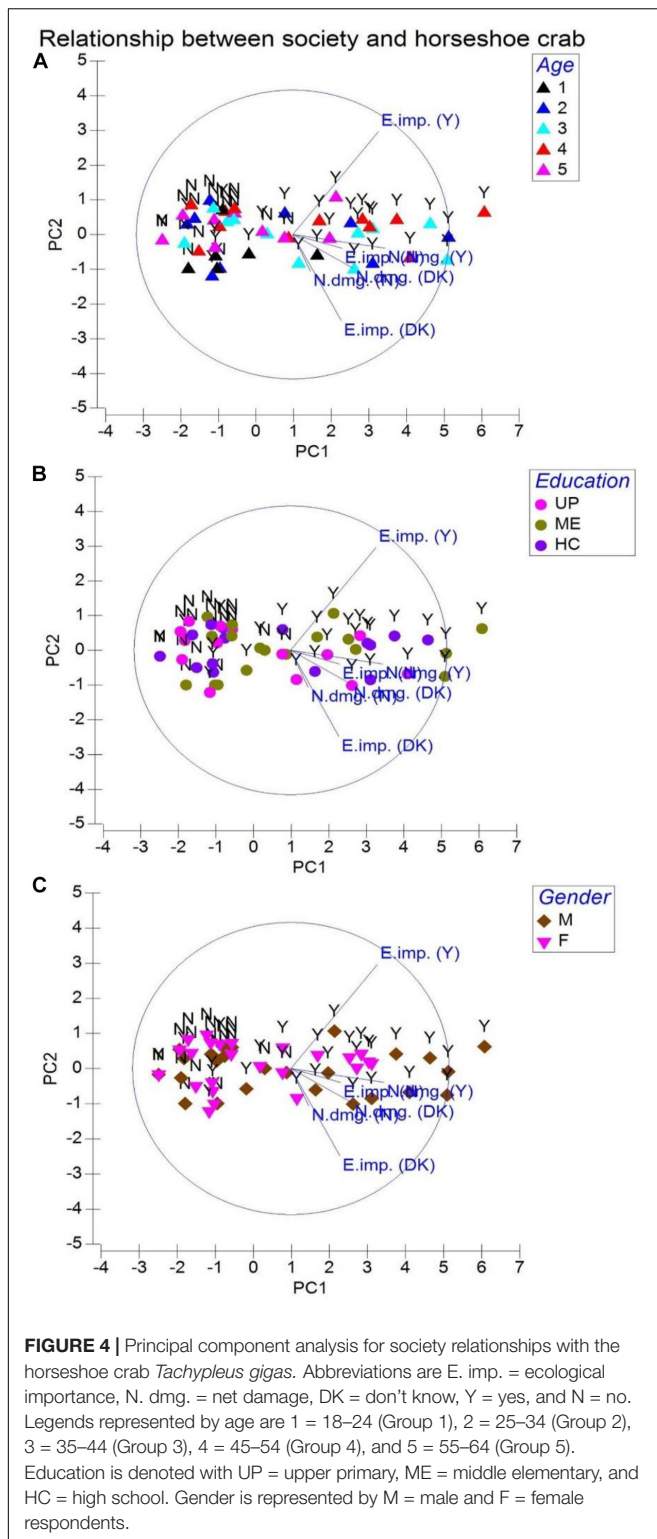


FIGURE 3 | Principal component analysis for local ecological knowledge on *Tachypleus gigas*. Abbreviations are avail. = availability, Ecol. funct. = ecological function, Recr. = recovery, DK = don't know, Y = yes and N = no, Rn. = rainy season, Wn. = winter season, and Sm. = summer season are components of the questionnaire that are assigned with values like 1 = yes and 0 = no to develop this analysis. Legends represented by age are 1 = 18–24 (Group 1), 2 = 25–34 (Group 2), 3 = 35–44 (Group 3), 4 = 45–54 (Group 4), and 5 = 55–64 (Group 5). Education is denoted with UP = upper primary, ME = middle elementary, and HC = high school. Gender is represented by M = male and F = female respondents.

types of aquatic species. For instance, we learned from *Odia* folks that horseshoe crabs are available throughout the year in Subarnarekha, Panchupada-Bardia, and Budhabalanga estuaries.

But researchers elsewhere wrongly assumed that horseshoe crabs have seasonal emergence (cf. Moore and Perrin, 2007; John et al., 2012). Compared with researchers, communities



reside and constantly utilize their environments. Only after two simultaneous long-term studies were carried out in Malaysia (Nelson et al., 2015, 2016a) and throughout Southeast Asia (John et al., 2018) that it is widely accepted that *T. gigas* are available

throughout the year. Similarly, we learned about the impacts of stranding toward horseshoe crab predation (Fraser et al., 2010; Pati and Dash, 2016), but the *Odia* community already witnessed this form of opportunistic predation on *T. gigas* by many other animals like crow, pigs, and dogs; all of these would have remained undocumented if not for this study.

Horseshoe crabs like *T. gigas* and *C. rotundicauda* do not receive conservation attention (ca. Smith, 1993; Sekhar, 2003; Tsetan and Ramanibai, 2011; Behera et al., 2014; Gupta et al., 2014) when compared with the Bengal tiger (*Panthera tigris tigris*), South Asian river dolphin (*Platanista gangetica*), Indian flapshell turtle (*Lissemys punctata*), or golden mahseer (*Tor putitora*), although the horseshoe crabs are listed in Wildlife Protection Act 1972 in India (John et al., 2018). These arthropods are less received for conservation projects in Indonesia. A similar (to the present) type of study was carried out on 277 respondents, but differently, the findings show that *T. gigas* is impacted by fishing gear (gill nets and bottom trawl), its habitat is impoverished by rubbish dumping, and the crab is consumed by locals in 62 districts of Java, Sumatra, Kalimantan, and Sulawesi Island (Meilana and Fang, 2020). With this, the Indian horseshoe crabs remain excluded from IUCN Red List updating simply because information on their population size and spatial occupancy by country and by region remains incompletely explored. For instance, studies in Thailand, Cambodia, and Vietnam relate horseshoe crabs to tetrodotoxin poisoning, but these studies do not map their availability and population size (John et al., 2018).

Although the coastal community of Balasore exploits finfish and shellfish through capture fisheries, they are governed by rules and regulations of Fisheries Act 1897. A seasonal fishing ban regulated by Fisheries Act 1897 was imposed for 45 days since 1998 in fishing zones (0–12 nautical miles) of maritime states (east and west coasts). This ban was revised to 60 days (15 April to 14 June onward year 2015) for resource recovery (Narayanakumar et al., 2017). Unfortunately, some respondents assert that horseshoe crab populations are not reducing since the last decade. Perhaps, these folks organize deep sea fishing where chances to entrap *T. gigas* in their nets are low. Comparatively, vast majority of *Odia* folks from Subarnarekha, Panchupada-Bardia, and Budhabalanga estuaries (Balasore) are near shore fishers. They witness unusual reductions in mating horseshoe crab pairs becoming entangled in their casted nets particularly when these folks compare the yields during their early fishing experiences. Researchers would rely on sampling time and project money to monitor horseshoe crab populations (Pati et al., 2015, 2017), and the outcome would be similar to ecological knowledge extractions from the *Odia* community.

While horseshoe crab spawning grounds are situated in shallow surf protected areas (estuaries or shallow seafront), these grounds are easily accessible, attractive for human encroachments (Berkson et al., 2009; Faurby et al., 2010; Lee and Morton, 2016; Nelson et al., 2019; Zauki et al., 2019a), and therefore, would provide substantial evidence on the declining population size of Asian horseshoe crabs (Nelson et al., 2016b; Pati et al., 2017; Fairuz-Fozi et al., 2018; John et al., 2018;

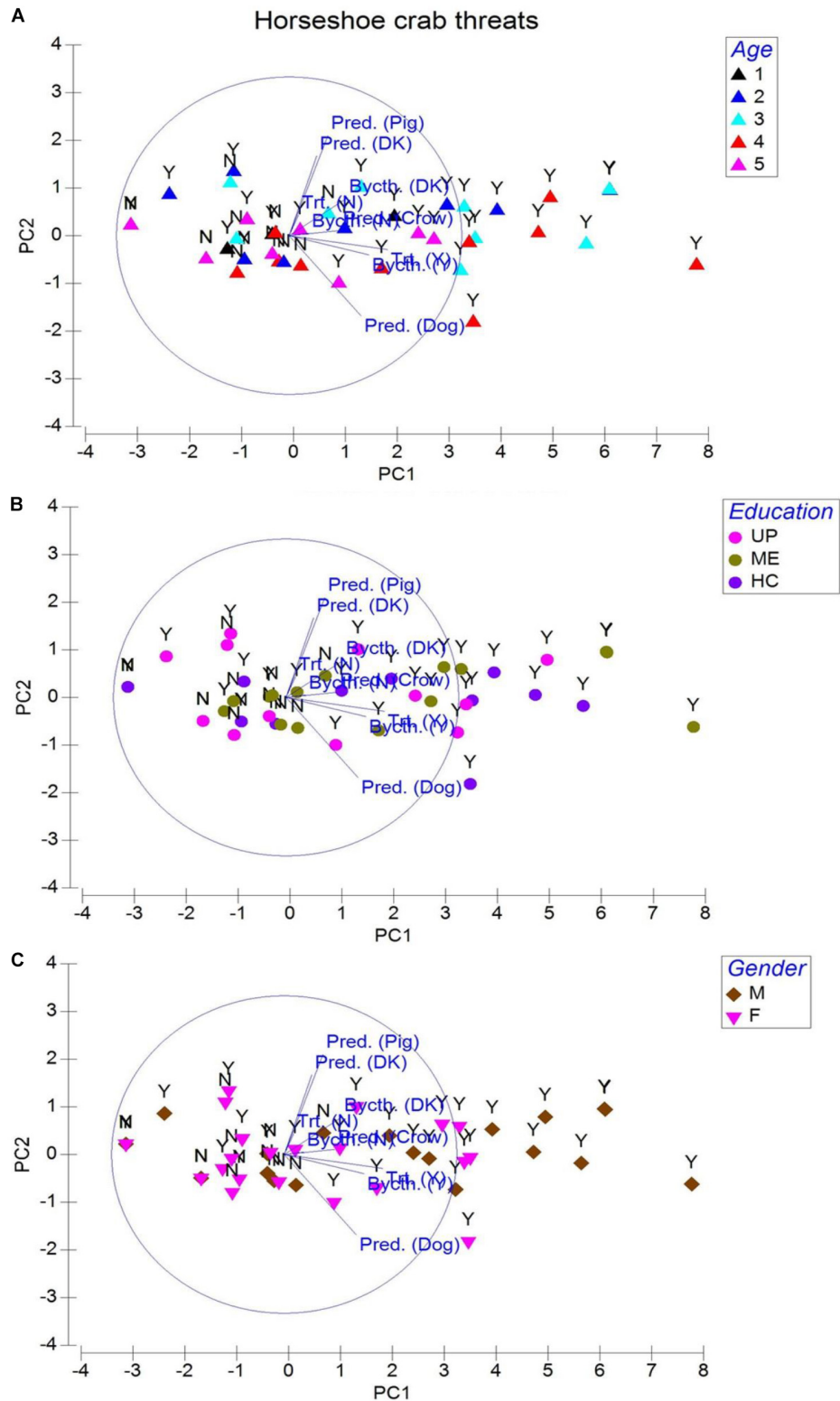


FIGURE 5 | Principal component analysis for society perception of threats to the horseshoe crab, *Tachypleus gigas*. Abbreviations are pred. = predation, byctb = by-catch, Trt. = threats, DK = don't know, Y = yes, and N = no. Legends represented by age are 1 = 18–24 (Group 1), 2 = 25–34 (Group 2), 3 = 35–44 (Group 3), 4 = 45–54 (Group 4), and 5 = 55–64 (Group 5). Education is denoted with UP = upper primary, ME = middle elementary, and HC = high school; gender is represented by M = male and F = female respondents.

Zauki et al., 2019b). Fortunately, the *Odia* community in Balasore relates “*Nilarakta Kankda*” with memory, grace, and love, whereas “*Ram Lakhan*” regards the crab as a goddess (grace and completion). Therefore, our 5-year continuous monitoring through citizen science conservation projects shows that *Odia* folks do not harm horseshoe crabs, although the crabs become entangled in the nets. This is strong evidence that local ecological knowledge has an outline of conservation awareness, which is constantly practiced by rural communities, although in the presence of local economy threats (net damage and resource competition).

CONCLUSION AND RECOMMENDATIONS

Horseshoe crab entry into the sixth extinction era is possible. Likewise, local ecological knowledge baselines are shifting by each passing human generation. This study shows that we wrongly practice conservation because our efforts are top-down due to community absence in policymaking and land-use decisions. In fact, by acknowledging people's perceptions, we are reducing expenditure on monitoring programs and, instead, use these funds for awareness projects and compassion instilment among folks in vulnerable areas. This questionnaire communicates science at the community level of understanding, and it appreciates community experiences and their interaction with horseshoe crabs. We highly recommend reliance on artisanal fishers who already bridged gaps between acquired and perceived knowledge in their area through their experiences. This study also creates awareness on fishing gears regardless of their application because these instruments cause horseshoe crab removal and unintentional mortalities in capture fisheries. In short, we recommend conservation projects that educate and empower communities with ecological roles whereby their interaction with communities and leaders enhance monitoring and surveillance. This bottom-up approach allows communities

to convey opinions that then are easily translated by researchers into practical applications for policies and resource good-governance, particularly conservation-neglected aquatic species like the Indian horseshoe crabs.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants, in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SP and BRN conceived and designed and performed the survey, analyzed the data, wrote the manuscript, prepared figures and tables, and reviewed drafts of the manuscript. DA, BRN, BPD, and HAE reviewed drafts of the manuscript and gave their support during fieldwork. SS and HAE analyzed the data and reviewed drafts of the manuscript. SP, SS, HAE, BRN, DA, and BPD approved the final manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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