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Could Orthoptera unlock Nutritional Potential for Humans and Livestock?

Riffat Sultana[1]*, Santosh Kumar[2], Jianjun Guo[3], Naila Bhanger[1], Saiqa Sanam[1] and Autif Hussain Mangi[4]

[1]Department of Zoology, University of Sindh, Jamshoro, Pakistan
[2]Department of Zoology, Cholistan University of Veterinary and Animal Sciences, Bahawalpur, Punjab, Pakistan.
[3]Institute of Entomology, Guizhou University, Huaxi District, Guiyang, Guiyang, China.
[4]Institute of Biochemistry, University of Sindh, Jamshoro, Pakistan

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ABSTRACT

The world is currently grappling with a substantial challenge in meeting the global demand for meat protein, particularly in arid regions where persistent food and water shortages render the population highly vulnerable. Scarce food resources contribute to severe malnutrition, including protein deficiency, resulting in elevated maternal mortality rates. To address these pressing issues, the consumption of insects, known for their protein richness, emerges as a valuable strategy to combat malnutrition in these communities. Unfortunately, the concept of entomophagy is poorly understood in Pakistan. To raise awareness and foster acceptance, an awareness campaign and a diversity-exploring survey have been planned for 2023-2024 in selected desert localities. To achieve our goals, the sensitization program aimed to: (1) To increase awareness among villagers about the benefits of using insects as a protein source in their diet. (2) To alleviate reluctance by highlighting that consuming locust adheres to halal principles in Islam. (3) To improve the nutritional content of livestock feed, emphasizing its cost-effectiveness compared to alternatives

INTRODUCTION

Orthoptera are the most diverse group of insects: With 30388 valid species and 2821 sub-species and many more still waiting to be discovered (Cigliano *et al*., 2025). Orthoptera stands out among alternative food sources due to various qualities. Ecologically, they function as primary consumers. Additionally, despite being univoltines, they represent a substantial biomass that people globally prepare and consume (Ramos-Elorduy, 2009; Blásquez *et al*., 2012). Moreover, they are often forward sold or stored, especially in their dried form. The consumption of swarming locusts is a prevalent practice in regions affected by locust plagues. Locusts and grasshoppers have been a part of human diets for centuries and continue to be consumed in certain areas today. This practice, known as entomophagy, holds significant nutritional benefits and plays a crucial role in regions within the habitat range of the desert locust, particularly in specific areas of Pakistan. In the Thar, Nara, Cholistan desert regions, the population has long grappled with persistent food and water shortages, rendering them highly susceptible to vulnerabilities. Scarce food resources contribute to severe malnutrition, notably protein deficiency, and contribute to elevated maternal mortality rates. The consumption of desert locusts, rich in protein, emerges as a valuable strategy to combat malnutrition in these communities. Therefore, viewing locust collection as an intriguing food source becomes imperative, especially for impoverished and undernourished rural populations. Insect protein is indeed much more sustainable than protein from other conventional sources, primarily due to their minimal environmental impact and limited use of natural resources (Oonincx and de Boer, 2012). Notably, the inclusion of insects in the market is driven by these environmentally friendly characteristics. Insects are also proposed as a remedy for world hunger, with their potential contribution to ensuring food security in developing countries being emphasized (Kari and Gates 2013; Kelemu *et al*., 2015). Locusts are mentioned in religious holy books, the Bible and The Holy Quran (7:133). The Quran refers to them two times, while The Holy Bible (Leviticus 11:20–25) contains as many as 36 references.

* Corresponding author: riffat.sultana@usindh.edu.pk
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The world is currently facing a significant challenge in meeting the global demand for meat protein. According to the United Nations (2022) the global population could grow to around 8.5 billion in 2030, and add 1.18 billion in the following two decades, reaching 9.7 billion in 2050 (World Population Prospects, 2022), the need for protein-rich food sources, particularly meat, is escalating. Traditional methods of meat production, such as livestock farming, are struggling to keep pace with this growing demand. The scarcity of meat protein is aggravated by resource scarcity, environmental issues, and inefficiency of feed-to-protein conversion. The shortfall not only threatens nutritional needs for a growing population but also creates potential problems with environmental sustainability. Therefore, the gap between demand and supply in the global meat protein market is gradually widening, and exploring alternative protein sources to meet the increasing demand is urgent. The response, entomophagy (the consumption of insects), presents as a sustainable option. Given that entomophagy is practiced in many cultures globally, over 2,100 species 66 consumed as food in more than 110 countries (Jongema, 2015). Despite certain limitations, entomophagy presents a promising opportunity to help bridge the protein gap in human diets. Within the domain of food security, it is particularly pressing that a broader evaluation and re-evaluations of entomophagy be conducted through the lens of contemporary living. Hinted as a potential solution to a range of critical environmental and human health issues from climate change to malnutrition, food insecurity, and the environmental degradation associated with agro-industrial production (Davis *et al*., 2015; van Huis and Oonincx, 2017; Godfray *et al*., 2018; Dickie *et al*., 2019; van Huis, 2020) edible insects Likewise, Chuanhui *et al.* (2010), Lesnik (2019) explored the editable insect from China and Florida and Chakravorty *et al.* (2011) from India and later reported that approximately 255 insect's species are consumed in India. In Pakistan, the practice of entomophagy, or consuming insects, is presently not widely acknowledged or embraced. Nonetheless, there is an innovative initiative underway to introduce and normalize this practice, particularly by tapping into the nutritional potential of orthoptera for both human and livestock consumption. With an estimated 1.5 billion chickens and numerous fish farms in the country, there exists a substantial market that could potentially benefit from the incorporation of high-protein locust meat (www.veterinariadigital.com). As part of our awareness campaign, we underscored the permissibility of consuming locusts in Islam, fostering a positive response from poultry and fish farm owners. This religious endorsement encouraged active engagement and advocacy for the inclusion of locusts, grasshoppers, and crickets in livestock feed. Through persistent efforts, we successfully heightened awareness among the Thari people regarding the nutritional advantages of incorporating locusts into their diets, addressing protein deficiencies, and promoting improved nutrition within the community.

MATERIALS AND METHODS

Village and farming facility selection

Fifteen villages across three districts Mithi, Tharparkar, (24.7436° N, 69.8061° E), and Choondiko, Khairpur, (27.1606° N, 68.9569° E) Sindh, as well as CUVAS Bahawalpur, Punjab (29.3544° N, 71.6911° E) were selected for a human awareness campaign (Figure 1). Additionally, two farming facilities: The Government Poultry Farm and the Fish Hatcheries and Nurseries in Bahawalpur,

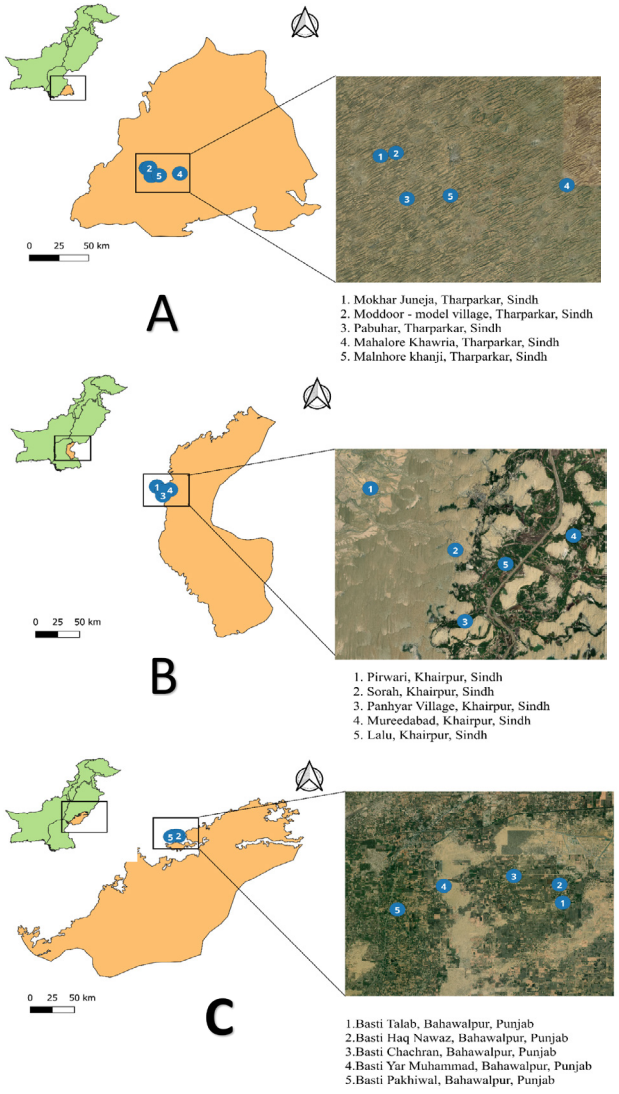

Fig. 1. Surveying areas of selected villages during 2023 in Sindh-Punjab.

Fig. 2. The Government Poultry Farm, Bahawalpur.

were included in the program for livestock feed supplementation (Figure 2). The sensitization program took place between June and August 2023, followed by another phase from May to July 2024.

Sampling and identification

All specimens were collected from different agricultural crops in various selected localities (Figure 1). Material was brought to Entomology and Bio-control Research Lab (EBCRL), Department of Zoology, University of Sindh, Jamshoro. The mounting, labeling, and taxonomic identification of collected Orthoptera were conducted following appropriate keys given by Otte (1995) and Sultana and Wagan (2015), Sultana *et al.* (2021), Sultana and Song (2024) and taxonomic status and validity of Orthoptera were also verified by consulting with OSF Cigliano *et al.* (2025).

Empowering desert communities

During the awareness campaign, individuals were adeptly trained in the collection and cleaning of insects. This hands-on approach allowed participants to engage in practical experiences, experimenting with diverse recipes. The culmination of these efforts resulted in the preparation and serving of delightful insect-based dishes (Figure 3). The shared recipes were disseminated to encourage ongoing exploration and adoption of insect-based cuisine. Simultaneously, proprietors of farming facilities were actively involved in discussions that illuminated the nutritional value inherent in insects, Emphasizing the cost-effectiveness and nutritional impact of these insect-based options, we underscored their potential as alternatives to the conventional livestock feed currently provided. In regions characterized by arid conditions and widespread financial constraints, where conventional meat sources are not easily accessible, our campaign endeavors to introduce sustainable alternatives. By promoting the utilization of locally available insects such as locusts, grasshoppers, and crickets, we aim to mitigate the economic challenges faced by these communities. This dual approach seeks to alleviate financial burdens while enriching diets with valuable protein sources, thereby contributing to the overall well-being of these communities.

Fig. 3. Different locust dishes were cooked during locust swarm 2019-2020 (after Samejo *et al.,* 2021).

RESULTS AND DISCUSSION

Table I illustrates a comprehensive survey of Orthoptera (mostly we focused on locust, grasshoppers, and crickets) diversity, including both nymphs and adults, in selected villages across three regions. The survey occurred in Mithi, Tharparkar (Sindh) during the last week of June 2023, Choondiko, Khairpur (Sindh) in mid-July 2023, and CUVAS, Bahawalpur (Punjab) in mid-August 2023. The counts of three Orthoptera groups grasshoppers, locusts, and crickets over three days reveal variability across villages, highlighting notable diversity in the selected areas. In the villages of Mithi, Tharparkar, total Orthoptera counts range from 1377 to 1959 across the three survey days. Examining the counts for each group exposes specific patterns within each village; for example, Malnhore Khanji displays a relatively balanced distribution, while Moddoor model village exhibits a

Table I. Surveying orthoptera diversity in respective areas of selected villages during 2022.

Villages	First day			2nd Day			3rd Day			Total	%
	G.	L.	C.	G.	L.	C.	G.	L.	C.		
A. Mithi, Tharparkar (Sindh) (Last week June-2023)											
1. Mokhar Juneja,	274	39	323	189	21	301	193	13	289	1642	7.64%
2. Moddoor - model village	203	49	198	274	72	287	293	49	303	1728	8.04%
3. Pabuhar	187	17	349	399	53	403	177	87	287	1959	9.11%
4. Mahalore Khawria	162	19	271	173	69	194	208	92	189	1377	6.40%
5. Malnhore khanji	233	51	133	151	182	309	79	56	167	1361	6.33%
B. Choondiko, Khairpur (Sindh) (Mid-July-2023)											
1. Pirwari	122	23	204	203	23	186	55	83	173	1072	4.98%
2. Sorah	176	14	387	197	47	169	124	18	203	1335	6.21%
3. Panhyar Village	78	35	179	238	77	201	206	13	289	1316	6.12%
4. Mureedabad	103	5	134	134	37	302	157	---	303	1175	5.46%
5. Lalu	157	19	129	73	11	382	149	29	204	1153	5.36%
C. CUVAS, Bahawalpur (Punjab) (Mid-August-2023)											
1. Basti Talab	307	41	204	298	11	189	207	49	199	1505	7.00%
2. Basti Haq Nawaz	208	32	186	203	--	203	301	19	205	1357	6.31%
3. Basti Chachran	197	--	132	305	7	246	153	31	308	1379	6.41%
4. Basti Yar Muhammad	243	9	309	109	37	287	178	44	401	1617	7.52%
5. Basti Pakhiwal	181	41	402	137	23	389	128	7	203	1511	7.03%

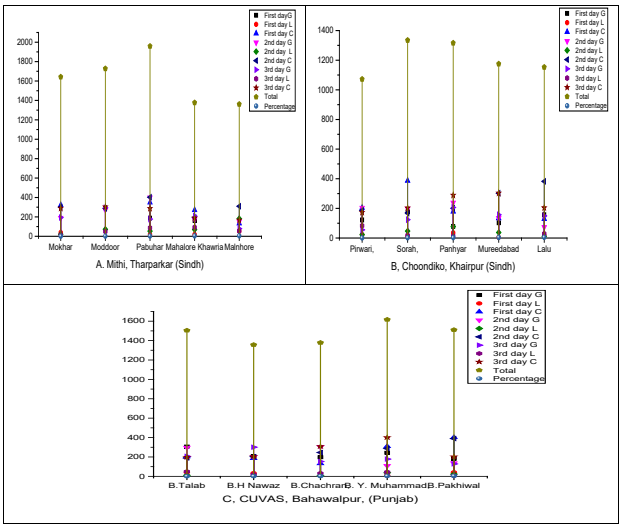

Fig. 4. Surveying orthoptera diversity in respective areas of selected villages during 2023.

higher count of locusts (this area was not surveyed and sprayed by the plant protection during the 2019-2020 locust-swarm-control operation (Sultana *et al*., 2021). In Choondiko, Khairpur, Orthoptera counts vary significantly across villages, with Panhyar totaling 1316 and Pirwari recording 1072. Besides this, in Bahawalpur villages, orthoptera counts range from 1357 to 1617. However, it's noteworthy that no locusts were collected from Mureedabad on the third day and Basti Haq Nawaz on the second day. Overall, the observed low percentages of locusts in all localities may be attributed to extensive insecticide spraying during the 2019-2020 locust swarm, coupled with continuous monitoring of locust emergence/ hatching in different areas of Pakistan, resulting in fewer reported locust numbers during our survey days (Table I, Fig. 4). Table II provides information about common Orthoptera species predominantly consumed by invertebrates and vertebrates during field surveys. A total of 26 species were observed, belonging to 18 genera, 11 subfamilies, and 4 families. Regrettably, *Schizodactylus* was captured by younger individuals for their domestic pets, but unfortunately, its population is declining at the regional level. This study underscores the urgent need for counseling to discourage hunting of *Schizodactylus* in Pakistan. Within the Gryllidae family, 22 species from 12 genera and 2 subfamilies were reported as frequently consumable by domestic pets (Table III). In the case of fish, common species were highlighted, providing information on their habitat, common coloration, and season of hatching. A total of 6 families, including 11 subfamilies and 13 species, were listed (Table IV). Table V

presents common predators of grasshoppers and crickets, revealing that globally, 11 bird species, 5 mammal species, and 7 other insect species are known to feed on adults, nymphs, larvae, and eggs of these insects.

Table II. Taxonomy of some common edible Orthoptera of Pakistan.

Genus	Species	Consumption stage
Family: Acrididae		
Subfamily: Acridinae		
Acrida	*Acrida exaltata*	Nymphs/ Adults
Acrida	*Acrida gigantea*	Nymphs/ Adults
Truxalis	*Truxalis eximia*	Nymphs/ Adults
Subfamily: Calliptaminae		
Subfamily: Cyrtacanthacridinae		
Acorypha	*Acorypha glaucopsis*	Nymphs/ Adults
Anacridium	*Anacridium aegyptium*	Nymphs/ Adults
Anacridium	*Anacridium rubrispinum*	Nymphs/ Adults
Schistocerca	*Schistocerca gregaria gregaria*	Nymphs/ Adults
Subfamily: Eyprepocnemidinae		
Eyprepocnemis	*Eyprepocnemis alacris alacris*	Nymphs/ Adults
Tylotropidius	*Tylotropidius varicornis*	Nymphs/ Adults
Subfamily: Gomphocerinae		
Leva	*Leva indica*	Nymphs/ Adults
Ochrilidia	*Ochrilidia geniculata*	Nymphs/ Adults
Hieroglyphus	*Hieroglyphus banian*	Nymphs/ Adults
Hieroglyphus	*Hieroglyphus nigrorepletus*	Nymphs/ Adults
Hieroglyphus	*Hieroglyphus oryzivorus*	Nymphs/ Adults
Subfamily: Oedipodinae		
Acrotylus	*Acrotylus humbertianus*	Nymphs/ Adults
Aiolopus	*Aiolopus thalassinus tamulus*	Nymphs/ Adults
Phlaeoba	*Phlaeoba tenebrosa*	Nymphs/ Adults
Subfamily: Oxyinae		
Oxya	*Oxya hyla hyla*	Nymphs/ Adults
Oxya	*Oxya fuscovittata*	Nymphs/ Adults
Subfamily: Pyrgomorphinae		
Chrotogonus	*Chrotogonus trachypterus trachypterus*	Nymphs/ Adults
Chrotogonus	*Chrotogonus homalodemus homalodemus*	Nymphs/ Adults
Family: Tettigoniidae		
Subfamily: Phaneropterinae		
Trigonocorypha	*Trigonocorypha unicolor*	Nymphs/ Adults
Phaneroptera	*Phaneroptera (Phaneroptera) spinosa*	Nymphs/ Adults
Phaneroptera	*Phaneroptera (Phaneroptera) gracilis*	Nymphs/ Adults
Conocephalus	*Conocephalus (Anisoptera) maculatus*	Nymphs/ Adults
Schizodactylus	*Schizodactylus minor*	Nymphs/ Adults

Note: In Pakistan, people use these species as their domestic pet's diet. *Indicate that species within this family are becoming endangered worldwide, emphasizing the urgent need for counseling to discourage people from hunting these species.

Table III. Taxonomy of some common edible Gryllidae of Pakistan.

Genus	Species	Consumption stage
Family: Gryllidae		
Subfamily: Gryllinae		
Acheta	*Acheta chudeaui* (Chopard, 1927)	Adults
	A. domesticus (Linnaeus, 1758)	Adults
	A. meridionalis (Uvarov, 1921)	Adults
	A. hispanicus Rambur, 1838	Adults and Larvae
Gryllus	*Gryllus* (*Gryllus*) *multipulsator* Weissman, 2009	Adults
Gryllodes	*Gryllodes sigillatus* (Walker, 1869)	Adults
	G. supplicans (Walker, 1859)	Adults
Callogryllus	*Callogryllus ovilongus* Saeed, Saeed and Yousuf, 2000	Adults
	Callogryllus saeedi Malik, *et al.,* 2013	Adults and Larvae
	*C. bilineatus (*Bolívar, 1900)	Adults
Modicogryllus	*Modicogryllus sindhensis* Sultana *et al*, 2021,	Adults
Phonarellus	*Phonarellus* (*Phonarellus*) *minor* (Chopard, 1959)	Adults
	P. (Phonarellus) humeralis (Walker, 1871)	Adults and Larvae
Plebeiogryllus	*Plebeiogryllus retiregularis* Saeed, Saeed and Yousuf, 2000	Adults
Tartarogryllus	*Tartarogryllus tartarus* (Saussure, 1874)	Adults
Gryllopsis	*Gryllopsis pubescens* Chopard, 1928	Adults
Eumodicogryllus	*Eumodicogryllus bordigalensis* (Latreille, 1804)	Adults and Larvae
Teleogryllus	*Teleogryllus (Brachyteleogryllus) occipitalis (*Serville, 1838)	Field crickets
Subfamily: Nemobiinae		
Pteronemobius	*Pteronemobius concolor* Walker 1871	Adults
	P. (Pteronemobius) indicus (Walker, 1869)	Adults and Larvae
Loxoblemmus	*Loxoblemmus (Loxoblemmus) formosanus* Shiraki, 1930	Adults

Table IV. Taxonomy and habitat of common occurring fish of Pakistan.

Family	Genus	Species	Habitat	Color	Common name	Spawning period
Anabantidae	*Anabas*	*Anabas testudineus*	Freshwater	Greenish to Brownish,	Anabas	April-August
Ariidae	*Arius*	*Arius arius.*	Freshwater	*Gray to Grayish Brown*	Khaga	April -October
Bagridae	*Sperata*	*Sperata seenghala*	Rivers, canals ditches	Brownish Gray	Singhara	April-August
Belonidae	*Xenentodon*	*Xenentodon cancila*	Freshwater	Green, Silver, Whitish	Garfish	June-July
Cichlidae	*Oreochro-mis*	*Oreochromis niloticus*	Fresh and Brackish water	Gray and Light Pink	Tilapia	April -December
Clariidae	*Clarias*	*Clarias batrachus*	Freshwater	Gray or Grayish Brown	Mangur, walk-ing catfish	June-August
Channidae	*Channa*	*Channa striataus*	Ponds, streams and rivers	Brown and Black	Sowra	April-August
Channidae	*Channa*	*Channa punctatus*	Ponds and Brackish	Tan to Black	Gurrie	April-September
Channidae	*Channa*	*Channa gachua*	Freshwater	Grey, Brown	Sauri	December-February
Channidae	*Channa*	*Channa marulius*	Freshwater	Deep Black	Saul	June-July
Cyprinidae	*Cyprinus*	*Cyprinus carpio*	Freshwater	Brownish green	Gulfam com-mon carp	Jan-August

Table contines on next page.....

Family	Genus	Species	Habitat	Color	Common name	Spawning period
Cyprinidae	*Catla*	*Catla catla*	Freshwater brackish water	Grayish	Theila	June – August.
Cyprinidae	*Labeo*	*Labeo rohita*	Fresh water brackish water.	Bluish or Brown	Rohu	June – August.
Cyprinidae	*Labeo*	*Labeo callasu*	Freshwater	Bluish	Kalbans	June – August.
Cyprinidae	*Cirrhina*	*Cirrhina mrigala*	Freshwater	Silvery Dark Grey	Mirgal Mori	June – August.
Cyprinidae	*Barbus*	*Barbus eputitora*	Cold waters of hilly areas	Greenish and Whitish	Mahaseer	April – September
Cyprinidae	*Cteno-pharyngoden*	*Ctenopharyngoden idellus*	Freshwater river and lake fish	Bluish to Grey	Mullee	Monsoon
Cyprinidae	*Barbut*	*Barbut tor*	Hilly streams and river	Silvery Grey with Red Fins	Bhor	April -September
Salmonidae	*Salmo*	*Salmo* sp.	Clear, cold and fast flowing water.	Ventral Dark Grey,	Trout	October - March
Siluridae	*Wallago*	*Wallago attu*	Freshwater river and lake fish	Bluish to Grey	Mullee, Parhin	Monsoon
Mugilidae	*Mugil*	*Mugil corsula*	Rivers	Silver or Gray,	Corsula Mullet	June -February
Mastacem-belidae	*Mastacem-belus*	*mastacembelus armatus*	Stream and rivers	Dark-Sliver	Baam	September-Oct
Notopteri-dae	*Notopterus*	*Notopterus chitala*	Standing and sluggish waters	Silvery Dark or Green-ish	Chital	May-August

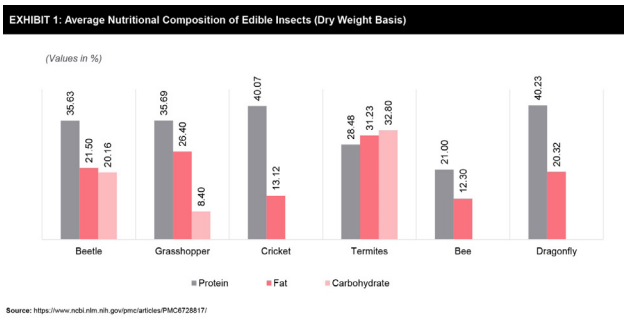

Fig. 5. Average nutritional composition of editable insects (Dry weight basis). (Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6728817/).

Consultation with communities

Our three teams conducted visits to selected areas, organizing separate meetings and seminars for men and women to inform the community about the nutritional value of orthoptera as a protein source in their diet. During these sessions, we distributed informative pamphlets and visual materials illustrating the benefits of incorporating orthoptera into livestock diets. To amplify our message, we strategically engaged local influencers, community leaders, and religious figures, seeking their endorsement of the campaign and their assistance in emphasizing the positive impact on agriculture and nutrition. Recognizing the importance of aligning with cultural and religious values, we collaborated closely with Islamic scholars and local religious authorities, resulting in the development of educational content focused on showcasing the compatibility of locust consumption with halal principles in Islam (Fig. 5). To deepen understanding and acceptance, we conducted nutritional awareness campaigns emphasizing the benefits of orthoptera-based protein, encompassing high protein content, essential amino acids, and vitamins. Moreover, we conducted a comparative analysis to demonstrate the cost-effectiveness of locusts, grasshoppers, and crickets compared to traditional livestock feed ingredients, highlighting the potential economic advantages for farmers. Besides this, for a tangible and experiential dimension to our efforts, we presented a documentary from abroad where villagers could directly observe the positive effects of integrating locusts into animal feed, benefiting both livestock health and economic returns. This comprehensive and forward-thinking approach not only addresses immediate needs but also lays the foundation for enduring positive change, fostering community acceptance, and promoting sustainable practices deeply rooted in the values of the communities we aim to empower. Many delicious dishes, such as burgers, candies, chocolate powders, cookies, drinks, flours, granola and musli, pasta, pasta sauce, protein bars, protein powders, snacks, spreads, tofu, whole fire and

Table V. Common predators of grasshoppers and crickets.

Common names	Scientific names	Regions
Birds		
Crow	*Carvus corax*	North Hemisphere
Collared King fishers	*Todiramphus chloris*	Tropical region of Africa and Asia
House Sparrow	*Passer domesticus*	Europe, Mediterranean, Basin, Asia
Duck	*Anas platyrhyncos*	Asia, Europe, and other countries
Parrots	*Psittaciformes*	Australia, Oceania, South Asia, America and Africa
Squacco heron	*Ardeola ralloides*	Europe, Africa, Iran
Myna	*Acridotheres tristis*	Asia, Iran, Pakistan, India and other countries
Hen	*Gallus domesticus*	Mostly Asia, Europe, and Africa
Brown partridge (Teether)	*Pondicerianus splenden*	Asia, Europe, and Africa
House crow	*Carvus splenden*	Native to the Indian subcontinent, including all of India, Pakistan, the Maldives, and Sri Lanka.
Rusty black bird	*Euphagus, carolinus*	Canadian provinces and territories, the state of Alaska, several Great Lakes states and most New England states
Mammals		
Giant anteaters	*Myrmecophaga tridactyla*	Central America and Northern South America
Giant Armadillos	*Priodontes maximus*	Central America and Northern South America
Common Shrews	*Sorex araneus.*	Northern Europe
Numbat	*Myrmecobius fasciatus)*	Australia
Wongai Ningaui	*Ningaui ridei*	Central Asia
Echidina	*Tachyglossus aculeatu*	Australia
Insects eat grasshoppers and crickets' eggs		
Dragonflies,	*Odonata*	Tropical region
Hornets,	*Hymenoptera.*	Asia and Europe
Ladybugs,	*Coleoptera*	Africa and other countries
Robber flies,	*Diptera*	All countries except Antartica
Praying mantides	*Mantodea*	All countries except Antartica
Ants	*Hymenoptera,*	Asia, Africa and other countries
Mosquito	*Diptera*	All countries, except Antartica

boil insects, locust fried, locust biryani, cricket cake, locust karahi, fried bar-bi-qab locust, and locust Chinese rice, made from insects are very famous in many countries like Mexico, Thailand, China, Zimbabwe, Brazil, Kenya, Australia, Cambodia, India, China, and Thailand, including Tokyo, Japan (Hanboonsong *et al*., 2000; Bugs Feed, 2016). In Pakistan, locusts were consumed during the historical swarm of 2019-2020 and people first tasted locusts specifically in Karachi and Thar, Sindh (Samajo *et al*., 2021).

Engagement with live-stock holders

A comprehensive meeting was organized with fish and poultry Farm's owners/in-charge, focusing on the discussion of insect protein ratios in feed. It was emphasized that Pakistan currently imports 0.3 million tonnes of soybeans, utilizing the crushed residue for animal feed after oil extraction. Notably, soybeans contain 45% protein, while locusts boast an impressive 70% protein content. Introducing a rich protein diet, such as locusts, grasshoppers, crickets could potentially enhance the growth and flavor of farming products. Various valuable fish varieties in Pakistan, including Gulfam, Seengari, Jarka, Khaga (Rohu fish), Tilapia (dayo), Theeli, and others, hold significant commercial value. Despite being rich in protein, these fish face high production costs. Pakistan's global reputation for delicious fish dishes is a testament to its culinary heritage, blending traditional

Fig. 6. Fish Bar B Q at University of Sindh Jamshoro Pakistan 2023.

recipes with modern innovations, making it a culinary destination for fish enthusiasts (Fig. 6). Similarly, poultry feeding is a critical aspect of industry, influencing chicken growth, health, and productivity. An impassable issue in this process is the dependence on traditional, often low diversity and unbalanced feed components. Changes in the prices of these poultry feed ingredients can therefore create economic difficulties of poultry farms, reducing profitability. Moreover, probing contamination and feeding of adulterated feeds is a risk to poultry flock health and product quality. Inadequate awareness among some farmers regarding proper feed management practices such as appropriate storage and feed formulation further exacerbates poultry feeding challenges. A farmer who switches to an insect-based diet for its livestock can achieve better feeding efficiency and maximum acceptability level by the livestock. This saves time and money but indeed enhances the protein content of fish and chicken also making it a powerful method for effective and healthy farming at lower costs. Therefore, solving these problems is fundamental for the development of the poultry industry and the production of healthy and high-quality poultry products. There is a clear need to simply promote the use of insects in poultry feeding to solve these problems and augment nutritional profile of poultry and fish as a feed. This move makes the diet plan more balanced with a proper ratio of protein with more awareness and promotion of sustainable practices, the poultry and fish industry in Pakistan could (i) overcome the existing challenges faced and (ii) contribute substantially to the nutritional requirements of its population. While researchers encounter innumerable obstacles in combating these problems, the adoption of entomophagy projects is practical and necessary to create a paradigm change in our diet. Such a transition is imperative to fulfil the increasing food demand and curtail the looming protein crisis soon.

Current hurdles

Entomophagy is receiving increasing acceptance in many developed nations due to the nutritional ability of insects, but its acceptance remains a great hurdle in areas where there is little or no knowledge of the concept. Cultural and religious beliefs frequently preclude insects from national or traditional diets, and hesitation is drawn into their consumption or their use as feed for livestock. Humans like familiar foods, and the ignorance about the nutritional and ecological advantages of insects reinforce this resistance. Widespread myths about insects being pests or vectors for disease also live on, so community education about how to farm or eat bugs safely is vital. A lack of clear regulations and standards in terms of safety, in conjunction with communication gaps regarding the benefits of entomophagy, also explains public scepticism. Insect-based feed, as a relatively new concept, is not well known among livestock farmers who may also worry about its implementation in their systems. In addition, uncertainty over consumer acceptance of livestock products from animals fed insects, together with concerns over potential effects on animal health and productivity, also limit investment and may require awareness, education and policy support. It requires a combination of approaches to normalizing eating insects and feeding livestock with insects. Even better is to work with cultural and religious leaders so that such practices can be consistent with what is generally accepted in the community at local and national levels. Food targeting communication strategies need to be developed to inform the public about the nutritional, economic, and environmental benefits associated with eating insects. Addressing misconceptions with varied media channels will broaden reach and dispel myths, whilst awareness campaigns can educate on the safety and advantages of insect farming which is done under controlled practices. Concurrently, partnerships should be built with relevant stakeholders of the food industry on the development of insect-based products that are attractive for consumers. Moreover, help programs for insurance plans or incentives from the state might mitigate the perceived threats for the livestock holders. Stakeholders can consequently work together to strategically solve major roadblocks along the path toward a sustainable and culturally appropriate implementation of insect-based food and feed systems.

CONCLUSIONS

This indicates the diversity of Orthoptera in Pakistan

and their prospects as sustainable protein to humans and livestock. The community engagement showed increasing interest, alongside cultural, regulatory and awareness challenges. Educating the population, developing relevant policies, and working together with community leaders can help promote insect-based diets as an affordable, healthy and environmentally sustainable option to meet protein demands and promote agricultural sustainability in Pakistan.

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Availability of data and material (data transparency)

The data that support the findings of this study are made available by contacting the author (riffat.sultana@usindh.edu.pk)

Generative AI or AI-assisted technology statement

The authors declare that no generative AI or AI-assisted technologies were used in this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

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