

## Article

# Could Entomophagy Be an Effective Mitigation Measure in Desert Locust Management?

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**Abstract:** The desert locust has been a notorious pest since ancient times. A population upsurge hit Pakistan in 2019 and caused tremendous damage to agriculture and livelihoods. To take advantage of this ongoing upsurge, we conducted a field study to verify whether locust collection could be an interesting control method to protect crops in the event of an invasion, as well as an accepted food resource for poor rural communities. A village in the Thar desertic region was selected as a type-locality. An awareness campaign was launched to promote the collection and consumption of locusts as well as to alert people of their nutritional value. Two large swarms arrived near the village and several other swarms affected places nearby. Around 3033 kg of locusts were collected through handpicking at night. Most of the locusts were eaten and, as a result, hoppers of the next generation did not emerge in the type-locality; however, hopper bands appeared in areas where entomophagy was not practiced. The study area had less locust activity because swarms could not lay eggs due to entomophagy by the villagers. The consumption of desert locusts could be an effective practice to prevent malnutrition and protein deficiency and, to a certain extent, an efficient mitigation measure to help local populations to better protect themselves and their crops against locust outbreaks. Collection and consumption of locusts should be encouraged while remaining realistic about its real impact on locust control. This should also be done in concert with local authorities to take into account the risks to human health and to avoid the consumption of insects treated with pesticides.

**Keywords:** entomophagy; malnutrition; desert locust; outbreak; food; insect



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## 1. Introduction

Among the large number of pest locust species, the desert locust *Schistocerca gregaria* (Forskål, 1775) is the best known and most feared across borders and centuries. Major invasions follow one another at high frequency (eight for the period 1860–1962) [1–3]. These invasions occur when rainfall conditions are favorable to the insects (rainfall well distributed in time and space) in their primary breeding areas. Outbreaks are mainly located in desertic zones that are often difficult to access, but whose total area remains limited (12%) relative to the total area that can be invaded by swarms (up to 31 million km<sup>2</sup>) [2,4]. Plagues of desert locusts are disastrous for agriculture and vegetation, destroy cash crops and livestock, and cost billions of dollars to control. The two most recent upsurges in 1986–1989 and 2003–2005 required treatment with insecticides mainly in Africa and the Middle East, 16.8 and 13 million hectares, and costing an estimated 274 and 500 million US dollars, respectively [5–7].

Desert locusts are difficult to combat but can be controlled by proactive monitoring, early action, and the targeted use of appropriate control measures, as needed. Prevention is coordinated internationally by the Food and Agriculture Organization of the United Nations (FAO) [8–11]. Thanks to this strategy, ever-more efficient pesticides, and other control

measures, new products that are less environmentally damaging, such as the mycopesticides, and 50 years of hindsight, the invasions are now less frequent, less widespread, and if they cannot be stopped at an early stage, shorter lived and better managed [1,3,10,12–16].

This insect was calamitous in the past [5,17], and dramatic events continue to occur. For various reasons, some outbreaks cannot be stopped at an early stage [12,14,18]. During outbreaks, the swarms disperse quickly over a vast territory; control measures are not used because they are too expensive and difficult to utilize; villagers are overwhelmed in the face of the massive and sudden arrival of the swarms; and crop damage is considerable [3,14]. This is evidenced by the recent upsurge initiated in 2018, which is still ongoing. Originating on the southern Arabian Peninsula, *S. gregaria* has invaded much of East Africa, the Middle East, and Southwest Asia to Pakistan and India and is causing alarm for the food security of many developing and poor countries [9,19]. The economic, social, and environmental consequences of such events may persist or appear several years later [20].

Whether for prevention or in the event of an upsurge, organizing control measures relies mainly on state agencies. Rural communities are often destitute with no means at their disposal. These farmers have developed physical methods that they continue to practice: making noise or burning tires to scare away swarms, burning locusts as they roost at night in the vegetation, digging trenches and burying hopper bands, and plowing the egg-laying fields to destroy the eggs [21]. Harvesting locusts as food can replace other control methods [22]. Manual collection, which may seem derisory, is widely practiced around the world and represents a control method (to reduce the local population), a nutritionally interesting food resource, and a source of income for families to at least partially compensate for crop damage.

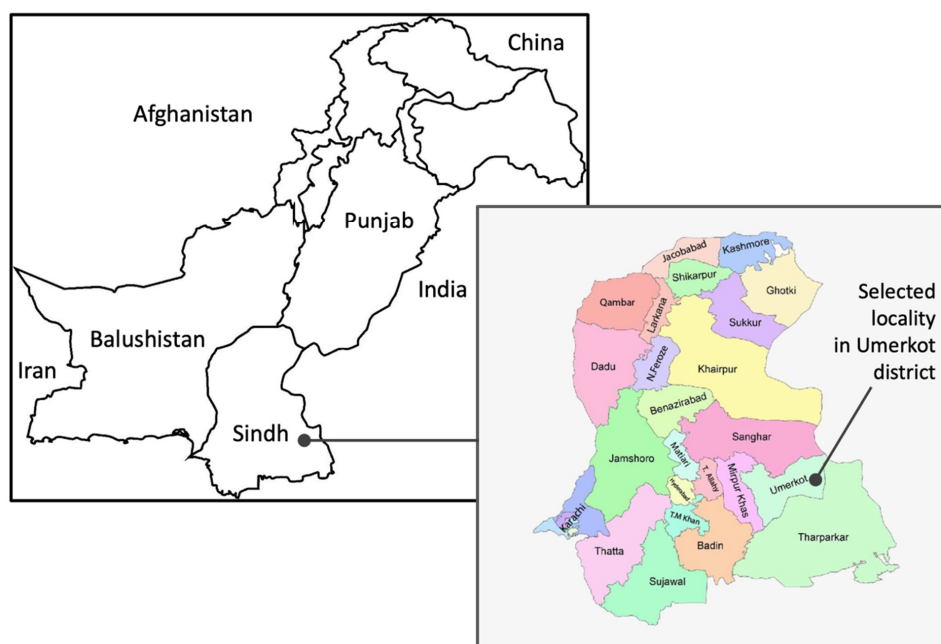
The practice of entomophagy is ancient. Locusts have been consumed for centuries and still are in some regions today. In many countries around the world, they are considered a delicacy [23–25]. Entomophagy is an old strategy used to get food after locusts have devastated crops, and the FAO [24] has already documented the importance of edible insects including locusts. When they are swarming, locusts can be collected in large numbers (a single swarm can cover 1200 km<sup>2</sup>), relatively quickly and easily during the night when they remain almost motionless. The insects can be collected using hands, bags, and buckets. Nutritionally, locusts are excellent sources of protein and other essential nutrients, both as food for people or feed for other animals [26,27]. To take advantage of the ongoing upsurge in Pakistan, we conducted a field study to verify whether locust collection could indeed control locust populations as well as be an accepted food resource for poor rural communities.

## 2. Materials and Methods

### *Selection of Villages and Local People Awareness*

Ten villages of the Mahandre-Jo-Par union council (25°35′17.59″ N/70°10′13.16″ E), in the Thar desertic area within Sindh province, were selected as a study site (Figure 1). A sensitization program was conducted in June–July 2019 (1) to raise awareness of the benefits of consuming desert locusts as a source of protein and (2) to determine if collecting locusts on a massive scale could control their proliferation. To remove any reluctance, the villagers were reminded that locusts are halal in the Islamic religion.

Villagers collected locusts at night, by hand picking, in July–October 2019, using light traps (torches or headlights of vehicles) (Figure 2A,B). Locusts were stored in polypropylene bags or other locally available containers (Figure 2C,D). Each bag was weighed (Metis electronic scale with a capacity of 100 kg). The people who consumed the locusts were interviewed about their methods of preparation and cooking, the quantity they consumed each day, and the quality of their taste. To control the locusts locally, we carried out four field trips into their type-locality and other surrounding villages, after the arrival of each of the swarms, to control the emergence of hoppers, the occurrence of hopper bands, and the insects' behavior.



**Figure 1.** Locality surveyed to inform the local Thari populations about the benefits of locusts as a source of protein.



**Figure 2.** Collecting desert locusts at night in a field of crops: (A) vehicle headlight used as a light trap, (B) hand torch for collecting locusts and container for storage, (C) polypropylene bag for locusts, (D) polypropylene bag containing locusts ready for delivery. Photos by Ahmed Ali Samejo, Santosh Kumar, and Samiullah Soomro.

### 3. Results

Villagers said swarms of locusts arrived in this area of Pakistan after 22 years of recession. Locusts began to damage all green vegetation, cash crops, and fodder. As a result, people were motivated to collect and eat the locusts both to protect their crops and to improve their diets. On 4 July 2019, a mature swarm of desert locusts landed in the vicinity of Mahandre-Jo-Par village (type-locality) in the evening. Word travelled between

villages about the arrival of the swarm, spread over 5 km<sup>2</sup>. Residents went to that area at night carrying torches and polypropylene bags for catching locusts. The people knew from local tradition that locusts cannot be caught during the day, but are easily caught at night using light traps. At night, locusts mostly roost on crops and wild shrubs, and some females dig in soil with their ovipositor. For four consecutive nights, the villagers filled bags with locusts. In those four days, around 1275 kilograms of locusts were collected (Table 1). After collection, the bags were closed and brought back to the villagers' homes. Most of the locusts were eaten, although a few fled due to the disturbance. To prepare them for consumption, the locusts were first put in boiling water (Figure 3A), then dried for a day (Figure 3B). The dried locusts were then fried in various ways to make crisp, spicy, and crunchy dishes (Figure 3C–F).

**Table 1.** Collection of desert locust by villagers after the arrival of the first swarm on 4 July 2019.

Villages	Weight of Desert Locust Collected (kg)				Total
	1st Day	2nd Day	3rd Day	4th Day	
Agrani	22	41	81	45	189
Mahendrani	-	41	74	48	163
Jam-ji-Dhani	17	27	53	24	121
Saadon-j-Dhani	12	21	47	18	98
Jamal-ji-Dhani	-	19	44	23	86
Senhrani	23	31	62	17	133
Ramlani	18	35	52	24	129
Mehlani	-	25	66	26	117
Misryani	-	20	51	27	98
Sekharjo	17	33	67	24	141
Total	109	293	597	276	1275



**Figure 3.** Various dishes based on desert locusts prepared by the Thari. (A) Locust boiling in water, (B) locusts spread out on a bed for drying, (C) cooking of dried locusts, (D) locust cooked with lemon, (E) “Biryani” (a typical dish of the Indian subcontinent) with locusts, (F) crispy locust snacks. Photos by Santosh Kumar, Nawaz Ali Samejo, Muhammad Ibrahim Samejo, Saraj-ud-din Samejo, and Samiullah Soomro.

Another huge mature swarm, covering “a large area” (villager estimate unfortunately imprecise), arrived on 24 September 2019, moving westward. The swarm likely originated from the adjacent breeding areas in Rajasthan, India. The villagers were more motivated to collect these locusts, as they remembered the previous July swarm, and the preparation and consumption of tasty dishes. The villagers formed groups to collect locusts in the field, using vehicle headlights as a light trap. The desert locusts were often in pairs for mating and were easily picked by hand. During this swarm’s time in the fields, the people collected about 1758 kg of locusts over five consecutive nights (Table 2).

**Table 2.** Collection of desert locusts by villagers after the arrival of the second swarm on 24 September 2019.

Villages	Weight of Desert Locust Collected (kg)					Total
	1st Day	2nd Day	3rd Day	4th Day	5th Day	
Agrani	26	61	53	59	19	218
Mahendrani	17	48	57	51	22	195
Jam-ji-Dhani	12	34	29	66	27	168
Saadan-j-Dhani	21	41	33	39	13	147
Jamal-ji-Dhani	15	46	29	33	-	123
Senhrani	27	53	34	57	23	194
Ramlani	31	37	52	47	18	185
Mehlnani	25	42	58	39	28	192
Misryani	17	26	57	38	-	138
Sekhario	28	63	48	37	22	198
Total	219	451	450	466	172	1758

In early October 2019, desert locust hoppers emerged from the ground, where the swarms had arrived earlier for laying. However, no emerging hoppers were observed around the village of Mahandre-Jo-Par as most of the locusts have been collected and eaten or had already migrated away. In areas where young hoppers emerged, they were observed marching in bands and damaging moth bean (*Vigna aconitifolia*), a cash crop in the Thar. In Mahandre-Jo-Par, out of 3620 ha cultivated with moth bean, only 4000 rupees per hectare was lost. However, in the three surrounding villages (Khokhrapar, Laplo, and Shekhro), where locusts had not been harvested, losses on the 5888 hectares cultivated with moth bean totaled about 43,000 rupees/hectare. In the fields around the Mahandre-Jo-Par village, the crops were hardly damaged since there were no hoppers there. Sometime later, hopper bands came to these fields from other areas, but the farmers had already harvested their crops. Thus, while the moth bean crop was completely destroyed in other parts of the Thar region, in our study area losses were lower, likely as a result of locust collection by the villagers.

#### 4. Discussion

Our main observational study shows that entomophagy can, to a certain extent, be locally effective in desert locust control. This method cannot prevent locust invasions, but can mitigate the problems caused by locusts to allow the villagers to better cope with the plague. Entomophagy has an important advantage over other control methods: it reduces the number of locusts while providing a diet of better nutritional quality to the local residents.

Collecting locusts had a strong local impact on the insects’ population in two important ways: the method greatly reduced the locust population at the time of collection and also reduced the next generation to almost nothing, thereby avoiding most of crop losses. Crop losses continued to take place where no locusts were collected. Unfortunately, we cannot determine the precise impacts of locust collection on the swarm because the characteristics of the swarms were not noted, including their size and approximate density; depending on these parameters, the collection efficiency could be more or less effective. When locust

swarms are very dense and large, the local villagers may be overwhelmed and their collection efficiency may be lower, while the nutritional benefit remains the same.

Collection efficiency also depends on the maturity of the locust population. Collection is less efficient and has a less significant impact on population density if the swarm is immature, arrives during or at the end of the day, eats a large part of the available vegetation and crops, and continues its migration the next day. If the swarm is mature, the locusts may remain for several consecutive days and nights for female laying, before flying away. The collection can then be more intense (as in our study), the reduction of the locust population greater, and the impact on local dynamics and crop damage reduced.

Residents of various countries (i.e., Indonesia, M. Lecoq p.c.) have better ways to collect locusts, such as using large nets carried by several people. Of course, the techniques must be within the capacity of the local farmers. Selling locusts can be a significant source of income for poor rural families, and farmers can be encouraged to collect locusts to be processed into feed for poultry. During the most recent invasion in Pakistan's Punjab province, as part of a pilot project led by the Food Security Department, farmers were encouraged to collect locusts and sell them to poultry feed businesses. In addition, researchers from the Pakistan Agriculture Research Council collected dead locusts to make bio-fertilizers for crops; locust-based fertilizers have advantageous N (9%) and P (7%) content [28]. Locusts also can be mixed with other bio-waste to make compost [29].

Finally, we should not expect to control invasions by collecting locusts by hand, even on a large scale. First, there is general agreement that it is impossible to collect enough locusts to end an invasion; there are simply too many insects (a swarms spotted in Kenya in January 2020 covered an area of 40 km by 60 km [30]). It is also impossible to prevent an invasion as the locusts emerge from outbreak areas, which are most often located in desertic and sparsely populated regions. At best, this collection method could be a useful mitigation measure in the event of an upsurge/invasion that could not be controlled at an earlier stage using preventative measures. The collection method also allows local residents, in the absence of other control tools, to protect their own crops, and also to compensate for possible nutritional deficiencies by eating the insects.

Eating swarming locusts is a widespread practice wherever plagues occur. Locusts and grasshoppers have been eaten for centuries and, in some places, still are today. During periods of increased locust activity, piles of dead locusts can be found in the market places [30]. Locusts are rich in protein; about 62% of the dry weight of an adult desert locust is proteins, 17% is fats, and the remainder is inorganic constituents [31]. Thus, entomophagy may have a large positive nutritional impact, and it is an important practice in parts of the desert locust habitat range, especially in certain regions of Pakistan. For a long time, the people of the Thar desert region have faced shortages of food and water, making them extremely vulnerable. Food shortages lead to severe malnutrition (especially to protein deficiency), leading to high maternal mortality rates [32,33]. As an important source of protein, the consumption of desert locusts can help prevent malnutrition. Therefore, collection must, perhaps above all, be considered an interesting food source for poor and undernourished rural populations.

However, using locusts as food has many potential risks [34]. Edible insects are underestimated as a reservoir of human and animal parasites [35]. Using locusts as food for humans or animals must consider health constraints, the health risk being not only microbiological but also chemical [36]. Indeed, outbreaks are currently managed using chemical insecticides [37]. As pesticides do not always kill the locusts immediately, collected locusts may still contain traces of pesticides and be toxic. During an ongoing locust upsurge in East Africa, the FAO [30] strongly advises against eating swarming locusts (living or dead) because it is highly unlikely that the nutritional benefits will outweigh the negative effects of the chemical residues of organophosphate, carbamate, or pyrethroid insecticides [38,39]. The practice of entomophagy, if it is to go beyond its current limits, should therefore be closely supervised by state agencies to avoid health risks and be coordinated with pesticide applications.

## 5. Conclusions

The consumption of desert locusts could effectively prevent malnutrition and protein deficiency and, to a certain extent, could also be an efficient mitigation measure to help local human populations to better protect themselves against locust outbreaks and the resulting crop damage. Collecting and consuming locusts should be encouraged wherever outbreaks are observed, while remaining realistic about the real impact entomophagy has on locust control. This practice should be coordinated with the local authorities to avoid the consumption of insects treated with pesticides. Sensitization about entomophagy, its health and crop protection benefit, as well as its constraints, is surely required as is a research development on this subject in order to better assess the nutritional and economic benefits in the long-term.

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