Perception and knowledge of grasshoppers among indigenous communities in tropical forest areas of southern Cameroon: Ecosystem conservation, food security, and health

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Abstract

The increased attention given to health, food security, and biodiversity conservation in recent years should bring together conventional scientists and indigenous people to share their knowledge systems for better results. This work aims to assess how grasshoppers are perceived by the local people in southern Cameroon, particularly in terms of food, health, and landscape conservation. Villagers were interviewed individually using a rapid rural assessment method in the form of a semi-structured survey. Nearly all people (99%) declared that they are able to identify local grasshoppers, generally through the color of the insect (80%). Crop fields were the most often cited landscape (16%) in terms of abundance of grasshoppers, with forest being less mentioned (8%). In general, villagers claimed that grasshopper abundance increased with forest degradation. Grasshoppers were found during all seasons of the year but noted to be more abundant during the long dry seasons. People found grasshoppers both useful and harmful, the most harmful reported being *Zonocerus variegatus*, an important crop pest. Cassava is the most attacked crop with 75–100% losses. Industrial crops, such as cocoa, coffee, and bananas, were not cited as being damaged by grasshoppers. The most effective conventional method cited for the control of pest grasshoppers is the use of pesticides (53%) with, in most cases (27%), a 75–100% efficiency. The traditional method of spreading ash was also often cited (19%), with an estimated efficiency of 25–75%. Biological methods were neither cited nor used by the villagers. Most of them (87%) declared that they eat grasshoppers; some sold these insects in the market (58%) and some used them to treat diseases (11%).

Keywords

biodiversity conservation, Caelifera, crop pest, disease, indigenous people, Orthoptera

Introduction

Sustainable development is now emerging as an alternative to conventional development as a way to reduce poverty in the Third World (UN 2019). A sustainable development perspective is consistent with the need to conserve ecosystems and agrosystems for better development (Ulluwishewa 1993, Andres and Bhullar 2016). In the last century, ecosystem transformations due to agricultural intensification and rapid industrial and urban development have imposed pressures on biological diversity, such that there is an urgent need to create interest and awareness regarding functional biodiversity (Rastogi and Kumar 2009, Rastogi 2011), biodiversity conservation (Kearns 2010), and the economic resources provided by biodiversity (Nijkamp et al. 2008). Accelerated exploitation of natural resources in the Third World leads to environmental degradation and loss of biodiversity, which, combined with the harmful effects of climate change, threatens to reverse decades of development efforts and have a negative impact on agriculture, health, settlement, and infrastructure in developing countries (Thornton et al. 2011). As a Sub-Saharan African country, Cameroon is seriously affected because it depends mainly on rain-fed agriculture. Due to the current effects of climate change, the livelihoods of local farmers are vulnerable to unpredictable floods, prolonged droughts, and related famine, pests, and diseases, thus calling for adaptive strategies to be undertaken (Akinnagbe and Irohibe 2014, Torquebiau et al. 2016). Early warning systems have proven to be indispensable in preparedness for such climatic consequences (Tadesse et al. 2008, Singh and Zommers 2014). This increased attention to climate change and landscape degradation is bringing together both conventional scientific and indigenous communities to share their knowledge systems (Nakashima et al. 2012). Historically and to date, local communities in different parts of the world have continued to rely on indigenous knowledge to conserve the environment and deal with natural disasters (Iloka 2016). However, various people now consider that, especially in Africa, the knowledge of indigenous people should be included when designing adaptations to natural disasters and particularly to climate change (Robinson and Herbert 2001, Joshua and Jürgen 2013).

Indigenous knowledge can be defined as a set of strategies, practices, tools, explanations, beliefs, intellectual sources, and other values accumulated through time by indigenous communities without interference or involvement of hegemonies or external forces (Emeagwali and Sefa-Dei 2014). The knowledge of indigenous communities has been accumulated through generations of living in a given environment and allows the members of these communities to live in harmony with nature; this knowledge provides valuable tools for food security, health, education, environmental conservation, and the reduction of the degradation of natural resources. To a certain extent, indigenous knowledge allows for the foreseeing of hot weather, periods of seeding, and anticipation of the rainy season (Mwaura 2008). The use and application of appropriate indigenous knowledge systems can promote environmental conservation and aid in the management of disasters in terms of disaster prevention, mitigation, recovery, prediction, early warning, preparedness, response, and rehabilitation (Mwaura 2008). In Africa, the indicators used by indigenous knowledge systems include temperature variation, astronomical observations, plant phenology, and the behavior of birds, amphibians, reptiles, and insects (Mwaura 2008). In Tanzania, various environmental and astronomical means have been used to predict rainfall, including plant phenology and the behavior and movement of animals such as birds and insects (Chang'a et al. 2010). In Uganda, indicators for the onset of the dry season include the appearance and movement of insects, specifically butterflies, red caterpillars, western honeybees (*Apis mellifera* Linnaeus, 1758), and bush-crickets (*Ruspolia baileyi* Otte, 1997; Joshua and Jürgen 2013). In Ghana, the presence of the bird *Butastur rufipennis* Sundevall, 1850 would indicate an imminent invasion of crops by locusts (Owusu 2010). According to Mwaura (2008), many people of Africa use indigenous knowledge on insects' behavior, such as grasshoppers, to protect forests used for rituals, i.e., forests that have trees or animals considered sacred or totems.

Grasshoppers are one of the more diverse taxa in the world (Zhang 2011). While some species are harmful, many are not, but all grasshopper species are a crucial link in food chains (Badenhausser 2012), playing an important role in the recycling and equilibrium of natural ecosystems (Hao et al. 2015). The decline in grassland bird species has been shown to have a positive correlation with an increase in grasshopper densities (Bock et al. 1992). Grasshoppers are a major component in the diet of grassland birds, and studies have shown that there is a direct decrease in birds when grasshoppers are less abundant (Bock et al. 1992). Grasshoppers are also an important food source for other fauna in grassland ecosystems (Latchininsky et al. 2011), such as shrews, moles, bats, armadillos, and anteaters (Srivastava et al. 2009). They are also a food source for many people in the world (Paul et al. 2016). Several authors have reported that grasshoppers and crickets, especially *Hieroglyphus africanus* Uvarov, 1922, *Acanthacris ruficornis citrina* (Serville, 1838), *Zonocerus variegatus* (Linnaeus, 1758), *Ornithacris cavroisi* (Finot, 1907), *Brachytrupes membranaceus* (Drury, 1770), *Oxya cyanoptera* Stal, 1873, *Cyrtacanthacris aeruginosa* (Stoll, 1813), *Ornithacris turbida* (Walker, 1870), and *Anacridium melanorhodon* (Walker, 1870), are the insects predominantly eaten by humans in Nigeria, Cameroon, Benin, and in many other parts of Africa because of their high protein content (Banjo et al. 2006, Riggi et al. 2013, Meutchieye 2019, Zabentungwa et al. 2020). According to De Conconi and Moreno (1988), grasshoppers are also used by many people throughout the world in the preparation of traditional medicines used to cure certain diseases; *Sphenarium* spp., *Taeniopoda* sp., and *Melanoplus* sp. are used to treat kidney diseases and intestinal sickness. Nevertheless, most of the indigenous knowledge on grasshoppers has not been documented and remains the secret of the local populations of Africa, especially in Cameroon. The aim of this study is to assess the indigenous knowledge and perception of communities of South Cameroon on the local forest grasshoppers, especially as it pertains to (1) the use of grasshopper diversity to predict the level of forest degradation; (2) pest grasshoppers, damage to crops, and known and/or used methods to control these pests; and (3) use of grasshoppers in medicine, culture, and as a food source.

Materials and methods

Study site.—This study was conducted in villages in the forest areas of the southern Cameroon plateau (between 3°27'N, 11°32'E and 4°10'N, 11°49'E). This area covers almost 42% of Cameroon and is a vast plateau of about 650 m a.s.l., belonging to a strip of plateau that forms the north and west edges of the Congo basin (Westphal et al. 1981). It is dominated by a Guinean climate with four seasons: a long dry season (mid-November to March), a short rainy season (April to June), a short dry season (July to August), and a long rainy season (September to mid-November). Precipitation ranges from 1500 to 2000 mm per year (Santoir and Bopda 1995). These forests are characterized by the dominance of Sterculiacae and Ulmacae, which have great expansion potential, with the undergrowth being invaded by herbaceous plants such as Maranthacae and Acanthacae (Westphal et al. 1981). In these ecosystems, the forest cover is not uniform, as it is regularly degraded because of the economic exploitation of wood and the practice of slash and burn agriculture. The resulting vegetation after degradation are the less diversified fallowlands, dominated by *Chromolaena odorata* (L.) R.M.King & H.Rob., 1970, *Ageratum conizoides* L., 1753, *Synedrella nodiflora* (L.,) Gaertn, and *Imperata cylindrica* (L.) P.Beauv. Plantain and cocoyam, cassava, yam, maize, and groundnuts are the main food crops (Westphall et al. 1981), while industrial crops include cocoa, coffee, sweet banana, and oil palm (Santoir and Bopda 1995). In the southern Cameroon plateau, our surveys were conducted in four regions (Center, South, East, and Littoral) with the following eight divisions: Mbam and Inoubou (villages investigated: Tchekos, Biabetom, Bokito, Dang, Bygna, and Goufe), Mbam and Kim (village investigated: Ngoro), Mefou and Akono (villages investigated: Ongot and Ngoumou), Nyong and Kelle (villages investigated: Memel, Elale, and Bof Makak), Mvilla (villages investigated: Adoum, Mekam, Mang, Djop, and Biyeyem), Valley of Ntem (villages investigated: Ngutadjap, Aloum, Meko, Akonangui, and Olamze), Sanaga Maritime (village investigated: Ngambe), and High Nyong (village investigated: Ngoyla) (Fig. 1).

Surveys and data analysis.—A total of 341 people were interviewed individually in the 24 villages selected. Rapid rural appraisal methods (RRA) (Chambers 1981, Polidoro et al. 2008, Sattout et al. 2008) were used between January and July 2017; interviews were conducted using a semi-structured survey form. Thirty-one questions were asked to each participant: two questions about personal information (origin, age, sex, and background); eleven questions on the respondents' general knowledge of grasshoppers, the influence of forest degradation on grasshopper diversity, and on the potential use of these insects to trace the disruption level of forests due to human activities; nine questions on harmful grasshoppers and the methods used to control pest species; and nine questions on the importance of grasshoppers to the local popula-

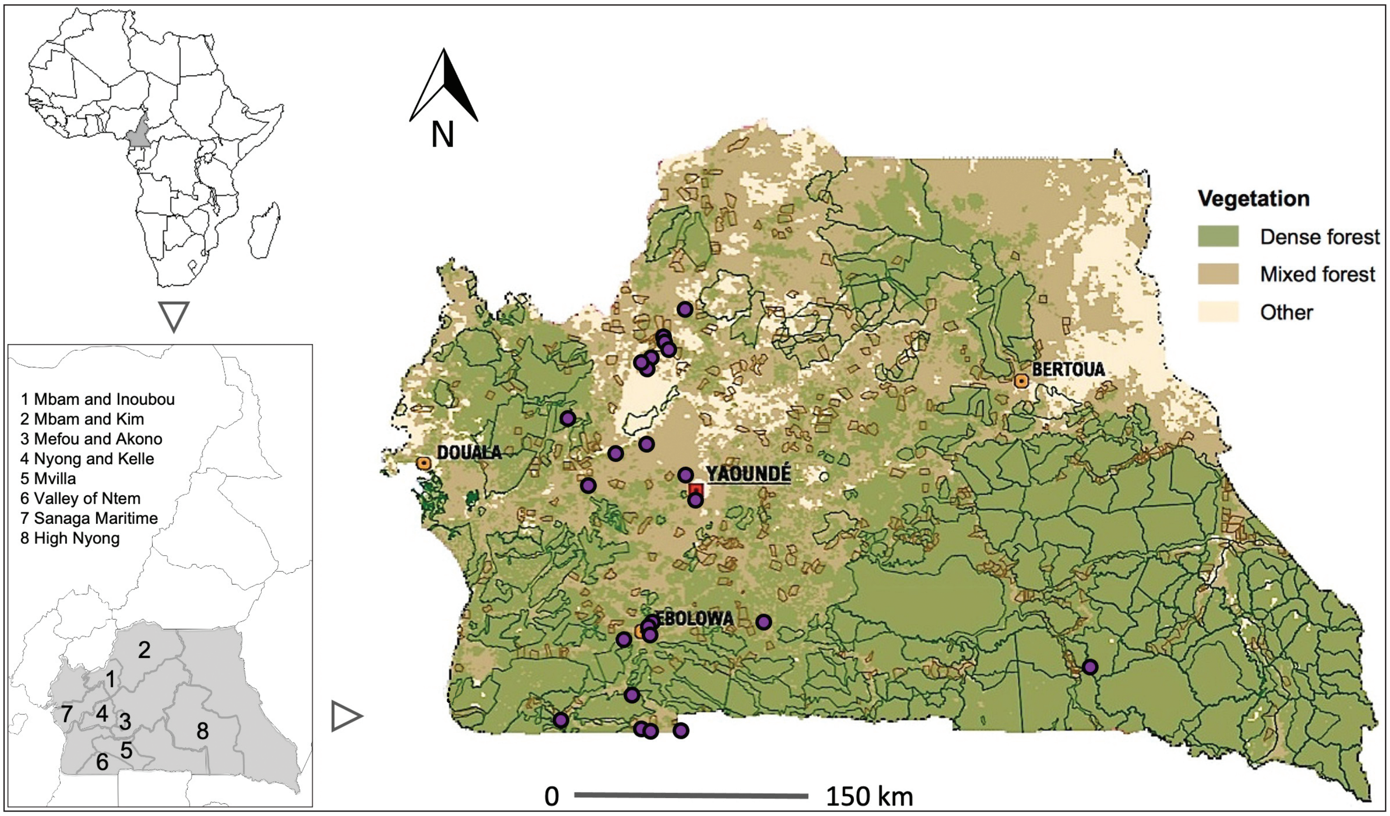

Fig. 1. Study sites in Cameroon.

tion as a food source or for commerce, medicine, traditional rites, and magic (See supplementary file). The interviews were done in French or in the common language of the area with the help of a local translator. Assessment of the recognition of grasshopper species by the local people was facilitated by the use of pictures of many species from the area around the villages. All frequencies (calculated using EXCEL version 2016) were compared using the Chi^2 found using the Kruskal-Wallis test in PAST version 4.03 (Hammer et al. 2001). The Mann-Whitney test was used with the same software for two samples. Differences were considered significant at a probability less than 0.05.

Results

Socio-demographic characteristics of the surveyed people

The population studied consisted of 58.9% males (201 respondents) and 41.1% females (140 respondents) (Table 1). Most respondents were 18–30 years old (40.1%), followed by 31–40 years (22.6%), 51–60 years (14.7%), 41–50 years (12.3%), and over 60 years (10.3%). Most (53.4%) had a high school level education, while 29.6% had a primary level education and 11.4% had a university level education. A small number of respondents (5.6%) never went to school at all.

Grasshopper recognition by local people

Only one respondent said he did not know what a grasshopper is. In general, in all the villages, the respondents said that they know these insects (99.7%) from their personal experiences (50.4%) or from school (48.7%). Some (33.7%) got their experience from their neighbors and 18.8% from the media. The people surveyed said that they used general coloring (80.1%), form (66.9%) or odor (30.2%) to recognize grasshoppers, with color predominating in some divisions, and form predominating in others (Table 2).

Landscapes reported as habitat for grasshoppers

The data shows that most villagers reported that grasshoppers were in all landscapes (79.8%) (Table 3). However, some villagers (16.4%) reported that crop fields hosted grasshoppers more often, while a few (9.7%) thought grasshoppers were mainly in fallow lands (9.7%).

The grasshoppers were called by many names, depending on the village and language: "Etandak" in the Beti language (Mefou and Akono, Mvilla and Valley of Ntem divisions), "Gomatataï" and "Ketataï" in the Bafia language (Mbam and Inoubou division), "Kanè" in the Mvouté language (Mbam and Kim division), "Ndenga" in the Bassa language (Nyong and Kelle and Sanaga Maritime), and "Atjembeka" in the Nvjem language (High Nyong division).

In general, species-specific names do not exist in these villages, with the exception of *Z. variegatus*, called "Mbakssana" in the Beti language and "Ikadjala" in the Nvjem language. However, 23 species were recognized by the local people : *Parapetasia femorata* Bolívar, 1884, *Dictyophorus karschi* (Bolívar, 1904), *Mazea granulosa* Stål, 1876, and *Gemeneta terrea* Karsch, 1892 in forest; *Odontomelus kamerunensis* Ramme, 1929, *Cyphocerastis tristis* Karsch, 1892, and *Eupropacris coerulea* (Drury, 1770) in fallow, crop fields, and forests; *Pteropera balachowskyi* Donskoff, 1981 and *Pteropera mirei* Donskoff, 1981 in fallow lands and forest; *Zonocerus variegatus* (Linnaeus, 1758), *Oxycatantops spissus* (Walker, 1870), *Taphronota ferruginea* (Fabricius, 1781), *Chirista compta* (Walker, 1870), and

Table 1. Socio-demographic characteristics of respondents in the investigated divisions. Each value represents a frequency in % (number of respondents); N = size of the sample; p value = probability; χ^2 = value of the Kruskal-Wallis test. The letters a, b, and c represent the results of the Mann-Whitney test for two samples in the same column; the same letter indicates non-significant differences between the values.

Comparison parameters	Mbam and Inoubou	Mbam and Kim	Mefou and Akono	Nyong and Kelle	Mvilla	Valley of Ntem	Sanaga Maritime	High Nyong	χ^2	*P* value	Total
Sex											
Male	58.9(50)	43.3(13)	48.5(16)	64.5(20)	59.0(36)	73.7(28)	40.0(12)	78.8(26)	14.2	0.006	58.9(201)
Female	41.1(35)	56.7(17)	51.5(17)	35.5(11)	41.0(25)	26.3(10)	60.0(18)	21.2(7)	14.2	0.006	41.1(140)
χ^2	3.9	1.8	0.04	3.8	2.9	12.6	1.8	16.6			15.3
p value	0.02	0.1	0.8	0.02	0.04	<0.001	0.1	<0.001			<0.001
N	85	30	33	31	61	38	30	33			341
Age (in years)											
18 – 30	36.5(31)a	56.7(17)a	42.4(14)a	6.4(2)a	57.4(35)a	36.8(14)a	23.3(7)ab	51.5(17)a	21.9	< 0.001	40.1(137)a
31 – 40	21.2(18)b	16.7(5)b	18.2(6)b	35.5(11)b	16.4(10)b	23.7(9)ab	46.6(14)b	12.1(4)b	9.4	0.01	22.6(77)b
41 – 50	17.6(15)b	3.3(1)b	9.1(3)b	9.7(3)a	6.6(4)b	21.1(8)ab	16.7(5)a	9.1(3)bc	3.4	0.2	12.3(42)c
51 – 60	11.8(10)b	10.0(3)b	30.3(10)ab	19.4(6)ab	9.8(6)b	10.5(4)b	6.7(2)a	27.3(9)b	5.7	0.03	14.7(50)c
Above 60	12.9(11)b	13.3(4)b	0.0(0)c	29.0(9)b	9.8(6)b	7.9(3)b	6.7(2)a	0.0(0)c	6.1	0.002	10.3(35)c
χ^2	10.1	15.9	11.1	5.8	32.8	6.1	9.7	15.5			61.3
p value	< 0.001	< 0.001	< 0.001	0.02	< 0.001	0.01	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341
Background											
unschooled	8.2(7)b	0.0(0)c	6.0(2)b	6.5(2)c	1.6(1)c	0.0(0)c	0.0(0)c	21.2(7)a	3.8	0.001	5.6(19)a
Primary	34.1(29)a	16.7(5)a	39.4(13)a	29.0(9)a	18.0(11)a	36.8(14)a	40.0(12)a	24.2(8)a	7.3	0.01	29.6(101)b
High school	45.9(39)a	76.7(23)ab	36.4(12)a	54.8(17)b	68.9(42)b	52.7(20)a	46.7(14)a	45.5(15)b	47.6	< 0.001	53.4(182)c
University	11.8(10)b	6.6(2)ab	18.2(6)ab	9.7(3)c	11.5(7)a	10.5(4)b	13.3(4)b	9.1(3)a	0.8	0.9	11.4(39)d
χ^2	24.8	33.0	7.3	13.7	53.7	19.7	12.9	6.7			142.7
p value	< 0.001	< 0.001	0.004	< 0.001	< 0.001	< 0.001	< 0.001	0.007			< 0.001
N	85	30	33	31	61	38	30	33			341

Acanthacris ruficornis (Fabricius, 1787) in fallow lands and crop fields; *Heteropternis thoracica* (Walker, 1970) and *Pyrgomorpha vignaudii* (Guérin-Méneville, 1849) near houses, in fallow lands, and in crop fields; *Spathosternum pygmaeum Karsch*, 1893, near houses and in fallow lands; *Gymnobothrus temporalis* (Stål, 1876), *Abisares viridipennis* (Burmeister, 1838), *Catantops stramineus* (Walker, 1870) and *Afroxyrrhepes obscuripes* Uvarov, 1943, only in fallow lands; *Atractomorpha acutipennis* (Guérin-Méneville, 1844) and *Eucoptacra anguliflava* (Karsch, 1893) near houses, in fallow lands, in crop fields, and in forest (Appendix 1).

Abundance of grasshoppers in different landscapes, forests, and seasons

Crop fields were cited most often as having an abundant number of grasshoppers (45.7%), while fallow areas were cited as having only moderate levels (38.7%) (Fig. 2). Grasshoppers were seen as being less abundant to rare in forests (37–38.4%) and rare near houses (49.3%). In general, respondents reported that the abundance of grasshoppers increased with degradation of the forest. They recognized that grasshoppers were generally rare in pristine forests (63.9%) and, in severely degraded forests, they noted low (27.3%), moderate (41.3%) or high (8.2%) abundance levels. In general, respondents reported that grasshoppers were present in all seasons but more abundant during the dry season than in the rainy season. Mainly, high grasshopper abundance was reported during the long dry season (39.3%), with lower levels during the short dry season (16.7%) and the long rainy season (11.7%). Grasshoppers were considered to be least common during the short rainy season, the rarest categories being predominant (31.4%).

Perception of grasshoppers by local people

In all the divisions visited, the respondents recognized grasshoppers as both useful and harmful in Mbam and Kim (100%), Mefou and Akono (94%), Nyong and Kelle (93.5%), Mvilla (91.8%), Sanaga Maritime (90%), Mbam and Inoubou (88.2%), High Nyong (63.6%), and Valley of Ntem (50%) (Fig. 3A). Grasshoppers were reported as only harmful in seven of the eight divisions studied: Valley of Ntem (34.2%), High Nyong (12.2%), and Sanaga Maritime (10%) had the high frequencies of this response, with the four others presenting a low frequency. Only the respondents of the divisions Mbam and Kim and Nyong and Kelle did not recognize grasshoppers as harmful. Grasshoppers were reported as only useful more often by some people in the High Nyong (21.2%) and Valley of Ntem (13.2%) divisions.

Harmful effects of grasshoppers.—In general, in all the divisions, the most harmful action of grasshoppers reported by respondents was damage to crops (Fig. 3B). Some people cited wounds due to the spines of grasshoppers in Valley of Ntem (28.9%), Mbam and Inoubou (5.9%), and in Mvilla (1.6%). Skin irritation was only reported in Mbam and Inoubou (9.4%).

Grasshoppers cited as crop pests.—In all divisions visited, respondents recognized all grasshopper species as crop pests (51%) (Table 4). However, in these divisions, only *Zonocerus variegatus* was cited as a crop pest having a significant economic impact by a high proportion of respondents (33.1%). With the exception of *Oxycatantops spissus* (3.5%) and *Pyrgomorpha vignaudii* (1.5%), all other grasshoppers were cited as crop pests by less than 1% of the respondents and only in the areas of Mbam and Inoubou, and Mvilla.

Table 2. Recognition of grasshoppers by local people. Frequency in % (number of respondents); N = size of the sample; p value = probability; χ^2 = value of the Kruskal-Wallis test. The letters a, b, and c represent the results of the Mann-Whitney test for two samples in the same column; the same letter indicates non-significant differences between the values.

Comparison parameters	Mbam and Inoubou	Mbam and Kim	Mefou and Akono	Nyong and Kelle	Mvilla	Valley of Ntem	Sanaga Maritime	High Nyong	χ^2	p value	Total
Knowledge of grasshoppers											
Yes	100.0(85)	100.0(30)	100.0(33)	100.0(31)	100.0(61)	100.0(38)	100.0(30)	97.0(32)	0.08	0.2	99.7(340)
No	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	3.0(1)	0.08	0.2	0.3(1)
χ^2	126.8	44.3	45.8	45.7	90.8	56.3	44.3	44.4			506.3
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341
Where knowledge was gained											
School	47.1(40)a	90.0(27)a	36.4(12)a	71.0(22)a	21.3(13)a	28.9(11)a	76.7(23)a	54.5(18)a	43.3	< 0.001	48.7(166)a
Media	25.9(22)b	23.3(7)b	15.2(5)b	19.3(6)b	1.6(1)b	7.9(3)b	50.0(15)b	15.2(5)b	17.8	< 0.001	18.8(64)b
Neighbor	24.7(21)b	10.0(3)b	18.2(6)ab	54.8(17)a	18.0(11)a	60.5(23)c	53.3(16)ab	54.5(18)a	32.7	< 0.001	33.7(115)c
Personal experience	61.2(52)a	33.3(10)b	63.6(21)c	32.3(10)b	90.2(55)c	26.3(10)a	23.3(7)c	21.2(7)b	68.6	< 0.001	50.4(172)a
χ^2	23.7	30.2	14.9	14.7	84.1	16.2	12.8	13.2			67.2
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341
Recognition of grasshoppers											
Form	83.5(71)a	93.3(28)a	66.7(22)a	90.3(28)a	32.8(20)a	60.5(23)a	70.0(21)	45.5(15)	47.6	< 0.001	66.9(228)a
Color	94.1(80)b	70.0(21)b	54.5(18)a	80.6(25)a	96.7(59)b	86.8(33)b	53.3(16)	63.6(21)	27.1	< 0.001	80.1(273)b
Odor	43.5(37)c	20.0(6)c	27.3(9)b	19.4(6)b	18.0(11)c	18.4(7)c	40.0(12)	45.5(15)	13.8	0.003	30.2(103)a
χ^2	36.2	26.7	7.9	24.8	63.6	26.9	4.0	2.2			57.7
p value	< 0.001	< 0.001	0.004	< 0.001	< 0.001	< 0.001	0.7	0.2			< 0.001
N	85	30	33	31	61	38	30	33			341

Table 3. Landscapes reported as habitats for grasshoppers in the divisions studied. Frequency in % (number of respondents); N = size of the sample; p value = probability; χ^2 = value of the Kruskal-Wallis test. The letters a, b, and c represent the results of the Mann-Whitney test for two samples in the same column; the same letter indicates non-significant differences between the values.

Landscapes	Mbam and Inoubou	Mbam and Kim	Mefou and Akono	Nyong and Kelle	Mvilla	Valley of Ntem	Sanaga Maritime	High Nyong	χ^2	p value	Total
All landscapes	82.4(70)c	70.0(21)c	84.8(28)c	100.0(31)a	100.0(61)a	68.4(26)a	63.3(19)c	48.5(16)c	26.1	< 0.001	79.8(272)c
Forest	2.4(2)b	3.3(1)a	12.1(4)b	0.0(0)b	0.0(0b)	7.9(3)b	26.7(8)ab	24.2(8)b	6.1	< 0.001	7.6(26)a
Fallow	9.4(8)ab	6.7(2)ab	12.1(4)b	0.0(0)b	0.0(0)b	15.8(6)b	16.7(5)ab	24.2(8)b	5.7	0.002	9.7(33)a
Crop fields	14.1(12)a	20.0(6)b	9.1(3)ab	0.0(0)b	0.0(0b)	21.1(8)b	36.7(11)b	48.5(16)c	22.3	< 0.001	16.4(56)b
House	16.5(14)a	16.7(5)ab	0.0(0)a	0.0(0)b	0.0(0)b	10.5(4)b	10.0(3)a	3.(1)a	4.9	0.001	7.9(27)a
χ^2	107.8	26.0	47.1	73.9	154.9	28.2	17.0	14.5			398.6
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341

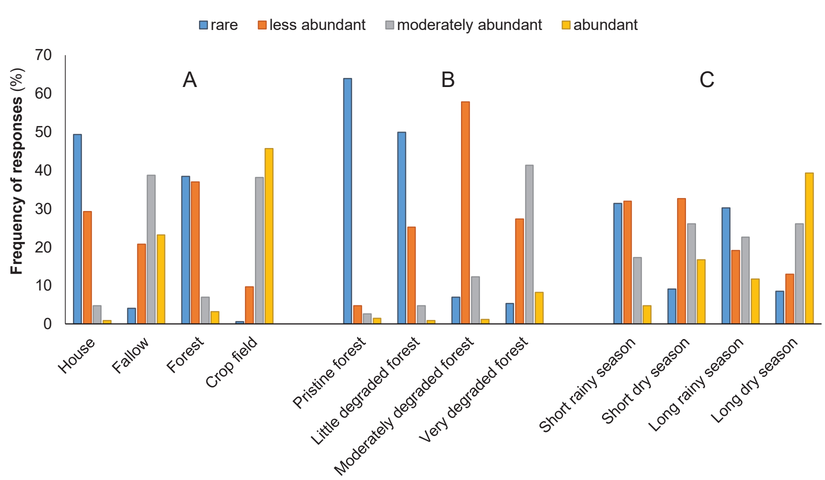

Fig. 2. Abundance of grasshoppers in different landscapes (**A**), forests (**B**), and seasons (**C**).

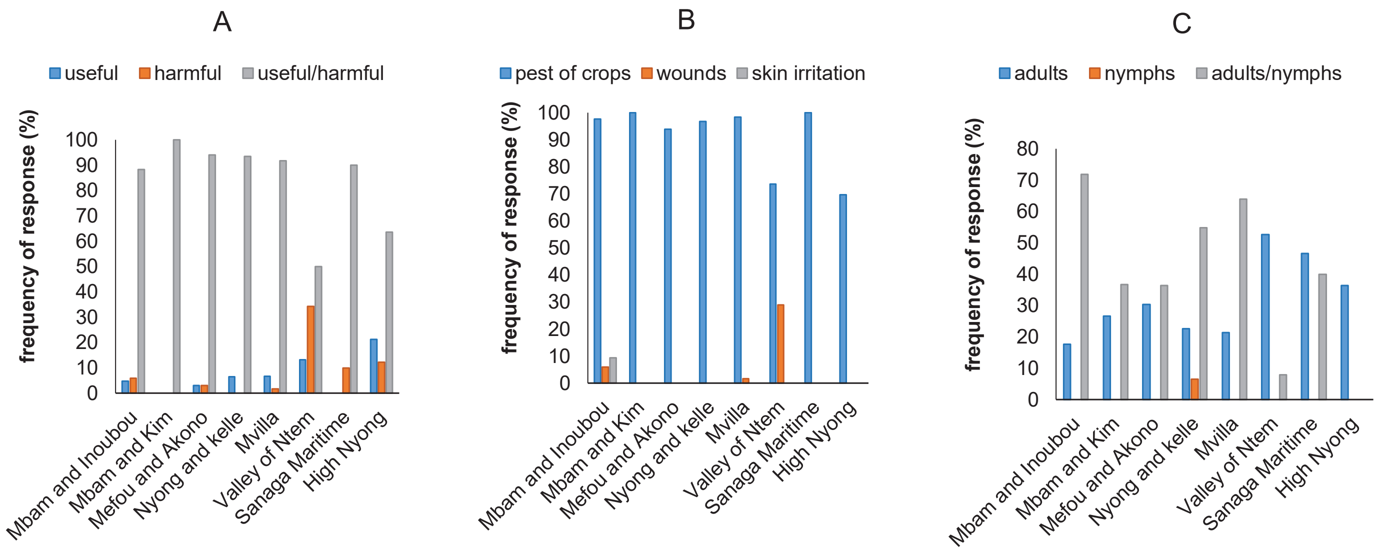

Fig. 3. Perception of grasshoppers by local people: general perception (**A**), harmful effects of grasshoppers (**B**), and development stage of pest grasshoppers (**C**).

Table 4. Pest grasshoppers cited by local people. Frequency in % (number of respondents); N = size of the sample; *p* value = probability; χ^2 = value of the Kruskal-Wallis test. The letters a, b, c, and d represent the results of the Mann-Whitney test for two samples in the same column; the same letter indicates non-significant differences between the values.

Grasshoppers species	Mbam and Inoubou	Mbam and Kim	Mefou and Akono	Nyong and Kelle	Mvilla	Valley of Ntem	Sanaga Maritime	High Nyong	χ^2	*p* value	Total
All the species	67.1(57)a	63.3(19)a	42.4(14)a	51.6(16)a	32.8(20)a	31.6(12)a	73.3(22)a	42.4(14)a	24.2	< 0.001	51.0(174)a
Zonocerus variegatus	28.2(24)b	53.3(16)b	30.3(10)b	38.7(12)a	55.7(34)b	31.6(12)a	13.3(4)b	3.0(1)b	25.5	< 0.001	33.1(113)b
Taphronota ferruginea	2.4(2)c	0.0(0)c	0.0(0)c	0.0(0)b	0.0(0)c	0.0(0)b	0.0(0)c	0.0(0)b	0.2	0.5	0.6(2)c
Acanthacris ruficornis	1.2(1)c	0.0(0)c	0.0(0)c	0.0(0)b	1.6(1)cd	0.0(0)b	0.0(0)c	0.0(0)b	0.05	0.9	0.6(2)c
Atractomorpha acutipennis	1.2(1)c	0.0(0)c	0.0(0)c	0.0(0)b	3.3(2)cd	0.0(0)b	0.0(0)c	0.0(0)b	0.2	0.6	0.9(3)cd
Pyrgomorpha vignaudii	1.2(1)c	0.0(0)c	0.0(0)c	0.0(0)b	6.6(4)d	0.0(0)b	0.0(0)c	0.0(0)b	0.6	0.06	1.5(5)cd
Oxycatantops spissus	1.2(1)c	16.7(5)c	6.1(2)c	0.0(0)b	6.6(4)d	0.0(0)b	0.0(0)c	0.0(0)b	2.6	< 0.001	3.5(12)d
χ^2	97.8	41.2	18.4	27.7	48.5	16.2	40.2	14.9			258.7
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341

Developmental stage of crop pests.—Except in the Sanaga Maritime (12%), Valley of Ntem (7.9%), and High Nyong (3%) divisions, the most frequent pest grasshopper stages reported by respondents were both adults and nymphs (Fig. 3C). However, a few respondents in the Nyong and Kelle division reported that grasshoppers were only harmful during the nymphal stage (6.5%).

Crops cited as most often damaged by pest grasshoppers.—The crops most cited by the respondents as affected by pest grasshoppers were cassava (*Manihot esculenta* Crantz, 1766) (60.1%), corn (*Zea mays* L., 1753) (58.1%), groundnut (*Arachis hypogaea* L., 1753) (35.5%), and okra (*Abelmoschus esculentus* (L.) Moench, 1794) (27.9%) (Table 5). Less cited were green vegetable (15.5%), cucumber (*Cucumis sativus* L., 1753) (9.1%), sweet potato (*Ipomoea batatas* (L.) Lam., 1793) (7.3%), bean (*Phaseolus vulgaris* L., 1753) (6.2%), macabo-cocoyam (*Xanthosoma sagittifolium* (L.) Schott, 1832) (5.3%), and bitter leaf (*Vernonia amygdalina* Delile) (2.3%). No other crops were cited.

Impact of pests on crops productivity.—Cassava was most cited (32.3%) as suffering high losses (75–100%) due to pest grasshoppers, followed by corn (12.6%), green vegetable (12.3%), and groundnut (8.2%) (Fig. 4). The loss of 50–75% of crops was most cited in the same plants, while a loss of about 25–50% was more often reported in corn (29.3%) than in cassava (14.7%). High levels of damage (75–100%) were rarely reported for cucumber (3%), macabo-cocoyam (3%), and bitter leaf (1.2%).

Methods known and used to control pest grasshoppers.—The conventional grasshopper control methods cited by respondents were insecticides, weeding, picking by hand, and the use of improved seeds (Table 6). Insecticides were the most cited (52.5%), but many thought they were little used due to their high cost. Weeding (4.5%) and picking (13.5%) grasshoppers by hand were less cited but most used by the villagers. Improved seeds were rarely cited (0.6%), and biological methods were not cited at all. Among the traditional methods, the most cited and used by the villagers was spreading ash (18.8%), smoke (7.9%), or litter (2.3%) on crops. Other traditional methods were rarely mentioned or used.

Efficiencies of the methods used to control pest grasshoppers.—Insecticides were considered to be most effective in removing grass-

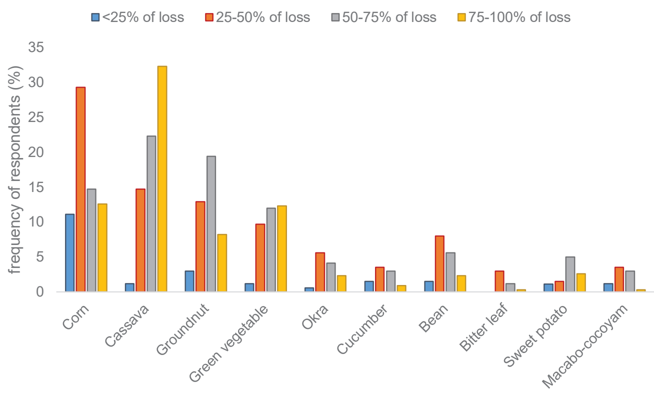

Fig. 4. Impact of pest activities on the productivity of crops.

hoppers, with 26.7% of respondents saying that insecticides can remove 75–100% of the grasshoppers in crop fields, although 1.5% said they were not very effective, removing less than 25% (Fig. 5). Weeding and picking grasshoppers by hand seems to be less effective, as such methods were claimed only by 2.1% and 8.2% of the people, respectively, to remove 25–50% of the grasshoppers in the crops. Improved seeds were rarely used (0.3%) but, according to the villagers, they guarantee an efficiency of up to 75–100%. A few people (0.9–3.8%) expressed a belief that the use of smoke can remove up to 50–100% of pest grasshoppers in the crop fields, but some (1.5–2.1%) purported it to have less efficiency. A slightly higher proportion (2.3–10.6%) of respondents said ash can efficiently (25–75%) control pest grasshoppers in crop fields. Other traditional methods of control were rarely mentioned and cited as having an efficiency less than 50%.

Table 5. Crops cited by local people as damaged by pest grasshoppers. Frequency in % (number of respondents); N = size of the sample; *p* value = probability; χ^2 = value of the Kruskal-Wallis test. The letters a, b, c, d, e, and f represent the results of the Mann-Whitney test for two samples in the same column; the same letter indicates non-significant differences between the values.

Crops	Mbam and Inoubou	Mbam and Kim	Mefou and Akono	Nyong and Kelle	Mvilla	Valley of Ntem	Sanaga Maritime	High Nyong	χ^2	*p* value	Total
Corn	67.1(57)a	83.3(25)a	48.5(16)a	90.3(28)a	55.8(34)a	21.1(8)a	50.0(15)a	45.5(15)a	36.2	< 0.001	58.1(198)a
Cassava	81.2(69)b	66.7(20)a	48.5(16)a	71.0(22)ab	73.8(45)b	28.9(11)a	40.0(12)a	30.3(10)ab	44.5	< 0.001	60.1(205)a
Groundnut	43.5(37)c	13.3(4)b	30.3(10)ab	16.1(5)c	59.0(36)a	34.2(13)a	30.0(9)ab	21.2(7)bc	23.5	< 0.001	35.5(121)b
Green vegetables	27.1(23)d	16.7(5)b	3.0(1)c	19.4(6)c	19.7(12)c	0.0(0)b	10.0(3)b	9.1(3)bc	8.8	0.002	15.5(53)c
Okra	20.0(17)de	66.7(20)a	21.2(7)b	48.4(15)bd	31.1(19)c	23.7(9)a	16.7(5)b	9.1(3)bc	24.4	< 0.001	27.9(95)d
Cucumber	12.9(11)e	10.0(3)c	3.0(1)c	0.0(0)e	8.2(5)c	15.8(6)a	3.3(1)c	12.(4)bc	1.8	0.5	9.1(31)e
Bean	5.9(5)ef	3.3(1)d	6.1(2)c	12.9(4)f	9.8(6)c	0.0(0)b	3.3(1)c	6.1(2)c	1.0	0.4	6.2(21)ef
Bitter leaf	3.5(3)f	0.0(0)d	3.0(1)c	0.0(0)e	0.0(0)d	0.0(0)b	0.0(0)c	12.(4)bc	8.7	< 0.001	2.3(8)g
Sweet potato	0.0(0)f	0.0(0)d	6.1(2)c	32.3(10)d	9.8(6)c	0.0(0)b	16.7(5)b	6.1(2)c	1.9	0.02	7.3(25)ef
Macobo-cocoyam	0.0(0)f	0.0(0)d	0.0(0)c	6.5(2)f	19.7(12)c	0.0(0)b	6.7(2)b	6.1(2)c	5.4	< 0.001	5.3(18)f
χ^2	190.4	86.5	29.9	79.8	108.5	19.7	23.8	13.9			437.6
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341

Table 6. Methods for controlling pest grasshoppers cited and used by local people. Frequency in % (number of respondents); N = size of the sample; *p* value = probability; χ^2 = value of the Kruskal-Wallis test. The letters a, b, c, d, and e represent the results of the Mann-Whitney test for two samples in the same column; the same letter indicates non-significant differences between the values.

Methods of control	Mbam and Inoubou	Mbam and Kim	Mefou and Akono	Nyong and Kelle	Mvilla	Valley of Ntem	Sanaga Maritime	High Nyong	χ^2	*p* value	Total
Conventional methods											
Insecticide	69.4(59)a	50.0(15)a	24.2(8)a	29.0(25)a	37.7(23)a	57.8(22)a	46.6(14)a	39.4(13)a	28.8	< 0.001	52.5(179)a
Weeding	7.1(6)b	0.0(0)b	21.2(7)a	3.2(1)b	0.0(0)b	0.0(0)b	0.0(0)b	3.0(1)b	3.9	< 0.001	4.5(15)b
Picking	2.4(2)b	0.0(0)b	42.4(14)b	38.7(12)c	19.7(12)c	7.9(3)b	0.0(0)b	9.1(3)b	21.5	< 0.001	13.5(46)c
Improved seed	2.4(2)b	0.0(0)b	0.0(0)c	0.0(0)b	0.0(0)b	0.0(0)b	0.0(0)b	0.0(0)b	0.1	0.5	0.6(2)d
χ^2	81.1	16.7	8.9	36.3	17.9	26.4	14.6	9.9			173.6
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341
Traditional methods											
Smoke	5.9(5)a	30.0(9)a	3.0(1)	0.0(0)a	3.3(2)	10.5(4)a	13.3(4)a	6.1(2)	6.1	< 0.001	7.9(27)a
Ashes	36.5(31)b	33.3(10)a	3.0(1)	35.5(11)b	1.6(1)	0.0(0)b	20.0(6)a	12.1(4)	25.0	< 0.001	18.8(64)b
Litter	1.2(1)c	13.3(4)a	0.0(0)	0.0(0)a	0.0(0)	0.0(0)b	10.0(3)ab	6.1%(2)	1.9	0.003	2.3(10)c
Paracetamol	1.2(1)c	0.0(0)b	0.0(0)	0.0(0)a	0.0(0)	0.0(0)b	0.0(0)b	0.(0)	0.03	0.9	0.3(1)d
Cow dung	0.0(0)c	0.0(0)b	0.0(0)	0.0(0)a	0.0(0)	0.0(0)b	3.3(1)ab	0.0(0)	0.08	0.3	0.3(1)d
Hot pepper water	0.0(0)c	23.3(7)a	0.0(0)	0.0(0)a	0.0(0)	0.0(0)b	0.0(0)b	0.0(0)	4.5	< 0.001	2.1 (7)ce
Bell sounds	0.0(0)c	0.0(0)b	0.0(0)	6.5(2)c	0.0(0)	0.0(0)b	0.0(0)b	6.1(2)	0.6	0.02	1.2(4)ce
Tobacco leaf water	0.0(0)c	0.0(0)b	0.0(0)	0.0(0)a	0.0(0)	0.0(0)b	0.0(0)b	3.0(1)	0.08	0.2	0.3(1)d
χ^2	28.5	13.3	0.1	10.0	0.2	1.4	3.2	1.3			29.3
p value	< 0.001	< 0.001	0.5	< 0.001	0.2	< 0.001	0.002	0.2			< 0.001
N	85	30	33	31	61	38	30	33			341

Importance of grasshoppers cited by local people

Grasshoppers were reported as used mainly as food (86.8%), but also sold at markets (57.7%), used as fishing bait (13.2%), or to treat diseases (10.9%) (Table 7). Grasshoppers are eaten and commercialized in all the divisions studied, used to treat diseases in five divisions, and as fishing bait in four. A very few respondents mentioned using grasshoppers as a charming medium (1.8%), as being important for ecosystem balance (0.9%), or considered them to be biological control agents against weeds (0.3%) or a pollinator agent (0.3%).

Types of grasshoppers eaten and commercialized.—Zonocerus variegatus and *Oxycatantops spissus* (Fig. 6) were the two grasshopper species most often reported as eaten and sold in the markets (Table 8). Orthopteran species coming from the families Tettigonidae and Gryllidae were also eaten-fried or braised and marketed fresh or fried.

Diseases treated with grasshoppers.—Zonocerus variegatus (Fig. 6A) was cited by the respondents as used to treat a wide variety of diseases including spleen pain, burns, tuberculosis, angina, malaria and several others (Appendix 2). *Atractomorpha acutipennis* (Fig 6C) was crushed to treat disease of the baby's fontanelle and sighting this grasshopper was a sign of luck in hunting, while *Oxycatantops spissus* (Fig 6B) was used in treatment of some diseases and as a charming medium (Appendix 2).

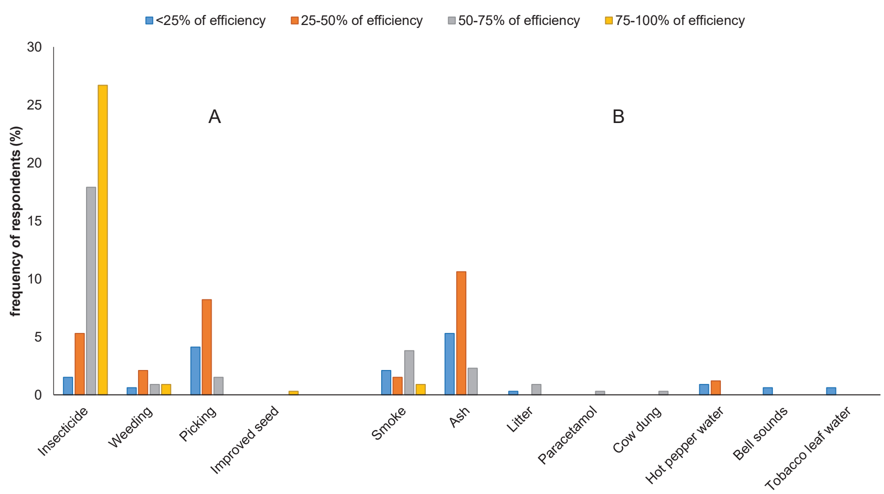

Fig. 5. Efficiency of the methods used to control pest grasshoppers: conventional methods (**A**) and traditional methods (**B**).

Table 7. Importance of grasshoppers cited by local people. Frequency in % (number of respondents); N = size of the sample; *p* value = probability; χ^2 = value of the Kruskal-Wallis test. The letters a, b, c, and d represent the results of the Mann-Whitney test for two samples in the same column; the same letter indicates non-significant differences between the values.

Uses	Mbam and Inoubou	Mbam and Kim	Mefou and Akono	Nyong and Kelle	Mvilla	Valley of Ntem	Sanaga Maritime	High Nyong	χ^2	*p* value	Total
Food	89.4(76)a	100.0(30)a	93.9(31)a	83.8(26)a	95.1(58)a	57.8(22)a	90.0(27)a	78.8(26)a	13.8	< 0.001	86.8(296)a
Commerce	57.6(49)b	76.7(23)b	72.7(24)b	77.4(24)a	32.8(20)b	34.2(13)b	66.7(20)b	72.7(24)a	29.6	< 0.001	57.7(197)b
Treat diseases	17.6(15)c	0.0(0)c	6.1(2)c	32.2(10)b	3.3(2)c	21.1(8)bc	0.0(0)c	0.0(0)b	11.2	< 0.001	10.9(37)c
Charming medium	2.4(2)d	0.0(0)c	0.0(0)c	0.0(0)c	0.0(0)c	10.5(4)bc	0.0(0)c	0.0(0)b	1.2	0.04	1.8(6)d
Fishing bait	16.5(14)c	0.0(0)c	0.0(0)c	0.0(0)c	21.3(13)b	36.8(14)ab	0.0(0)c	12.1(4)c	14.3	< 0.001	13.2(45)c
Pollinator agent	1.2(1)d	0.0(0)c	0.0(0)c	0.0(0)c	0.0(0)c	0.0(0)cd	0.0(0)c	0.0(0)b	0.03	0.9	0.3(1)d
Biological control	1.2(1)d	0.0(0)c	0.0(0)c	0.0(0)c	0.0(0)c	0.0(0)cd	0.0(0)c	0.0(0)b	0.03	0.9	0.3(1)d
Ecosystem balance	0.0(0)d	0.0(0)c	0.0(0)c	0.0(0)c	0.0(0)c	7.9(3)c	0.0(0)c	0.0(0)b	0.6	0.001	0.9(3)d
χ^2	193.3	107.3	102.8	86.9	140.2	33.5	84.9	81.8			764.6
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			< 0.001
N	85	30	33	31	61	38	30	33			341

Table 8. Grasshoppers and other Orthopterans cited by local people as eaten and sold commercially.

Species/Family	Consummation forms	Commercialization forms	Divisions
Zonocerus variegatus	fried or braised	fresh or fried	Mbam and Inoubou, Mvilla, Valley of Ntem, High Nyong, Mefou and Akono, Nyong and Kelle
Oxycatantops spissus	fried or braised	fresh	Mbam and Inoubou
Tettigonidae	fried or braised	fresh or fried	All the divisions
Gryllidae	fried or braised	not sold	Mbam and Inoubou

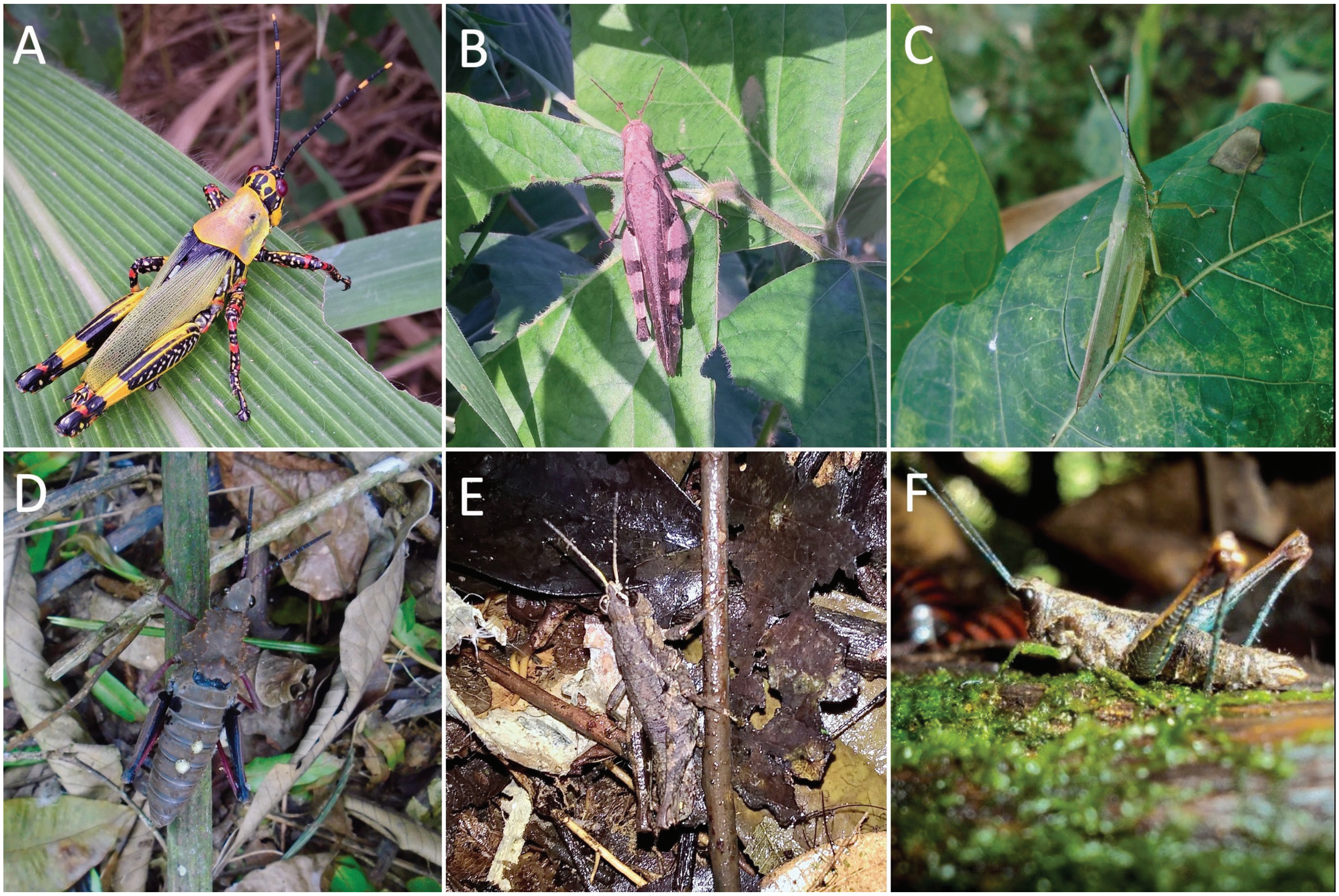

Fig. 6. Some grasshoppers mainly used/cited by local people: *Zonocerus variegatus* (pest of crops, fallowland species, use as food and to treat diseases) (**A**), *Oxycatantops spissus* (pest of crops, fallowland species, use as food and to treat diseases) (**B**), *Atractomorpha acutipennis* (pest of crops, species of forest edge and fallow, use to treat diseases) (**C**), *Parapetasia femorata* (forest species, use as indicator to characterize forest ecosystems) (**D**), *Mazea granulosa* (forest species, use as indicator to characterize forest ecosystems) (**E**), *Gemeneta terrea* (forest species, use as indicator to characterize forest ecosystems) (**F**).

Discussion

Our data allow an assessment of the perception of grasshoppers by local people in Southern Cameroon, particularly in terms of food, health, and landscape conservation. Grasshoppers are known to be herbivore insects common to grassland ecosystems worldwide (Lockwood et al. 2000, Branson et al. 2006). Most of the respondents interviewed (99.7%) thought grasshoppers were found in all landscapes.

Our study shows that the local people understand that the abundance of grasshoppers increases with the degradation or opening of forests: grasshoppers were reported to be rare in pristine forests and abundant in much degraded forests, which is consistent with Badenhausser's (2012) conclusion that abundance increases with environmental degradation. According to Latchininsky (1996), in the ex-USSR, some forest Orthopteran species (especially *Tetrix tartara subacute* Bey-Biento, 1951, *Acrida oxycephala* (Pallas, 1771), *Duroniella gracilis* Uvarov, 1926, *Duroniella kalmyka* (Adelung, 1906), and *Mesasippus kozhevnikovi iliensis* Mistshenko, 1951) become rare after forest degradation; this author noted an increase in grassland species in the degraded areas, especially of *Sphingonotus maculatus* Uvarov, 1925, *Sphingonotus halocnemi* Uvarov, 1925, *Sphingonotus satrapes* Saussure 1884, and *Sphingoderus carinatus* (Saussure, 1888). Hao et al. (2015) suggested that, apart from steppes and deserts, the abundance of grasshoppers was almost the same in other ecosystems. Unlike our work, Joshi et al. (1999) reported that in India, species diversity and richness were higher in less disturbed sites, followed by replanting environments and severely disturbed environments. These differences show that the behavior of grasshoppers related to the opening of the environment depends on the eco-climatic zones and the structure of the vegetation. The changes to ecosystems strongly affect grasshoppers' behavior, as grasshoppers use plants as both food and habitat (Latchininsky et al. 2011, Oumarou Ngoute et al. 2020). The challenge is to predict the potential responses of the grasshoppers, in a given ecosystem, to global environmental change.

The respondents said grasshoppers were present in all climatic seasons, but more abundant during the dry seasons. Kijazi et al. (2013) claimed that indigenous peoples in Nigeria used insect abundance and movement to predict the onset of the dry season, and Joshua and Jürgen (2013) reported that the appearance of the bushcricket *Ruspolia baileyi* Otte, 1997 is known to indicate the dry season in western Uganda. Poubom et al. (2005) and Oladele et al. (2014) recorded the abundant activity of *Z. variegatus* during the dry seasons in Cameroon and Nigeria.

In general, respondents recognized grasshoppers as being both useful and harmful. They reported that all species consume crops, but only *Z. variegatus* was recognized as a pest with economic impact. According to Poubom et al. (2005), the majority of farmers in Cameroon consider insects to be pests, and after the green mite *Mononychellus tanajoa* (Bondar, 1938), it is the stinky grasshopper *Z. variegatus* that is responsible for most of the damage observed on crop leaves, especially during the dry seasons. The farmers in the study said that *Z. variegatus* is a polyphagous pest and that its damage has increased over the past 10 years as forest destruction has increased (Poubom et al. 2005). Oladele et al. (2014) found that in Nigeria, grasshoppers were reported as the main pest followed by beetles and butterflies; the grasshopper *Z. variegatus* is known to be polyphagous in this area and can devastate fields of vegetables during the dry season. In the same country, Okunlola and Ofuya (2010) reported that *Z. variegatus* is the third most frequent crop pest after *Dysdercus superstitiosus* (Fabricius, 1775) (Hemiptera) and *Sylepta derogata* (Fabricius, 1775) (Lepidoptera).

Our data reveal that the villagers felt that insecticides were the most effective method to control pest grasshoppers, but because of the high cost of chemical insecticides, most farmers used weeding and picking by hand; biological and ecological methods were not mentioned. Worldwide, most locust and grasshopper management programs still rely on chemical pesticides (Zhang et al. 2019). Suggested products, pros and cons, and doses are regularly made publicly available by the FAO Pesticide Referee Group (FAO 2014). In recent years, a very remarkable advance has been the use of biopesticides, prepared with the fungus *Metarhizium acridum*, as important components of management programs and with good efficacy (Zhang et al. 2019). However, in our study, traditional methods of grasshopper control were the most used, which is consistent with the results of Joshua and Jürgen (2013), who reported that the majority of African farmers still depended on indigenous pest management approaches. In Nigeria, according to Oladele et al. (2014), 76.7% of farmers use cultural or traditional methods due to the unavailability and high cost of chemical insecticides. In the same country, Okunlola and Ofuya (2010) found that 76% of farmers were aware of indigenous methods for the control of vegetable pests. Our study shows that the most-used traditional methods were spraying smoke and spreading ash and litter on crops. Respondents reported that smoke can be up to 75–100% effective in repelling grasshoppers, but the control of *Z. variegatus* comes down to hand picking and human consumption. Poubom et al. (2005) reported that in most regions of Cameroon, the traditional methods of grasshopper control were manual collection or capture of edible species that provide additional food for families. Some local people in southern Cameroon collect grasshopper species (mainly *Z. variegatus*) as a food source for poultry. Page (1978) recommends plowing to control *Z. variegatus*. When females have laid their eggs in clumps in the soil, plowing brings the eggs to the surface and causes them to dry out. If this practice was adopted by all farmers, populations of *Z. variegatus* may be greatly reduced and damage minimized (Modder 1994). In Uganda, the natives use extracts of natural plants to control crop pests, specifically *Capsicum frutescens* L., 1753, *Tagetes* spp., *Nicotiana tabacum* L. 1753, *Cypressus* spp., *Tephrosia vogelii* Hook.f., 1849, *Azadirachta indica* A.Juss., 1830, *Musa* spp., *Moringa oleifera* Lam., 1785, *Tithonia diversifolia* (Hemsl.) A.Gray, 1883, *Lantana camara* L., 1753, *Phytolacca dodecandra* L'Her., *Vernonia amygdalina* Delile, *Aloe* spp., *Eucalyptus* spp., *Cannabis sativa* L., 1753, *Coffea* sp., and *Carica papaya* L., 1753 (Joshua and Jürgen 2013). Extracts with insecticidal properties come from the roots, stems, leaves, or flowers of these plants; they have a low spectrum of action, are easily usable, and have few residues capable of accumulating in animal or plant tissues. However, many farmers have reported that some botanical formulations take a long time to prepare and are not easy to apply, especially on a large scale (Mugisha-Kamatenesi et al. 2008).

Most of the respondents (85.9%) in our study said grasshoppers are used as food in addition to Tettigonidae and Gryllidae, and the grasshopper species consumed by the local people are *Z. variegatus* and *O. spissus*. Orthoptera species are used as food in many parts of the world, such as Australia, India, South America, and Africa (van Huis 2003, Srivastava et al. 2009, Mitsuhashi 2016, Niassy et al. 2016, Jongema 2017, Tchibozo and Lecoq 2017). Gullan and Cranston (2010) reported that most of the edible insects used worldwide come from a relatively small number of orders, including crickets, grasshoppers, and locusts. According to Riggi et al. (2013), Coleoptera are the most commonly consumed, and Orthoptera are the second group of insects consumed in Africa, specifically grasshoppers such as *Hieroglyphus africanus* Uvarov, 1922, *Acanthacris ruficornis citrina* (Serville, 1838), *Ornithacris cavroisi* (Finot, 1907), locusts [*Locusta migratoria* (Linnaeus, 1758)], and crickets [*Brachytrupes membranaceus* (Drury, 1773)] which have a nutritional quality superior or similar to that of the meat products currently available. Insects as food are not inferior to other sources of protein, such as other animals or plants (Xiaoming et al. 2010). A recent analysis of the nutrient composition of *Z. variegatus* from Nigeria showed high values of protein, crude lipids, and minerals (potassium, sodium, and calcium) (Anaduaka et al. 2021). Our study shows that *Z. variegatus* and *O. spissus* are also sold in the markets. Bronwyn (2013) noted that grasshoppers are eaten and sold in the markets of Dimapur and Kohima, India: the legs, wings, and viscera are removed, and they are fried in oil with ingredients such as onion, bamboo, ginger, and salt. Pemberton and Yamasaki (1995) reported that grasshoppers appear on restaurant menus in Japan.

Zonocerus variegatus, *Atractomorpha acutipennis*, and *Oxycatantops spissus* are used by local people to treat spleen pain, burns, tuberculosis, angina, malaria, stomachaches, and anal tingling. Grasshoppers are considered to have therapeutic value in Australia, India, South America, and Africa (Srivastava et al. 2009). De Conconi and Moreno (1988) reported that most of the insects (such as grasshoppers and locusts) sold in the markets in Mexico are also used as diuretics, analgesics, anesthetics, or aphrodisiacs. The species *Sphenarium* spp., *Taeniopoda* sp., and *Melanoplus* sp. are used to treat kidney diseases and intestinal disorders (the hind legs of grasshoppers are crushed and mixed with water, then drunk as a powerful diuretic). Locusts of the species *Schistocerca* spp. are helpful in cases of postnatal anemia and in pulmonary diseases, asthma, and chronic cough. The legs of the crickets *Acheta domesticus* (Linnaeus, 1758) are crushed and mixed with water and drunk as a diuretic for dropsy edema (De Conconi and Moreno 1988). Lawal and Banjo (2007) reported that the grasshoppers *Z. variegatus* and *Zabalius lineolatus* (Stal, 1873) are used to treat childhood illness and injuries in Nigeria. Some species are involved in the magic and mystical treatment of diseases in Mexico: *Brachytrypes* sp. crickets are used to treat bleeding in women before delivery (De Conconi and Moreno 1988).

All these examples demonstrate that, as in many regions of the world, diverse use is made of grasshoppers in southern Cameroon, whether as a food source, remedies, or as indicators of environmental change. In addition, numerous local solutions (of varying effectiveness) are used to control pest species. It is important to continue to identify, understand, and develop this traditional knowledge as a possible source or at least partial solution to some of the environmental changes currently underway.

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Appendix 1

Grasshoppers recognized by local people in the different landscapes; + indicates species recognized as present by villagers.

Sub-Family	Grasshoppers species	House	Fallow	Crop	Forest	Divisions
Acridinae	*Chirista compta*		+	+		Mbam and Inoubou, Mbam and Kim, Mefou and Akono, Mvilla, Valley of Ntem, Sanaga Maritime
	Gymnobothrus temporalis		+			Mbam and Inoubou, Mefou and Akono, Mvilla, Valley of Ntem
	Odontomelus kamerunensis		+	+	+	Mbam and Inoubou, Mbam and Kim, Mefou and Akono, Nyong and Kelle, Mvilla, Valley of Ntem
Catantopinae	*Abisares viridipennis*		+			Mbam and Inoubou
	Catantops stramineus		+			Nyong and Kelle, Mvilla, Valley of Ntem
	Eupropacris coerulea		+	+	+	Mbam and Inoubou, Mbam and Kim, Mefou and Akono, Nyong and Kelle, Mvilla, Valley of Ntem
	Gemeneta terrea				+	Mbam and Kim, Mefou and Akono, Mvilla
	Mazea granulosa				+	Mbam and Kim, Mefou and Akono, Mvilla, Valley of Ntem

Sub-Familly	Grasshoppers species	House	Fallow	Crop	Forest	Divisions
Catantopinae	*Oxycatantops spissus*		+	+		Mbam and Inoubou, Mbam and Kim, Mefou and Akono, Nyong and Kelle, Mvilla, Valley of Ntem, Sanaga Maritime
	Pteropera balakoswki		+		+	Mbam and Inoubou, Mefou and Akono, Valley of Ntem
	Pteropera mirei		+		+	Mbam and Inoubou, Mefou and Akono, Mvilla
Coptacrinae	*Cyphocerastis tristis*		+	+	+	Mbam and Inoubou, Mbam and Kim, High Nyong
	Eucoptacra anguliflava	+	+	+	+	Mbam and Inoubou, Mvilla
Cyrtacantacridinae	*Acanthacris ruficornis*		+	+		Mbam and Kim, Mvilla
Spathosterninae	*Spathosternum pygmaeum*	+	+			Mbam and Inoubou, Mbam and Kim, Mvilla, Valley of Ntem
Oedipodinae	*Heteropternis thoracica*	+	+	+		Mbam and Inoubou, Mbam and Kim, Mvilla, Valley of Ntem
Pyrgomorphinae	*Atractomorpha acutipennis*	+	+	+	+	Mbam and Inoubou, Mbam and Kim, Mefou and Akono, Nyong and Kelle, Mvilla, Valley of Ntem, High Nyong, Sanaga Maritime
	Dictyophorus karschi				+	Mvilla, Valley of Ntem, Mbam and Kim
	Parapetasia femorata				+	Mbam and Inoubou, Mbam and Kim, Mefou and Akono, Nyong and Kelle, Mvilla, Valley of Ntem, High Nyong
	Pyrgomorpha vignaudii	+	+	+		Mbam and Inoubou, Mbam and Kim, Mvilla, Valley of Ntem, Sanaga Maritime
	Taphronota ***ferruginea***		+	+		Mefou and Akono, Mvilla, Valley of Ntem
	Zonocerus variegatus		+	+		Mbam and Inoubou, Mbam and Kim, Mefou and Akono, Nyong and Kelle, Mvilla, Valley of Ntem, High Nyong, Sanaga Maritime
Tropidopolinae	*Afroxyrrhepes obscuripes*		+			Mbam and Inoubou

Appendix 2

Diseases cited by local people as treated using grasshoppers.

Grasshoppers species	Diseases/cultural uses	Preparation	Posology	Divisions
Zonocerus variegatus	Spleen pain	Crush the grasshopper and extract its oil	Scarify the patient with spines of the grasshopper's legs and rub oil extracted	Mbam and Inoubou, Mvilla
	Spleen pain	Remove head and viscera of the grasshopper, wash with boiling water, and cook in cucumber dishes	Eat in three days	Mbam and Inoubou
	Spleen pain	Crush the grasshopper and mix with water	Purge the patient with the solution	Valley of Ntem
	Scabies and burns	Crush the grasshopper and mix with red palm oil	Rub on the scabies or burns	Valley of Ntem
	Belly swollen of children	Remove head and viscera of the grasshopper, wash with boiling water, fry, and mix with red palm oil	Eat once daily until disease regression	Mbam and Inoubou
	Tuberculosis	Remove head and viscera of the grasshopper, wash with boiling water, and cook in cucumber dishes	Eat daily until disease regression	Mbam and Inoubou
	Angina	Crush the head and viscera grasshopper and mix with "the king of grass" Algeratum conizoides	Rub on the throat every day during illness	Mvilla
	Malaria	Put the grasshopper on the child so the child is stung by its spines		High Nyong
	Burn	Burn and crush the grasshopper and mix it with a little water	Rub on the wound	Mefou and Akono
	Anal itching of children of 2 to 3 years old	Crush head and viscera of the grasshopper and mix with "the king of grass" Algeratum conizoides	Purge the patient with the solution	Nyong and Kelle
	Anal itching of children of 2 to 3 years	Sting three times the anus of child with the spines of grasshopper		Nyong and Kelle
Atractomorpha acutipennis	« abobo » disease of the baby's fontanelle	Crush grasshoppers	Rub on the fontanelle	Valley of Ntem
	luck		Viewed in the forest by a hunter reflects a successful hunt	Mefou and Akono
Oxycatantops spissus	Burns and painful menstruation of women	Remove head and viscera of the grasshopper, wash with boiling water, and cook in dishes or cucumber sauces	Eat during the period of menstruation	Mbam and Inoubou
	Spleen pain	Scarify the child at the hip with the spines of grasshopper's legs		Mvilla
	Charming medium	Remove grasshopper viscera and cook it with smoked freshwater fish in cucumber dishes	Give food only to the person you want to charm	Mbam and Kim

Supplementary material 1

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Data type: Survey sheet
Explanation note: Grasshoppers Survey sheet. This survey sheet was used in the villages to collect informations about grasshoppers.

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