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Bioecology of the panicle-feeding bug *Eurystylus oldi* Poppius (Heteroptera: Miridae), a key pest of sorghum in Mali

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Abstract — Panicle-feeding mirid bugs, particularly *Eurystylus oldi* Poppius have recently become major pests of sorghum in West and Central Africa. Detailed studies on the bioecology and population dynamics of this species were conducted in 1991-1996 in Mali. In particular these studies have shown several significant correlations ($P < 0.001$) between the peak head bug number and weather variables. Castor (*Ricinus communis* L. Euphorbiaceae) was the only indigenous plant species found to harbor eggs and nymphs of *E. oldi* in the Samanko area, including during the dry season. Further laboratory studies demonstrated the ability of adult insects originating from nymphs bred from sorghum to oviposit on castor, and that of nymphs to develop equally well on castor and sorghum. Several potential predators of head bugs were collected on sorghum panicles, of which three species of assassin bugs (Heteroptera: Reduviidae) were actually observed feeding on *E. oldi* nymphs. Information on weak links in the bioecology of the pest, derived from these findings, including its interactions with the cultivated host plant, alternate hosts, natural enemies, environmental factors, is discussed, in view of developing effective control strategies. Other research areas that need to be investigated are proposed. These include a regional study of weather/head bug/grain mold interaction, and detailed on-farm head bug studies.

Résumé — Bioécologie de la punaise des panicules *Eurystylus oldi* Poppius (Heteroptera: Miridae), un ravageur-clé du sorgho au Mali. Les punaises mirides des panicules, particulièrement *Eurystylus oldi* Poppius, sont récemment devenues des ravageurs-clés du sorgho en Afrique de l'Ouest et du Centre. Des études détaillées sur la bioécologie de l'espèce et la dynamique des populations ont été conduites de 1991 à 1996 au Mali. Les résultats de ces recherches ont permis, entre autres, d'établir plusieurs corrélations significatives ($P < 0,001$) entre les nombres maximaux de punaises et les paramètres climatiques. Parmi toutes les plantes sauvages examinées, seul le ricin (*Ricinus communis* L.-Euphorbiaceae) abrite des œufs et des larves de *E. oldi* dans la région de Samanko, y compris durant une partie de la saison sèche. D'autres études de laboratoire ont montré que des adultes issus de larves élevées sur sorgho pouvaient pondre sur ricin, et que les larves issues de ces œufs se développaient aussi bien sur le ricin que sur le sorgho. Plusieurs prédateurs potentiels des punaises ont été rencontrés sur panicules de sorgho, dont trois espèces de réduves se nourrissant sur des larves de *E. oldi*. Les informations sur les points faibles dans la bioécologie du ravageur fournies par ces recherches, les interactions avec la plante hôte cultivée, les hôtes alternatifs, les ennemis naturels, les facteurs environnementaux sont discutés, en vue de développer des stratégies de lutte efficaces. D'autres domaines de recherche sont proposés, notamment une étude régionale sur les interactions entre climat, punaises et moisissures des grains, et des études détaillées sur l'incidence des punaises en milieu réel.

Panicle-feeding bugs, particularly especies, have recently become major pests of sorghum in West and Central Africa, particularly in Mali (Ratnadass and Ajayi, 1995), where this cereal is the staple food crop. Feeding and oviposition of these mirids on maturing sorghum grains result in severe quantitative and qualitative losses, including higher grain mold incidence, particularly on improved compact-headed types (Doumbia and Bonzi, 1985; Steck *et al.*, 1989; Ratnadass *et al.*, 1994a; Ratnadass *et al.*, 1995a). The genus *Eurystylus* was recently revised by Stonedahl (1995), and it is now recognized that only one dominant species, namely *Eurystylus oldi* Poppius, is associated with sorghum in Africa.

Some information on *E. oldi* bioecology was available from earlier reports (MacFarlane, 1989; Steck *et al.*, 1989; Sharma, 1989; Doumbia, 1992; Doumbia and Teetes, 1994). However, in order to further improve our knowledge of this pest, in view of its increasing importance, the present studies were conducted in 1991-1996 in Mali, as a prelude to its management. Information on weak links in the bioecology of an insect pest, including its interactions with the cultivated host plant, alternate hosts, natural enemies, environmental factors, is necessary for developing effective control strategies.

Life history of *E. oldi*

Detailed studies on life history and immature stages of the sorghum head bug *E. oldi* were carried out in the laboratory of the Icrisat-Cirad research station at Samanko (08.07° N 12.32° W), Mali, under natural photoperiod and controlled temperature and relative humidity, from November 1991-March 1992 (25 ± 2°C; 80 ± 10 % r.h.) and from January-April 1993 (27 ± 1°C and 67 ± 10 % r.h.) (Ratnadass *et al.*, 1994b).

Insect cultures were started from adults and nymphs of *E. oldi,* collected at the end of the rainy season, from sorghum panicles in the fields of the station. Panicles at the milk stage of caudatum sorghum varieties, from rainy season or irrigated off-season plots, were used for these studies. These panicles had been protected from insect infestation with pollinating bags at the heading stage.

One pair of newly emerged adults was confined on fresh sorghum rachis with four to six sprigs, held in an upright position in a glass vial filled with water. This was held in a 1.25 l transparent plastic container with mesh-covered perforations to provide aeration. Sorghum rachis were changed daily, and observed under the microscope for egg counts and hatching records. Freshly emerged first instar nymphs were transferred individually in 0.25 l plastic containers where fresh sorghum sprigs, with the base wrapped in wet cotton wool covered with parafilm, were provided for feeding. Food was changed every second day; containers were observed daily, in order to record all molts.

In October 1993, further studies were conducted in the field at Samanko (mean temperature 28.6°C; mean relative humidity 71.4%). One panicle of head bug susceptible sorghum cultivar Icsv 197, protected with a pollinating bag at the heading stage, was confined for one day with 20 days in its cage in the field, then cut and kept in an aerated plastic container in the laboratory; hatching was recorded daily, for a period of three days. Two protected panicles of the same cultivar were then caged 9 days after completion of anthesis with 14 first instar nymphs each. The panicles were cut 6 days later and kept in aerated plastic containers in the laboratory; adult emergence was recorded daily, for a period of 4 days. Laboratory conditions during these studies were: 27 ± 2°C; 88 ± 6% r.h.; natural photoperiod.

Eggs were laid inside the maturing sorghum grains (then at the milk stage), on the part exposed outside the glumes; eggs were detectable by their protruding tip (*operculum*). The number of eggs laid in a single grain varied from 1 to 7. The egg incubation period was 4-7 days. Nymphs pushed the *operculum* to come out of the egg. There were five nymphal instars, and the total nymphal period was 6-11 days. The durations of first, second, third, fourth and fifth nymphal instars were 1-3, 1-2, 1-2, 1-3 and 1-3 days, respectively (Ratnadass *et al.*, 1994b).

In 1991, nymphal survival until adult was 81 ± 5%. Sex ratio was 1:1. Pre-oviposition period was 2-3 days in 1992 and 1993. In 1992, maximum longevity observed for a mated female was 18 days, during which 181 live nymphs were produced. In 1993, mean adult longevity was 13.5 ± 7.3 days for mated males (maximum 26 days), and 7.6 ± 3.5 days for mated females (maximum 11 days). Mean number of live progeny for five mated females was 80.4 ± 56.3 (Ratnadass *et al.*, 1995b).

Population dynamics of *E. oldi* on sorghum

During the rainy seasons from 1992-1994, head bug population dynamics were studied at Samanko, on sorghum cultivar Icsv 197, sown on eight different dates (Dos) at weekly intervals, from mid-June to early August, in a randomized complete block design (Rcbd) with six replications per Dos. Twice a week, from flowering to grain maturity, three panicles per plot were sampled. Each head was first covered with a polythene bag and then excised at the peduncle. The bag and its content were kept in a deep freezer for at least one day to kill the insects, which were then sorted and counted in the laboratory (Ratnadass *et al.*, 1994c; Ratnadass *et al.*, 1995b).

E. oldi was the dominant mirid species during the study period. Counts of *E. oldi* generally rose and fell between 70 and 120 days after sowing (Das). On Dos 1 in 1992-1994, the first adults of *E. oldi* were observed in early September, towards the end of anthesis, and this colonization by first generation adults continued over a period of more than 2 weeks, the level of infestation remaining low (less than 10 per panicle).

The first nymphs were observed one week after complete anthesis, at the milk stage of the grain, and peaked 3 weeks later, at the hard dough stage of the grain, with more than 40 nymphs per panicle on average. This peak in nymphal population coincided with a second peak in adult infestation (about 10 per panicle).

Adults of the second generation left the panicles of Dos 1 on which they had developed and moved onto panicles of other later maturing Dos, as they developed through vulnerable stages. In all 3 years, there was a peak in adult infestation at the milk stage of the grain (the most attractive); egg-laying was then probably maximum, which resulted in a peak in nymphal population at the dough stage. In all cases, only one generation developed on a particular panicle (figure 1). Over the staggered/extended panicle flowering/maturing period (7-8 weeks) as achieved in these trials (which is not a situation commonly found in farmers' fields) there were three succeeding generations each year (Ratnadass *et al.,* 1994c; Ratnadass *et al.,* 1995b).

Alternate hosts of *E. oldi*

A search for indigenous host plants of sorghum head bugs was carried out at the Samanko Icrisat-Cirad station and in the surrounding villages and fields, during the dry seasons from 1991-1996 (Ratnadass *et al.,* 1997). Castor (*Ricinus communis* L. - Euphorbiaceae) was the only indigenous plant species found to harbour immature stages of *E. oldi.* Eggs and all nymphal instars were found on inflorescences of castor up to February, along the banks of the Samanko river (1 km north of the Icrisat-Cirad station), and in the villages of Samanko (about 1 km west), Samanko-Sodjéni (1 km south) and Nafadji (about 20 km southwest).

Eggs were inserted into the rachis and green capsules of castor spikes, and nymphs fed mainly on young flower parts, notably male buds. An average of 19 ± 1.0 and 18 ± 1.6 of nymphs and adults were recovered from flowering castor spikes, collected respectively in early December 1995 and early January 1996 at Nafadji.

Oviposition, incubation and nymphal development studies were also carried out at Samanko from 15 January to 5 February 1996 (laboratory conditions: temperature 25 ± 1°C; relative humidity 80 ± 10%; natural photoperiod: daylength 11:20-11:31). Adults of *E. oldi* reared from sorghum panicles (cultivar Mr 906) were confined to four fresh inflorescences of castor placed individually in 1.25 l aerated transparent plastic containers.

Castor spikes were changed every day, and egg hatching was recorded. Groups of 15-20 newly emerged first instar nymphs were transferred onto five fresh castor spikes and five sorghum panicles (cv. Mr 906), and placed individually in plastic containers. Food was replaced as it dried, and containers were observed daily to record adult emergence.

In the laboratory, the incubation period of *E. oldi* on castor was 6.1 ± 0.4 days (mean of four castor spikes with 48-65 hatchings on each). The duration of the nymphal development was 10.4 ± 1.1 for males and 10.0 ± 0.5 for females on castor, compared with 10.5 ± 1.1 and 10.1 ± 0.1 on sorghum. The mean sex ratio was 1:1 on both hosts (Ratnadass *et al.,* 1997).

In 1996, population dynamics of *E. oldi* were monitored on both sorghum and castor, as part of an "insect reserve" trial, which had been conducted at Samanko since 1993 (Maïga, 1993). While first adults were observed in early August on castor spikes on the

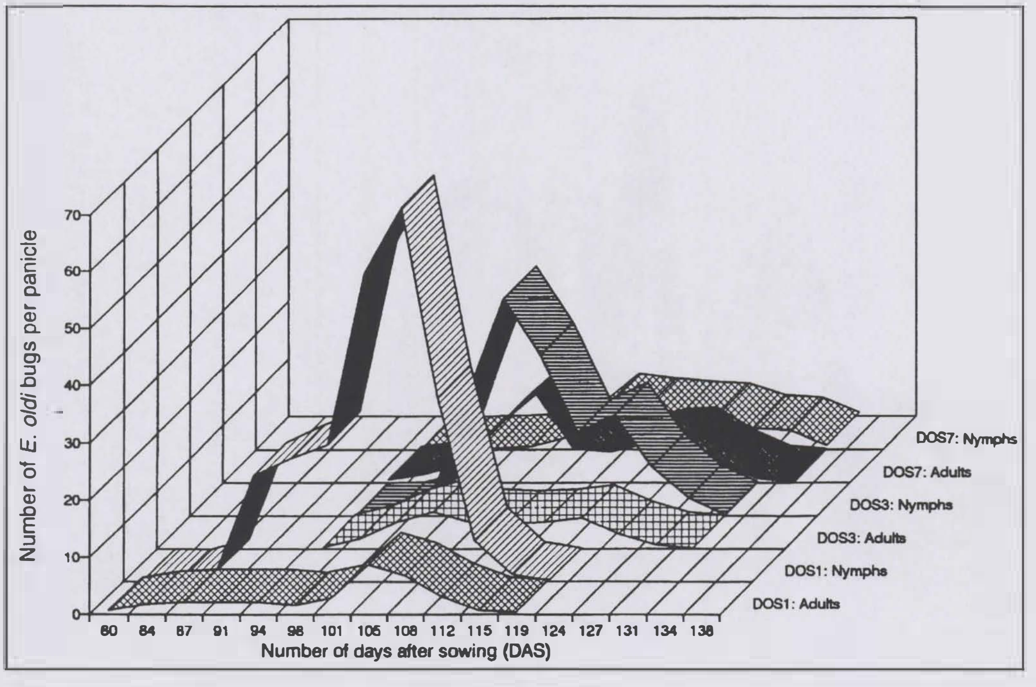

Figure 1. *E. oldi population dynamics on sorghum cv. Icsv 197 (Samanko, means 1992-1994).*

Samanko river banks, one generation developed on castor planted on the station in late August-September, before sorghum was infested (which occurred in late September). Only one generation developed on sorghum, then 2-3 more developed on castor spikes in November-December (figure 2).

On the other plots of the "insect reserve" (fallow, cotton and groundnut crops), only a few adults of *E. oldi* were found, around the peak of abundance on sorghum. These probably came from neighboring castor and sorghum plants. On castor, there was a first peak in adult population in late August, followed by a peak in nymphal population in early September, then a second peak in adult population, which coincided with a first peak in adult population on sorghum, in mid-October. Adults of another *Eurystylus* species, namely *Eurystylus antennatus* Odhiambo, first identified on sorghum at Samanko in 1995, were also found in 1996 on the groundnut and fallow plots of the insect reserve, at par with *E. oldi.*

Factors affecting the bioecology of *E. oldi*

Climate

To search for empirical relationships between weather and plant diseases, Coakley *et al.,* (1988) described a computer program called "Window". This carries out numerous correlations studies between individual weather factors, averaged or accumulated over different windows of time, throughout the crop growing season. An analysis using Window was carried out in 1995 for sorghum head bugs, using data from the above-reported population dynamics trial. As this trial was repeated in 3 consecutive years with 8 different Dos each year, by treating each different Dos as a separate data set, 24 "growing seasons" were compared (Butler, 1996).

Several significant correlations ($P < 0.001$) were found between the peak head bug number and weather variables. There were positive correlations with the average minimum temperature from 91 to 115 days after sowing (Das) (figure 3a, $r = 0.66$), and with the average minimum relative humidity from 66 to 70 Das (figure 3b, r = 0,66) (Butler, 1996). On the other hand, a negative correlation was found with the average maximum temperature from 46 to 55 Das ($r = -0.67$), and a positive one with the average temperature range (maximum minus minimum) from 1 to 5 Das ($r = 0.68$).

Natural enemies

A qualitative inventory of arthropodan predators associated with *E. oldi*-infested panicles was carried out from 1991-1996 on the Samanko station. Randomly selected panicles from complete anthesis to maturity were visually observed, then introduced into polyethylene bags and vigorously shaken so as to dislodge all insects present, which were then sorted in the laboratory. When immature stages of predatory bugs were collected, they were reared in the laboratory, providing them nymphs of *E. oldi* as preys (Ratnadass *et al.,* 1996). Part of this inventory done on the sorghum plots of the above-mentioned "insect reserve" trial carried out from 1993-1996.

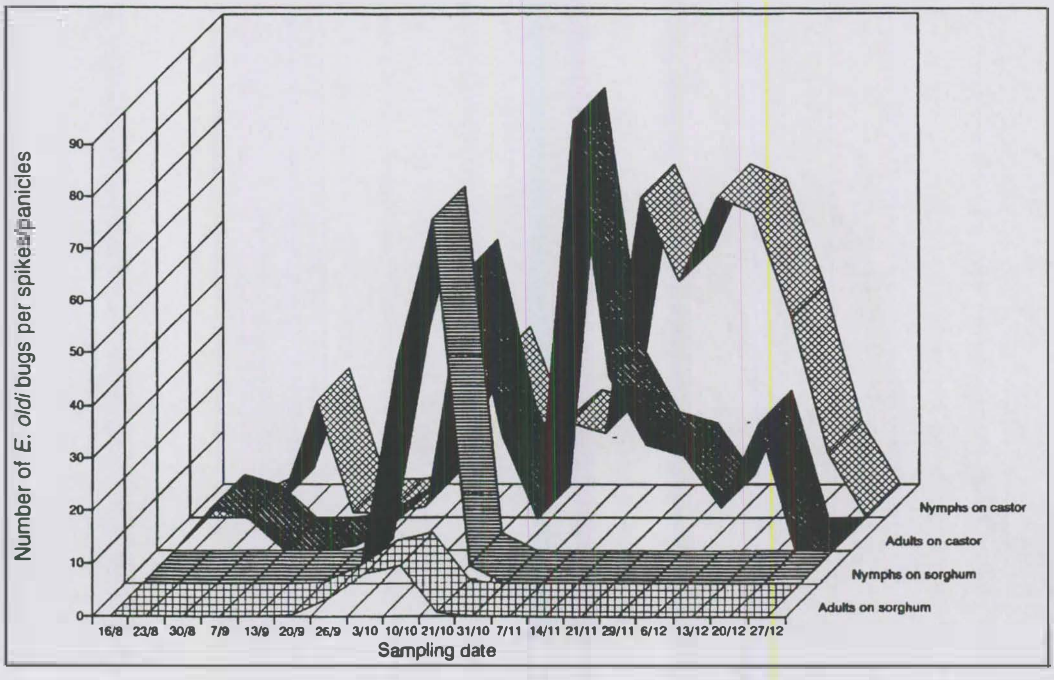

Figure 2. *E. oldi population dynamics on sorghum cv. Icsv 1063 and castor (Samanko, 1996).*

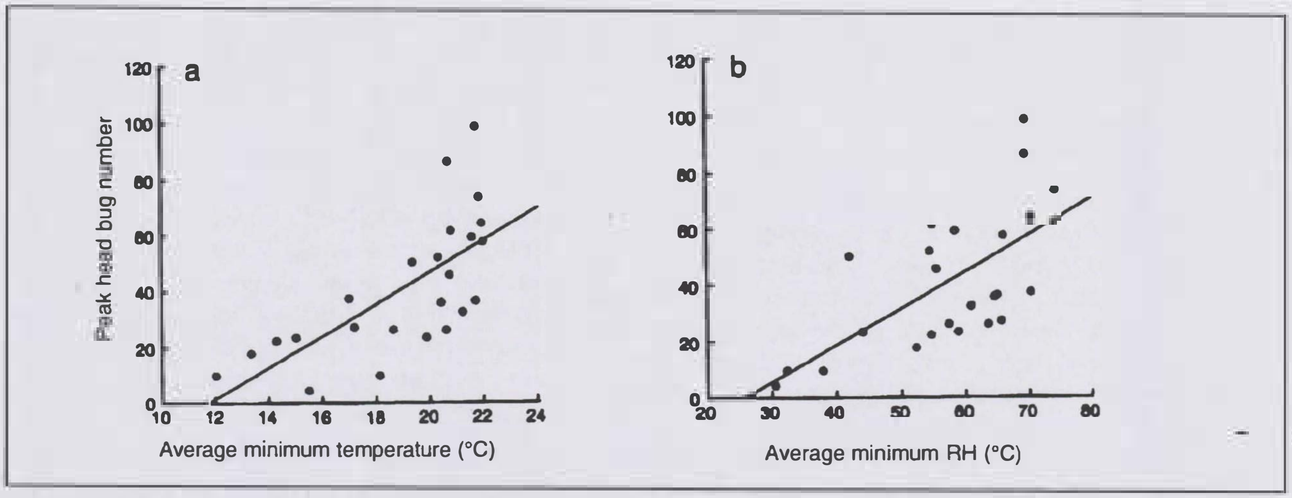

Figure 3. Relationships between different weather variables and peak head bug numbers. The weather variables were averaged over different time periods (windows) during the crop growing season (a = minimum temperature from 91 to 115 Das; b = minimum relative humidity from 66 to 70 Das).

Of the potential predators of head bugs that have been reported before (MacFarlane, 1989, Steck *et al.*,1989, Sharma, 1989), we found on *E. oldi*-infested sorghum panicles a number of spiders, two earwigs species, namely *Forficula senegalensis* Serville and *Diaperasticus erythrocephalus* (Olivier) (Dermaptera: Forficulidae) and several Heteropteran predators, a list of which is provided in table I. *Orius* sp. was abundant at the time of anthesis. It is known as a predator of the sorghum midge *Stenodiplosis sorghicola* (Coquillett) (Diptera: Cecidomyidae), but could also predate on the first instars of *E. oldi* (MacFarlane, 1989). *Orius* sp. was also present on *E. oldi*-infested castor spikes.

Table I. List of predatory heteropteran bugs collected on sorghum panicles infested by *E. oldi* (Samanko, 1994-1996).

Family	Genus/species
Anthocoridae	*Orius* sp.
Reduviidae	*Cosmolestes pictus* (Klug)
	Pseudophonoctonus paludatus (Distant)
	Phonergates guitati Villiers
	Rhynocoris ? albopilosus (Signoret)
	Rhynocoris segmentarius (Germar)

Rhynocoris segmentarius was the most commonly found Reduviid species. Although it has been known for long as a predator of several species of Heteropteran pests (Risbec, 1950), we did not observe it feeding on *E. oldi*. All the same for *Phonergates guitati,* which should therefore also be considered at this stage only as a potential predator of *E. oldi*. On the other hand, a *Cosmolestes pictus* adult was observed on a sorghum panicle, feeding on a third instar nymph of *E. oldi* (Ratnadass and Cissé, 1996). Total nymphal periods of *Pseudophonoctonus paludatus* and *Rhynocoris* sp. ? (*albopilosus*), whose ootheca had been found on sorghum panicles, were respectively 45.3 ± 2.5 days (4 insects evaluated), and 71.4 ± 9.9 days (7 insects evaluated).

Discussion

Several key aspects of the bioecology of *E. oldi* were studied, reported and elucidated for the first time during these studies. For instance, although Schouteden (1937) and Risbec (1950) reported *E. oldi* from castor in Zaïre and Senegal, respectively, results from our studies were the first to suggest that castor could serve as an alternate host for *E. oldi* in West Africa, and at least partly explain its off-season carry-over, and sorghum reinfestation. Other surveys conducted in Nigeria, Cameroon and Chad, provided a list of several plant species harboring *E. oldi,* including during the dry season, but only at the adult stage, and no evidence was provided that the pest could complete its full cycle on them (Ajayi and Ajiboye, in press).

In the vicinity of Bamako in Mali, castor occurs on river banks, and in almost every village. It is a tall, multi-branched perennial that flowers over a long period (year-round in some cases). It is unclear whether the main source of population carry-over of *E. oldi* can be explained by several cycles of the pest being completed on an alternate host such *R. communis,* or whether the insect undergoes embryonic diapause in the tissues of the alternate host, as was suggested by Steck *et al.,* (1989). As a matter of fact, it is not known what are the state and activity of *E. oldi* from March-July, since the pest was never caught in light-traps, even at the peak of its abundance at the end of the rainy season (Sylla, 1995). Due to adverse climatic conditions, it could also, though not diapausing, survive at population levels and activity rates too low to detect.

Our laboratory studies demonstrated the ability of adult insects originating from nymphs bred from sorghum to oviposit on castor, and that of nymphs to develop equally well on castor and sorghum. These observations will contribute to the integrated control of mirid head bugs as sorghum pests. Priority should be given to interruption of the infestation cycle passing through castor. This could be achieved by eliminating castor spikes or spraying them with insecticides before sorghum flowering, since infestation appears to originate from a small number of localized plants. However, there is a need to search for other potential alternative hosts, as castor could only be one of those.

While the climatic factors occurring 46 to 70 Das may affect head bug populations which are on castor, those (temperature range) occuring 7 weeks before could be just spurious. Generally speaking, even if correlations calculated using the Window software (Butler, 1996) should not be used to indicate cause and effect, they are valuable, however, for indicating times when a variable may be affecting head bugs. For instance, based on assumptions made by Steck *et al.,* (1989), some of the factors prevailing before head bug occurrence on castor spikes and sorghum panicles, could also trigger the termination of diapause in the eggs inserted in alternate host(s). This could be tested experimentally.

As for other correlations derived from our population dynamics studies, they can result in recommendations in terms of cultural practices, such as sowing dates. In our studies we found two major peaks of head bug populations, like Doumbia and Teetes (1994). However, we went further in establishing that they corresponded to three generations of the pest.

No parasite or parasitoid of *E. oldi* has been recorded so far. As for its predators, although sorghum has little scope for biological control through augmentation in West and Central Africa, their conservation should be a constant concern, although their actual impact on head bug populations has not been documented. In view of the effect of host plant genotype, which has been well documented in the case of sorghum and head bugs, there could be a scope for studying tritrophic interactions (namely sorghum-head bugs-predators).

Some other aspects still need to be documented, such the interaction between bug damage and grain mold infection. In the case of the Regional sorghum head bug and grain mold trial that was conducted for the first time in 1996 in 15 research stations distributed over 11 countries of the region, under the auspices of the West and Central Africa Sorghum Research Network (Wcasrn), multilocational testing, made it possible to expose cultivars to a range of situations in terms of biotic and abiotic environments. The preliminary results further confirm those obtained in 1991 in Mali on sorghum cultivar Icsv 1002 (Intsormil, 1993, Ratnadass *et al.,* 1995), that grain mold infection is positively and significantly correlated to head bug damage, and that panicle protection from bugs alone with insecticide application, results in a reduction in grain mold infection comparable to that observed for head bug damage (unpublished data).

Such a trial constitutes an ideal way of regional collaboration, as it makes pest resistance sources available to interested scientists in Wcasrn member Nars, for use in national breeding programs, while providing the Icrisat-Cirad team involved in the coordination of the trial, information on the spectrum and stability of the resistances identified, as well as on variability in insect pest populations at different sites. These strategic results obtained through regional cooperation, would then be jointly published and thus be made available to all interested individuals or institutions.

On the other hand, head-bug population dynamics studies need also to be conducted on-farm, to determine whether infestations level as dramatic as those observed on research stations are likely to occur in case of extension and cultivation of improved cultivars in large stands. Preliminary studies carried out in the Kolokani area (North of Bamako) suggest that sort of a "dilution effect" might be at work, namely that hybrids and improved varieties cultivated in large plots are much less heavily infested by bugs than when cultivated in small plots (Somporo, 1995, Massa, 1996).

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References

AJAYI O., AJIBOYE T.O., in press. Non crop plant hosts of the sorghum head bug, *Eurystylus oldi* Poppius in Cameroon, Chad and Nigeria. International Sorghum and Millets Newsletter 38.

BUTLER D.R., 1996. Microenvironment studies: their Role in Crop Protection Research. *In* Sorghum-perspectives of a global research agenda. Icrisat Sorghum projects consultative group meeting, 11-14 December 1995, Icrisat Western and Central Africa Region, Bamako, Mali (NWANZE K.F., BANDYOPADHYAY R., eds). Patancheru, India, Icrisat, p. 97-105.

COAKLEY S.M., MCDANIEL L.R., LINE R.F., 1988. Quantifying how climatic factors affect variation in plant disease severity: a general method using a new way to analyze meteorological data. Climate Change 12: 157-175.

DOUMBIA Y.O., 1992. Connaissances actuelles sur la punaise de la panicule du sorgho au Mali : *Eurystylus marginatus* Odhiambo (Hemiptera, Miridae). *In* La lutte intégrée contre les ennemis des cultures vivrières dans le Sahel. Actes du deuxième séminaire sur la lutte intégrée contre les ennemis des cultures vivrières dans le Sahel, 4-9 janvier 1990, Bamako, Mali (Institut du Sahel éd.). Bamako, Mali, Insah, p. 127-132.

DOUMBIA Y.O., BONZI S.M., 1985. Note sur les problèmes des insectes des panicules du sorgho au Mali. *In* Proceedings of the West African Regional Sorghum Network Workshop, 21-24 October 1985, Bamako, Mali. Ouagadougou, Burkina Faso, Safgrad, p. 173-182.

DOUMBIA Y.O., TEETES G.L., 1994. Distribution, dégâts et dynamique des populations d'*Eurystylus marginatus* (Heteroptera, Miridae), ravageurs du sorgho au Mali. *In* Progress in Food Grain Research and Production in Semi-Arid Africa: Proceedings of the Safgrad Inter-Network Conference, 7-14 March 1991. Palais des congrès, Niamey, Niger (MENYONGA, J.M., BEZUNEH T., YAYOCK J.Y., SOUMANA I., Eds). Ouagadougou, Burkina Faso, Safgrad, p. 321-331.

INTSORMIL, 1992. Grain Sorghum/Pearl Millet Collaborative Research Support Program (Crsp) Annual Report 1991. Lincoln, Nebraska, USA, University of Nebraska, 241 p.

MacFARLANE J., 1989. The hemipterous insects and spiders of sorghum in Northern Nigeria. Insect Science and its Application 10: 277-284.

MAIGA H.M., 1993. Inventaire systématique des insectes associés à une réserve d'entomofaune, dynamique des populations de lépidoptères foreurs de tiges de sorgho et piégeage sexuel de *Busseola fusca*. Rapport de fin de cycle de l'Ipr de Katibougou. Koulikoro, Mali, Ipr, 22 p.

MASSA M.B., 1996. Etude en milieu paysan (Mali) de l'infestation et des dégâts comparés des punaises des panicules sur variétés de sorgho guinea et caudatum, et en grandes et petites parcelles. Mémoire de fin d'études de l'Ipr de Katibougou. Koulikoro, Mali, Ipr, 19 p.

RATNADASS A., CISSE B., MALLE K., 1994. Notes on the biology and immature stages of West African sorghum head bugs *Eurystylus immaculatus* and *Creontiades pallidus* (Heteroptera: Miridae). Bulletin of Entomological Research 84: 383-388.

RATNADASS A., CISSE B., SANGARE M.L., 1994. Dynamique des populations des punaises mirides des panicules de sorgho au Mali. *In* 3^{e} séminaire international sur la Lutte intégrée au Sahel, 1-9 avril 1994, Uctr/Pv/Insah/Cilss, Dakar, Sénégal, 21 p.

RATNADASS A., DOUMBIA Y.O., AJAYI O., 1995. Bioecology of sorghum head bug *Eurystylus immaculatus* and crop losses in West Africa. *In* Panicle insect pests of sorghum and pearl millet: proceedings of an International Consultative Workshop, 4-7 October 1993, Icrisat Sahelian Center, Niamey, Niger (NWANZE, K.F., YOUM, O., Eds.). Patancheru, India, Icrisat, p. 91-102.

RATNADASS A., AJAYI O., 1995. Panicle insect pests of sorghum in West Africa. *In* Panicle insect pests of sorghum and pearl millet. Proceedings of an International Consultative Workshop, 4-7 October 1993, Icrisat, Sahelian Center, Niamey, Niger (NWANZE, K.F., YOUM O., eds.). Patancheru, India, Icrisat, p. 29-38.

RATNADASS A., CISSE B., 1996. New options for the integrated management of sorghum head bug *Eurystylus oldi* Poppius (Hetroptera: Miridae) in West Africa. Presented at the XX International Entomology Congress, 25-31 August 1996, Florence, Italy, 12 p.

RATNADASS A., CISSE B., DIARRA D., SANGARE M.L., 1997. Indigenous host plants of sorghum headbugs (Heteroptera: Miridae) in Mali. African Entomology 5 (1): 158-160.

RISBEC J., 1950. La faune entomologique des cultures au Sénégal et au Soudan français. Dakar, Sénégal, Gouvernement général de l'Afrique occidentale française, 498 p.

SCHOUTEDEN H., 1937. Un capside parasite du ricin. Revue de zoologie et de botanique africaines 29 : 216-217.

SHARMA H.C., 1989. Tour report: Studies on sorghum head bugs in West Africa (17 September-19 October 1989). Report of cooperative work carried out at Wasip, Kano, and Wasip, Samanko. Patancheru, India, Icrisat, 38 p.

SOMBORO D., 1995. Evaluation comparative des hybrides et variétés de sorgho en milieu paysan dans le cercle de Kolokani. Mémoire de fin d'études de l'Ipr de Katibougou. Koulikoro, Mali, Ipr, 64 p.

STECK G.J., TEETES G.L., MAIGA S.D., 1989. Species composition and injury to sorghum by panicle feeding bugs in Niger. Insect Science and its Application 10: 199-217.