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Effect of cowpea (*Vigna unguiculata* L. Walp.) sowing season on population dynamics of pest insects

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ABSTRACT

Several factors limit cowpea quality and yield, such as the choice of a cultivar better adapted to the region, the ideal sowing season, as well as diseases and pests. Aimed to evaluate the effect of different sowing seasons on the population dynamics of pest insects of cowpea crops. The study was carried out during the dry season, the rainy season, and the season recommended for sowing by the Experimental Farm of the Federal University of Amazonas (FAEXP–UFAM), Brazil. A total of 33 weekly collections were carried out during the three sowing seasons, distributed in two ways according to the phenological stage of the crop: manual collection per linear meter of plantation and entomological scanning net. The faunistic analysis detected the pest insects *Acromyrmex laticeps nigrosetosus*, *Cerotoma arcuata, Crinocerus sanctus, Euschistus heros, Horciasinus signoreti, Liriomyza sativae*, and *Nezara viridula*. Of these species, *H. signoreti* stands out for being recorded for the first time as predominant in cowpea crops in the Brazilian state of Amazonas. Infections by hemipterans such as *C. sanctus, E. heros, H. signoreti*, and *N. viridula* were detected throughout the study, regardless of the sowing season, except for *H. signoreti*, which was dominant in all three seasons. The highest infestation of *C. arcuata* occurred during the recommended sowing season for cowpeas (June to August). According to the Jaccard index, plantation I e II share 86% of the species. This study provides important information to programs in insect control and management and to the agronomic decision-making process.

Keywords: faunistic analysis; population dynamics; phenology.

INTRODUCTION

The cowpea (*Vigna unguiculata* L. Walp), locally known as *feijão-de-praia*, has significant socioeconomic importance in the state of Amazonas, Brazil. In this state, a yield of 41,700 tons was obtained from 18,700 ha in the 2019–2020 harvest, which represents approximately 2,230 kg·ha^{-1} (CONAB, 2020). Such average yield was lower than that from the other states in northern Brazil. Factors like climate, soil, cultivar choice, management, as well as plant diseases and pest attacks, limit the yield and quality of the cowpea (OLIVEIRA et al., 2019).

Accordingly, several insect species are considered important pests of the cowpea crops in the Amazon region due to direct and indirect damage to crops and the regularity and intensity of their occurrence. Examples of these species include the cowpea aphid *Aphis craccivora* (Koch, 1854) (Hemiptera: Aphididae); the green leafhopper *Empoasca kraemeri* (Rossi & Moore, 1957) (Hemiptera: Cicadellidae); the silverleaf whitefly *Bemisia tabaci* (Gennadius, 1889) (Hemiptera: Aleyrodidae); the bean leaf beetle *Cerotoma arcuata* (Olivier, 1791) (Coleoptera: Chrysomelidae); the weevil *Chalcodermus bimaculatus* (Fiedler, 1936) (Coleoptera: Curculionidae); the chinch bug *Crinocerus sanctus* (Fabricius, 1775) (Hemiptera:

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Coreidae); the green stink bug Nezara viridula (Linnaeus, 1758) (Hemiptera: Pentatomidae); the brown stink bug *Euschistus heros* (Fabricius, 1798) (Hemiptera: Pentatomidae); the vegetable leaf miner *Liriomyza sativae* (Blanchard, 1938) (Diptera: Agromyzidae); the lesser cornstalk borer *Elasmopalpus lignosellus* (Zeller, 1848) (Lepidoptera: Pyralidae), and the southern armyworm *Spodoptera cosmioides* (Walker, 1858) (Lepidoptera: Noctuidae) (FAZOLIN et al., 2016).

Studies on the population dynamics of insects related to sowing seasons of cowpea crops cultivated in solid ground in the Manaus region are scarce. Therefore, the present study analyzed how the populations of pest insects of cowpeas fluctuate when sowing is anticipated or delayed with regard to the recommended sowing season for this crop in solid ground, aiming to obtain valuable data for integrated pest management.

MATERIAL AND METHODS

The present study was carried out at the Experimental Farm of the Federal University of Amazonas (FAEXP–UFAM), located at highway BR 174, km 38, Manaus, state of Amazonas, Brazil, in an area of 5,000 m^2 (50 × 100 m). Three sowing periods were implemented: sowing season I, which occurred after the recommended cultivation period, from September 18 to December 04, 2017, at the transition between the dry season and the beginning of the rainy season; sowing season II, before the recommended period, from February 13 to April 24, 2018, during the rainy season; and sowing season III, which took place during the recommended period, from June 08 to August 10, 2018, between the end of the rainy season and the beginning of the dry season. The cultivar 'BRS Guariba' was used for the three periods since it is recommended for cultivation in solid ground (VILARINHO, 2007). Meteorological data such as temperature, precipitation, and relative humidity were provided by the National Institute of Meteorology (INMET, 2018).

Collections were performed from the seventh day of sowing, with the collector making an intense effort to obtain an optimal representation of the crop area. Insects were sampled weekly, between 09:00 am and 12:00 pm on the same day, until the end of the crop cycle. The sampling method was performed according to the phenological stage, considering the vegetative and reproductive stages defined by CAMPOS et al. (2000).

However, for each day of sampling, ten collection points were randomly defined. Initially, in the phenological stages V2 and V3, 1 m linear area/point was marked in the planting, and the plants were analyzed individually. From the vegetative stage V4 until the stages of flowering and pod formation (last stages), the samplings were performed by entomological sweep net, totaling ten throws in horizontal movements per collection point, involving useful area and border of the planted area. This procedure resulted in 100 throws per weekly sampling. The collected insects were sent to the Laboratory of Entomology and Acarology (LEA) at the UFAM for further sorting and identification.

Each sowing season was considered to harbor a particular pest insect community with its own characteristics. Frequency, abundance, constancy, dominance, Shannon–Weiner diversity, and the similarity index were calculated per sowing season, using the ANAFAU program (SILVEIRA NETO et al., 1995). Graphs were constructed on population fluctuations of the main pests surveyed over the course of the crop cycle during the three cowpea sowing seasons. The predominant species, i.e., those that stood out for presenting the highest faunal indices and/or those considered pests of the cowpea crop, will be discussed next, along with the presentation of their results.

RESULTS AND DISCUSSION

A total of 1,282 insects were collected in the three sowing seasons, representing 6 orders (Blattodea, Orthoptera, Hemiptera, Coleoptera, Diptera, and Hymenoptera), 38 families, 12 genera, and 123 species. This number is lower when compared to the study on the fluctuation of pest insects in the cowpeas cultures in Rio Branco (Acre), using the sweep net method, where in 13 weeks of evaluations during the two experimental periods, FAZOLIN (1995) computed 3,597 individuals distributed in 6 orders, 21 families and 19 species. The entomofauna associated with cowpea cultivation in the Amazon is still poorly known, as both the quantity and composition of taxonomic groups are distinct among localities (FAZOLIN et al., 2016). For example, only the orders Orthoptera, Hemiptera, and Coleoptera were common in the studies conducted in Rio Branco (Acre) and in the present study conducted in Manaus (Amazonas).

More recently, FAZOLIN et al. (2016) recorded 12 known cowpea pest species for the Amazon, belonging to the orders Hemiptera, Coleoptera, and Lepidoptera, without records of their natural enemies for Brazil's Legal Amazon. The present study also recorded species of Diptera and Hymenoptera, confirming that more studies are necessary on insects associated with cowpeas,

considering those with potential as pests and those that can be useful as natural pest enemies. Thus, priority should be given to species that stand out for their regional importance, for the exclusivity of their occurrence, and for the damage they cause to crops.

Based on the analysis of dominance, frequency, abundance, and constancy of insects in the cowpea crop in the three planting seasons, it was found that *C. arcuata*, *L. sativae*, *Acromyrmex laticeps nigrosetosus* (Forel, 1908) (Hymenoptera: Formicidae), *C. sanctus, E. heros, N. viridula*, and *Horciasinus signoreti* (Stal, 1859) (Hemiptera: Miridae) showed a higher incidence in certain sowing seasons (Table 1).

Table 1. Faunistic analysis of the pest species of cowpea cultivated at the Experimental Farm, UFAM, Manaus, Amazonas, Brazil, from September 2017 to August 2018.

Order/species	Sowing season											
	I				II				III			
	D (1)	A (2)	F (3)	C (4)	D (1)	A (2)	F (3)	C (4)	D (1)	A (2)	F (3)	C (4)
Hemiptera												
C. sanctus	D	ma	MF	w	O	O	O	O	O	O	O	O
E. heros	ND	d	PF	z	ND	d	PF	z	O	O	O	O
N. viridula	O	O	O	O	D	ma	MF	y	O	O	O	O
H. signoreti	D	ma	MF	y	D	c	F	y	D	ma	MF	y
Coleoptera												
C. arcuata	O	O	O	O	O	O	O	O	D	ma	MF	w
Hymenoptera												
A. laticeps nigrosetosus	D	ma	MF	z	O	O	O	O	O	O	O	O
Diptera												
L. sativae	SD	sa	SF	y	D	ma	MF	z	O	O	O	O

(1) Dominance: SD = super dominant; D = dominant; ND = non-dominant. (2) Abundance: s = scattered; c = common; va = very abundant; ha = highly abundant. (3) Frequency: Inf = infrequent; F = frequent; VF = very frequent; HF = highly frequent. (4) Constancy: z = accidental; y = accessory; w = constant.

In this work, the occurrence of attacks by the species *A. laticeps nigrosetosus* and *H. signoreti* on the cowpea crop in the Amazon was recorded for the first time. Therefore, these results contribute to the increase in knowledge about the geographical distribution of these species in the Amazon region.

In sowing seasons I and III, pest insects became more frequent from vegetative stage V5 onward and occurred more intensely during the reproductive stage. In contrast, in sowing season II, pest insects occur mainly in the last three reproductive stages (Fig. 1). According to SILVA et al. (2005), insects attack cowpeas when the plant is at the phenological stage that produces the insect's ideal food. Therefore, in the reproductive stage, the variety of food increases with the emergence of flower buds, flowers, and pods, attracting and enabling pest populations.

The species *C. arcuata* is a defoliator (SOUSA; PACHOUTE, 2019). In the present study, its occurrence in the crops was recorded from vegetative stage V3, with increased occurrence from stage V5 (Fig. 1b,c) when cowpea plants complete their vegetative stage. This last stage is the most sensitive because 25% of defoliation on the 25th day after plant emergence can lead to yield losses of approximately 40% (SILVA, 2016). It is interesting to note that, in a study carried out on cowpea crops in Rio Branco (Acre), FAZOLIN (1995) recorded the ladybug *Cerotoma tingomarianus* throughout the crop cycle, similar to the present study, which recorded the congeneric species *C. arcuata* in sowing season III.

The population of *L. sativae* was high, showing about 50% and 35.29% of the total number of the other pest species in sowing seasons I and II, respectively, but was absent in sowing season III (Fig. 1). The first records in sowing season II were made in the final stages of the vegetative stage, while in sowing season I, the species was dominant in five of the seven reproductive stages. The larvae of *L. sativae* damage the leaf by opening irregular galleries when feeding on the leaf mesophyll. When in high densities, larvae can reduce the green area of the plant and, consequently, its photosynthetic capacity (COSTA-LIMA et al., 2015; SILVA, 2016). In the Amazon, records of *L. sativae* have been sporadic, making it a regional pest without much significance. However, in the semiarid region, its populations are potential pests of cowpea crops and other vegetables (COSTA-LIMA et al., 2009).

It is worth mentioning the predominance of the chinch bug *C. sanctus* (Coreidae) at the reproductive stages of the cowpea during the three sowing seasons, with greater abundance in sowing season I. According to FAZOLIN (1995), the period between the beginning of fruiting and the maximum accumulation of dry matter in the beans is most sensitive to attack by these sucking insects. The damage occurs directly in the pods, which become withered, resulting in hollow and stained beans that are impractical for sale and sowing (SILVA, 1987).

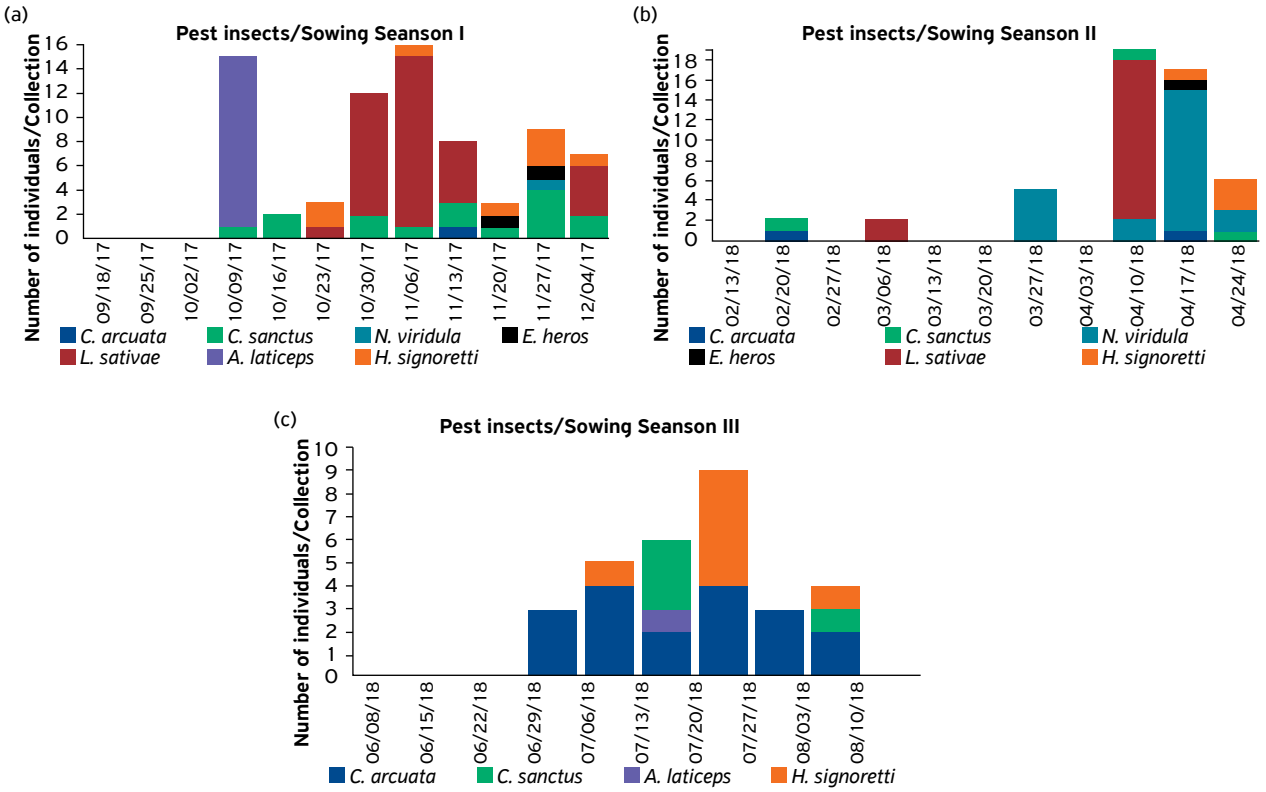

Figure 1. Population fluctuation of pest insects from cowpea crops of three sowing seasons, at the Experimental Farm (UFAM) Manaus, Amazonas, Brazil. (a) sowing season I; (b) sowing season II; (c) sowing season III.

The green and brown stink bugs *N. viridula* and *E. heros* (Pentatomidae) were found only at the reproductive stages of the plants, during sowing seasons I and II (Fig. 1), which are not recommended periods for growing cowpea in the region. The number of individual *E. heros* collected was very low in both sowing seasons, while *N. viridula* was the predominant species in the reproductive stage of sowing season II, with 23 individuals collected at that time (Fig. 1b). For these two pest species, the same tendency to appear in similar quantities at the reproductive stages of the plants was observed in crops in the state of Roraima (MARSARO JÚNIOR; PEREIRA, 2013). It is important to note that an increase of one green stink bug *N. viridula* per meter of cowpea row leads to a yield loss of 6.36%. The established control level is 0.7 bug per meter of row (SILVA; SOBRINHO, 2017), which justifies the monitoring of this species in crops regardless of the time of year.

Signs of the bug *H. signoreti* (Miridae) were evident in the vegetative and reproductive stages of the cowpeas during the three sowing seasons (Fig. 1). The species was detected in the vegetative stages throughout the seasons, but predominance and population peaks occurred during the reproductive stage. This polyphagous bug (ARELLANO; VERGARA, 2016) is widely distributed in South America (VÉLEZ et al., 2020). It has been reported to cause damage at the vegetative and reproductive stages of plants, attacking early fruits and pods of cowpea crops in the states of Pará and Minas Gerais (SILVA; MAGALHÃES, 1980; FERREIRA et al., 2001). However, the species has not been reported as a relevant pest, and this is its first recorded occurrence in cowpeas cultivated in solid ground of the state of Amazonas.

Sowing season I showed the highest number of pest insect species, while sowing season II showed the lowest number. Only the occurrence of *C. arcuata*, *C. sanctus*, and *H. signoreti* were constant among the three sowing seasons, both at the vegetative and reproductive stages (Fig. 2).

A higher occurrence of *C. arcuata* was observed in the recommended growing season for the region (sowing season III) compared to sowing seasons I and II, after and before the recommended season, respectively. Sowing season III was implemented at the end of the rainy season and the beginning of the Amazonian summer, coinciding with the highest occurrence of *C. arcuata*. This finding may be related to high temperatures that increase the metabolic rate of insects, which feed more and, consequently, multiply throughout the crop cycle (RODRIGUES, 2004), in addition to the decrease in average daily precipitation. HOHMANN; CARVALHO (1989) also found the highest population peak of *C. arcuata* in the dry period, although the pest occurs throughout the year. It is worth noting that the time change from the season I or II (Fig. 2) allowed the low occurrence of *C. arcuata*, a key pest in cowpea crops in several regions of the Amazon and northeastern Brazil (MARSARO JÚNIOR; PEREIRA, 2013; SILVA, 2016).

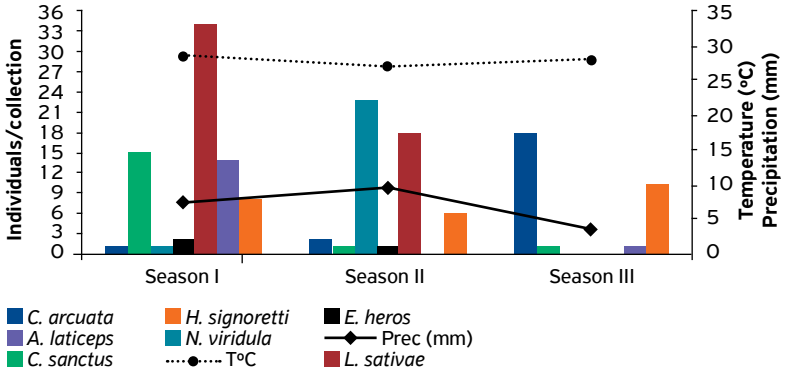

Figure 2. Population fluctuation of pest insects in cowpea crops of three sowing seasons at the experimental farm (UFAM), Manaus, Amazonas, Brazil, associated with temperature and precipitation.

Sowing season I was implemented from September to December 2017. The transition from the dry season to the rainy season begins in November, during the reproductive stage of the plants. Even without significant statistical correlations between population data and abiotic factors, it is possible to observe the influence of precipitation on the populations of *C. sanctus* and *L. sativae* at the same phenological stage of the plants. For example, while the population growth of *C. sanctus* and *L. sativae* increased in sowing season I, there was a decrease in the number of individuals of both species collected in seasons II and III (Fig. 2).

Unlike the other pests analyzed in the present study, *H. signoreti* occurred in the three sowing seasons, with almost constant population size, although it was predominant in sowing season III. That is, populations of this species are among those that reached the highest category in all the analyzed indexes. In this period, the lowest average rainfall among the periods studied was recorded. In studies on population fluctuation of cowpea pests from Pará, *H. signoreti* was observed throughout the year, although a population peak was noted in the rainiest period (SILVA; MAGALHÃES, 1980).

Considering that the main limiting factors of cowpea bean production in the region are pest insects, sowing seasons, and diseases (OLIVEIRA et al., 2019), the planting season factor provides a better observation of the climatic elements, temperature, and precipitation, which may have influenced the characterization of the faunal indices.

Analysis of similarity using the Jaccard index indicated 86% similarity between sowing seasons I and II (Fig. 3). This similarity is mainly because almost all analyzed pest species were detected in both sowing seasons. On the other hand, only four of the seven considered pest insect species of the cowpea crops were recorded in sowing season III: *A. laticeps nigrosetosus, C. arcuata, C. sanctus*, and *H. signoreti*. Thus, sowing season III was the season with the lowest presence of pest species, explaining its difference with the cluster formed by sowing seasons I and II.

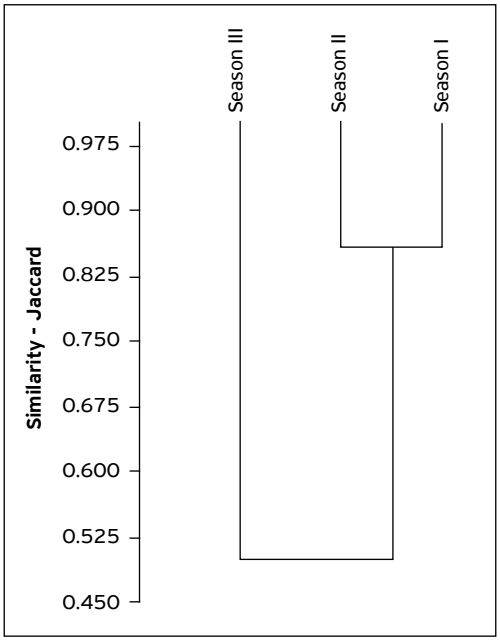

Figure 3. Dendrogram of similarity (Jaccard index) produced by cluster analysis of cowpea crops, considering three growing seasons (I, II, and III) implemented at the Experimental Farm UFAM Manaus, Amazonas, Brazil, from September 2017 to August 2018.

Biological diversity is generally high in tropical regions, and for this reason, the similarity indices usually show low values. However, in this study, the values found were high for growing seasons I and II, especially considering that similarity values higher than 50% have already been considered high by some studies (e.g., FELFILI et al., 1994). Thus, we considered the observed similarity values between sowing seasons I and II as high.

CONCLUSIONS

For the first time, the pest insect *H. signoreti* (Hemiptera: Miridae) was recorded as predominant in a cowpea crop in Amazonas. The largest population of hemipterans was concentrated in the reproductive phenological stage of sowing seasons I and II. Hence, despite advancing or delaying the sowing season, there will always be infestation by the hemipterans *E. heros, C. sanctus, H. signoreti*, and *N. viridula*, although these bug species have shown preferences for different sowing seasons. Changing the sowing season period to no recommended seasons (I and II) allowed the lowest infestation by *C. arcuata*. In contrast, the highest infestation was detected during the recommended season, sowing season III (June to August), at the vegetative and reproductive plant stages. Sowing seasons I and II showed a considerable similarity of species (86%) for the three economically important families (Diptera, Formicidae, and Hemiptera).

AUTHORS' CONTRIBUTIONS

Conceptualization: Alves, A.S.S.C.; Silva, N.M. **Data curation:** Alves, A.S.S.C.; Acioli, A.N.S.; Ferreira, G.S.L. **Formal analysis:** Alves, A.S.S.C.; Acioli, A.N.S. **Funding acquisition:** Ferreira, G.S.L. **Investigation:** Alves, A.S.S.C.; Acioli, A.N.S.; Ferreira, G.S.L. **Methodology:** Alves, A.S.S.C.; Silva, N.M. **Project administration:** Alves, A.S.S.C.; Silva, N.M. **Resources, Software:** Alves, A.S.S.C.; Silva, N.M. **Supervision:** Silva, N.M.; Acioli, A.N.S. **Validation:** Alves, A.S.S.C.; Silva, N.M.; Acioli, A.N.S. **Visualization:** Alves, A.S.S.C. **Writing – original draft:** Alves, A.S.S.C. **Writing – review & editing:** Alves, A.S.S.C.; Silva, N.M.; Acioli, A.N.S.; Ferreira, G.S.L.

AVAILABILITY OF DATA AND MATERIAL

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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CONFLICTS OF INTEREST

All authors declare that they have no conflict of interest.

ETHICAL APPROVAL

Not applicable.

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