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Field work undertaken during 2017–2018 on the Critically Endangered moth *Callioratis millari* (Lepidoptera: Geometridae, Diptychinae)

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Abstract: Thirty-seven species of nectar-producing flowering plants were recorded in grassland at Entumeni Nature Reserve (ENR) during the normal flight period of *Callioratis millari*. This suggests no shortage of nectar for the adult *C. millari*. Eggs and larvae on grass cycads *Stangeria eriopus* at the ENR monitoring site and at the nearby Dreadnaught Peak Farm (DPF) were counted in May 2017, with the ENR yielding a satisfactory count since 2005, but DPF recording only one egg counted after a fire. In 2018 ENR recorded 26 eggs, whilst DPF had no eggs. The *S. eriopus* cycads established in a new grassland area at ENR had become overgrown by adjacent vegetation and no eggs or larvae were found. Pre-burn inspections were conducted at ENR and two distinct burning periods, one in mid-winter and the other in late winter are recommended to prevent dominance of certain indigenous grass species, encroaching indigenous shrubs and alien invasive plants. Further knowledge of the life history and ecology of *C. millari* is required to inform better monitoring techniques and optimal management of its habitat.

Key words: *Callioratis millari*, cycad moth, nectar plants, egg and larval counts.

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INTRODUCTION

Callioratis millari Hampson, 1905 is a Critically Endangered day-flying cycad moth species which, despite widespread searches by members of the Lepidopterists' Society of Africa and Ezemvelo KZN Wildlife personnel, is still only known to occur at small grassland patches in the Entumeni Nature Reserve (ENR) and on nearby farms in KwaZulu-Natal, South Africa. *C. millari* caterpillars in their early stages feed on the Grass Cycad *Stangeria eriopus* (Kunze) Baillon (Staude 2001).

MATERIALS AND METHODS

The ENR was visited on 10 April and 10, 11 and 23 May 2017, and again on 9 and 23 April 2018, to record flowering plants in two of the grassland areas, to ascertain from which species the adult moths may obtain nectar. Plant identifications were done with the aid of photographs and utilising the skills of Richard Boon.

The annual egg monitoring was carried out on 10 May 2017 and 2018 at ENR. All *S. eriopus* established within the monitoring area were located and the fronds and also overhanging grass blades checked for *C. millari* eggs and the fronds for the characteristic larval feeding signs (Fig. 1). The Ezemvelo KZN Wildlife staff who participated in the 2017 egg count are shown in Figure 2. The *C. millari* egg count at Dreadnaught Peak Farm (DPF) took place on 11 May 2017 and 2018.

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Figure 1 – Hatched *C. millari* eggs and typical larval feeding signs.

RESULTS

Flowering plants

Thirty-seven flowering species were recorded in the grassland areas searched (Table 1). Two species, *Senecio panduriformis* Hilliard LC (Fig. 3) and *Blumea dregeanoides* Sch.Bip. ex A.Rich. (Fig. 4), had expanded their local distributions noticeably.

Figure 2 – The egg counting team in 2017.

Table 1 – Flowering plants recorded during April and May 2017 and April 2018 in two grassland areas.

Species	Family
Abutilon sonneratianum (Cav.)	Malvaceae
Alectra sessiliflora (Vahl) Kuntze	Orobanchaceae
Athrixia phylicoides DC.	Asteraceae
Blumea dregeanoides Sch.Bip. ex A.Rich.	Asteraceae
Berkhaya sp.	Asteraceae
Chamaecrista mimosoides (L.) Greene	Fabaceae
Chlorophytum krookianum Zahlbr.	Anthericaceae
Crotaleria lanceolata E.Mey. *subsp. lanceolata*	Fabaceae
Cynoglossum sp.	Boraginaceae
Gladiolus sericeovillosus Hook. f.	Iridaceae
Gnidia anthylloides Gilg	Thymelaeaceae
Gnidia calocephala (C.A. Mey.) Gilg	Thymelaeaceae
Gnidia kraussiana Meisn.	Thymelaeaceae
Helichrysum decorum DC.	Asteraceae
Hesperantha baurii Baker	Iridaceae
Leonotis leonurus (L.) R.Br.	Lamiaceae
Pavonia columella Cav.	Malvaceae
Polygala virgata Thunb.	Polygalaeceae
Polygala hottentotta C.Presl	Polygalaeceae
Pseudarthria hookeri Wight & Arn.	Fabaceae
Rabdosiella calycina (Benth.) Codd	Lamiaceae
Rhynchosia caribaea (Jacq.) DC.	Fabaceae
Rubia cordifolia L.	Rubiaceae
**Rubus cuneifolius* Pursh	Roseaceae
Sebaea grandis (E.Mey.) Steud.	Gentianaceae
Selago trinervia E. Mey.	Scrophulariaceae
Senecio panduriformis Hilliard LC	Asteraceae
Senecio polyanthemoides Sch.Bip.	Asteraceae
Senecio serratuloides DC.	Asteraceae
Senecio tamoides	Asteraceae
Stachys natalensis Hochst.	Lamiaceae
Striga asiatica (L.) Kuntze	Orobanchaceae
Syncolostemon densiflorus Benth.	Lamiaceae
Vernonia myriantha Hook. f.	Asteraceae
Vernonia oligocephala (D.C) Sch.Bip. Ex Walp.	Asteraceae
Watsonia densiflora Baker	Iridaceae
Xysmalobium orbiculare (E.Mey.) D.Dietr.	Apocynaceae

*** Alien invasive species**

Figure 3 – A robust *S. panduriformis* with similar growth form to *Vernonia myriantha* Hook. f., a popular nectar plant at Entumeni Nature Reserve.

Figure 4 – *Blumea dregeanoides*.

<u>*Callioratis millari* egg counts at ENR</u>

In 2017, a total of 22 hatched eggs and 4 larvae were recorded (Table 2) and 64 *S. eriopus* cycads were checked for eggs or characteristic feeding signs. Eggs were recorded from two *S. eriopus* and feeding signs recorded from seven (Table 2). A spot check on 11 May 2017 of 40 *S. eriopus* cycads in another area of ENR and on a neighbouring farm, where 15 cycads had been established by Ezemvelo KZN Wildlife, revealed a total of 21 eggs (Table 3). In May 2018, after the successful burning of the grassland, a total of 100 *S. eriopus* were checked and 26 eggs and the characteristic feeding signs of *C. millari* were recorded from two of the cycads.

In 2017, the height and thickness of the grassland, dominated by *Cymbopogon validus* (Stapf) Burtt Davy (Giant Turpentine Grass) and *Pteridium aquilinum* L.

(Kuhn) (Bracken fern), and the dense moribund vegetation made the egg count the most strenuous to date (Fig. 5). It was difficult to locate *S. eriopus* cycads, of which the fronds of many were senescing due to overgrowth by the surrounding vegetation. The low number of *S. eriopus* plants located was partly a result of the dense vegetation and the fact that the *S. eriopus* with senescing fronds had very few fronds visible.

Table 2 – Summary of the *Callioratis millari* egg count in the monitoring area.

Year	**2017**	**2018**
Stangeria eriopus with eggs and/or larvae and/or feeding signs.	7	2
Eggs	7+10*	24+2*
Larvae	4	0

Legend: * = unhatched eggs

Table 3 – Summary of the *Callioratis millari* egg count in another part of ENR and on a neighbouring farm in 2017.

S. eriopus no.	**Eggs**	**Feeding**	**Larvae**
1	2	Y	0
2	8+2*	Y	0
3	6	Y	0
4	3	Y	0
Total	**21**	**4**	**0**

Legend: * = unhatched eggs; Feeding = evidence of larval feeding

Figure 5 – Conducting line sweeps through tall *Cymbopogon validus*-dominated grassland.

Assessing condition of the *Stangeria eriopus* plants

The monitoring team visited a part of ENR on 11 May 2017 to assess the condition of *S. eriopus* cycads previously transplanted to there as part of a relocation plan from Ongoye Forest Reserve. A total of 13 transplanted *S. eriopus* cycads were relocated, all of which were overgrown by surrounding vegetation, and no evidence of *C. millari* breeding was observed.

Callioratis millari egg counts at Dreadnaught Peak Farm

The *C. millari* egg count at Dreadnaught Peak Farm (DPF) in 2017 took place on 11 May with the assistance of three Field Rangers and a Cadet. The landowner, Mr Louis Gunter, was informed of the planned egg count and this was when we were alerted to the planned burn which took place less than 2 weeks before the egg count. An arson fire had been set on the farm's southern boundary where *C. millari* had been observed flying in the past. The *S. eriopus* cycads established on this ridge (Fig. 6), across the valley from the monitoring site on DPF, have been visited several times over the years but no evidence of *C. millari* breeding was obtained. The arson fire burnt through the valley and triggered safety concerns which resulted in the planned burn of the adjacent ridge which included the *C. millari* monitoring site on DPF. Mr Gunter stated that the grasslands between DPF and Longhurst Farm had not been burnt in two years and presented a fire threat.

The *S. eriopus* colony on DPF was visited even though the site had been burnt (Fig. 6). The monitoring team located several *S. eriopus* growing within the forest ecotone which had escaped being burnt. The cycads, although in good condition, were mostly overgrown by typical forest margin species and the encroachment of *P. aquilinum*. A single hatched egg was recorded on a host plant after locating 24 *S. eriopus* which had escaped the fire along the forest margin.

The timing of this fire seems to have negatively impacted upon the breeding success at this site. Several *Cyrtanthus breviflorus* Harv. (Yellow Fire Lily) plants were observed (Fig. 7). The fire had burnt most of the *S. eriopus* on the slope (Fig. 8).

The egg count results and the probable negative consequences of the planned fire on DPF indicated that a fire break should be used to secure the DPF monitoring site from early season fire threats.

The egg count on DPF on 11 May 2018 recorded no eggs nor characteristic feeding signs from a total of 142 *S. eriopus* cycads within the monitoring site. Although the 2017 fire likely decimated this population, re-colonization might take place from ENR. Continued egg monitoring at ENR and DPF will enable long term trends to be ascertained.

Figure 6 - The *Stangeria eriopus* colony is established on the lower part of the ridge over which the arson fire swept.

The monitoring sites at ENR and DPF should only be burnt later in the season (at the end of August or in September) to minimise the risk of decimating the numbers of *C. millari* there.

Figure 7 – *Cyrtanthus breviflorus*.

Figure 8 – Burnt *Stangeria eriopus* cycad.

DISCUSSION

A variety of flowering plants that could provide nectar for adult *C. millari* during their flight period were recorded. *Rabdosiella calycina* (Benth.) Codd is a known nectar plant for *C. millari* adults. No nectar shortage is apparent. The results of all the egg counts conducted at the monitoring site in ENR since 2005 are shown in Figure 9, and reveal that 2018 was the 6th highest count on record. The long term monitoring programme has not established population trends with any certainty yet. The reason for the fluctuating number of eggs laid at the monitoring site is currently unknown.

Mature *S. eriopus* rescued from Ongoye Forest Reserve (OFR) have been planted within ENR. These cycads would otherwise have been doomed by the widening and tarring of a road through the OFR. By increasing the host plant numbers at ENR, an increase in the population size of *C. millari* may result.

The planned burn identified for the monitoring site at ENR was not carried out in 2016. The team delayed the burning in this and an adjacent grassland area to test for the possibility that *C. millari* may have a second brood in October, owing to the fact that one or more specimens of

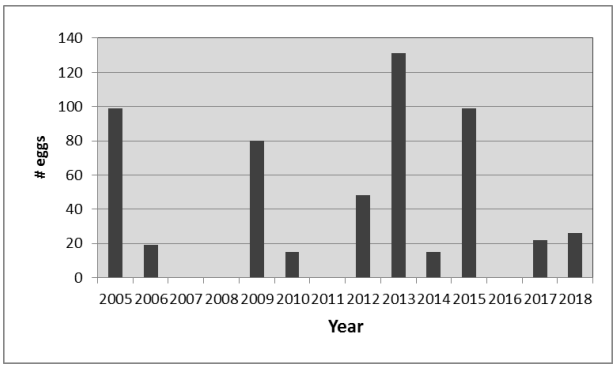

Figure 9 – Summary of *Callioratis millari* egg counts from 2005 until 2018 at the monitoring site in Entumeni Nature Reserve.

C. millari from elsewhere in KZN have a label date of October.

No adult *C. millari* were observed flying during visits to ENR in March and April 2016. No eggs or characteristic *C. millari* feeding signs were observed on the host plants during the annual egg counts conducted on 11 and 12 May 2016, at ENR and DPF, respectively. The Millar's Tiger Moth team continued monitoring for adult *C. millari* at ENR into October. None were observed in 2016.

Knowledge about important parts of the life history and ecology of *C. millari* has yet to be obtained, including environment triggers that may induce quiescence. Whether the monitoring site is prime habitat for the species in ENR or not is also unknown. Unscheduled early season burning events, at both ENR and DPF, appeared to have negatively impacted on the potential population growth rate of this Critically Endangered species, something it can ill afford.

The tall, rank grasslands were in need of burning in 2017. Fire plays an important role in grassland management at the ENR. Reduced fire frequency in the past resulted in the encroachment of indigenous *Maesa lanceolata* Forssk. (False-assegai) trees into the grasslands. This encroachment was controlled using cut-stump herbicide treatment. *Vachellia karroo* (Hayne) Banfi & Galasso (Sweet Thorn), *C. validus* and *P. aquilinum* continue to encroach into the grasslands (Figs 10 & 11).

Figure 10 – *Vachellia karroo* encroachment at the monitoring site.

Woody encroachment facilitates forest margin expansion. *Miscanthus capensis* (Nees) Andersson (Daba Grass) observed at the monitoring site adjacent to the *V. karroo* encroachment could indicate increased soil moisture levels that might favour woody plants. Mechanical and chemical management of *V. karroo*, *P. aquilinum*, *Rubus cuneifolius* Pursh (American Bramble) and *Acacia melanoxylon* R. Br. (Australian Blackwood) is required, the latter two species being invasive alien plants specific to the grasslands.

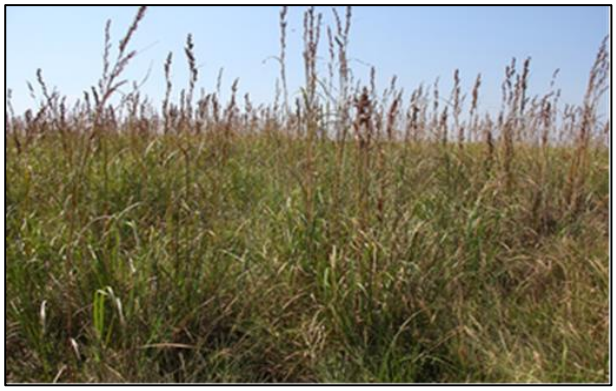

Figure 11 - Encroachment of *C. validus* within Entumeni Nature Reserve.

A pre-burn inspection was conducted at the ENR on 23 May 2017. Hot fires burning away from forest margins were planned for July 2017 for five grassland areas, including the southern part of the monitoring site, to reduce the extremely high fuel loads. The escape of a planned burn on the boundary of ENR caused the destruction of part of a commercial timber plantation adjacent to ENR. As a result, the planned burn for the monitoring site did not take place in July. A hot fire assists with the control of woody plant encroachment. Chemical control of *V. karroo* was implemented when coppice growth was sufficient for foliar herbicide application. Burning between 20 August and 10 September 2017 to complete the late season burn took place at the monitoring site with the assistance of neighbouring farmers. The planned 2018 burns will focus on a few rotational burning blocks not burnt in 2017, one of which is an important *C. millari* site which is planned to be burnt in August.

CONCLUSIONS

Further investigation into the life history and ecology of *C. millari* is urgently required, especially if conservation translocations are to be attempted in the future. Another imperative is that appropriate fire management of all grassland habitat of *C. millari* is carried out to ensure that fire does not negatively impact the species and its larval host plants and nectar plants for the adults. Ezemvelo KZN Wildlife needs to continue with the *C. millari* long term monitoring programme, modified if necessary to ensure that core habitat at ENR is included. The implementation of management interventions, identified through the fieldwork done on *C. millari* not only supports the survival of this single species but also the rich biodiversity of the grasslands.

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