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Abstract

The banana weevil, *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae), is an important constraint to East African highland banana production because larval feeding damages the corm and basal tissues, weakens plant anchorage and can reduce productivity over successive crop cycles. Banana residues can function simultaneously as agronomic resources and as habitat for adult weevils, making their configuration and placement relevant to integrated pest management. This study evaluated the effects of residue configuration, distance from the standing banana mat, season and study site on adult *C. sordidus* abundance in south-western Uganda. A four-factor factorial field experiment was implemented in a randomized complete block design with three replications at Bubare, Mbarara District, and Kaberebere, Isingiro District, during dry and rainy seasons. Three residue configurations Alternating, Prostrate and Chopped were established at 0–1, 2–3 and 4–5 m from standing Kibuzi banana mats. Adult abundance was monitored weekly for 10 consecutive weeks, and the 10 observations for each replicate were averaged before factorial ANOVA. Residue configuration, distance, season and site each had significant main effects ($P < 0.001$), whereas none of the interaction terms was significant. Alternating residues had the highest mean abundance (11.69 ± 0.50 adults), followed by Prostrate residues (8.42 ± 0.50) and Chopped residues (5.17 ± 0.50). Abundance declined from 11.33 ± 0.50 adults at 0–1 m to 8.33 ± 0.50 at 2–3 m and 5.61 ± 0.50 at 4–5 m. Rainy-season abundance (10.39 ± 0.40) was approximately 60.8% higher than dry-season abundance (6.46 ± 0.40), while Bubare recorded higher abundance (9.44 ± 0.40) than Kaberebere (7.41 ± 0.40). The findings indicate that residue structure and spatial

position are associated with adult weevil aggregation. They support targeted habitat modification and strategic residue placement rather than blanket removal of banana residues. Because the study measured adult abundance rather than mortality, crop damage or yield, the observed aggregation patterns should not be interpreted as direct evidence of control efficacy.

Keywords: *Banana weevil; Cosmopolites sordidus; Banana residues; Residue configuration; Habitat modification; Crop sanitation; Integrated pest management.*

1.0 Introduction

Banana Production and the Banana Weevil Constraint

Banana (*Musa spp.*) is an important food, income and livelihood crop for smallholder households in Uganda. Its productivity is constrained by several pests and diseases, among which the banana weevil, *Cosmopolites sordidus* Germar, remains a persistent problem in East African highland banana systems. The larval stages feed within the corm and basal plant tissues, where damage is protected from direct intervention. Progressive injury can compromise plant anchorage, reduce bunch performance and contribute to deterioration of banana mats over successive crop cycles [1,2].

The biology of *C. sordidus* makes habitat management particularly relevant. Adults are associated with banana mats, plant bases, soil surfaces and freshly cut plant material, while immature stages develop within protected plant tissues [2]. Consequently, crop sanitation, residue management and trapping have long been considered components of integrated banana-weevil management. Contemporary reviews similarly emphasize combining compatible management practices rather than relying on a single intervention [10,11].

Banana Residues as both Agronomic Resources and Pest Habitat

Post-harvest banana residues present a management dilemma. Freshly cut corms and pseudostems can provide food, shelter and oviposition substrates for *C. sordidus*, and experimental studies have demonstrated that residue age and tissue condition influence attraction, oviposition and larval survival [5,6]. At the same time, residues contribute organic matter, moisture retention and nutrient cycling and may therefore have agronomic value when retained in the field. Management based simply on complete residue removal can consequently impose labour costs and remove functions that are beneficial to soil and crop management.

The more useful management question is therefore how residue condition, structure and placement can be modified to reduce persistent pest habitat while retaining as many agronomic benefits as possible. Field research in Uganda has associated improved crop sanitation with lower weevil populations and corm damage [3], while mulch studies indicate that residue placement can alter weevil abundance and crop responses [9]. These findings justify examining residue configuration as a specific management attribute rather than treating residue presence as a binary condition.

Residue Configuration, Distance and Seasonal Context

Physical configuration can change the continuity of shelter, the amount of exposed tissue and the persistence of residue patches. Chopping large pieces into smaller fragments may reduce continuous protected surfaces and accelerate drying and decomposition, whereas intact prostrate material retains larger surfaces that can provide shelter. In the present study, the alternating configuration combined prostrate and chopped residues within the same patch. Such a

heterogeneous arrangement could produce a different aggregation environment from either configuration alone. However, mechanisms involving moisture, temperature, decomposition or chemical cues were not measured and therefore remain hypotheses rather than demonstrated explanations.

Spatial position is also relevant because adult weevils are commonly associated with banana mats and nearby residues. Pseudostem trapping has been investigated as a means of concentrating adults for subsequent removal or destruction [7]. More recent trapping research indicates that climatic conditions and trap location can influence capture patterns [8]. These observations provide a basis for evaluating residue placement relative to standing banana mats.

Season may modify the suitability of residue habitats. Rainfall can affect soil and residue moisture and the persistence of sheltered microsites, while dry conditions may increase desiccation. The present experiment therefore evaluated residue configuration and distance under both dry and rainy conditions and compared two banana-growing locations.

1.1 Problem Statement and Knowledge Gap

Existing studies have established the importance of crop sanitation, residue age, mulch and pseudostem trapping in banana-weevil management [3,5–7,9]. However, field evidence remains limited on how different physical residue configurations interact with their spatial position relative to standing banana mats under contrasting seasonal conditions in south-western Uganda. In particular, the aggregation response to a configuration combining prostrate and chopped residues has not been adequately quantified. Addressing this gap can help distinguish residue practices that increase adult aggregation from those that reduce persistent refuge, while avoiding recommendations for indiscriminate removal of useful organic material.

1.2 Objective

The study evaluated the effects of residue configuration and distance from standing banana mats on adult *C. sordidus* abundance during dry and rainy seasons at two sites in south-western Uganda. Specifically, it: (i) determined whether residue configuration affected adult abundance; (ii) assessed the spatial pattern of abundance with increasing distance from the banana mat; and (iii) determined whether seasonal and site conditions influenced adult abundance and whether they modified the principal treatment responses.

2.0 Materials and Methods

2.1 Study Design and Experimental Setting

A factorial field experiment was conducted at Bubare in Mbarara District and Kaberebere in Isingiro District during dry and rainy seasons. A randomized complete block design with three replications was used within each site-season combination. The treatment factors were residue configuration, with three levels (Alternating, Prostrate and Chopped), and distance from the standing banana mat, with three levels (0–1, 2–3 and 4–5 m). Thus, each site-season experiment contained nine residue-by-distance combinations, each replicated three times, giving 27 experimental treatment mats per site-season and 108 replicate-level observations across the full design.

2.2 Experimental Unit and Residue Treatments

The independently treated banana mat associated with each residue-by-distance combination constituted the experimental unit. Each block contained one replicate of each of the nine treatment

combinations. Fresh residue from *Kibuzi* banana plants was used throughout because of its availability.

For the Prostrate treatment, intact banana corm/residue pieces approximately 30 cm long were laid horizontally on the soil surface. For the Chopped treatment, approximately 2 kg of fresh residue was cut into pieces of approximately 5 cm and placed within the designated treatment area. The Alternating treatment combined prostrate and chopped residues in an alternating arrangement using approximately equivalent quantities of fresh residue; the chopped component was arranged in layers of approximately 5 cm while the intact component remained prostrate. In this article, “Alternating” refers specifically to this combined spatial configuration and not to changing treatments over time. Residue dimensions, quantities and placement were kept as consistent as practicable among treatment locations and maintained throughout the 10-week monitoring period.

2.3 Distance Treatments and Experimental Containment

Residue patches were positioned at 0–1, 2–3 and 4–5 m from the standing banana mat. Fine-mesh physical barriers were installed around designated experimental areas to minimize movement of adults among neighbouring treatment locations. Soil-contact points and joints were checked during establishment and the barriers were inspected regularly. Adults found outside designated experimental areas were recorded separately and removed to reduce cross-contamination.

2.4 Adult Collection, Release and Monitoring

Adult *C. sordidus* were collected from naturally infested banana fields and acclimatized before release. Twenty-five adults were released per experimental mat, comprising 13 females and 12 males. Each block therefore received 225 adults, giving 675 adults per site-season experiment and 2,700 adults across the four site-season experiments when releases were made independently. The standardized density and sex ratio provided a common starting pest pressure across treatments.

Adult abundance was monitored for 10 consecutive weeks. Each treatment mat was inspected once per week. Observations covered the upper and lower residue surfaces, soil-residue interface, sheltered spaces beneath intact residue and spaces between residue pieces. All adults observed within the designated treatment location were counted and recorded for the relevant site, season, residue configuration, distance, replicate and week.

2.5 Response Variable and Statistical Analysis

The 10 weekly observations from each treatment replicate were averaged to produce one 10-week mean weekly adult-abundance value. The weekly observations were therefore treated as repeated observations within a replicate rather than as independent experimental replicates. The factorial analysis used these replicate-level means, giving 108 observations and 107 total degrees of freedom.

A four-factor factorial analysis of variance tested the main effects of site, season, residue configuration and distance and all two-, three- and four-way interactions. The residual degrees of freedom were 72 and the residual mean square was 8.843. Statistical significance was assessed at $\alpha = 0.05$. For significant factors with more than two levels, Tukey’s honestly significant difference test was used for pairwise mean separation. Results are presented as mean $\pm$ standard error (SE). Means with different Tukey letters differ significantly at the 5% level.

3.0 Findings and Discussion

3.1 Dry-Season Treatment Patterns

During the dry season, alternating residues generally recorded the greatest adult abundance at all three distances at both sites. At Bubare, alternating abundance declined from 15.00 adults at 0–1 m to 10.00 at 2–3 m and 8.00 at 4–5 m. At Kaberebere, the corresponding means were 11.00, 7.00 and 3.33. Prostrate residues showed the same broad spatial decline, whereas Chopped residues generally recorded the lowest values.

Table 1: 10-week mean weekly abundance of adult C. sordidus under different residue configurations and distances during the dry season

Site	Residue	Distance (m)	Rep. 1	Rep. 2	Rep. 3	Mean
Bubare	Alternating	0–1	19	15	11	15.00
Bubare	Alternating	2–3	14	10	6	10.00
Bubare	Alternating	4–5	11	7	6	8.00
Bubare	Prostrate	0–1	18	10	5	11.00
Bubare	Prostrate	2–3	9	6	3	6.00
Bubare	Prostrate	4–5	6	4	2	4.00
Bubare	Chopped	0–1	11	5	2	6.00
Bubare	Chopped	2–3	6	4	2	4.00
Bubare	Chopped	4–5	3	2	1	2.00
Kaberebere	Alternating	0–1	16	10	7	11.00
Kaberebere	Alternating	2–3	10	6	5	7.00
Kaberebere	Alternating	4–5	5	3	2	3.33
Kaberebere	Prostrate	0–1	12	10	5	9.00
Kaberebere	Prostrate	2–3	9	6	3	6.00
Kaberebere	Prostrate	4–5	6	4	2	4.00
Kaberebere	Chopped	0–1	9	5	1	5.00
Kaberebere	Chopped	2–3	5	3	1	3.00
Kaberebere	Chopped	4–5	3	2	1	2.00

3.2 Rainy-Season Treatment Patterns

The rainy-season observations showed the same overall ordering of residue configurations. Alternating residues had the highest abundance at each site and distance, whereas Chopped residues had the lowest values. Adult abundance was also concentrated closer to the standing banana mat.

Table 2: Ten-week mean weekly abundance of adult *C. sordidus* under different residue configurations and distances during the rainy season.

Site	Residue	Distance (m)	Rep. 1	Rep. 2	Rep. 3	Mean
Bubare	Alternating	0–1	22	20	18	20.00
Bubare	Alternating	2–3	19	18	14	17.00
Bubare	Alternating	4–5	14	11	8	11.00
Bubare	Prostrate	0–1	16	15	14	15.00
Bubare	Prostrate	2–3	13	11	9	11.00
Bubare	Prostrate	4–5	10	9	5	8.00
Bubare	Chopped	0–1	12	10	5	9.00
Bubare	Chopped	2–3	10	8	6	8.00
Bubare	Chopped	4–5	7	5	3	5.00
Kaberebere	Alternating	0–1	19	16	13	16.00
Kaberebere	Alternating	2–3	16	14	9	13.00
Kaberebere	Alternating	4–5	12	8	7	9.00
Kaberebere	Prostrate	0–1	15	12	9	12.00
Kaberebere	Prostrate	2–3	11	9	7	9.00
Kaberebere	Prostrate	4–5	9	6	3	6.00
Kaberebere	Chopped	0–1	10	7	4	7.00
Kaberebere	Chopped	2–3	8	5	5	6.00
Kaberebere	Chopped	4–5	7	5	3	5.00

3.3 Factorial ANOVA

Table 3: Factorial ANOVA of 10-week mean weekly abundance of adult *C. sordidus* according to site, season, residue configuration, and distance. SS = sum of squares; MS = mean square.

Source	SS	df	MS	F	P-value
Site	112.037	1	112.037	12.670	<0.001
Season	416.148	1	416.148	47.062	<0.001
Residue configuration	767.019	2	383.509	43.371	<0.001
Distance	589.852	2	294.926	33.353	<0.001
Site × Season	2.370	1	2.370	0.268	0.606
Site × Residue	34.574	2	17.287	1.955	0.149
Season × Residue	25.796	2	12.898	1.459	0.239
Site × Distance	6.741	2	3.370	0.381	0.684
Season × Distance	7.630	2	3.815	0.431	0.651
Residue × Distance	63.870	4	15.968	1.806	0.137
Site × Season × Residue	5.574	2	2.787	0.315	0.731
Site × Season × Distance	2.741	2	1.370	0.155	0.857
Site × Residue × Distance	2.981	4	0.745	0.084	0.987
Season × Residue × Distance	2.759	4	0.690	0.078	0.989
Site × Season × Residue × Distance	3.648	4	0.912	0.103	0.981
Error	636.667	72	8.843	—	—
Total	2680.407	107	—	—	—

The factorial ANOVA identified significant main effects of site, season, residue configuration and distance. Residue configuration produced the largest F-statistic among the four factors, followed by season and distance. None of the two-, three- or four-way interactions was statistically significant ($P > 0.05$).

3.4 Effect of residue configuration

Table 4: Mean weekly abundance of *C. sordidus* according to residue configuration

Residue configuration	Mean $\pm$ SE	Tukey group
Alternating	11.69 $\pm$ 0.50	a
Prostrate	8.42 $\pm$ 0.50	b
Chopped	5.17 $\pm$ 0.50	c

Residue configuration significantly affected adult abundance ($F_{2,72} = 43.37$, $P < 0.001$). Alternating residues had the highest mean abundance, followed by Prostrate and Chopped residues. The three means formed distinct Tukey groups, indicating significant pairwise differences at $\alpha = 0.05$.

3.5 Effect of Distance from the Banana Mat

Table 5: Mean weekly abundance of *C. sordidus* according to distance from the banana mat.

Distance	Mean $\pm$ SE	Tukey group
0–1 m	11.33 $\pm$ 0.50	a
2–3 m	8.33 $\pm$ 0.50	b
4–5 m	5.61 $\pm$ 0.50	c

Distance significantly affected adult abundance ($F_{2,72} = 33.35$, $P < 0.001$). Abundance declined progressively from 11.33 $\pm$ 0.50 adults at 0–1 m to 8.33 $\pm$ 0.50 at 2–3 m and 5.61 $\pm$ 0.50 at 4–5 m. The three distance classes were separated into distinct Tukey groups.

3.6 Seasonal and site effects

Table 6: Mean weekly abundance of *C. sordidus* according to season

Season	Mean $\pm$ SE	Tukey group
Rainy	10.39 $\pm$ 0.40	a
Dry	6.46 $\pm$ 0.40	b

Season significantly affected adult abundance ($F_{1,72} = 47.06$, $P < 0.001$). Mean abundance was 10.39 $\pm$ 0.40 in the rainy season and 6.46 $\pm$ 0.40 in the dry season, representing an increase of approximately 60.8%.

Table 7: Mean weekly abundance of *C. sordidus* according to study site

Study site	Mean $\pm$ SE	Tukey group
Bubare	9.44 $\pm$ 0.40	a
Kaberebere	7.41 $\pm$ 0.40	b

Site significantly affected adult abundance ($F_{1,72} = 12.67$, $P < 0.001$). Bubare recorded 9.44 ± 0.40 adults compared with 7.41 ± 0.40 at Kaberebere, a difference of 2.03 adults.

3.7 Interaction effects

None of the two-, three- or four-way interaction terms was statistically significant. In particular, residue configuration did not interact significantly with distance, season or site, and the highest-order interaction was also non-significant. Within the conditions represented in the experiment, the main-effect patterns were therefore broadly consistent across the tested combinations.

4.0 Discussion

4.1 Residue configuration and adult aggregation

Residue configuration produced a clear difference in adult abundance. The Alternating treatment supported the highest mean abundance, followed by Prostrate and Chopped residues. This result is consistent with evidence that *C. sordidus* adults respond to the condition and type of banana plant residue and that residues can provide shelter and resources associated with adult activity and oviposition [5,6].

The higher abundance associated with alternating residues may reflect the physical heterogeneity created when intact prostrate material is combined with chopped material. The configuration provides different surfaces and degrees of shelter within the same patch. This interpretation is biologically plausible, but the present experiment did not measure residue moisture, temperature, decomposition rate or volatile emissions. Those variables should therefore be treated as candidate mechanisms requiring direct testing rather than as established causes of the observed response.

The lower abundance associated with Chopped residues is compatible with the principle of habitat modification. Fragmentation can interrupt continuous protected surfaces and may alter the persistence of suitable refuge. Previous Ugandan work has shown that improved sanitation can reduce weevil populations and crop damage [3]. The present results extend that line of reasoning by indicating that the physical configuration of retained residue matters, not merely whether residue is present.

4.2 Distance from the banana mat

Adult abundance declined consistently as residue patches were positioned farther from standing banana mats. The 0–1 m zone recorded the highest abundance, whereas the 4–5 m zone recorded the lowest. This spatial gradient agrees with the established association of *C. sordidus* with banana mats and nearby crop residues [2, 5, 7].

The finding has two distinct management implications. First, where residues are retained primarily for soil-management purposes, persistent sheltered structures immediately adjacent to the banana mat may warrant particular attention. Second, where residue is intentionally deployed as a trapping substrate, placement near the mat may increase the likelihood of encountering resident adults. Attraction alone, however, does not constitute control. A residue trap that attracts adults without subsequent removal or killing could increase the availability of a suitable habitat. Effective trapping therefore requires a validated procedure for capture, destruction or lethal treatment [7].

4.3 Seasonal variation

Adult abundance was approximately 60.8% higher during the rainy season than during the dry season. The result is compatible with the ecological importance of moisture and sheltered residue

habitats and with evidence that climatic conditions can influence banana-weevil trapping performance [8].

The seasonal comparison should not be interpreted as evidence that rainfall alone caused the difference. Continuous rainfall, relative humidity, soil moisture, residue moisture and temperature were not measured in the experiment. The appropriate interpretation is therefore that adult abundance was strongly associated with season under the conditions studied. Future experiments that quantify these environmental variables would help identify which components of seasonal change are most closely related to adult aggregation.

4.4 Differences between study sites

Bubare recorded greater adult abundance than Kaberebere. Because sanitation, field history and other environmental variables were not independently manipulated as site-level treatments, the difference cannot be attributed to a single causal factor. Variation in local pest pressure, previous crop history, soil conditions, residue availability, microclimate and farm management could contribute to site-level differences. Regional variation in banana-weevil damage in Uganda has also been documented [4].

Importantly, the absence of significant site-by-treatment interactions indicates that the relative treatment patterns did not differ statistically between the two study sites. This supports cautious interpretation of the residue and distance effects across the two locations, while recognizing that additional farms and agroecological settings are needed before generalizing the magnitude of the effects to all banana-growing areas.

4.5 Interpretation of the Non-Significant Interactions

The non-significant interaction terms indicate that the principal treatment effects were statistically consistent across the site, season and distance combinations represented in the experiment. In practical terms, the higher abundance associated with Alternating residue was not statistically confined to one site or season, and the distance gradient did not differ significantly among residue configurations.

Non-significance should not be interpreted as proof that interactions do not exist under other conditions. Interaction detection depends on the range of environments sampled, experimental precision and replication. Broader multi-location studies with additional seasons and environmental measurements would provide stronger evidence about context dependence.

4.6 Implications for integrated pest management

The findings support residue management as one component of an integrated banana-weevil strategy. Reviews of *C. sordidus* management emphasize combining cultural practices with host resistance, biological control, trapping and other compatible measures [10,11]. Nutritional management can also influence weevil-related damage under particular crop and soil conditions [12].

The strong aggregation response associated with Alternating residue creates a research opportunity for deliberate residue-based trapping. Nevertheless, this study measured adult abundance associated with residue patches; it did not measure adult mortality, larval survival, corm damage or yield. Alternating residue should therefore be described as a promising aggregation substrate, not as a demonstrated control treatment.

A practical distinction should be made between residues retained for agronomic functions and residues deliberately deployed for trapping. Retained residues can be fragmented or otherwise configured to reduce continuous sheltered habitat. Where an attractive residue configuration is used as a trap, it should be inspected regularly and coupled with timely removal, destruction or another validated lethal intervention. This approach could convert aggregation into a management opportunity without recommending blanket residue removal.

5.0 Conclusion

Residue configuration, distance from the standing banana mat, season and study site each significantly influenced adult *C. sordidus* abundance under the conditions of this field experiment. Alternating residues recorded the highest abundance, followed by Prostrate and Chopped residues. Adult abundance declined progressively with increasing distance from the banana mat, was higher during the rainy season than the dry season, and was higher at Bubare than Kaberebere. No interaction term was statistically significant.

The results demonstrate that the physical arrangement and spatial placement of retained banana residues are relevant to adult weevil aggregation. They support a habitat-modification approach in which residues are managed according to both their pest-related and agronomic functions. The evidence does not support blanket residue removal and does not by itself establish that any residue configuration suppresses infestation, damage or yield loss.

6.0 Recommendations

- i. Prioritize prompt chopping or processing of post-harvest residues where the primary objective is to reduce persistent *C. sordidus* refuge.
- ii. Where residues are retained for soil fertility, moisture conservation or other agronomic purposes, modify their configuration to reduce continuous sheltered structures.
- iii. Give particular attention to residue patches within 0–1 m of standing banana mats during monitoring because this zone recorded the highest adult abundance.
- iv. Strengthen residue inspection and sanitation during rainy periods when adult abundance was higher in this study.
- v. Use Alternating residue as a trapping substrate only within a managed trapping system that includes timely removal, destruction or another validated lethal intervention.
- vi. Integrate residue management with clean planting material, host resistance, biological control, trapping and other locally appropriate integrated pest-management measures.
- vii. Measure residue moisture, temperature, decomposition rate and volatile emissions to test the mechanisms underlying the stronger aggregation response observed in Alternating residue.
- viii. Conduct mark–recapture studies to estimate movement distances and determine whether residue patches intercept resident adults or dispersing adults.
- ix. Evaluate residue-based trapping systems for adult retention and mortality and determine whether repeated trapping reduces infestation, corm damage and yield loss.
- x. Repeat the experiment across additional farms, agro ecological settings and seasons to assess the stability and context dependence of the observed effects.
- xi. Assess the economic costs and benefits of residue processing, retention and trapping so that recommendations can be evaluated under farmer-managed conditions.

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Author Contributions

The authors' contributions are reported according to the CRediT (Contributor Roles Taxonomy): Conceptualization: Tumwine J. Barugahare, Richard Y. M. Kangalawe, Edward Ssemakula, and Emma T. Liwenga. Methodology and study design: Tumwine J. Barugahare, Richard Y. M. Kangalawe, Edward Ssemakula, and Emma T. Liwenga. Field investigation: Tumwine J. Barugahare and Edward Ssemakula. Data curation: Tumwine J. Barugahare and Edward Ssemakula. Data analysis: Tumwine J. Barugahare and Richard Y. M. Kangalawe. Interpretation: Tumwine J. Barugahare, Richard Y. M. Kangalawe, Edward Ssemakula, and Emma T. Liwenga. Original draft preparation: Tumwine J. Barugahare. Review, editing and critical revision: Richard Y. M. Kangalawe, Edward Ssemakula, and Emma T. Liwenga. Supervision and scientific guidance: Richard Y. M. Kangalawe, Edward Ssemakula, and Emma T. Liwenga. All authors reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the research, authorship or publication of this article.

Data Availability

The experimental dataset generated and analysed during this study is available from the corresponding author upon reasonable request. Access may be granted for legitimate research purposes, subject to appropriate institutional and ethical considerations and agreement on the intended use of the data.

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