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Morphological Characteristics of Paddy Earthworm in Heirloom Rice Farms in Upper Kalinga Province

Haneelyn M. Magguia
College of Agriculture, Cagayan State University, Piat Campus, Cagayan, 3527, Philippines
haneelyndmoling16@gmail.com

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ABSTRACT

This comparative observational study examined the morphological characteristics of paddy earthworms collected from heirloom rice farms in Tanudan, Tinglayan, and Balbalan in Kalinga Province, Philippines. A total of 90 specimens were collected and analyzed. Each station was treated as a replicate, and the average values per station were used for the statistical analysis. The traits measured were the body length, the body diameter, and the number of annuli. Other features like the setal arrangement, body shape, coloration, and prostomium type were also observed using microscopes. The results showed that the body length ranged from 75.03 mm to 81.59 mm, while the body diameter ranged from 1.13 mm to 1.18 mm. There was no significant difference in the body length ($p = 0.0565$) and body diameter ($p = 0.6211$) among the three locations. However, the number of annuli showed a significant difference ($p = 0.0068$), with Study Site 2 having the highest values. All specimens have four pairs of closely paired setae per segment (eight setae per segment) and a zygolobous prostomium, which supports their identification under the genus *Sparganophilus.* These traits were consistent across all sites. The presence of paddy earthworms suggests their role in soil processes such as decomposition and soil mixing in rice fields. However, their actual impact on rice plants was not directly measured in this study, which could be studied further. Thus, this study provides baseline information about paddy

earthworms in Kalinga heirloom rice farms. It also suggests the need for future studies about the inclusion of molecular analysis and soil testing to better understand these organisms and their environment.

Keywords: *paddy earthworms, Sparganophilus species, morphometric analysis, heirloom rice farms, taxonomy*

Introduction

Rice is one of the most important staple foods in the world, especially in Asia, where it is part of daily life and culture (Food and Agriculture Organization, 2023). In the Philippines, rice farming is closely linked to food security and cultural identity, particularly in indigenous communities like those in the Cordillera region. In Kalinga Province, heirloom rice varieties such as Chong-ak and Ulikan are grown in traditional rice terraces using indigenous farming practices. These farms depend on natural water sources like springs and rivers (PhilRice, 2025). Although heirloom rice is valued for its aroma and nutritional quality, farmers often experience lower yields compared to modern rice varieties because of traditional farming methods and limited use of chemical inputs (Augustine et al., 2025; Bairagi et al., 2020; Langngag, 2018; Manikandan et al., 2025).

Essentially, soil organisms are important in rice ecosystems because they help in decomposition and nutrient cycling. One of these organisms is the earthworm, which plays a role in improving soil structure and breaking down organic matter (Lavelle, 1988). In paddy fields, endogeic earthworms live inside the soil and contribute to soil mixing and nutrient movement. However, earthworms may also have complex roles depending on their population and environment (Zhang et al., 2022). In some cases, high numbers of earthworms may affect the young rice plants, especially in wet soil conditions. This shows that their role in agriculture is not only beneficial but also needs a proper understanding, depending on the ecosystem (Jouquet et al., 2024; Sofo et al., 2023).

In Kalinga heirloom rice farms, earthworms are commonly observed, but there is still limited scientific information about their morphological characteristics and taxonomic identity. Studies about earthworms under the genus *Sparganophilus* in the Philippines rice ecosystem are still limited (Flores, 2009; Joshi et al., 2020). Because of this, there is a need to document and describe the morphological characteristics of paddy earthworms found in heirloom rice fields.

This study described the morphological characteristics of paddy earthworms collected from heirloom rice farms in Tanudan, Tinglayan, and Balbalan, Kalinga Province. It specifically collected earthworm specimens using standard taxonomic references; described the morphological characteristics of the collected paddy earthworm specimens in terms of body length, diameter, number of annuli, and setal arrangement; compared the morphometric variations from the aforementioned selected heirloom rice farms in Kalinga Province; and classified the earthworms based on their external morphological characteristics using a dichotomous key. The results of this study may serve as baseline information for future ecological and taxonomic research in heirloom rice ecosystems.

Methods

Study Area Collection

The study was conducted in three selected heirloom rice farms in Kalinga Province, Philippines. The collection sites were in Dacalan, Tanudan; Bugnay, Tinglayan; and Pantikian, Balbalan. These areas were selected because paddy earthworms were frequently observed in these rice fields. The sampling followed this order: municipality, barangay or sites, stations, and specimens.

The three municipalities served as sampling locations. Tanudan was Study Site 1, Tinglayan was Study Site 2, and Balbalan was Study Site 3. Each study site had three specific sites, and each station served as one replicate. Ten paddy earthworm specimens were collected from each station. A total of 90 specimens were collected for the study.

In Dacalan, Tanudan, Kalinga, Station 1 was located at 17^0 13' 48" N, 121^0 13' 36" E; Station 2 was located at 17° 14' 09" N, 121° 13' 38" E; and Station 3 was located at 17° 13' 46" N, 121° 13' 34" E. On the other hand, in Bugnay, Tinglayan, Kalinga, Station 1 was located at 17° 29' 37" N, 121° 10' 02" E; Station 2 was located at 17° 29' 38" N, 121° 10' 03" E; and Station 3 was located at 17° 29' 38" N, 121° 10' 04" E. In Pantikian, Balbalan, Kalinga, Station 1 was located at 17° 12' 07" N, 121° 05' 26" E; Station 2 was located at 17° 12' 09" N, 121° 05' 29" E; and Station 3 was located at 17° 12' 14" N, 121° 05' 21" E.

Collection

The collection of paddy earthworms was conducted early in the morning when the rice fields were still undisturbed. The specimens were carefully collected by using shovels and hand-digging around the base of paddy plants to avoid injury. Collected specimens were first placed in a clean basin for sorting and then transferred into labeled plastic containers containing moist field soil to prevent desiccation when traveling. Mobile cameras were used to get the exact longitude and latitude coordinates of the area. The specimens were brought to Room CA 104, College of Agriculture Laboratory, Kalinga State University, for cleaning, preservation, measurement, observation, and identification. A compound microscope, a stereomicroscope, and an LCD digital biological microscope were used to observe the external morphological identification of the specimens.

Preservation of Collected Samples

In the laboratory, the collected specimens were gently rinsed with clean water using fine-mesh sieves to remove soil particles from the body surface. They were then placed on tissue paper for several minutes to remove excess water before measurement. The specimens were soaked in 70% ethanol to relax their body and make the external morphology easier to observe. Body length and maximum body diameter were measured after relaxation in 70% ethanol and before transfer to 95% ethanol. After measurement and documentation, the specimens were transferred to 95% ethanol for long-term preservation.

All the specimens were measured using the same preservation procedure to reduce differences caused by handling. However, ethanol may still affect the body length and body diameter because it can cause slight shrinkage or changes in body size. This was considered a limitation of the study. The preserved specimens were then placed in labeled tubes. The labels included the study site number, station or replicate number, specimen number, collection site, and date of collection. This specimen was stored at Room CA 104, College of Agriculture Laboratory, Kalinga State University, for future

reference and verification. All the used ethanol and biological materials were handled and disposed of following laboratory safety procedures.

Sampling Design

This study employed a comparative field sampling design to evaluate the morphometric characteristics of paddy earthworms collected from three heirloom rice farming areas in Kalinga Province. The three sampling sites were Dacalan, Tanudan; Bugnay, Tinglayan; and Pantikian, Balbalan. Within each sampling site, three independent sampling stations were established. Each sampling station served as one replicate, and ten earthworm specimens were collected from each station. The ten specimens were treated as subsamples because they originated from the same sampling station and were therefore not considered statistically independent. For each morphometric variable, the mean of the ten specimens was calculated for each station, and these station means were used as the replicate values in the statistical analysis. Differences among the three sampling sites were evaluated using one-way analysis of variance (ANOVA).

Morphometric Data

The morphological data were gathered using digital calipers, a compound microscope, a stereomicroscope, and an LCD digital biological microscope. The recorded traits were the body length, maximum diameter, number of annuli, setal arrangement, presence of clitellum, coloration pattern, and body shape. On the other hand, the body length was measured in millimeters from the prostomium at the anterior end to the pygidium at the posterior end. The maximum body diameter was measured in millimeters at the thickest part of the body, usually located near or within the clitellar region when the clitellum was visible.

The number of annuli was counted from the whole body of each specimen. In this study, annuli referred to the visible ring-like divisions on the earthworm's body. Counting was done under a stereomicroscope from the anterior region after the prostomium up to the posterior region before the pygidium. Damaged, unclear, or highly contracted body parts were noted because they could affect the accuracy of counting. Moreover, setae were recorded based on their arrangement per segment. Each visible segment had four pairs of closely paired setae, equal to eight setae per segment. The setal arrangement was used as a diagnostic character for identification and was not treated as a separate total setae count.

The presence and absence of a clitellum were also recorded. Specimens with a visible clitellum were considered adult or clitellate, while the specimens without a visible clitellum were recorded as juvenile or non-clitellate. Coloration patterns were observed based on the visible dorsal-ventral color of the specimens. Body shape was described based on the external form of the specimens, such as elongated, slender, or contracted. Representative photographs were taken to document external morphology and counting methods. An annotated image or diagram showing the anterior ends, posterior end, annuli or body segments, and setal arrangement was also included to make the counting method clearer.

Gathered Data

The following data were measured, counted, and recorded:

1. *Average body length (mm).* The body length was measured from the prostomium to the pygidium using a digital caliper. The body length of the ten specimens per station was measured individually, and the average was computed.
2. *Maximum diameter (mm).* The maximum body diameter was measured at the thickest part of the body, usually located near or within the clitellar region. The diameter of the ten specimens per station was measured individually, and the average was computed.
3. *Number of annuli.* The number of annuli was counted from the whole body of each specimen using a stereomicroscope. Counting started after the prostomium and ended before the pygidium.
4. *Setal arrangement.* The arrangement of setae was observed under a stereomicroscope. Each segment had four pairs of closely paired setae, which is equal to eight setae per segment. This was recorded for identification purposes.
5. *Presence of a clitellum*. The presence of the clitellum was observed. When present, its position was recorded based on the corresponding body region or annuli.
6. *Coloration pattern.* The dorsal and ventral body of each specimen was observed and recorded.
7. *Body shape.* The body shape of each specimen was described based on its external appearance.

Morphological Characterization and Identification

The morphological characterization was done using the dichotomous key in Appendix B and the description of *Sparganophilus species* from Joshi et al. (2020), Rota et al. (2014), and Sims and Gerard (1985). These references were used to compare the observed morphology of the collected specimens with established taxonomic descriptions. The main characters used for identification were prostomium type, setal arrangement, body shape, coloration, habitat, and presence or absence of clitellum. The specimens showed a zygolobous prostomium and four pairs of closely paired setae per segment. The specimens were also collected from wet paddy field conditions, which supported their identification as paddy earthworms.

Other possible earthworm groups were considered during identification. They were ruled out based on differences in prostomium type, setal arrangement, body form, coloration, clitellar condition, and habitat. Since the study used external morphology only and did not include molecular analysis or internal dissection, the specimens were identified only up to the genus level of *Sparganophilus sp.*

Soil Characteristics

Soil characteristics such as soil moisture, soil texture, pH, and organic matter were not measured in this study. Consequently, these factors were not subjected to statistical analysis or interpreted in relation to existing literature. Instead, they were presented as direct findings of the study. Future studies might include soil analysis to better explain the relationship between soil condition and paddy earthworm morphology.

Statistical Analysis

The quantitative data were analyzed using the Statistical Tool for Agricultural Research (STAR). One-way Analysis of Variance (ANOVA) was performed to determine whether significant differences existed among the three sampling sites with respect to the morphometric characteristics of the collected earthworms.

The mean value of the ten specimens collected from each sampling station was used as the observational unit for statistical analysis. Each sampling site consisted of three independent sampling stations, with each station serving as one replicate. The ten specimens collected within each station were considered subsamples because they originated from the same sampling unit and were not assumed to be statistically independent. Consequently, the replicate mean for each station was used in the ANOVA to avoid pseudoreplication. With three sampling sites and three replicates per site, the analysis included two degrees of freedom for sampling sites, six degrees of freedom for error, and eight total degrees of freedom.

Descriptive statistics, including the mean, standard deviation, and coefficient of variation, were computed for each quantitative variable. When the ANOVA indicated significant differences among sampling sites, the Least Significant Difference (LSD) test at the 5% level of significance was used for pairwise comparisons of site means. Prior to analysis, the assumptions of normality and homogeneity of variance were assessed. The results were reported in terms of the F-statistic, degrees of freedom, exact p-values, and the corresponding level of significance. Differences among sampling sites were considered statistically significant at $p \leq 0.05$.

Ethical Considerations

The study did not involve human participants or vertebrate animals. Permission to collect specimens was secured from the concerned farm owners. The collection was done carefully to reduce disturbance to the rice plants and the surrounding field area. The handling and disposal of specimens and used ethanol were included under the preservation and handling procedures.

Results and Discussion

General Observations

The paddy earthworms collected from heirloom rice farms in upper Kalinga Province were generally small, slender, and thread-like. Their bodies were unpigmented to light pink, and some internal parts were slightly visible under the stereomicroscope. They also reacted quickly when disturbed, which shows their sensitivity to movement. These characteristics are similar to those of earthworms that usually live in wet and waterlogged soils, as described by Lee (1985) and Rota et al. (2014), where species adapted to low-oxygen environments tend to be pale and slender.

Earthworm castings were seen near rice plants in the field. Although earthworms are known to help improve soil fertility and structure through casting and decomposition (Blouin et al., 2013; Fonte et al., 2023), the actual effects on rice seedlings were not measured in this study. Because of this, the observation is only considered a field note and not part of the main results. All measurements were done using a standard procedure, where specimens were first relaxed in 70% ethanol before being preserved in 95% ethanol. This was done to make sure that all samples were measured under the same conditions and to reduce possible errors.

Taxonomic Results

All specimens showed a zygolobous prostomium and four pairs of closely paired setae per segment (eight setae per segment). These traits support identification under the genus *Sparganophilus*. This is also consistent with descriptions of earthworms that are usually found in wet and muddy habitats (Rota et al., 2014; Magahud et al., 2017).

The same traits were observed in all sampling sites, which suggests that the specimens may belong to a similar group. However, since the identification was only based on external characteristics and no molecular analysis was done, the identification is limited only to the genus level, following standard practice in morphological studies (Sims & Gerard, 1985).

Body Length

The body length of the specimens ranged from 75.03 mm to 81.59 mm, with an average mean of 77.97 mm. There was no significant difference among the three sampling sites ($p = 0.0565$). This suggests that the earthworms from the different locations are relatively similar in size. According to Tripathi et al. (2021), the body size of earthworms can remain stable when they are found in similar environmental conditions. In this study, it may indicate that the sites have comparable soil conditions, although this cannot be confirmed because soil properties were not directly measured.

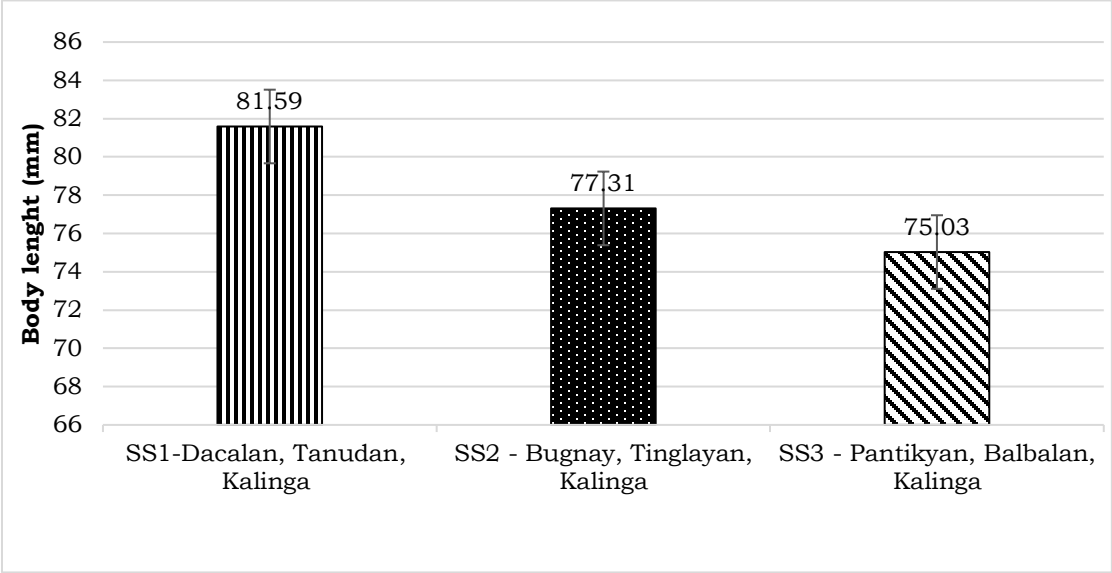

Figure 1. *Mean Body Length (mm) of Paddy Earthworms Collected from Heirloom Rice Farms in Dacalan (Tanudan), Bugnay (Tinglayan), and Pantikian (Balbalan), Kalinga Province, Philippines*

Body Diameter

The body diameter ranged from 1.13 mm to 1.18 mm, with an overall mean of 1.16 mm. No significant differences were found among treatments ($p = 0.6211$). This shows that the body thickness of the earthworms is also consistent across all sites. This result is similar to the description of endogeic earthworms, which are usually thin and adapted to moving in wet soil conditions (Lee, 1985). It also supports the idea that the specimens likely belong to the same population group.

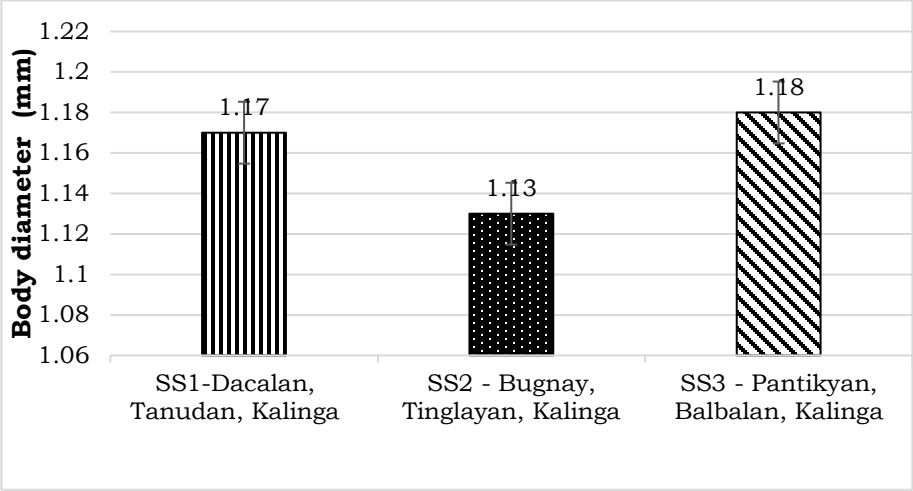

Figure 2. *Mean Maximum Body Diameter (mm) of Paddy Earthworms Collected from Heirloom Rice Farms in Dacalan (Tanudan), Bugnay (Tinglayan), and Pantikian (Balbalan), Kalinga Province, Philippines*

Number of Annuli

The number of annuli ranged from 112.80 to 168.00, and there was a significant difference among study sites (p = 0.0068). Study Site 2 showed the highest values. This result shows that there is some variation in body segmentation among the sampling sites. Tripathi et al. (2021) and Mariappan and Isaiarasu (2013) explained that differences in earthworm morphology, including segmentation, can be affected by soil conditions such as moisture and organic matter. However, since soil factors were not measured in this study, the reason for this variation cannot be confirmed and is only based on related literature.

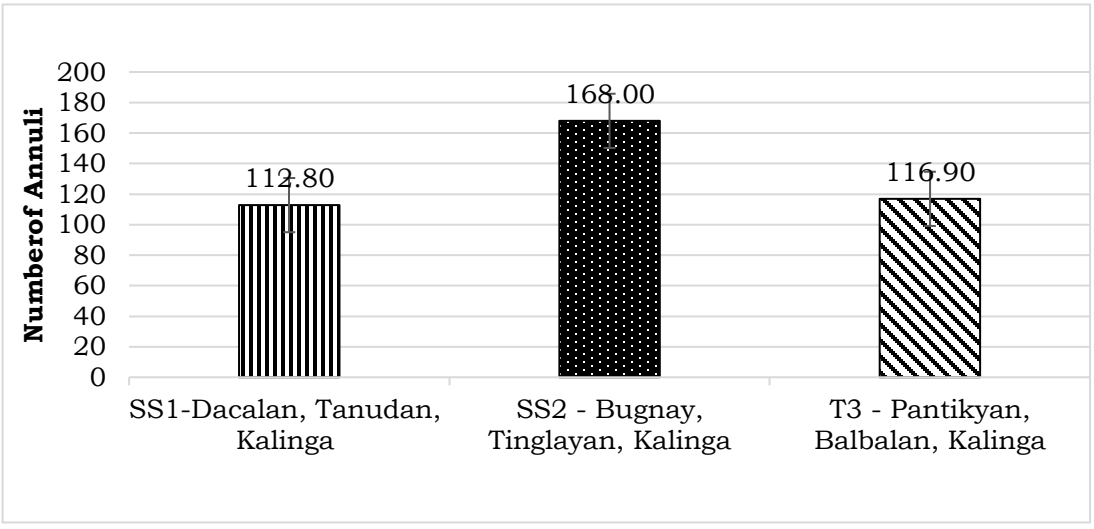

Figure 3. *Number of Annuli or Body Segments of Paddy Earthworms Collected from Heirloom Rice Farms in Dacalan (Tanudan), Bugnay (Tinglayan), and Pantikian (Balbalan), Kalinga Province, Philippines*

Setal Arrangement

All specimens had four pairs of setae per segment, which is equal to eight setae per segment. This pattern was consistent in all samples. Because the setae depend on the number of body segments, they were not treated as a separate variable for statistical analysis. Instead, this trait was mainly used for identification purposes. Sims and Gerard (1985) noted that setal arrangement is an important character in identifying earthworm species.

Coloration and Body Shape

The specimens were pale to pinkish in color and had a slender, thread-like body. Some of them curled when touched or disturbed. These traits are common in earthworms that live in wet soil environments where light exposure is low. According to Rota et al. (2014), earthworms in saturated soils often have reduced pigmentation and softer body forms, which help them survive in such conditions.

Overall Interpretation

Generally, the results show that body length and body diameter are consistent across the three sites, while the number of annuli varies significantly. This means that some traits are stable, while others may change depending on local conditions. Tripathi et al. (2021) explained that earthworms' morphology can be influenced by environmental factors like soil moisture and organic matter, but in this study, these factors were not measured, so the explanation remains theoretical. In general, this study provides baseline information about the morphology of paddy earthworms in heirloom rice farms in Upper Kalinga Province, which can be useful for future studies.

Conclusion and Future Works

The study described the morphological characteristics of paddy earthworms collected from heirloom rice farms in Upper Kalinga Province. The specimens showed characteristics that matched the genus *Sparganophilus*, such as a zygolobous prostomium, four pairs of setae per segment, and a slender and pale to pinkish body. The aforementioned morphology is common among earthworms living in wet and waterlogged rice fields.

The results of the study also showed that the body length and body diameter were not significantly different among the three sampling sites. This means that the earthworms from different locations are generally similar in size. On the other hand, the number of annuli showed a significant difference among the sites, which suggests that some body features may vary depending on local conditions. The presence of paddy earthworms in heirloom rice fields showed that they are part of the soil organisms that help in breaking down organic materials and improving soil structure. However, their exact role in rice production was not fully measured in this study. Because of this, their ecological effects still need further investigation.

Overall, this study provided basic information about the morphology of paddy earthworms in Upper Kalinga heirloom rice ecosystems. It can serve as a reference for further studies about earthworms in similar agricultural areas. For future studies, it is recommended to confirm the species identity using DNA barcoding, especially COI gene analysis, to check if there are other hidden or similar species in the area. It is also suggested to conduct long-term studies to understand their population changes and habitat preferences. Lastly, future research should include soil properties such as

moisture, pH, texture, and organic matter, since these may help explain differences in earthworm morphology and distribution.

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Conflict of Interest

The author declares that there are no competing interests regarding the publication of this paper.

Artificial Intelligence (AI) Declaration Statement

ChatGPT (OpenAI) was used only as a writing assistant to help the author improve grammar, sentence structure, and clarity of the manuscript. It was not used for data collection, statistical analysis, or interpretation of results. All data analysis, findings, and conclusions were done by the author. Any AI-generated suggestions were reviewed, checked, and edited to make sure they match the actual data and content of the study.