



Diversity of Soil Arthropods in the Ranu Pani Restoration Area: An Indicator of Mountain Ecosystem Recovery

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ABSTRACT

Purpose of the study: This study aims to identify the diversity of soil arthropods in the restoration area of Ranu Pani, Lumajang, determine the ecological roles of each arthropod group, and analyze the diversity index as an indicator of ecosystem condition and restoration progress in the study area.

Methodology: Descriptive research design with block plot sampling, pitfall trap method using plastic cup traps, digital thermometer, lux meter, binocular microscope, alcohol preservation solution, field observation, ecological identification keys, abiotic factor measurement, Shannon-Wiener diversity index analysis, Important Value Index calculation, density and frequency analysis, supported by literature review.

Main Findings: A total of 916 soil arthropod specimens belonging to 9 orders and 13 families were collected. Diversity index was higher in the first-year location ($H' = 2.523$) than the second-year location ($H' = 1.899$). Dominant families were Gryllidae and Talitridae. Ecological roles consisted of predators, herbivores, scavengers, and parasitoids, with herbivores and scavengers showing the highest proportions across restoration sites.

Novelty/Originality of this study: This study provides updated ecological baseline data on soil arthropod diversity in Ranu Pani restoration areas by integrating diversity, community structure, ecological roles, and abiotic factors. It advances restoration ecology knowledge by demonstrating the use of soil arthropods as bioindicators for assessing ecosystem recovery and restoration effectiveness in highland conservation landscapes.

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1. INTRODUCTION

Soil arthropods are a crucial biotic component of terrestrial ecosystems, playing a role in maintaining ecological balance [1], [2]. These organisms encompass various groups, such as insects, arachnids, myriapods, and crustaceans, which live in the litter layer and in the soil. The presence of soil arthropods is closely related to the decomposition of organic matter, nutrient cycling, and the formation of soil structure [3], [4]. The biological activities of soil arthropods can increase soil aeration and porosity, thus supporting ecosystem productivity [5], [6]. Therefore, the presence and diversity of soil arthropods are often used as indicators of environmental quality and ecosystem health.

Soil arthropod diversity is influenced by various environmental factors, such as humidity, temperature, organic matter content, vegetation cover, and the level of anthropogenic disturbance. Habitats with stable

environmental conditions generally have higher levels of soil arthropod diversity than areas experiencing ecological stress [7], [8]. Changes in land use and human activities can cause changes in the composition of soil arthropod communities [9], [10]. This occurs because each species has a different tolerance to changing environmental conditions. Therefore, studying soil arthropod diversity is crucial for understanding the ecological conditions of a region [11], [12].

A restoration area is an area undergoing ecosystem restoration efforts following environmental damage or degradation. Restoration aims to restore the area's ecological function to a state close to its natural state [13], [14]. One indicator of restoration success is the recovery of soil biota communities, including soil arthropods. The presence of various types of soil arthropods can reflect the ongoing ecosystem recovery process. Therefore, analyzing soil arthropod diversity can be used as an evaluation tool for the effectiveness of environmental restoration programs [15], [16].

Ranu Pani, located in Lumajang Regency, is a strategic area with high ecological value as part of the buffer zone of Bromo Tengger Semeru National Park. In recent years, this area has faced various environmental problems, such as sedimentation, land conversion, and ecosystem degradation. Restoration efforts have been undertaken to improve environmental conditions and maintain the area's ecological function [17], [18]. This restoration involves vegetation rehabilitation and land management to restore ecosystem balance [19], [20]. These conditions make Ranu Pani a relevant location for studying the dynamics of soil arthropod communities.

Soil arthropods in restoration areas have diverse ecological roles. Some groups function as decomposers, aiding the decomposition of organic matter, while others act as predators, maintaining the balance of soil organism populations [21], [22]. Furthermore, some arthropods function as herbivores and bioindicators of environmental conditions. This diversity of roles demonstrates that soil arthropod communities contribute significantly to ecosystem stability [23], [24]. Therefore, identifying the types and roles of soil arthropods in restoration areas is crucial for understanding their ecological function.

Research on soil arthropods has been extensively conducted in various ecosystem types, such as natural forests, agricultural lands, and conservation areas. However, studies specifically examining soil arthropod diversity in the Ranu Pani restoration area are still very limited. Most research in this area focuses on vegetation, hydrology, or the physical conditions of the environment. Limited data on soil arthropod communities creates a knowledge gap regarding the response of soil biota to the ongoing restoration process. The novelty of this research lies in the presentation of empirical data on the species, ecological roles, and diversity indices of soil arthropods in the Ranu Pani restoration area as indicators of ecosystem recovery success.

The urgency of this research is based on the importance of information on soil arthropod diversity as a basis for evaluating the ecological condition of the restoration area. The data obtained can serve as a reference for environmental management and decision-making regarding conservation and restoration strategies in Ranu Pani. Furthermore, this research also contributes scientifically to the development of soil ecology studies, particularly in restoration ecosystems in Indonesia. Information on the role of each arthropod can enrich our understanding of the biological interactions occurring in the area. Based on this, the main objective of this study is to determine the types of soil arthropods found in the Ranu Pani restoration area, to determine the role of each arthropod in Ranu Pani, and to determine the diversity index of soil arthropods in Ranu Pani.

2. RESEARCH METHOD

2.1. Time and Place

Research on soil arthropod diversity in the Ranu Pani restoration area, Lumajang Regency, was conducted over a period of fieldwork that included several stages of observation and analysis. The research activities were conducted in the Bromo Tengger Semeru National Park conservation area. Data collection locations were in the Ranu Pani and Ranu Regulo areas, located in Lumajang Regency. The selection of these locations was based on the characteristics of the restoration area, which has the potential for soil arthropod diversity [25]. This area was chosen as the research location because it represents a relevant ecosystem restoration area for study.

2.2. Description of the Study Area

Ranu Pani is a village within the Bromo Tengger Semeru National Park and is surrounded by mountainous landscapes. Most residents in this area are farmers, employing a rudimentary land management system. This land use condition also impacts the environmental stability of the area surrounding the lake. The Bromo Tengger Semeru National Park area is a highland conservation area known for the presence of two active volcanoes: Mount Bromo and Mount Semeru. Furthermore, the area is home to three main lakes: Ranu Pani, Ranu Regulo, and Ranu Kumbolo, which play a vital role in maintaining the balance of the conservation area's ecosystem.

2.3. Research Design

This descriptive study used a block design to assess soil arthropod diversity at two observation sites during different study periods. The aim of this study was to compare the abundance, diversity, composition, and structure

of soil arthropod communities in the restoration area. Observed parameters included abundance, frequency, relative abundance, relative frequency, importance value index, and Shannon-Wiener diversity index. Additionally, abiotic factors included light intensity, air humidity, and air temperature. These parameters were observed to obtain a comprehensive picture of the condition of the soil arthropod community in the study area.

Sampling locations were randomly selected based on field observations. The study area encompassed several plantation sites, forest areas, and restoration zones considered representative of the ecosystem conditions in the study area. Three to five pitfall traps were placed at each observation site for sampling. Sampling was carried out using the pitfall trap method, which was set randomly at plot points and left overnight. The soil arthropod samples were then preserved in alcohol solution before being identified in the laboratory using a binocular microscope and a soil arthropod identification key.

Table 1. Arthropod Sampling Locations

Block Name	Information
A and B	The land was completely cleared of weeds, shrubs, and herbs. The bushes and grasses were pruned, and planting rows were created using the "cemplongan" (stem-splitting) system.
E-M	The bushes and weeds were pruned, and the Acacia trees were left. Next, planting rows were created. The area around the planting rows was cleared using the "cemplongan" system.
N-S	Using the cemplongan system, the land around the planting area was cleared and planting holes were then dug.
Edelweiss	The seedlings and plantlets were cleared of weeds, and the empty areas were planted first.
Hydrogen Forest	There was a population of <i>Dodonea viscosa</i> . The land around the planting area was cleared, and planting distances were randomized.
Planting (restoration zone)	The land was completely cleared of weeds, shrubs, and herbs. The bushes and grasses were pruned, and planting rows were created using the "cemplongan" (stem-splitting) system.

2.4. Data Analysis

Data analysis in this study was conducted to determine the dominance, abundance, frequency, and diversity of soil arthropods in the restoration area. Data calculations were conducted using a quantitative approach based on community ecology parameters. The parameters analyzed included density, relative density, frequency, relative frequency, importance value index, and the Shannon-Wiener diversity index [26], [27]. This analysis aims to describe the overall structure of the soil arthropod community. The results were then used to interpret the ecological conditions of the study area.

Density was calculated to determine the number of individuals of each species within a specific observation area. Next, relative density was used to determine the percentage contribution of each species to the total soil arthropod community. Frequency was calculated based on the number of plots occupied by each species, while relative frequency indicated the species' distribution across all observation plots [28], [29]. Relative density and relative frequency data were then summed to obtain the importance value index. This index is used to determine the level of dominance of a species within the community.

Soil arthropod diversity was analyzed using the Shannon-Wiener diversity index. This calculation is based on the proportion of individuals of each species to the total number of individuals found. The diversity index value is used to indicate the level of community stability and species variation in the study area. The higher the index value, the higher the level of soil arthropod community diversity. All data analysis results were used as the basis for describing soil arthropod diversity in the Ranu Pani restoration area.

Table 2. Diversity values based on the Shannon-Wiener index (H')

H' value	Diversity Level	Decomposition Level	Fertility Rate
> 3	High	High	High
1-3	Medium	Medium	Medium
<1	Low	Low	Low

2.5. Measurement of Abiotic Factors

Abiotic factors were measured to determine environmental conditions that influence the presence and distribution of soil arthropods in the study area. Observed abiotic factors included air temperature and light intensity around the sampling locations. This environmental factor data was used to support the analysis of the relationship between habitat conditions and soil arthropod diversity. Measurements were conducted directly in the field at each observation point. The results were then analyzed alongside soil arthropod community data.

Air temperature was measured using a digital thermometer by pointing the sensor at the air around the sample trap location. This measurement aimed to determine the thermal conditions of the microhabitat that may influence soil arthropod activity. Meanwhile, light intensity was measured using a luxmeter, placing the sensor

facing upward on the soil surface [30], [31]. Light intensity measurements were taken to determine the level of illumination in the study area. Both parameters are used as indicators of the physical environmental conditions that influence the presence of soil arthropods.

3. RESULTS AND DISCUSSION

3.1. Abundance and Diversity of Soil Arthropods at Locations with Activity Levels

The results of soil arthropod sampling in the Ranu Pani area using pit traps showed that hundreds of specimens were collected, representing various families from several orders of arthropods. The most abundant arthropod groups were from the orders Orthoptera, Amphipoda, and Opiliones. The dominance of these groups indicates that the soil arthropod community in the study area is dominated by species highly adaptable to local environmental conditions. The abundance of soil arthropods is influenced by the availability of food sources, shelter, and favorable abiotic conditions. These findings indicate that the Ranu Pani restoration area has considerable ecological potential to support the sustainability of the soil arthropod community.

Based on relative density analysis, several families showed higher abundance levels than others. At the initial observation location, the families with the highest relative abundance included Talitridae, Gryllidae, and Noctuidae larvae. Meanwhile, at subsequent observation locations, the dominant families were Gryllidae, Talitridae, and Carabidae. The Gryllidae family was recorded as the most dominant group at both observation locations. The high abundance of this family indicates good adaptation to environmental conditions in the restoration area.

The results of the importance value index calculation indicate that several families have a high level of dominance in the soil arthropod community. Dominant families at the observation sites include Talitridae, Gryllidae, Acrididae, and Carabidae. The dominance of these families indicates that the soil arthropod community structure in the study area is not evenly distributed. This condition reflects the presence of certain species that are better able to utilize environmental resources than others. Differences in dominance between sites also indicate variations in habitat conditions that influence the composition of the soil arthropod community.

The high abundance of the Gryllidae family is thought to be closely related to environmental conditions during the observation period. Weather factors and microtemperature changes in the study area influence the presence and activity of this group. In relatively stable environmental conditions, Gryllidae are found in higher abundance. This group plays an important ecological role as decomposers, aiding the decomposition of organic matter. Thus, its presence contributes to increased soil fertility in the restoration area.

Analysis of the Shannon-Wiener diversity index indicates differences in soil arthropod diversity levels between observation sites. One location showed a higher diversity index than the others. This index value indicates that the soil arthropod diversity level in the study area is moderate. This difference in index values indicates variations in species composition influenced by local environmental conditions. The more balanced the proportions between species within a community, the higher the resulting diversity.

Differences in soil arthropod abundance and diversity indicate that the ecological conditions at each observation location have distinct characteristics. Variations in environmental factors, such as humidity, temperature, and vegetation conditions, contribute to the formation of distinct community structures in each area. This suggests that soil arthropod communities are highly responsive to habitat changes. Changes in community composition can be an indicator of ongoing ecosystem dynamics in restoration areas. Therefore, analysis of soil arthropod diversity can be used as a tool to evaluate the ecological condition of an area.

Overall, the study results indicate that the soil arthropod community in the Ranu Pani restoration area has a diverse composition, with certain levels of species dominance. Dominant families play an important role in maintaining soil ecological functions, particularly in decomposition and nutrient cycling. Differences in abundance and diversity values between locations indicate the influence of habitat conditions on soil arthropod distribution. These findings suggest that the restoration process in the Ranu Pani area has supported the soil arthropod community, although its community structure still exhibits imbalances. These data can serve as a basis for evaluating the success of ecosystem restoration in the area.

3.2. Composition and Structure of Soil Arthropod Communities at the First and Second Year Locations in Ranu Pani, Lumajang

The soil arthropod community found in the study area showed differences in ecological composition between the observation locations in the first and second years. Based on the identification results, the soil arthropods found can be grouped into four main ecological roles: predators, herbivores, scavengers, and parasitoids. Each group had different proportions across the two observation periods, indicating a dynamic community structure. In the first year, scavengers dominated at 33%, followed by herbivores at 28%, predators at 27%, and parasitoids at 12%. Meanwhile, in the second year, herbivore dominance increased to 49%, followed by scavengers at 37%, predators at 13%, and parasitoids at 1%. This change indicates a shift in the balance of the soil arthropod community at the study site.

The high proportion of herbivores in the second year is thought to be related to the availability of more abundant vegetation as a food source. Conversely, the decline in predators during this period may have influenced the increase in herbivore populations due to reduced predation pressure. This relationship indicates a strong ecological interaction between arthropod groups in maintaining the balance of the soil ecosystem. The predator group at the study site was dominated by the Carabidae family, which plays a crucial role in controlling the populations of other organisms. In the first year, the presence of predators was relatively high, thus maintaining the stability of the herbivore population. However, in the second year, a decrease in predator numbers could potentially lead to an increase in herbivore dominance.

The scavenger group also showed a significant contribution in both observation periods. The presence of this group is crucial in the decomposition of organic matter and the recycling of soil nutrients. The high proportion of scavengers indicates active decomposition activity in the Ranu Pani restoration area. Meanwhile, parasitoids were found in very low numbers in both observation periods. The low presence of this group indicates that parasitoids play a relatively minor role in the structure of the soil arthropod community at the study site. Overall, the variation in the composition and structure of the soil arthropod community reflects changing ecological conditions that influence the ecosystem balance in the Ranu Pani restoration area.

3.3. Relationship between Abundance and Diversity of Soil Arthropods and Environmental Factors

The abiotic factors measured were Light Intensity (kLux), Air Humidity (%) and Air Temperature (°C). Temperature and humidity are abiotic factors that influence the interaction between organisms and their environment. The results of the observations obtained can be seen in Table 3.

Table 3. Average Abiotic Factors

Location	Abiotic Factors				
	Light Intensity (Lux)		Humidity %		Air
	Range	Average	Range	Average	Temperature °C
A	379±1169	917,25	46±83	73.5	14±18
D	360±1258	996,5	46±83	71.5	14±19
N	420±1251	992	42±83	71	15±22
O	425±1195	985.75	38±91	73.75	16±23
P	105±1227	894.75	47±91	74.75	15±19
Q	261±1223	934.5	40±91	72.5	14±19
R	326±1303	1029	42±82	71.25	14±19
S	393±1329	1063.5	42±82	69.75	15±21

Based on observations, data on abiotic factors, such as light intensity, air humidity, and air temperature, were only available at the observation sites in the second year; no measurements were taken in the first year. However, because sampling for both periods was conducted during the rainy season, environmental conditions are suspected to have relatively similar characteristics. In the second year, light intensity showed quite striking differences between locations, while air humidity also varied at each observation point. Meanwhile, air temperature tended to show a nearly uniform range. Variations in these abiotic factors influence the presence and distribution of soil arthropods in the study area.

Light intensity is one environmental factor influencing soil arthropod activity. Sunlight serves as a biological marker that regulates organism activity patterns, including foraging and reproductive behavior. Some arthropod groups are active during the day, while others are more active at night. These differences in response to light lead to variations in the distribution of organisms in certain habitats. Therefore, changes in light intensity can influence the composition of arthropod communities at a location. In addition to light, temperature and humidity also play a crucial role in determining the survival of soil arthropods. These factors influence metabolism, reproductive activity, and the organisms' ability to adapt to the environment. Suitable microclimatic conditions will support high diversity and stability of soil arthropod communities. Conversely, extreme environmental changes can reduce the abundance of some sensitive groups. This suggests that soil arthropods can be used as bioindicators of changing environmental conditions.

The presence of soil arthropods is crucial for the success of ecosystem restoration programs. These organisms play a role in the decomposition of organic matter, improving soil structure, and cycling nutrients, which are essential for vegetation growth. Good soil conditions will support successful restoration because soil is the primary nutrient source for plants. Therefore, soil arthropod diversity can reflect the ecological quality of the restoration area. The results of this study provide important information regarding the condition of the soil ecosystem in the Ranu Pani and Ranu Regulo restoration areas. The data obtained can serve as a basis for evaluating restoration management to make it more effective and sustainable. Furthermore, information on soil arthropod diversity can increase public understanding of the importance of maintaining ecosystem balance. These

findings also confirm that monitoring soil arthropods can be an indicator in assessing the success of environmental restoration.

The research results show that the Ranu Pani restoration area supports a diverse soil arthropod community. The presence of 9 orders and 13 families of arthropods indicates that the restoration area has provided habitat conditions conducive to soil organism activity. The moderate level of diversity indicates that the ecosystem recovery process is gradually underway. This finding aligns with previous research that suggests soil arthropods are sensitive bioindicators of changing environmental conditions and the success of ecosystem restoration. The presence of certain arthropod groups, particularly those from the Gryllidae and Talitridae families, indicates that the habitat in the restoration area has sufficient organic matter and moisture to support soil organism life.

The dominance of the Gryllidae family at both observation locations demonstrates a high degree of adaptability to restoration environmental conditions. This group is known to have good tolerance for changes in temperature, humidity, and developing vegetation. In addition to acting as detritivores, Gryllidae also help accelerate the decomposition of organic matter, thus supporting soil nutrient cycling [32]. The high dominance of a particular family within an arthropod community may indicate that the habitat is still in a phase of ecological adjustment, where some groups of organisms adapt more quickly than others. This condition is common in ecosystems recovering from environmental disturbances.

The difference in diversity index values between the first-year and second-year locations indicates the dynamics of the soil arthropod community during the restoration process. Higher diversity values at the first-year location indicate a more even distribution of individuals across species compared to the second-year location. Conversely, a decrease in the diversity index in the second year indicates the dominance of certain groups, leading to an unbalanced community structure. This phenomenon can be influenced by changes in vegetation cover, microhabitat conditions, or competition between organisms for available resources. Thus, changes in arthropod community composition can be used as an ecological indicator in evaluating the progress of ecosystem restoration.

The composition of the ecological roles of soil arthropods also indicates that the soil organism community in the restoration area has quite complex ecological functions. Herbivores and scavengers were found in high proportions in both observation periods. The dominance of scavengers indicates that organic matter decomposition is actively occurring in the soil, thus helping to improve soil fertility and quality [33], [34]. Meanwhile, the increase in the proportion of herbivores in the second year indicates that vegetation is beginning to develop and provide a more abundant food source. This condition indicates a close relationship between vegetation development and changes in the structure of the soil arthropod community.

The decrease in the proportion of predators in the second year can provide insight into changes in the trophic balance in the restoration ecosystem. Predators, such as members of the Carabidae family, play a crucial role in controlling herbivore populations and maintaining the stability of soil organism communities. The reduction in predator numbers allows for an increase in herbivore populations due to lower predation pressure [35], [36]. This condition indicates that the restoration process not only affects the presence of specific species but also influences the ecological interactions between organisms in the soil. Therefore, the stability of the arthropod community is an important indicator in assessing the success of ecosystem restoration.

Abiotic factors such as light intensity, air humidity, and air temperature also influence the presence and distribution of soil arthropods in the study area. Variations in light intensity at each location lead to differences in microhabitat conditions, which influence the activity of soil organisms [37], [38]. Furthermore, relatively high air humidity during the rainy season supports decomposer activity and maintains the survival of drought-sensitive soil arthropods. Relatively stable air temperatures also provide environmental conditions conducive to the sustainability of arthropod communities. This suggests that microclimate factors are closely related to the diversity and structure of soil organism communities.

Ecologically, the presence of soil arthropods in the Ranu Pani restoration area makes a significant contribution to the restoration of ecosystem function. The activity of soil organisms in decomposition, soil aeration, and nutrient cycling helps improve soil quality, thus supporting the growth of restoration vegetation [39], [40]. The better the condition of the soil arthropod community, the greater the potential for successful ecosystem restoration. Therefore, monitoring soil arthropod diversity can be used as a biological approach to evaluate the success of environmental restoration programs, particularly in mountain conservation areas like Ranu Pani.

This research has significant implications for the development of restoration ecology studies, particularly in the use of soil arthropods as bioindicators of environmental conditions. Data on the diversity, community structure, and ecological roles of soil arthropods in the Ranu Pani restoration area can provide a scientific basis for conservation area managers in evaluating the success of ecosystem restoration programs. Furthermore, the results of this study contribute to an increased understanding of the relationship between environmental factors and the dynamics of soil organism communities in mountain ecosystems. This information can be used as a reference in developing more sustainable habitat management strategies, particularly in maintaining ecosystem stability and soil quality in conservation areas.

However, this study still has several limitations. Observations were conducted only over a specific period, thus not being able to describe the dynamics of soil arthropod communities seasonal and long-term. Furthermore,

abiotic factor measurements were only available at the observation sites in the second year, preventing a comprehensive analysis of the relationship between environmental conditions and arthropod diversity across both study periods. Another limitation lies in the pitfall trap method, which tends to be more effective at capturing arthropods active on the soil surface, so there may be other arthropod groups that have not yet been identified. Therefore, further research with longer observation periods, variations in sampling methods, and more complete analysis of environmental factors is needed to obtain a more comprehensive picture of the dynamics of soil arthropods in restoration areas.

4. CONCLUSION

Based on the research results, 269 soil arthropod specimens were found at the observation site in the first year, belonging to 9 orders and 11 families. In the second year, 647 specimens were also found, also from 9 orders and 11 families. The level of soil arthropod diversity was higher in the first year than in the second year, as indicated by the Shannon-Wiener diversity index of 2.523 in the first year and 1.899 in the second year. The structure of the soil arthropod community at the two locations showed different dominance patterns, with the Talitridae family dominating in the first year with an importance value index of 72.66%, while the Gryllidae family dominated in the second year with an importance value index of 73.057%.

These differences in composition and diversity levels indicate the existence of ecosystem dynamics in the Ranu Pani restoration area. Soil arthropods play a crucial ecological role in supporting the restoration process, particularly through their activity in decomposing organic matter, improving soil structure, and maintaining a balanced food chain. The presence and abundance of soil arthropods are also influenced by abiotic factors, particularly light intensity and air humidity. Therefore, soil arthropod diversity can be used as a biological indicator to assess ecosystem conditions and the success of restoration efforts in the Ranu Pani area, Lumajang Regency. Future research is recommended to conduct observations over a longer period and in different seasons to more comprehensively analyze the dynamics of soil arthropod communities. Furthermore, further research could utilize more diverse sampling methods and include analyses of soil chemistry and vegetation factors to gain a deeper understanding of the relationship between environmental conditions and soil arthropod diversity in restoration areas.

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AUTHOR CONTRIBUTIONS

Conceptualization, J.S.A.; Methodology, J.S.A.; Software, J.S.A.; Validation, J.S.A.; Formal Analysis, J.S.A.; Investigation, J.S.A.; Resources, J.S.A.; Data Curation, J.S.A.; Writing – Original Draft Preparation, J.S.A.; Writing – Review & Editing, J.S.A.; Visualization, J.S.A.; Supervision, J.S.A.; Project Administration, J.S.A.; Funding Acquisition, J.S.A.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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