AQUATIC AND TERRESTRIAL INVERTEBRATES DENSER AND MORE DIVERSE IN A SUBURBAN LOCATION ALONG BLIND BROOK STREAM

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ABSTRACT

How invertebrates relate to each other and their environment is an important aspect of understanding species distribution. Invertebrates are also more sensitive to changes in their environment than most other organisms. Things like climate change and land use can affect invertebrates in their habitat. Due to this, taking samples of invertebrates and recording their species richness and species diversity in both aquatic and terrestrial settings can help us understand the impact of our actions on the environment. Purchase College is unique in that it has both urban and suburban development on campus, which can lead to differences in invertebrate populations and densities. We set out to find the differences in density and diversity between invertebrates in both aquatic and terrestrial environments in two different locations on campus (alongside Lincoln Ave., which had a more suburban setting, and alongside the West 2 parking lot, which was more urban). We collected aquatic invertebrates using dip nets and terrestrial invertebrates using beat sheets. We found Lincoln Ave. stream was both more diverse and denser in both terrestrial and aquatic invertebrates than the West 2 stream was. These results could be used as a groundwork for examining how different aspects like land use affect invertebrates.

Keywords: Aquatic-terrestrial linkage; freshwater ecology; invertebrate density; species richness

INTRODUCTION

Species distribution is a major topic in conservation biology and ecology, especially how invertebrates interact with each other and the environment (Ptatscheck et al. 2019). Differences in density and diversity of invertebrates can vary based on rural vs. urban environments, marine vs. freshwater, and terrestrial vs. aquatic niches. Previous studies suggest that macroinvertebrate richness is strongly related to land use, where agricultural streams exhibit the highest macroinvertebrate diversity (Moore and Palmer 2005). Terrestrial and freshwater niches in particular have a symbiotic relationship. If the population of aquatic species decreases, there is a negative impact on the terrestrial invertebrates who use them as their primary source of food, which many terrestrial invertebrates (like arthropods and spiders) do (Krell et al. 2015). The populations of these invertebrates can also be affected by climate change (Hader and Barnes 2019).

There is also evidence to suggest that abiotic factors can affect diversity and richness. Urbanization can lead to shifts in species composition in spider and arthropod populations (Melligar et al. 2018). Abiotic stress, like environmental change, affects predator richness which in turn positively affects prey richness (Kulkani and Laender 2017). Freshwater niches are unique from other bodies of water and interact often with terrestrial environments. Less than three percent of the freshwater on Earth is an accessible body of water. This means that the ecosystems created around these bodies of water are unique. Temperature and dissolved oxygen (DO) play a role in these ecosystems by affecting species diversity. DO is essential for organisms to survive in aquatic environments. As water gets colder, it can hold more oxygen (Wateratlas.org). Along with that, litter breakdown aids in invertebrate diversity in freshwater (Nadaei- Monoury et al. 2014). These are factors that should be considered when doing research on ecosystems and invertebrates in and around these water systems.

Purchase College, State University of New York (SUNY) has a complex ecosystem on its grounds. There is a large amount of human presence, but also areas of seclusion located in the area. There is also a freshwater stream that runs through campus and interacts with the more heavily populated and more secluded areas of the campus. Invertebrates found in terrestrial- freshwater linkages, like the one found on campus, are affected by things like land use but the density and diversity of these invertebrates is not well known. We wanted to see if there is a difference in diversity and density of invertebrates in different parts of Purchase campus stream, Blind Brook. Throughout the month of October 2021, we collected data from two sections of the Blind Brook stream to answer the question of whether different areas of the stream have different species densities and distributions of invertebrates. We predicted that the terrestrial and aquatic invertebrates located in the Blind Brook on Purchase College campus will differ based on location.

METHODS

Field Sites. We collected data in two different locations in the Blind Brooke to perform sampling of density and diversity of invertebrates. The first site was labeled as ‘Lincoln Ave. Stream’, which was the suburb location, and the other site was labeled ‘West 2 Stream’ which was the urban location (Fig. 1). Data was collected between October 14th- October 29th.

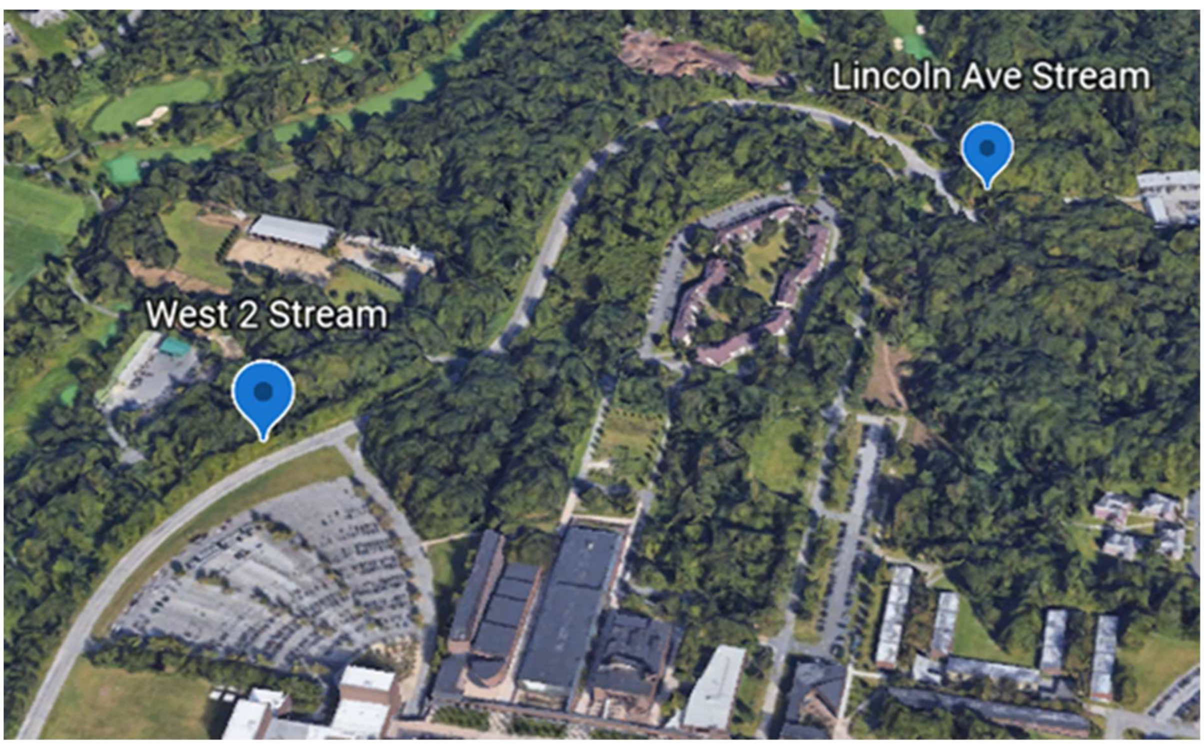

Figure 1. Google Map view of the sampling sites.

Experimental Design. We chose parts of the sampling sites with a decent amount of vegetation and water. First, we measured out 30m with a meter tape. We put marking flags every 10m, starting with 0m and ending with 30m, for collection. For terrestrial sampling, we used a beat sheet on every plant at each flag mark, extending 8m up from the mark. The bugs were collected using an aspirator and stored using jars with ethanol. These jars were labeled with the site name, the meter mark, the date, and where they were collected (on land). For aquatic sampling, we held a dip net in the stream water for 3-5 minutes and shifted rocks to stir any aquatic invertebrate activity. Any bugs caught were picked up out of the net and put into ethanol jars. The temperature and DO at each meter mark were also measured and recorded. These jars were labeled with the site name, the meter mark, the date, temperature, DO, and where they were collected (in the water).

Lab Work. The invertebrates we found in our sampling sites were collected in ethanol jars and brought back to the lab. The number of bugs at each meter mark at the sample sites, DO (and average for each sample site), temperature (and average for each sample site), and date were recorded. We examined each specimen under a dissecting microscope and determined the order if possible. Pictures were taken of all our samples.

Analysis. We analyzed our data using Microsoft Excel to generate tables and graphs. We calculated the averages of DO and temperature for each sample. We generated bar graphs to compare the differences in invertebrate density from the locations. We also calculated the correlation using Pearson's r and generated correlation charts for our DO and temperature data. Species were identified and categorized based on order; number of invertebrates in each order as well as the location they were found (table 1).

RESULTS

The results of the data analysis suggest no correlation between temperature and number of invertebrates, as well as no correlation between DO and number of invertebrates in both sampling locations. The correlation graphs show no correlation between temperature and number of invertebrates (Fig. 2), and no correlation between DO and number of invertebrates (Fig. 3). Calculations of Pearson's R state that correlation between temperature and number of invertebrates R = 0.15 and correlation between DO and number of invertebrates R = 0.17.

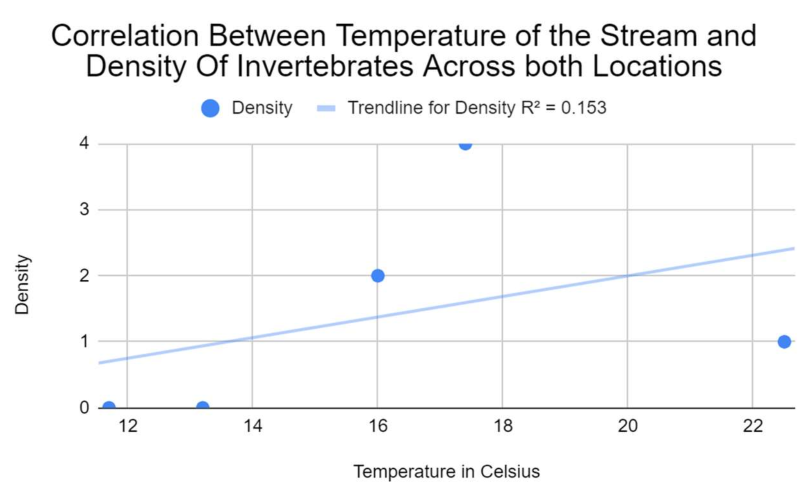

Figure 2. This figure displays the relationship between temperature of the stream and the density of invertebrates at each location.

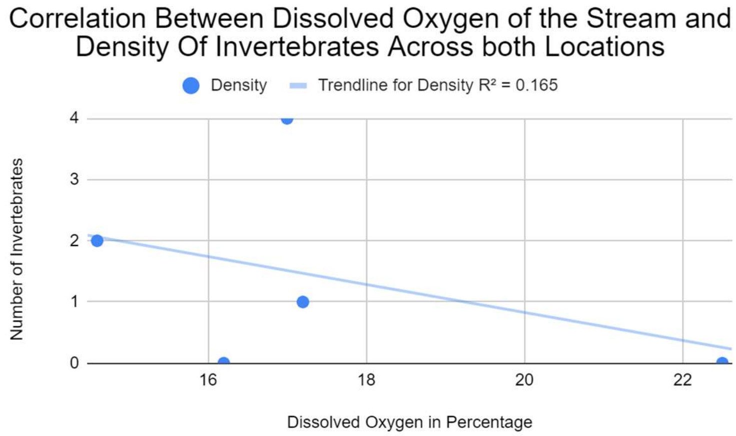

Figure 3. This figure displays the relationship between dissolved oxygen (DO), as a percent of air saturation of the stream and the density of invertebrates at each location.

The data also suggests a difference in density and diversity of invertebrates between the Lincoln Ave. location and the West 2 location. The total number of combined aquatic and terrestrial invertebrates collected was greater at the Lincoln Ave. location compared to the West 2 location. There was a total of 33 invertebrates collected at the Lincoln Ave. location compared to 16 total invertebrates collected at the West 2 location (Fig. 4). For aquatic invertebrates, there was a difference in the number of samples collected at each location. A total of seven invertebrates were collected at the Lincoln Ave. location and there were no aquatic invertebrates collected at the West 2 location (Fig. 5). There were more terrestrial samples collected at the Lincoln Ave. location compared to the West 2 location; a total of 26 terrestrial invertebrates collected at Lincoln Ave. and 16 invertebrates collected at the West 2 location (Fig. 5). Further analysis of this data shows that there is greater richness in invertebrates in the Lincoln Ave. location compared to the West 2 location (Fig. 6). Richness for the Lincoln Ave. location was 8 while the richness for the West 2 location was 5. The orders of the invertebrates collected are listed in Table 1.

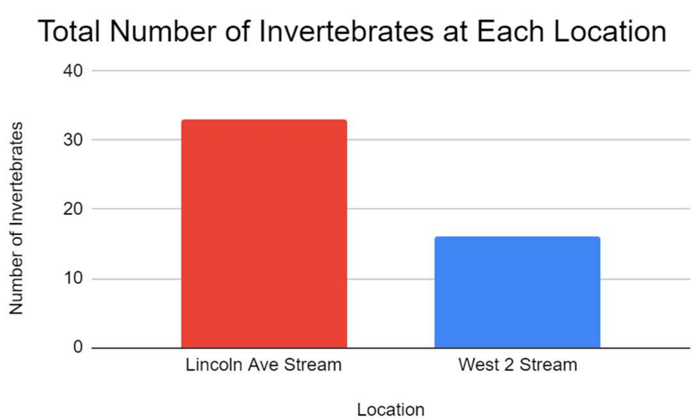

Figure 4. This graph shows the total number of invertebrates collected at each location, both aquatic and terrestrial. We collected more invertebrates at the Lincoln Ave. location than the West 2 Steam location.

Table 1. This table shows the order of invertebrates and their frequency in each location.

Location	Aquatic or Terrestrial	Order of Invertebrate	Number of Invertebrates
Lincoln Ave.	Aquatic	Hemiptera	7
Lincoln Ave.	Terrestrial	Araneae	9
Lincoln Ave.	Terrestrial	Coleoptera	2
Lincoln Ave.	Terrestrial	Diptera	2
Lincoln Ave.	Terrestrial	Hemiptera	2
Lincoln Ave.	Terrestrial	Hymenoptera	5
Lincoln Ave.	Terrestrial	Psocodea	1
Lincoln Ave.	Terrestrial	Trichoptera	3
Lincoln Ave.	Terrestrial	LOST	2
West 2 stream	Terrestrial	Araneae	9
West 2 stream	Terrestrial	Coleoptera	1
West 2 stream	Terrestrial	Diptera	1
West 2 stream	Terrestrial	Hymenoptera	3
West 2 stream	Terrestrial	Trichoptera	2

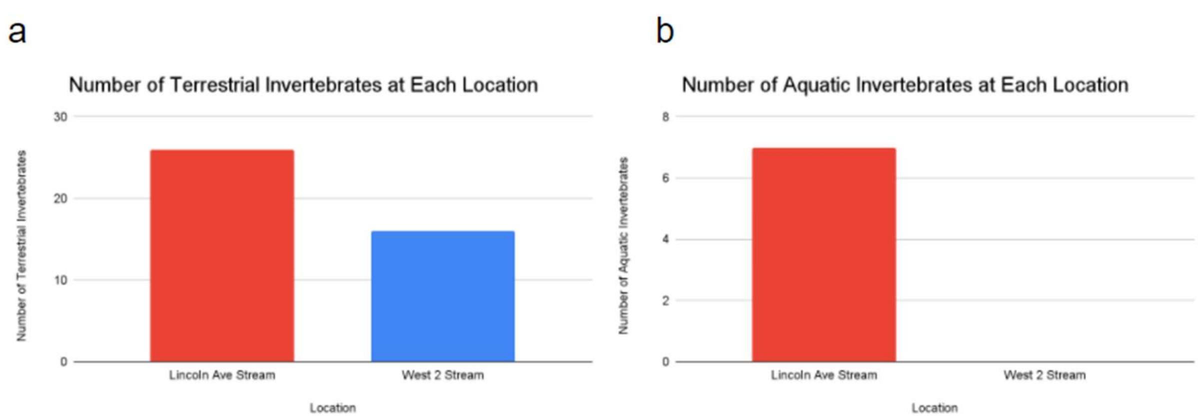

Figure 5. **a** This graph shows the total number of terrestrial invertebrates collected at each location. We collected more invertebrates at Lincoln Ave. location compared to the West 2 Stream location. **b** This graph shows the total number of aquatic invertebrates collected at each location. We collected more invertebrates at Lincoln Ave. location; we did not collect any aquatic invertebrates at the West 2 Stream location.

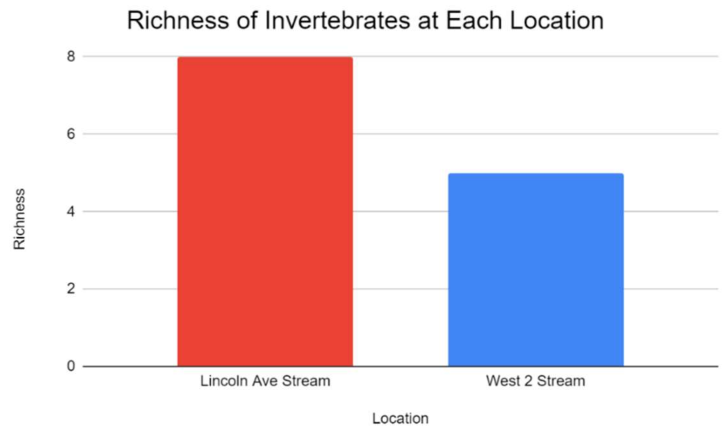

Figure 6. This figure shows the calculated richness of each location. The richness of each location was calculated using the order of the invertebrates which can be found in Table 1.

The data shows a difference in temperature and a small difference in DO when comparing the two sampling sites. The average temperature was higher at the Lincoln Ave. location compared to the West 2 location (Fig. 7). The Lincoln Ave. location had an overall temperature of 18.6 °C while the West 2 location had an overall temperature of 12.4 °C. There was a slight difference in DO in each location; the average DO at the Lincoln Ave. location was 17.5% while the average DO at the West 2 location was 15.9% (Fig.7).

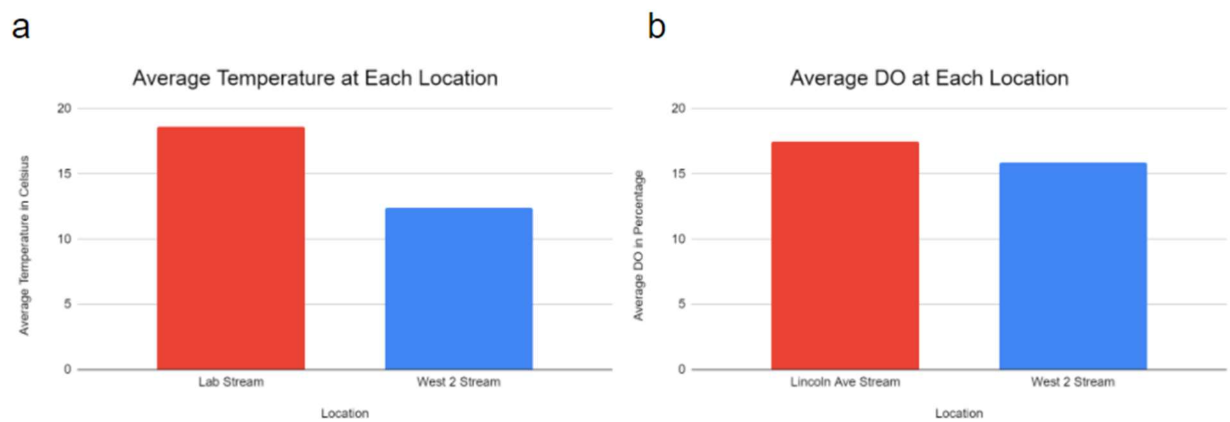

Figure 7. **a** This graph compares the average temperature, in Celsius, sampled at each location. **b** This graph compares the average dissolved oxygen (DO), as a percent of air saturation sampled at each location.

DISCUSSION

Purchase College has a diverse ecosystem and varying degrees of land use around campus. Previous research has suggested that there is a difference in invertebrate density and diversity based on their environment (terrestrial or aquatic). In this study we set out to examine the differences between terrestrial and aquatic invertebrate diversity and density. We examined these differences along two main facets: urban land use and suburban land use. The analysis of the data we collected suggests that there was a difference in invertebrate density and richness in both the Lincoln Ave. location compared to the West 2 location. The Lincoln Ave. location had higher invertebrate density as well as higher richness. The Lincoln Ave. location is in a suburban area of the Purchase college campus while the West 2 location is in an urban area of campus. Therefore, the data suggests that the urban area of Purchase college is less dense and less diverse compared to a suburban area.

Aquatic and terrestrial communities are considered to be separate by most ecologists, but they are both affected by wet and dry phases (Corti and Datry, 2015). From our research, we can conclude that there is a difference in diversity and density of invertebrates in different parts of the Blind Brook. There is also a noticeable difference in the density and diversity of aquatic vs. terrestrial invertebrates. In terms of species richness, Lincoln Ave. had eight different species that we found compared to the five in West 2. When we look specifically at the terrestrial and aquatic density of each location, there is also a stark contrast. The total number of invertebrates found at Lincoln Ave. was 33 and the amount found at West 2 was 16. All West 2 invertebrates were terrestrial finds; we did not collect any aquatic creatures. This could be due to the cold temperatures driving away the species that reside in that part of the stream. We also found a difference in temperature, and a slight difference in DO levels. There seems to be no correlation between temperature, DO, and number of invertebrates.

There were some limitations to our study. Because we only collected samples for a month, our sample size and density may not be accurate to the real diversity along the stream. This could be fixed by having a longer collection period and collecting along a larger area of the Blind Brook. Another issue is the time of collection. Habitat complexity has been shown to decrease in colder temperatures (Scrine et al. 2017). We collected our samples in October, while the weather was relatively chilly. This could have skewed our results because cold weather drives away invertebrates. This could be avoided by sampling in optimal weather and taking many samples to provide a more accurate depiction of the area. There was also an error introduced when two of the samples from the West 2 location were lost.

Another aspect of our study was determining if there was a correlation between temperature and the density of invertebrates across both locations. Although there were a variety of temperatures, there does not seem to be a correlation. The DO at each location was also similar between the areas, so the impact there would most likely be small at best. However, invertebrates are sensitive to temperature. The temperature of an environment affects an invertebrate's growth rate and changes in temperature have a large effect on distribution (Butterfield and Coulson 1997). The reason our results show no correlation may be due to having a sample size that is too small. DO is also a good indicator of the health and biodiversity of an aquatic ecosystem (Kelley 2019).

Land use and human interaction are important to consider when looking at density and species in a given environment. These factors can impact species abundance and richness. Many human activities affect aquatic ecosystems, in particular the usage of hydropower is very damaging to freshwater systems (Borgwardt et al. 2019). Because aquatic and terrestrial invertebrate life is connected, a negative impact on one can also affect the other. Previous research suggests that land use can have an effect on the aquatic insects that inhabit a community and that can affect the amount of terrestrial predators present (Stenroth et al., 2014). When aquatic life decreases, the terrestrial predators in the area experience a nutrition deficit, which can lead to the dying out of those species as well. A paper by Didham et al. (2007) focuses on how to deal with interactive effects between specific global change and native species decline. This paper creates a framework that creates a better quantitative understanding of how land change affects biotic communities, which is an important part of preserving biotic communities against environmental change.

Climate change also has an impact on terrestrial and aquatic ecosystems. Climate change is a problem that has only increased in intensity as time goes on. Habitats and natural enemy exchange will be impacted by land-cover/use and climate change (Dreyer and Gratton 2014). These impacts can change the density of invertebrates that exist in aquatic and terrestrial areas because of the multifaceted nature of climate change. Overall, climate change affects ecosystem biodiversity, structure, function, and an ecosystems' ability to offer important services (Hader and Barnes 2019). Human induced climate change has put stress on aquatic ecosystems. Aquatic ecosystems have absorbed a majority of the surplus heat being generated by climate change. Future work should include looking at ways to preserve and enhance aquatic and terrestrial environments for the sake of preserving species diversity and combatting the effects of climate change.

CONCLUSION

This research is useful in the field of ecology in reference to human induced climate change and preserving species diversity. Land use and human interaction are factors that contribute to climate change. These factors have an impact on species density and richness. This research is important because many human activities and types affect aquatic and terrestrial ecosystems. This research looks at how exactly invertebrates are affected by land use and it allows us to look into further research regarding preservation. Understanding inverts can also help researchers understand the effect of climate change in semi-real time and help predict how diversity and density will be affected in the future. The suburban land on Purchase College was much more diverse in comparison to the urban land. This research could be used as the groundwork for future studies examining how land use impacts the organisms in that environment.

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AUTHOR CONTRIBUTIONS

Conceptualization (all), Data collection (all), Data curation (all), Formal analysis (All), Methodology (all), Project Administration (AK), Visualization (JP), Writing- Abstract (AR), Writing- Introduction (AK), Writing- Methods (AK, AR), Writing- Results (JP), Writing- Discussion (AK, JP), Writing- Conclusion (AK), Writing- Review and Editing (AK, JP)

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