

## Research Article

# Diversity and Species Distribution of Aphids (Hemiptera: Aphididae) in District Sargodha (Punjab, Pakistan)

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**Abstract** | Aphids (Hemiptera: Aphididae) are small soft-bodied sap-sucking insects with about 5,000 described species worldwide. Many of the aphid species are destructive pests of a wide array of horticultural and agricultural plants. This study determined the prevailing diversity of aphids on different economically important plantations in district Sargodha. From November to April 2018-2019 and 2019-2020, about 51,000 apterous adult aphid specimens were collected from various plantations from all six tehsils of district Sargodha and were identified up to species level. Richness and relative abundance of different aphid species were determined by calculating Shannon Wiener's (H'), Evenness (J'), Dominance (D) and Sampson's diversity indices. Results revealed a total of 19 aphid species belonging to 12 genera from district Sargodha. *Brevicoryne brassicae* was recorded as the most abundant species with 8,470 (16.6%) specimens, followed by *Myzus persicae* with 6,655 (13%) and *Aphis gossypii* with 5,348 (10.5%) specimens. While, *Sitobion rosaeformis* with 276 (0.5%) and *Aphis nerii* with 210 (0.4%) specimens were recorded as the least abundant species. Maximum aphid diversity was recorded on cereal and oilseed crops, while minimum was observed on loquat and citrus plantations. Moreover, maximum aphid population was recorded in the 1<sup>st</sup> fortnight of March in most plantations sampled. These results demonstrate the prevailing diversity of this economically important family of pest insects and would be helpful in future studies regarding their management.

**Received** | September 17, 2021; **Accepted** | December 12, 2021; **Published** | February 24, 2022

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**Citation** | Riaz, M.F., A.B.M. Raza, M.Z. Majeed and T. Nazir. 2022. Diversity and species distribution of Aphids (Hemiptera: Aphididae) in district Sargodha (Punjab, Pakistan). *Sarhad Journal of Agriculture*, 38(2): 540-547.

**DOI** | <https://dx.doi.org/10.17582/journal.sja/2022/38.2.540.547>

**Keywords** | Aphididae, Biodiversity, Species richness, Evenness, Diversity indices, *Brevicoryne brassicae*, *Myzus persicae*, *Aphis gossypii*

## Introduction

Biodiversity is defined as variety of living organisms interacting in a given ecosystem and species is the fundamental unit of biodiversity (Gaston and Spicer, 2013). There is an increasing trend towards the awareness of species richness and relative abundance of organisms. Insects occupy more species diversity than any other group of living organisms on planet Earth. It is estimated that there are 1.5–1.7 million described species of eukaryotic organisms in

the world and about 65–70% of these are insects with much more species still undescribed (Grimaldi and Engel, 2005).

The family Aphididae belongs to order Hemiptera of class Insecta. It is a large and well-known family with about 5,000 described species throughout the world (Remaudière and Remaudière, 1997; Hullé *et al.*, 2010). Members of Aphididae are known as aphids, plant lice and green flies which are sap-feeding phytophagous pests. About 100 aphid species are highly

**Table 1:** Collection locations (tehsils), localities selected in each location and their geographic coordinates sampled for the diversity of aphids (Hemiptera: Aphididae).

Sr. No.	Locations (Tehsils)	Localities	Latitude (N)	Longitude (E)	Altitude (ft)
1	Sargodha	Chak No. 71 NB, 88 SB and 34 NB	32°05'01"	72°40'16"	610–650
2	Silanwali	Chak No. 107 NB, 130 SB and 126 SB	31°49'45"	72°32'21"	550–575
3	Bhalwal	Chak No. 4 SB, 7 SB and Ajnala Lok	32°15'57"	72°54'04"	590–610
4	Shahpur	Kandara, Jhugian and Jahanabad	32°16'01"	72°28'25"	620–645
5	Sahiwal	Lakhiwal, Farooqa and Kuddlathi	31°58'23"	72°19'31"	525–545
6	Kotmomin	Bhabhra, Mateela and Chak No. 106 SB	32°11'18"	72°01'45"	620–630

destructive pests of many agricultural and horticultural crops worldwide including Pakistan (Riedell and Blackmer, 1999; Blackman and Eastop, 2000; Khattak *et al.*, 2002; Aheer *et al.*, 2008). Moreover, apart from direct sap-feeding, these insects vector a wide array of plant viruses and other diseases in plants (Ng and Perry, 2004).

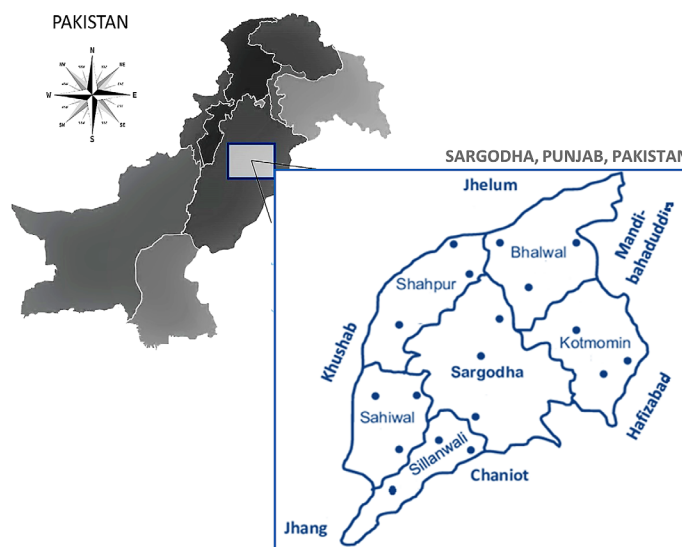
Although, much work has been conducted in Pakistan regarding the economic appraisal and management of important pest aphid species, there is a paucity of knowledge about their prevailing diversity and species richness in different agro-ecological zones of the country (Wains *et al.*, 2010). Some studies demonstrated diversity of aphids in temperate and subtropical regions of Pakistan (Bodla *et al.*, 2011; Amin *et al.*, 2017). However, there is still a need to study the distribution, ecology and host range of aphids in different areas of Pakistan including Sargodha district of Punjab province. Keeping in view the huge diversity and economic importance of aphids, this study was aimed to assess the prevailing diversity of different aphid species on various types of plantations in district Sargodha. Sargodha is a multi-crop zone and is famous for its agricultural importance. There are many economically important agricultural crops being cultivated in Sargodha. It is also known as California of Pakistan due to its 70% share in national citrus production (Ahmad *et al.*, 2018).

**Material and Methods**

*Study area*

This study was conducted in district Sargodha (Punjab, Pakistan). It is a 5<sup>th</sup> large district of Punjab province stretched over about 5,865 km<sup>2</sup> with longitude 32°05'02" N and latitude 72°40'16' E. Its climate is subtropical semiarid with average annual temperature and rainfall of 23.8°C and 410 mm, respectively (Zaka *et al.*, 2004). Adult aphid specimens were col-

lected from all six tehsils of district Sargodha as detailed in Table 1. Three different localities were selected in each of the tehsils of Sargodha district to ensure the capture of maximum aphid diversity (Figure 1).



**Figure 1:** Sampling locations selected in each tehsil of district Sargodha (Punjab, Pakistan).

*Plantation categories*

Aphids were sampled from different economically important plantations of Sargodha *i.e.* citrus, loquat, cereals, fodder, oilseed, ornamental and vegetables. Citrus plantation included different citrus cultivars particularly kinnow mandarin, mosambi and lemon orchards. Loquat plantations include only loquat plants. Cereals category included wheat, oats and barley crops. Fodder plantation included alfalfa, berseem and maize crops. Oilseed included mustard and canola plantations. Ornamental category included plantations of rose and marigold flowers, while vegetables included cabbage, radish, spinach, coriander and tomato crops.

*Collection of samples*

Apterous adult aphid individuals were collected by

extensive random samplings in winter season from November to April 2018-2019 and 2019-2020. Data of two winter seasons was recorded to ensure the maximum diversity. Collection was done fortnightly. In this way, two samplings were done in each month during the study period. At each sampling time, all localities of each tehsil were visited and three samples of aphids were collected from all available plantations. In this way, sampling was done 24 times from all localities in two study years.

While moving zig-zag into the field, aphids were collected from three randomly selected 1 ft<sup>2</sup> patches of each plantation by hand-picking or branch-shaking or using a camel-hair brush depending upon the nature of plantation sampled. Collected aphids were preserved in small eppendorf tubes containing 80% ethanol and 2% glycerin and were brought the laboratory for morphological examination. Field data of aphid collection was mentioned on the sampling tubes bearing observations such as locality, GPS location, plant name, plant stage and plant part from which aphids was collected, sampling date and time, color of aphid at the time of collection and attendance of ants (Blackman and Eastop, 2000).

#### Identification of aphids

Identification of collected aphid individuals was done in the laboratory of the Department of Entomology, PMAS Arid Agriculture University, Rawalpindi, Pakistan. For this purpose, permanent mounts of specimens were prepared as described by Martin (1983). Using a stereomicroscope, these mounts were used for identification of aphids up to species level with the help of available taxonomic keys of aphids as references and by local aphid experts (Blackman and Eastop, 2000). Their specific morphological characters such as body size, siphunculi length, antennae length, tarsal claws, cauda length and setae were observed and identification was done on the basis of these distinguishable characters. After identification, few selected undamaged specimens of each aphid species were preserved in ethanol-glycerin solution, labelled and submitted to the museum collection of the Department of Entomology, College of Agriculture, University of Sargodha.

#### Statistical analysis

All data regarding collection time, locality, plantation etc. were assembled in Excel sheets and were analyzed through different statistical analyses. The species

richness and relative abundance of different aphid species were determined by calculating Shannon Wiener's, Evenness, Dominance and Sampson's diversity indices which are famous and valid diversity indices in biological sciences (Ravandi *et al.*, 2017).

Diversity indices were calculated as per following formulae;

For Shannon-Wiener's diversity index

$$H' = \sum [pi - \ln (pi)]$$

For Maximum diversity index

$$H'_{max} = \log k$$

For Evenness index

$$J' = \frac{H'}{H'_{max}}$$

For Dominance index

$$D = 1 - J'$$

For Sampson's diversity index

$$Sampson's = 1 - \sum (pi)^2$$

Where;

$pi$ : Fraction of the entire population belonging of species  $i$  (for Shannon-Wiener's index) and proportion of number of individuals of each species over total numbers of individuals of that community (for Sampson's index);  $s$ : Numbers of species encountered;  $k$ : Maximum number of habitat units;  $\Sigma$ : Sum from species 1 to species  $N$ .

## Results and Discussion

### *Species and genera of aphids recorded from district Sargodha*

A total of 51,005 apterous aphid specimens were collected from various plantations during the two winter seasons. Among them, 25,189 aphid specimens were collected during first winter season from November 2017 to April 2018 and 25,816 aphid specimens were collected during second winter season from Novem-

ber 2018 to April 2019. A total of 12 genera of Aphididae were identified in this study belonging to 19 aphid species viz; *Acyrtosiphon pisum*, *Aphis citricola*, *Aphis eugeniae*, *Aphis gossypii*, *Aphis nerii*, *Aphis pomi*, *Brevicoryne brassicae*, *Diuraphis noxia*, *Lipaphis erysimi*, *Macrosiphum rosae*, *Myzus Persicae*, *Rhopalosiphum maidis*, *Rhopalosiphum padi*, *Schizaphis graminum*, *Sitobion avenae*, *Sitobion rosaeformis*, *Therioaphis trifolii*, *Toxoptera aurantii* and *Toxoptera citricida*. Genus *Aphis* was recorded as the most dominant one with five species, followed by genera *Myzus*, *Sitobion* and *Toxoptera* each with two species. These species recorded from district Sargodha along with number of individuals collected during both seasons are given in Table 2. *B. brassicae* was recorded as the most abundant aphid species with 8,470 specimens, followed by *M. Persicae* with 6,655 specimens and *A. gossypii* with 5,348 specimens. While, *S. rosaeformis* with 276 and *A. nerii* with 210 specimens were recorded as the least abundant species (Table 2).

**Table 2:** Total number of specimens of each species of aphids (Hemiptera: Aphididae) collected during the study.

Aphid species	Total number of specimens collected
<i>Brevicoryne brassicae</i>	8470
<i>Myzus persicae</i>	6655
<i>Aphis gossypii</i>	5348
<i>Schizaphis graminum</i>	3697
<i>Diuraphis noxia</i>	3582
<i>Rhopalosiphum maidis</i>	3458
<i>Sitobion avenae</i>	3116
<i>Therioaphis trifolii</i>	2926
<i>Rhopalosiphum padi</i>	2757
<i>Lipaphis erysimi</i>	2537
<i>Acyrtosiphon pisum</i>	1854
<i>Aphis citricola</i>	1677
<i>Aphis eugeniae</i>	1567
<i>Macrosiphum rosae</i>	1039
<i>Toxoptera aurantii</i>	822
<i>Aphis pomi</i>	641
<i>Toxoptera citricida</i>	373
<i>Sitobion rosaeformis</i>	276
<i>Aphis nerii</i>	210
Total	51005

*Plantation wise distribution of aphid species*

Data of aphids from different plantations were recorded from all tehsils of district Sargodha. Then the

data were processed and analyzed for calculating species richness (R), Shannon-Wiener's diversity index ( $H'$ ), maximum diversity ( $H'_{max}$ ), evenness ( $J'$ ), dominance ( $D'$ ) and Simpson's diversity index. A considerable diversity and abundance of aphids was observed among different plantation types sampled during the study. Aphid species collected from different plantation categories along with their host plantation(s) and collection localities are given Table 3.

*B. brassicae* was recorded as the most abundant species with 8,470 (16.6%) specimens, followed by *M. persicae* with 6,655 (13%) specimens and *A. gossypii* with 5,348 (10.5%) specimens. While, *A. pomi* with 641 (1.3%), *S. rosaeformis* with 276 (0.5%) and *A. nerii* with 210 (0.4%) specimens were recorded as the least abundant species (Table 3). Citrus plantations were dominated by *A. gossypii* and *A. citricola*. Loquat plants were maximally infested by *A. eugeniae*. In cereals, *S. graminum*, *S. avenae* and *D. noxia* were most dominant aphid species, while *M. persicae* was found maximum on fodder plantations. *B. brassicae* and *R. maidis* were most abundant on oilseed crops while *A. gossypii* and *M. persicae* were found most abundantly on ornamental and vegetable plantations, respectively (Table 3).

Moreover, maximum richness (5) was recorded in both ornamentals and vegetables, while minimum richness (2) was recorded in loquat. Maximum and minimum Shannon Wiener's diversity index was found for ornamentals (1.457) and loquat (0.602), respectively. Cereals and vegetable plantations showed maximum (0.978) and minimum (0.842) evenness ( $J'$ ) index, respectively. Maximum dominance (0.131) was shown by loquat, while minimum dominance (0.005) was calculated in cereals. Loquat showed maximum Simpson's diversity  $D$  (0.588), while minimum Simpson's diversity  $D$  (0.523) was shown by cereal plantations.

With about 5,000 species described worldwide, aphids belong to family Aphididae of sub-order Sternorrhyncha of order (Miller and Footitt, 2009). In this study, 51,005 apterous adult aphid specimens were collected from different economically important plantations of district Sargodha including citrus, loquat, fodder, cereals, oilseeds, ornamentals and vegetables. During study period, a total 19 different aphid species belonging to 12 different genera were recorded including *A. pisum*, *A. citricola*, *A. eugeniae*,

**Table 3:** Host plant wise diversity of different species of aphids (Hemiptera: Aphididae) in district Sargodha.

Plantation Category / Aphid Species	Citrus	Loquat	Fodder	Cereals	Oilseeds	Ornamentals	Vegetables	Total
<i>Acyrtosiphon pisum</i>	0	0	1854	0	0	0	0	1854
<i>Aphis citricola</i>	1677	0	0	0	0	0	0	1677
<i>Aphis eugeniae</i>	0	1567	0	0	0	0	0	1567
<i>Aphis gossypii</i>	1903	0	0	0	0	1462	1983	5348
<i>Aphis nerii</i>	0	0	0	0	0	0	210	210
<i>Aphis pomi</i>	0	641	0	0	0	0	0	641
<i>Brevicoryne brassicae</i>	0	0	0	0	4633	0	3837	8470
<i>Diuraphis noxia</i>	0	0	0	3582	0	0	0	3582
<i>Lipaphis erysimi</i>	0	0	0	0	2537	0	0	2537
<i>Macrosiphum rosae</i>	0	0	0	0	0	1039	0	1039
<i>Rhopalosiphum maidis</i>	0	0	0	0	2039	490	929	3458
<i>Myzus Persicae</i>	0	0	3136	0	0	1501	2018	6655
<i>Rhopalosiphum padi</i>	0	0	0	2757	0	0	0	2757
<i>Schizaphis graminum</i>	0	0	0	3697	0	0	0	3697
<i>Sitobion avenae</i>	0	0	0	3116	0	0	0	3116
<i>Sitobion rosaeformis</i>	0	0	0	0	0	276	0	276
<i>Therioaphis trifolii</i>	0	0	2926	0	0	0	0	2926
<i>Toxoptera aurantii</i>	822	0	0	0	0	0	0	822
<i>Toxoptera citricida</i>	373	0	0	0	0	0	0	373
N	4775	2208	7916	13152	9209	4768	8977	51005
R	4	2	3	4	3	5	5	19
H'	1.236	0.602	1.074	1.379	1.034	1.457	1.355	2.629
H' max	1.386	0.693	1.099	1.386	1.099	1.609	1.609	2.944
J'	0.892	0.869	0.978	0.995	0.941	0.905	0.842	0.893
D'	0.108	0.131	0.022	0.005	0.059	0.095	0.158	0.107
Simpson's D	0.318	0.588	0.348	0.253	0.378	0.254	0.293	0.087

**N:** Total number of aphids collected; **R:** Species Richness; **H':** Shannon-Weiner's Diversity Index; **H' max:** Maximum Diversity; **J':** Evenness; **D':** Dominance; **Simpson's D:** Simpson's Diversity Index.

*A. gossypii*, *A. nerii*, *A. pomi*, *B. brassicae*, *D. noxia*, *L. erysimi*, *M. rosae*, *M. Persicae*, *R. maidis*, *R. padi*, *S. graminum*, *S. avenae*, *S. rosaeformis*, *T. trifolii*, *T. aurantii* and *T. citricida*. In our findings, *Aphis eugeniae* is first time reported from Pakistan.

In present study, genus *Aphis* was recorded as most the dominant genus with five species (*A. citricola*, *A. eugeniae*, *A. gossypii*, *A. nerii* and *A. pomi*) followed by *Myzus*, *Sitobion* and *Toxoptera*. Blackman and Eastop (2000) reported that genus *Aphis* consists of more than 600 described species and are distributed ubiquitously worldwide. *A. citricola* and *A. eugeniae* were the most dominant species in citrus plants. These species are possibly originated in middle or Far East and are currently well distributed worldwide including tropical, sub-tropical and arctic regions except Antarctica (Eastop and Blackman, 2000).

During this study, *B. brassicae* was recorded as the most abundant species with 17% of the collected aphid specimens, followed by *M. Persicae* (13%) and *A. gossypii* (11%), while, *A. pomi*, *S. rosaeformis* and *Aphis nerii* were the least abundant species. Our findings are consistent with those of Singh *et al.* (2016) who reported *A. craccivora* and *A. gossypii* as diverse and abundant aphid species in the legumes in India.

As many aphid species are usually host-specific, three out of four aphid species found on citrus plantations i.e. *A. citricola*, *T. citricida* and *T. aurantii* are monophagous and one species *A. gossypii* is polyphagous and was also recorded from other plantations. *A. citricola* was also recorded from citrus by other studies (Irshad, 2001; Amin *et al.*, 2017). *T. citricida* and *T. aurantii* were also recorded on citrus and tea plantations in Pakistan by Naseem *et al.* (2016) and So-

hail *et al.* (2012), respectively. Irshad (2001) reported presence of *Aphis gossypii* in all citrus plantations in Pakistan. Only two monophagous aphid species were recorded from loquat *i.e.* *A. eugeniae* and *A. pomi*. *A. eugeniae* was reported first time in Pakistan during this study. Singh and Singh (2017) reported *A. eugeniae* from India. *A. pomi* was recorded by Khan *et al.* (2011) from Kashmir, Pakistan.

From cereal plantations, four species were recorded *i.e.* *S. graminum*, *S. avenae*, *D. noxia* and *R. padi* with *S. graminum* as the most dominant species. It was reported from Pakistan by Bodlah *et al.* (2011) and Irshad (2001) from wheat and barley. *S. avenae*, *D. noxia* and *R. padi* were also reported by Mushtaq *et al.* (2013) and Irshad (2001) from different cereals plantations in Pakistan. In fodder plantations, only two monophagous (*T. trifolii* and *A. pisum*) and one polyphagous (*M. persicae*) species were recorded with the latter one as most dominant one. *A. pisum* and *M. persicae* were also recorded by Irshad (2001), Hassan *et al.* (2010) and Amin *et al.* (2017) from fodder plantations in different geographical areas of Pakistan. While, *T. trifolii* was also recorded by Irshad (2001) and Bodlah *et al.* (2011).

Oilseed crops were found infested by one monophagous (*L. erysimi*) and two polyphagous (*R. maidis* and *B. brassicae*) aphid species with the latter one as most dominant which has been also reported on different oilseed crops in Pakistan by many studies (Irshad, 2001; Amer *et al.* 2009; Mushtaq *et al.*, 2013). Similarly, *L. erysimi* and *R. maidis* were also reported by Irshad (2001), Amer *et al.* (2009), Bodlah *et al.* (2011) and Mushtaq *et al.* (2013) from brassica and canola crops.

Ornamentals showed good diversity of aphids. Four species of aphids were recorded from ornamentals during the studies. Out of them, *S. rosaeformis* and *M. rosae* were recorded only from rose plants. *M. persicae* was recorded as most dominant species in ornamental plantations. Presence of *M. rosae*, *A. gossypii* and *S. rosaeformis* on rose plantations was also reported by Irshad (2001) and Amin *et al.* (2017). These results are in line with the findings of present study. Moreover, five aphid species *i.e.* *M. persicae*, *A. gossypii*, *A. nerii*, *R. maidis* and *B. brassicae* were recorded from different vegetable plantations. *B. brassicae* was recorded as most the most abundant aphid species in vegetable plantations. Presence of all these aphid

species on different vegetable crops in Pakistan was reported by Irshad (2001), Mushtaq *et al.* (2013) and Amin *et al.* (2017).

Population dynamics of aphids was also determined during the current study. Peak population was recorded in early to mid-March. Our findings were in agreement with Aheer *et al.* (2008), Iqbal *et al.* (2008), Wains *et al.* (2010) and Mushtaq *et al.* (2013). Our findings are not in line with as Singh *et al.* (2001) who reported peak population of different aphid species in early to mid-January. The reason of these different results may be due to different ecological and geological conditions. Our findings are similar to Aslam *et al.* (2004) and Hassan *et al.* (2004) who reported peak population of different aphid species in the start of March on oilseed and other crops.

## Conclusions and Recommendations

It is concluded from the current study that a considerable diversity of aphids (Hemiptera: Aphididae) prevails in semi-arid subtropical region of district Sargodha. A total 19 aphid species belonging to 12 genera different genera were recorded on different economically important plantations with *B. brassicae*, *M. Persicae* and *A. gossypii* as the most abundant species comprising of 40% of the collection. While, *A. pomi*, *S. rosaeformis* and *A. nerii* were the least abundant aphid species. More work is needed to explore biodiversity of Aphididae from other areas of Pakistan. Moreover, as aphid population on most of the sampled plantations peaked in early to mid-March, indigenous farmers are recommended to take necessary pest management action in time while combating aphid infestations on their crops.

## Novelty Statement

In current study, we determined the diversity of aphids (Hemiptera: Aphididae) on different economically important plantations in district Sargodha. A total of 19 aphid species belonging to 12 genera were recorded in the study area that has not been reported before in Sargodha, Punjab, Pakistan.

## Authors' Contribution

**Abu Baker Muhammad Raza:** Conceived the idea and planned the experiment.

**Muhammad Faisal Riaz and Talha Nazir:** Conduct-

ed the experiments.

**Muhammad Faisal Riaz and Talha Nazir:** Performed statistical analyses and prepared the results.

**Muhammad Faisal Riaz and Muhammad Zeeshan Majeed:** Wrote the first draft of manuscript.

**Muhammad Zeeshan Majeed and Abu Baker Muhammad Raza:** Technically revised the manuscript.

**Abu Baker Muhammad Raza:** Provided the technical assistance and proofread the manuscript.

All authors have read and approved the final manuscript.

#### Conflict of interest

The authors have no conflict of interest regarding the publication of this research work.

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