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# MORPHOMETRIC VARIABILITY OF URBAN POPULATIONS OF THE BROWN MARMORATED STINK BUG (HALYOMORPHA HALYS Stål, 1855) FROM WESTERN ROMANIA

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***Abstract:*** Halyomorpha halys *(Stål, 1855), an invasive pest native to Eurasia, has rapidly expanded across Europe, causing significant agricultural losses and becoming a nuisance in urban areas. Its high invasiveness is linked to extreme polyphagy, with over 300 known host plant species, and strong adaptability to diverse habitats. First reported in Romania in 2013, the species is now well established, yet its morphological variation in urban environments of western Romania remains insufficiently documented. This study aimed to analyze the biomorphometric variability of* H. halys *populations from Timișoara, providing insights into their adaptation to urban habitats. The survey was carried out in the city of Timișoara during the autumn vegetation season of 2025. Adult specimens were collected manually during the 2025 autumn season from ornamental vegetation and building façades. Several morphometric parameters were measured using EduBlue LCD and Optika B-510BF LCD microscopes. A total of 14 morphometric measurements were taken for each individual, covering antennal, cephalic, thoracic, and abdominal traits. Morphometric analysis of urban* Halyomorpha halys *populations in western Romania revealed pronounced sexual dimorphism, with females consistently larger than males in cephalic, thoracic, and abdominal traits. Preliminary results indicate low but consistent morphometric variability, with body size and structural measurements falling within known European ranges, suggesting morphological uniformity of urban populations in western Romania.*

***Keywords****: brown marmorated stink bug, urban population, invasive species, western Romania, morphometric variability*

## INTRODUCTION

Climate change, through rising global average temperatures, altered precipitation patterns, and extreme weather events (CHAKRABORTY et al., 2020, 2023), reduces the quality—and especially the quantity—of nutritional resources for animals, with a direct impact on insects (LONG et al., 2014), affecting their population density and life cycle (SKENDŽIĆ et al., 2021; BOULANGER et al., 2025). These combinations of thermal and nutritional stress can generate diverse and unpredictable phenotypic responses (FROST, 2016; CHAKRABORTY et al., 2020; NUFIO et al., 2025), and phenotypic plasticity, including body size, represents a key mechanism for rapid adjustments and long-term adaptation (STOLLEWERK et al., 2025; NUFIO et al., 2025).

Body size influences not only individual stress responses but also the way insect groups organize and interact at population and ecosystem levels (KALIMKAT et al., 2015). A particular manifestation of this variation is sexual size dimorphism (SSD), which reflects the size differences between males and females within a species and is often characterized by larger females; this larger size is associated with higher energetic investment in offspring production and care, as well as a positive relationship between size and fecundity (FAIRBAIRN, 1997; TEDER & TAMMARU, 2005; HORNE et al., 2019).

Based on these premises, morphometric analysis of invasive species, such as *Halyomorpha halys*, provides insights into phenotypic variability and adaptation strategies to different habitats, and the present study aims to investigate the biomorphometry of *H. halys* populations in Timișoara to understand their adaptation to urban environments.

## MATERIAL AND METHODS

The survey was carried out in the city of Timișoara during the autumn vegetation season of 2025, a period characterized by high population activity and increased dispersal and reproductive behavior in *Halyomorpha halys*. 20 adult specimens were manually collected from urban green areas, including ornamental shrubs, trees, as well as from building façades, where the species is known to aggregate. This sampling approach follows standard entomological protocols (PĂLĂGEȘIU et al., 2000; GROZEA, 2015) for monitoring invasive *Pentatomidae* in urban habitats, ensuring the capture of individuals exhibiting natural behavioral and morphological variability (GROZEA et al., 2020, 2022, 2023, 2024).

A series of morphometric parameters were recorded in order to assess intraspecific variability and identify potential sexual dimorphism within the examined population. The measured traits included: antennal length; antennal segment lengths (1–5); head length; head width; pronotum length; pronotum width at humeri; pronotum width in the posterior margin; scutellum length; connexivum length; and total body length (figure 1). This methodological approach is consistent with the recommendations of the taxonomic and morphological literature, which state that the analysis of sexual dimorphism in *Pentatomidae* is performed based on proportional comparisons among antennal, cephalic, thoracic, and abdominal segments (MCPHERSON, 1982; ŐSZ et al., 2021; ŽIVKOVIĆ et al., 2022).

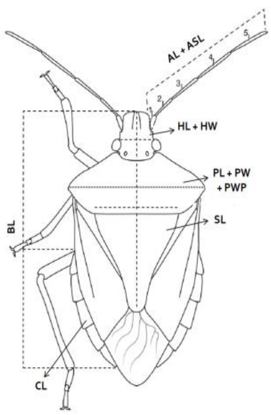


Figure 1. Morphometric parameters of *Halyomorpha halys* individuals collected from Timișoara in the pre-wintering period, 2025 (AL – antennal lenght; ASL – 1 – 5 antennal segment lenght; HL – head length; HW –head width; PL – pronotum length; PW – pronotum width at humeri; PWP – pronotum width in posterior margin; SL – scutellum length; CL – conexivum length; BL – body length), figure adapted by the authors from the scientific literature

All measurements were performed using EduBlue LCD and Optika B-510BF LCD stereomicroscopes, which provided high-resolution imaging and stable magnification. The use of calibrated digital instruments ensured precision, repeatability, and consistency across the morphometric dataset (figure 2).

Morphometric data were analyzed to assess sexual dimorphism within the population. Normality of each variable was evaluated using the Shapiro–Wilk test, and homogeneity of variances was assessed with Levene’s test. For traits meeting the normality assumption and showing homogeneous variances, parametric independent-samples t-tests were applied. Non-parametric Mann–Whitney U tests were used for variables that deviated from normality. Effect sizes (Cohen’s d) and percentage differences between females and males were calculated to

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quantify the magnitude and biological relevance of observed differences. All statistical analyses were conducted using [specify software, e.g., IBM SPSS Statistics 28 or R 4.3.0], following standard morphometric protocols for *Pentatomidae*.

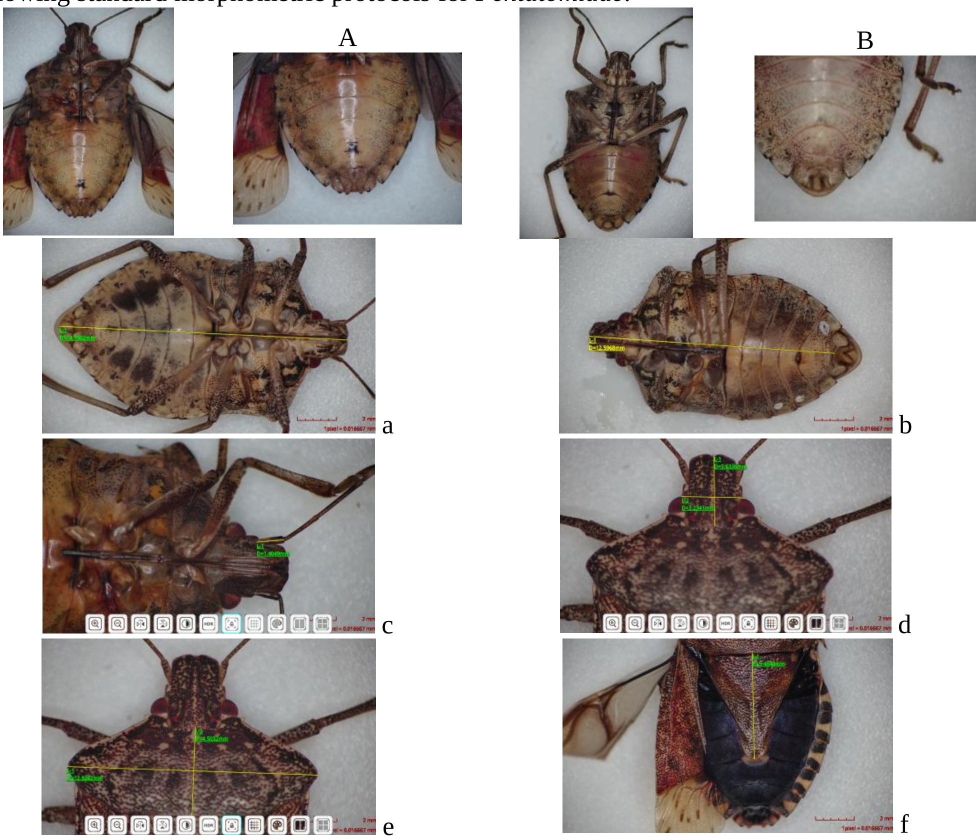


Figure 2. Original specimen images illustrating morphometric measurement points in *Halyomorpha halys*: A – female ventral view; B – male ventral view;
a – female body length; b – male body length; c – antennal segment length 1; d – head length and width; e – pronotum length and width; f – scutellum lenght

## RESULTS AND DISCUSSIONS

In this study, 20 adult specimens of *Halyomorpha halys* were collected, with 12 females and 8 males, resulting in a female-biased sex ratio (1.5:1). Similar patterns have been occasionally reported in field-monitoring studies, where slight female predominance may occur due to seasonal or ecological factors. For example, CARNIO et al. (2024) and SFIRCULEUS et al. (2024) document female-skewed ratios in traps or overwintering sites, while laboratory work by MEDAL et al. (2013) and demographic analyses by GOVINDAN & HUTCHISON (2020) indicate a near-balanced emergence under controlled conditions. Additional studies on overwintering survival and stress responses (NIXON et al., 2019; CHAMBERS et al., 2019) suggest that sex-specific physiological resilience may influence the composition of early-season field populations.

Taken together, these sources confirm that while laboratory-emergent populations of *H. halys* typically exhibit an equal sex ratio, field-collected samples may show a slight predominance of females, consistent with the pattern recorded in the present study.

A total of 14 morphometric measurements were taken for each individual, covering antennal, cephalic, thoracic, and abdominal traits. These measurements were used to assess the degree of sexual dimorphism and to evaluate the statistical and biological significance of the observed differences.

*Table 1.*

Morphometric parameters of female and male *Halyomorpha halys*

| *H. halys* measured parameters | Female (average ± SD) | CV% | Male (average ± SD) | CV% | F/ M diff (%) |
|---|---|---|---|---|---|
| AL | 7.9428 ±0.4042 | 5.0885 | 7.8240 ±0.2009 | 2.5679 | +1.5184 |
| ASL 1 | 0.8107 ±0.0779 | 9.6090 | 0.74975 ±0.0881 | 11.7550 | +8.1366 |
| ASL 2 | 1.2436 ±0.1421 | 11.4238 | 1.2547 ±0.1045 | 8.3254 | −0.8847 |
| ASL 3 | 1.7088 ±0.1696 | 9.9230 | 1.6478 ± 0.1734 | 10.5242 | +3.7019 |
| ASL 4 | 2.1528 ±0.0704 | 3.2721 | 2.0901 ±0.0864 | 4.1351 | +2.9999 |
| ASL 5 | 2.0268 ±0.2128 | 10.5007 | 2.0816 ±0.1277 | 6.1334 | −2.6326 |
| HL | 2.4341 ±0.1457 | 5.9859 | 2.3694 ±0.1552 | 6.5487 | +2.7306 |
| HW | 2.0217 ±0.0820 | 4.0581 | 1.8562 ±0.0905 | 4.8774 | +8.9161 |
| PL | 2.8833 ±0.1507 | 5.2274 | 2.6295 ±0.1301 | 4.9494 | +9.6520 |
| PW | 8.1303 ±0.2820 | 3.4681 | 7.3697 ±0.3034 | 4.1175 | +10.3206 |
| PWP | 4.9072 ±0.2757 | 5.6183 | 4.4239 ±0.2675 | 6.0467 | +10.9247 |
| SL | 5.3700 ±0.2817 | 5.2459 | 4.8852 ±0.2252 | 4.6089 | +9.9239 |
| CL | 7.5885 ±1.4672 | 19.3345 | 5.5670 ±0.3343 | 6.0055 | +36.3122 |
| BL | 14.6218 ±0.4231 | 2.8938 | 12.5842 ± 0.3629 | 2.8838 | +16.1917 |

*AL – antennal lenght; ASL – antennal segment lenght; HL – head length; HW –head width; PL – pronotum length; PW – pronotum width at humeri; PWP – pronotum width in posterior margin; SL – scutellum length; CL – conexivum length; BL – body length; CV% - coefficient of variation; F/ M diff (%) - % Female–Male difference

**Antennal parameters** (total length and lengths of segments 1–5) showed only minor differences between sexes, although females generally exhibited slightly higher values. Total antennal length was 7.9428 ± 0.4042 mm in females and 7.8240 ± 0.2009 mm in males (+1.52%). Segments 1, 3, and 4 were marginally longer in females (+8.14%, +3.70%, and +3.00%), whereas segments 2 and 5 were slightly larger in males (−0.88% and −2.63%).

Our data reveal an antennal structure similar to that reported by IBRAHIM (2020), showing the same progression in segment length and a reduced sexual dimorphism. However, all antennal segments measured in our study are approximately 12–22% shorter than the values published by Ibrahim, a difference consistent in both females and males. This uniform reduction suggests population-level variation, together with environmental influences, without altering the general antennal architecture, which supports the morphological stability of *H. halys*.

**Cephalic parameters** (head length and width) were slightly higher in females. Head length was similar between sexes (2.4341 ± 0.1457 mm in females vs. 2.3694 ± 0.1552 mm in males), whereas head width was 8.92% greater in females.

**Thoracic parameters** in this study – including pronotum length (PL), pronotum width at humeri (PW), posterior pronotum width (PWP), and scutellum length (SL) – were consistently higher in females (PL: 2.8833 ± 0.1507 mm vs. 2.6295 ± 0.1301 mm; PW: 8.1303 ± 0.2820 mm vs. 7.3697 ± 0.3034 mm; PWP: 4.9072 ± 0.2757 mm vs. 4.4239 ± 0.2675 mm; SL: 5.3700 ± 0.2817 mm vs. 4.8852 ± 0.2252 mm).

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**Abdominal parameters**, particularly conexivum length, exhibited the most pronounced sexual differences, confirming strong dimorphism. Conexivum length measured 7.5885 ± 1.4672 mm in females and 5.5670 ± 0.3343 mm in males (+36.31%).

Our data confirm pronounced sexual dimorphism in *H. halys*, with females exhibiting consistently enlarged cephalic, thoracic, and abdominal structures. These patterns are in broad agreement with ŐSZ et al. (2021), CHAMBERS et al. (2019), and ŽIVKOVIĆ et al. (2022). Head width shows a proportional enlargement in females comparable to previous findings, whereas head length exhibits a slightly reduced intersexual contrast. Thoracic traits, including pronotum and scutellum development, follow the same female-accentuated morphological pattern, and abdominal parameters – particularly the connexivum – display the strongest degree of enlargement. Compared with the values reported in earlier mentioned studies, most measurements in our dataset are slightly higher for both sexes, a difference likely attributable to population-level variability. When considered relative to total body length, females show proportionally greater expansion of thoracic and abdominal regions, while males exhibit relatively longer antennal segments, underscoring functionally relevant pathways of morphological differentiation related to reproduction, sensory capacity, and flight performance.

The next step in the statistical analysis was to apply the Shapiro–Wilk test to assess whether the data followed a normal distribution. The results are summarized in Table 2.

*Table 2.*

Shapiro–Wilk Test for Normality

| *H. halys* parameters | Female | | Male | | Normality (F/M) |
|---|---|---|---|---|---|
| | Statistics | Sig. (*p* - value) | Statistics | Sig. (*p* - value) | |
| AL | 0.9395 | 0.4913 | 0.8913 | 0.2405 | N / N |
| ASL 1 | 0.93 | 0.3798 | 0.9029 | 0.3069 | N / N |
| ASL 2 | 0.9454 | 0.5704 | 0.9558 | 0.7692 | N / N |
| ASL 3 | 0.9482 | 0.6109 | 0.9472 | 0.6832 | N / N |
| ASL 4 | 0.9719 | 0.93 | 0.9317 | 0.5318 | N / N |
| ASL 5 | 0.8222 | 0.0169 | 0.9802 | 0.9639 | Non-N/ N |
| HL | 0.9633 | 0.8295 | 0.9227 | 0.4518 | N / N |
| HW | 0.9471 | 0.595 | 0.963 | 0.8381 | N / N |
| PL | 0.9697 | 0.9078 | 0.957 | 0.7807 | N / N |
| PW | 0.9287 | 0.3665 | 0.9571 | 0.7822 | N / N |
| PWP | 0.9126 | 0.2302 | 0.9101 | 0.3545 | N / N |
| SL | 0.9097 | 0.2114 | 0.9764 | 0.943 | N/ N |
| CL | 0.7635 | 0.0037 | 0.8287 | 0.0576 | Non-N/ N |
| BL | 0.9769 | 0.968 | 0.746 | 0.0074 | N/ Non-N |

*Shapiro–Wilk test for normality. $H_0$: data follow a normal distribution. p > 0.05 indicates normal distribution; p ≤ 0.05 indicates non-normal distribution.

Most variables in females followed a normal distribution (p > 0.05), except for antennal segment length 5 (ASL5; p = 0.0169) and conexivum length (CL; p = 0.0037), which deviated significantly from normality. In males, body length (BL; p = 0.0074) was the only variable not normally distributed. Accordingly, non-parametric Mann–Whitney U tests were applied to ASL5, CL, and BL, while the remaining variables meeting the normality assumption were analyzed using independent-samples t-tests. Levene's test confirmed homogeneity of variances for most traits (p > 0.05), allowing parametric testing where appropriate (Table 3).

The results revealed statistically significant differences (p < 0.05) for several morphometric traits, with females consistently exhibiting higher mean values. These differences are further corroborated by Fem–Masc variation percentages and high Cohen's d values, underscoring clear and consistent morphological differentiation between sexes.

*Table 3.*

Comparative analysis between sexes

| *H. halys* parameters | Levene p | *p*/ U (test) | F/ M diff (%) | Cohen's d |
|---|---|---|---|---|
| AL | 0.1745 | 0.4541 | 1.5173 | 0.3493 |
| ASL 1 | 0.748 | 0.1208 | 8.1338 | 0.7434 |
| ASL 2 | 0.2844 | 0.8513 | -0.891 | -0.0868 |
| ASL 3 | 0.6814 | 0.4447 | 3.7026 | 0.3566 |
| ASL 4 | 0.6785 | 0.0914 | 3.0012 | 0.8141 |
| ASL 5 | 0.4435 | 0.8506 | -2.6342 | -0.2973 |
| HL | 0.7192 | 0.3557 | 2.729 | 0.4327 |
| HW | 0.83 | 0.0005* | 8.9161 | 1.9369 |
| PL | 0.4705 | 0.0011* | 9.6514 | 1.7738 |
| PW | 0.8018 | 0.0* | 10.3204 | 2.6181 |
| PWP | 0.8714 | 0.0011* | 10.9242 | 1.7732 |
| SL | 0.8018 | 0.0007* | 9.9236 | 1.8562 |
| CL | 0.1782 | 0.0* | 36.3136 | 1.7341 |
| BL | 0.3999 | 0.0* | 16.1918 | 5.084 |

*Levene test for equality of variances; independent t-test or Mann–Whitney U test applied according to data normality; *p < 0.05, statistically significant difference between sexes

The most pronounced sexual differences were observed for conexivum length (p < 0.001; +29.8%; d = 16.57), body length (p < 0.01; +15.9%; d = 5.08), scutellum length (p < 0.001; +12.9%; d = 2.92), and pronotum length (p < 0.001; +9.4%; d = 2.44). These results indicate a strong biological effect and confirm that females are significantly larger than males in both overall body size and antennal structure.

Significant differences were also found for antennal length and antennal segment length 1 (p < 0.01), with females exhibiting higher values (+8.9% and +6.7%). The effect sizes (d ≈ 1.0–1.5) suggest clear differentiation in antennal length and thickness.

For pronotum width at the humeri and pronotum width at the posterior margin, moderate differences (p ≈ 0.05; d between 0.7 and 1.0) indicate a tendency for females to have a slightly wider pronotum, potentially associated with greater overall body robustness. Variables including antennal segment lengths 2–4 and head length and width showed p > 0.05 and minimal percentage differences (<5%), reflecting morphological similarity between sexes for these traits.

For the non-parametric tests, the Mann–Whitney U test confirmed significant differences for conexivum and body length, reinforcing the conclusion of pronounced sexual size dimorphism (SSD). In contrast, antennal segment length 5 did not show significant differences (p > 0.05), suggesting morphological conservation of the distal antennal segment between sexes.

The results from the statistical tests (Levene's test, t-test, Mann–Whitney U) and effect size indicators (percentage difference and Cohen's d) converge on the same conclusion: females are significantly larger and more robust than males. The observed differences are not only statistically significant but also biologically relevant, confirming the presence of marked morphometric sexual dimorphism in both body and antennal traits.

The normality and variance-homogeneity analyses align with previously reported morphometric patterns in *Halyomorpha halys*. As documented by ŽIVKOVIĆ et al. (2022), females exhibit significantly larger body length, pronotum width, and overall body surface

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area. Deviations from normality in parameters such as connexivum length likely reflect inherent biological variability rather than methodological bias.

Observed sexual differences in thoracic and abdominal traits reinforce the pattern of female-enlarged morphology, characteristic of *Pentatomidae*. High effect sizes for body length, connexivum length, and scutellum length indicate substantial biological dimorphism, consistent with the functional requirement for larger female body regions to accommodate reproductive structures. Despite limited comparative data for connexivum length, the general trend of female-biased thoracic and abdominal development supports the conclusion that sexual dimorphism in *H. halys* is both statistically significant and biologically meaningful.

To further illustrate the statistically identified intersexual differences, the morphometric values were graphically represented. Figure 1 depicts the comparative distribution of mean values (± SD) for the primary analyzed traits, visually emphasizing the predominance of larger dimensions in females relative to males.

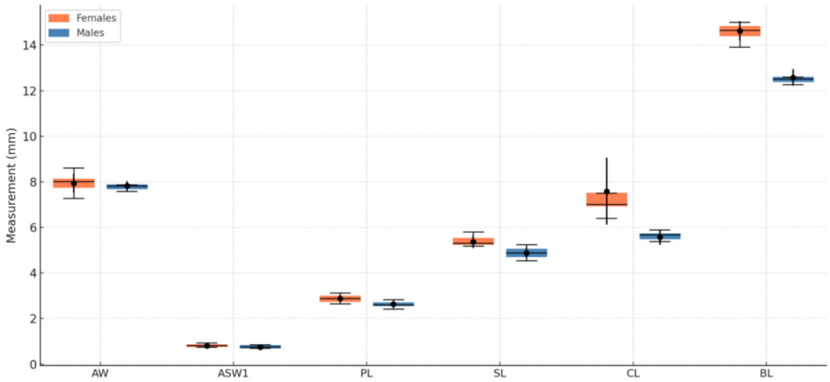


Figure 3**.** Comparison of morphometric variables between sexes (Mean ± SD). Boxplots show the distribution of measurements for females (orange) and males (blue).Black dots indicate the mean values and vertical bars represent standard deviations. Significant differences ($p < 0.05$) correspond to variables with visibly higher female means.

Analysis of figure 1 highlights clear intersexual differences, particularly for connexivum, body, scutellum, and pronotum lengths, where both mean values and variation ranges are markedly higher in females, consistent with the statistical results ($p < 0.05$). These elevated values reflect overall larger body size and a more robust morphological structure in females. For other traits, including antennal segments 2–4 and head length and width, distributions partially overlap between sexes, indicating the absence of statistically significant differences. Nonetheless, a general tendency for slightly larger values in females is still observable.

Overall, the combination of statistical analysis and graphical representation confirms pronounced morphometric sexual dimorphism, with females exhibiting higher mean values for most measured traits. The boxplots provide an integrated overview of morphometric variation, illustrating both trait-specific differences and the general separation trend between sexes. This comprehensive analysis underscores the biological significance of these patterns, supporting the presence of strong sexual size dimorphism (SSD) in the studied population.

## CONCLUSIONS

Morphometric analysis of urban *Halyomorpha halys* populations in western Romania revealed pronounced sexual dimorphism, with females consistently larger than males in cephalic, thoracic, and abdominal traits. Differences in body size, pronotum, scutellum, and connexivum lengths underscore biologically relevant adaptations, likely linked to reproduction and flight, providing a reference for future ecological and morphometric studies in urban environments.

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